CONFERENCE BOOK

SEISMOLOGY OF THE SUN AND THE DISTANT STARS 2016 / USING TODAY'S SUCCESSES TO PREPARE THE FUTURE

TASC2 & KASC9
/ *Workshop*

SPACEINN & HELAS8
/ *Conference*

11–15 July
Angra do Heroísmo
Terceira, Açores
Portugal

ORGANIZERS

ia instituto de astrofísica e ciências do espaço
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SEVENTH FRAMEWORK PROGRAMME
Governo dos Açores
FCT Fundação para a Ciência e a Tecnologia

SEISMOLOGY OF THE SUN AND THE DISTANT STARS 2016
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Scientific Rationale

For the last 30 years, since the meeting on Seismology of the Sun and the Distant Stars held in Cambridge, in 1985, the range of seismic data and associated science results obtained has far exceeded the expectations of the community. The continuous observation of the Sun has secured major advances in the understanding of the physics of the stellar interiors and has allowed us to build and prepare the tools to look at other stars. Several ground facilities and space missions have completed the picture by adding the necessary data to study stars across the HR diagram with a level of detail that was in no way foreseen in 1985.

In spite of the great science successes, astero- and helioseismic data still contain many secrets waiting to be uncovered. The opportunity to use the existing data and tools to clarify major questions of stellar physics (mixing, rotation, convection, and magnetic activity are just a few examples) still needs to be further explored. The combination of data from different instruments and for different targets also holds the promise that further advances are indeed imminent. At the same time we also need to prepare the future, as major space missions and ground facilities are being built in order to collect more and better data to expand and consolidate the detailed seismic view of the stellar population in our galaxy.

This conference aims at reviewing the major science achievements resulting from the extensive data collections available from space missions and ground facilities, as well as the tools the community has developed to study and explore those data. This will also include planning the asteroseismic activities of the TESS mission in preparation for its launch next year. The present view is fundamental to prepare the forthcoming facilities that will provide the data necessary to address challenging questions that have not yet been answered with the current data. The optimal way to achieve that should be one of the major outcomes of the conference which is expected to set a critical milestone for the astero- and helioseismology community to prepare the future.

The meeting will also cover major synergies with related fields, which benefit from a deeper understanding of the structure and evolution of the sun and stars across the HR diagram. These include topics covering the characterization of planet hosts, and their exoplanets, the description of stellar populations and impact on Galactic evolution, as well as star and planet formation and the early evolution of planetary systems. Also of major relevance is the driving of space weather in the solar system and other stellar systems and its impact on habitability, linking stellar evolution to the search for life.

PORTUGAL, 5 JULY, 2016

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CONFERENCE VENUE

The conference will take place in the auditorium of the **Centro Cultural e de Congressos**, in the town of **Angra do Heroísmo**, which is located in the island of **Terceira**, one of the nine islands that make up the archipelago of the **Azores**.

MAP goo.gl/maps/STYzt96fUEu **GPS** 38.6570193, -27.2270809

How to reach **Terceira Island** (Lajes airport). The most common routes into Terceira are either via Lisbon (from European cities) or via Boston (from American cities), with one of these two companies:

TAP airlines: www.flytap.com
SATA airlines: www.sata.pt
Lages airport: aerogarelajes.azores.gov.pt
Charter flights are also available from several European cities into Ponta Delgada, a town located in the island of São Miguel. These must be followed by a connection to Terceira, which is offered by SATA airlines.

From the airport to Angra do Heroísmo
Transfer from the Lajes Airport to the hotel in Angra do Heroísmo is done by taxi. The expected price is around 25 euros.

PRACTICAL INFORMATION

Help
Should you have any questions during the meeting, Elsa Silva, from the LOC, will be available daily at the registration desk, from 8:30 to help. You can also contact us by email at SpaceTK16@iastro.pt

Speakers
All oral presentations (**PDF** or **PowerPoint**) should be copied to the conference computer no later than the end of the coffee or lunch break preceding the corresponding session. **Office 2010** is installed in the conference computer. Projection is in wide screen (16:9) format.

The strict limit on duration of the presentations is:
IR Invited Review (30 min)
IC Invited Contribution (20 min)
RC Requested Oral Contribution (15 min)
OC Oral Contribution (15 min)

Poster presentations
The absolute upper limit on size is A0 (85 × 120 cm), with orientation being Portrait (only).

There will be two poster periods,
PA the first running from Monday to Wednesday lunchtime, and
PB the second from Wednesday lunchtime to Friday.

Information on the posters allocated to each period of display is available on this website under "posters".

One minute/one slide poster presentations will be organized on Monday and on Thursday

www.iastro.pt/
research/conferences/spacetk16

for the posters of the first and second periods, respectively. We kindly ask you to send us your slide for the poster presentation, with a clear identification of the poster number. The PDF file should be sent to spacetk16@iastro.pt no later than the morning coffee break on Monday (for posters in Period A) or lunch time on Wednesday (for posters in Period B).

Internet

A wireless network is available at the conference venue. We kindly ask you to consider turning off the wireless connection from your devices when not using them, to avoid overloading the network.

Network (SSID): **SPACEINN**
Password: **spaceinnazores**

Social hashtag

#spacetk16

SOCIAL PROGRAM

Sunday, 10th, from 18:30 to 20:30

Welcome drinks (and registration)
Open to all participants and registered guests.
Location: Pousada de Angra do Heroísmo São Sebastião (also known as Castelinho)

Tuesday, 12th, from 19:00 onwards

Young Astronomers Mixer
(Drinks and food to be payed by the participants)
Open to all.
Location: O Pirata Gastropub
Note: Age is irrelevant. If you feel young, come along!

Tuesday, 12th, 21:00

Public Talk (in Portuguese)
Portugal e o espaço –
A aventura científica na ESA
Mário J. P. F. G. Monteiro (IA U.Porto, PT)
Open to all.
Location: Auditório do Campus de Angra do Heroísmo da Universidade dos Açores

Wednesday, 13th, from 14:00 to 18:00 (approximately)

Excursion (see details at the end of the page)
The participants will be grouped according to the excursion preferences indicated during the registration, with priority given to those that registered earlier. When the first preference is not available, participants will be included in the group of their 2nd or 3rd preferences.
Open to all participants and registered guests.
Location: For the island trip and hiking trails the departure is from the conference venue. For the boat trip the departure is from the Marina.

Wednesday, 13th, from 20:00

Conference Dinner

Open to all participants and registered guests.
Location: Hotel do Caracol.

Thursday, 14th, 18:40

HELAS 10-year-celebration (with cake)

Open to all participants and registered guests.
Location: conference venue.

Friday, 15th, 18:20

Farewell drinks

Open to all participants and registered guests.
Location: conference venue.

Excursion

These activities will take place simultaneously during the afternoon of Wednesday, July 13, 2016. Each registered participant will thus be able to take part in one activity only, which will be chosen according to the participant's preference, subject to availability.

Boat trip

Whale and dolphin watching is possible throughout the whole year due to the great number of species that exist in the waters of the archipelago. In addition to resident species, such as common dolphins and common bottlenose dolphins, there are also the whales that pass through the Azores in their migration routes. Spotted dolphins are more common during the summer, while blue whales can be easily spotted at the end of the winter. Sperm whales, sei whales and bearded whales are frequent in the summer. During this boat trip you will mostly likely see dolphins and whales but also be able to appreciate the island coast line and the islets "ilhéu das Cabras". This activity may be cancelled due to weather or sea conditions.

Hiking trails

Terceira has several walking and hiking trails and much of the interior of the island is a nature reserve. Along these trails you will discover unique landscape: you will climb mountains, walk along the seashore, walk through valleys and calderas, discover the volcanoes that brought them to life and get to know the local vegetation.

Island trip

You will visit Monte Brasil where you will learn about Angra do Heroísmo history while enjoying some unique views. Monte Brasil is an extinct volcano surrounded by the four km long walls of the São João Baptista Fort. You will see some geological formations such as Caldeira Guilherme Moniz and visit Algar do Carvão.
A visit to the other town of the island, Praia da Vitória, and the views from Serra do Cume are also part of this tour. You will end the day either swimming in Biscoitos or seeing a traditional street bullfight.

Useful links

MAP

ANGRA DO HEROÍSMO, TERCEIRA, AZORES, PORTUGAL

Social map

Accommodation map

Venue

A Conference Venue

Social

B Marina d'Angra

C O Pirata

D Pousada de Angra do Heroísmo

E Hotel do Caracol

Online map: https://goo.gl/4Ts2xi

Accommodation

F Angra Marina Hotel (*****)

D Pousada de Angra do Heroísmo São Sebastião

G Terceira Mar Hotel (****)

E Hotel do Caracol (****)

H Angra Garden Hotel (***)

I University residence

Online map: https://goo.gl/dpkivr

SEISMOLOGY OF THE SUN AND THE DISTANT STARS 2016
USING TODAY'S SUCCESSES TO PREPARE THE FUTURE

Scientific Organizing Committee

Conny Aerts (Belgium)
Sarbani Basu (United States of America)
Timothy Bedding (Australia)
William Chaplin (United Kingdom)
Jørgen Christensen-Dalsgaard (Denmark, Co-Chair)
Margarida S. Cunha (Portugal)
João Miguel T.S. Ferreira (Portugal)
Rafael García (France)
Laurent Gizon (Germany)
Hans Kjeldsen (Denmark)
David W. Latham (United States of America)
Eric Michel (France)
Mário J.P.F.G. Monteiro (Portugal, Co-Chair)
Pere L. Pallé (Spain)
Ennio Poretti (Italy)
Markus Roth (Germany)

Local Organizing Committee

Margarida S. Cunha [Co-Chair]
João M. T. S. Ferreira [Co-Chair]
Paulo Peixoto
Elsa Silva

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List of participants (168)

Aarslev, Magnus Johan	Aarhus University
Aerts, Conny	Institute of Astronomy, University of Leuven
Agentoft, Camilla	Stellar Astrophysics Centre, Aarhus University
Antoci, Victoria	Stellar Astrophysics Centre, Aarhus University
Arentoft, Torben	Stellar Astrophysics Centre, Aarhus University
Augustson, Kyle	CEA/DRF/IRFU Service d'Astrophysique
Bachulski, Szymon	Pedagogical University of Cracow, Poland
Ball, Warrick	Institut für Astrophysik Göttingen
Ballot, Jérôme	IRAP
Barban, Caroline	Observatoire de Paris/LESIA
Basu, Sarbani	Yale University
Baudin, Frederic	IAS
Bazot, Michael	New York University Abu Dhabi
Beck, Paul	CEA, Paris-Saclay
Bedding, Tim	University of Sydney
Belkacem, Kevin	Paris Observatory
Bellinger, Earl	Max-Planck-Institut für Sonnensystemforschung
Benomar, Othman	New York University Abu Dhabi
Bigot, Leonel	Observatoire de la Côte d'Azur
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Broomhall, Anne-Marie	University of Warwick
Buldgen, Gaël	AGO, Université de Liège
Böning, Vincent	Kiepenheuer-Institut für Sonnenphysik
Campante, Tiago	University of Birmingham, UK
Cantiello, Matteo	Kavli Institute for Theoretical Physics
Cassisi, Santi	INAF - Astronomical Observatory of Teramo
Charpinet, Stephane	Observatoire Midi-Pyrénées
Chiappini, Cristina	Leibniz Institute for Astrophysics Potsdam (AIP)
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Colman, Isabel	The University of Sydney
Corsaro, Enrico	Service d'Astrophysique - CEA Saclay
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Derekas, Aliz	ELTE Gothard Astrophysical Observatory
Di Mauro, Maria Pia	INAF-Istituto di Astrofisica e Planetologia Spaziali

Dziembowski, Wojtek	Copernicus Astronomical Center, Polish Academy of Sciences
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Elsworth, Yvonne	University of Birminham
Eyer, Laurent	Geneva Observatory, University of Geneva
Ferreira, Joao Miguel	U. Açores & CAUP
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Fu, Jianning	Beijing Normal University
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Gehan, Charlotte	LESIA, Paris Observatory
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Pinçon, Charly	Paris Observatory
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Schou, Jesper	Max Planck Institute for Solar System Research
Sekii, Takashi	NAOJ
Serenelli, Aldo	Instituto de Ciencias del Espacio (ICE/CSIC-IEEC)
Sharma, Sanjib	University Of Sydney
Silva Aguirre, Victor	Aarhus University
Slawinska, Joanna	Center for Environmental Prediction, Rutgers University
Smolec, Radoslaw	Nicolaus Copernicus Astronomical Center, Polish Academy Of Sciences
Sowicka, Paulina	Nicolaus Copernicus Astronomical Center (Warsaw, Poland) and Isaac Newton Group of Telescopes (La Palma, Spain)
Stello, Dennis	University of Sydney
Szabo, Robert	Konkoly Observatory, MTA CSFK
Szewczuk, Wojciech	Astronomical Institute of the Wroclaw University
Takata, Masao	University of Tokyo
Themessl, Nathalie	Max Planck Institute for Solar System Research (MPS)
Thompson, Michael	NCAR / HAO
Thoul, Anne	University of Liege
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Turck-Chièze, Sylvaine	CEA/Saclay
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van Saders, Jennifer	Carnegie Observatories
Viani, Lucas	Yale University
Vidotto, Aline	Trinity College Dublin
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Wu, Tao	Yunnan Observatories, Chinese Academy of Sciences
Wu, Yaqian	Beijing Normal University
Yu, Jie	Sydney Institute for Astronomy, School of Physics, University of Sydney
Zhang, Ruyuan	Beijing Normal university
Zong, Weikai	IRAP, CNRS/Universite de Toulouse
Zwintz, Konstanze	Institute for Astro- and Particle Physics, University of Innsbruck

PROGRAMME

SR Special Invited Review (40 min)
IR Invited Review (30 min)
IC Invited Contribution (20 min)
RC Requested Oral Contribution (15 min)
OC Oral Contribution (15 min)

SUNDAY, 10 JULY 2016

18:00 REGISTRATION (Pousada no Castelinho)

18:30 WELCOME DRINKS (Pousada no Castelinho)

MONDAY, 11 JULY 2016

08:00 REGISTRATION

S1.
OPENING SESSION

Chairperson: *Jørgen Christensen-Dalsgaard*

08:30 SR **Where are we 30 years later!**
Jørgen Christensen-Dalsgaard (Aarhus University, DK) & Yvonne Elsworth (University of Birmingham, UK)

09:15 RC **TASC Overview: From KASC to TASC**
Hans Kjeldsen (Aarhus University, DK)

09:35 RC **SpaceInn overview: Results and impact**
Markus Roth (Kiepenheuer-Institut für Sonnenphysik, DE)

09:55 COFFEE BREAK

S2.
SPACE MISSIONS & DATA

Chairperson: *Rafael García*

10:30 IR **Gaia – Impact on stellar evolution**
Laurent Eyer (University of Geneva, CH)

11:05 IC **First scientific results from BRITE-Constellation**
Gerald Handler (Nicolaus Copernicus Astronomical Center, PL)

11:30 IC **Update on APOKASC results**
Yvonne Elsworth (University of Birmingham, UK)

11:55 OC **Rapid classification and coarse characterisation of cool stars in K2**
Guy Davies (University of Birmingham, UK)

12:15 OC **Breaking the bright limit: K2 photometry of the brightest stars in the ecliptic**
Tim White (Aarhus University, DK)

12:35 LUNCH

12:45 *TASC Steering Committee (members only)*

14:00 OC **200 nights with µ Herculis: early results from the SONG Hertzsprung telescope**
Jørgen Christensen-Dalsgaard (Aarhus University, DK)

14:20 IC **Update on asteroseismology with PLATO**
Marie-Jo Goupil (Observatoire de Paris, FR)

14:45 IC **Helioseismology with the Solar Orbiter mission**
Bjoern Loeptien (University of Goettingen, DE)

S5A.
POSTER SESSION

Chairperson: *Margarida Cunha*

15:10 **Poster Session (Group PA)**
One minute for one slide per poster (pre-merged)

16:00 COFFEE BREAK

S3.
SPECIAL SESSION: TASC & KASC

Chairperson: *Hans Kjeldsen*

16:30 IR **TESS: Where we are one year before launch**
Dave Latham (Harvard-Smithsonian Center for Astrophysics, USA)

17:05 RC **From K2/Kepler to TESS: Data preparation**
Mikkel Lund (University of Birmingham, UK)

17:25 RC **The TESS Input Catalog and Exoplanet Target Selection Strategy**
Daniel Huber (University of Sydney, AU)

17:45 OC **Evolved compact pulsators with TESS**
Stephane Charpinet (Observatoire Midi-Pyrénées, FR)

18:05 IC **Asteroseismology of exoplanet-Host stars with TESS**
Tiago Campante (University of Birmingham, UK)

18:30 END OF THE WORKING DAY!

TUESDAY, 12 JULY 2016

S4.
SPECIAL SESSION: SPACEINN & HELAS

Chairperson: *Markus Roth*

08:30 IR **Global seismology: From the Sun to the stars through solar analogs**
Rafael Garcia (CEA Saclay, FR)

09:05 RC **SpaceInn local helioseismology**
Laurent Gizon (Max-Planck-Institut für Sonnensystemforschung, DE)

09:25 OC **Solar cycle dependence of the Deep Meridional flow**
Zhi-Chao Liang (Max Planck Institute for Solar System Research, DE)

09:45	OC	**Pinsker estimators for local helioseismology: inversion of travel times for mass-conserving flows** *Damien Fournier (Institute for numerical and applied mathematics Göttingen, DE)*
10:05		COFFEE BREAK
10:30	RC	**Promoting the access to and use of seismic data in a large scientific community: The data handling and archiving Work Package of the SPACEInn Programme.** *Eric Michel (Observatoire de Paris, FR)*
10:50	OC	**A new method for extraction of seismic indices and stellar granulation parameters: application to all stars observed by CoRoT and Kepler** *Raphael Peralta (Observatoire de Paris, FR)*

S6.
PHYSICS: CONVECTION AND MODE BEHAVIOUR

Chairperson*: Mário J. P. F. G. Monteiro*

11:10	IR	**Surface effects in solar-like oscillators** *Warwick Ball (Institut für Astrophysik Göttingen, DE)*
11:45	OC	**Interaction of oscillations with near surface convection** *Jesper Schou (Max Planck Institute for Solar System Research, DE)*
12:05	OC	**Generation of internal gravity waves by penetrative convection** *Charly Pinçon (Paris Observatory, FR)*
12:25		LUNCH
13:00	*TASC WG7 (Red Giants) meeting – auditorium* *TASC WG8 (Compact Pulsators) meeting – small room*	
14:00	IC	**Evolution of solar intermediate-scale convection** *Jan Langfellner (Max-Planck-Institut für Sonnensystemforschung, DE)*
14:25	OC	**Calibrating linear damping rates with Kepler linewidths** *Günter Houdek (Aarhus University, DK)*

S7.
PHYSICS: ROTATION

Chairperson*: Eric Michel*

14:45	IR	**Differential rotation and angular momentum distribution of stars** *Tamara Rogers (Newcastle University, UK)*
15:20	OC	**2D dynamics of radiative zone of low-mass stars** *Delphine Hypolite (CEA-Saclay, FR)*
15:40	OC	**Kepler's eye on stellar spin-down** *Jennifer van Saders (Carnegie Observatories, USA)*
16:00		COFFEE BREAK
16:30	OC	**Rotation and oblateness of KIC11145123** *Takashi Sekii (NAOJ, JP)*

16:50	IR	**A theoretical insight on pulsations in fast, intermediate-mass rotators** *Rhita-Maria Ouazzani (Aarhus University, DK)*
17:25	OC	**Non-adiabatic pulsations in ESTER models** *Daniel Reese (Paris Observatory, FR)*
17:45	OC	**Constraining the near-core rotation rate in gamma Doradus stars** *Timothy Van Reeth (KU Leuven, BE)*
18:05	OC	**Seismic diagnosis based on gravity modes strongly affected by rotation** *Vincent Prat (CEA-Saclay, FR)*
18:25	OC	**The impact of differential rotation on gravito-inertial modes and applications to fast-rotating stars** *Giovanni Mirouh (IRAP/OMP, FR)*
18:45		END OF THE WORKING DAY!
19:00		YOUNG ASTRONOMERS MIXER (O Pirata Gastropub)
21:00		PORTUGAL E O ESPAÇO – A AVENTURA CIENTÍFICA NA ESA *(public talk in Portuguese)* *Mario J P F G Monteiro (IA U.Porto, PT)*

WEDNESDAY, 13 JULY 2016

S8.
PHYSICS: MAGNETIC FIELD AND ACTIVITY

Chairperson: *João Miguel Ferreira*

08:30	IR	**Seismological insights into solar and stellar magnetic activity cycles** *Anne-Marie Broomhall (University of Warwick, UK)*
09:05	IC	**Dynamos and Differential Rotation: Advances at the Crossroads of Observations, Analytics, and Numerics** *Kyle Augustson (CEA Saclay, FR)*
09:30	OC	**Signatures of magnetic activity discovered in the oscillation parameters of 22 solar-like stars observed by Kepler** *René Kiefer (Kiepenheuer Institute for Solar Physics, DE)*
09:50	OC	**Investigating the origin of flares in A-type stars** *May Gade Pedersen (Leuven University, BE)*
10:10		COFFEE BREAK
10:40	IC	**Magnetic fields inside red giants** *Dennis Stello (University of Sydney, AU)*
11:05	OC	**On the oscillation spectrum of magnetized core of giant stars** *Michel Rieutord (IRAP, FR)*
11:25	OC	**Asteroseismic signature of evolving internal stellar magnetic fields** *Matteo Cantiello (Kavli Institute for Theoretical Physics, USA)*

S5b.
POSTER SESSION
Chairperson: *Margarida Cunha*

11:45 **Poster Session (Group PB)**
One minute for one slide per poster (pre-merged)

12:35 LUNCH

13:00 *TASC WGs1&2 (TASOC data preparation) meeting – multimedia room*
TASC WG3 (Clusters) meeting – small room
TASC WGs4&5 (O-B-A-F) meeting – auditorium

14:00 END OF THE WORKING DAY!

14:00 **EXCURSION**
(departing point depends on activity: boat trip, hiking trails, island trip)

20:00 **CONFERENCE DINNER** (Hotel do Caracol)

THURSDAY, 14 JULY 2016

S9.
SEISMOLOGY: STARS NEAR AND IN THE MAIN SEQUENCE
Chairperson: *Sarbani Basu*

08:30 IR **Putting A and F stars into perspective**
Vichi Antoci (Aarhus University, DK)

09:05 OC **Can we do asteroseismology on F stars?**
Tim Bedding (University of Sydney, AU)

09:25 OC **What CoRoT tells us about d Scuti stars and their pulsational pattern**
Eric Michel (Observatoire de Paris, FR)

09:45 IC **The potential of space observations for pulsating pre-main sequence stars**
Konstanze Zwintz (University of Innsbruck, AT)

10:10 COFFEE BREAK

10:40 OC **Modelling the binary F-type g-mode pulsator KIC10080943**
Valentina Schmid (KU Leuven, BE)

11:00 OC **Accurate mean density and surface gravity of δ Scuti stars using Asteroseismology**
Antonio García Hernández (Institute of Astrophysics and Space Sciences, PT)

11:20 OC **The first K2 roAp star: HD 24355 pulsating in a distorted quadruploe mode**
Daniel Holdsworth (University of Central Lancashire, UK)

11:40 OC **Asteroseismic inversions in the Kepler era: application to the Kepler Legacy sample**
Gaël Buldgen (Université de Liège, BE)

S10.
SEISMOLOGY: STARS BEYOND THE MAIN SEQUENCE

Chairperson: *Timothy Bedding*

12:00	IC	**Asteroseismic Constraints on Evolutionary Models of Hot Subdwarfs** *Jan-Torge Schindler (University of Arizona, US)*
12:25		LUNCH
13:00		*TASC WG1&2 (solar-like) meeting – auditorium* *TASC Wg6 (RR Lyrae) meeting – small room*
14:00	IR	**Modelling of Red Giant Stars: The state-of-the-art** *Santi Cassisi (INAF - Osservatorio Astronomico di Teramo, IT)*
14:35	IC	**Are observed mixed modes able to slow-down the core of red-giants?** *Kevin Belkacem (Observatoire de Paris, FR)*
15:00	IR	**What red giant seismology is teaching us about stellar physics** *Sebastien Deheuvels (Institut de Recherche en Astrophysique et Planétologie, FR)*
15:35	OC	**Testing asteroseismic scalings for red giants with eclipsing binaries observed by Kepler** *Jean McKeever (New Mexico State University, USA)*
15:55	OC	**Period and light curve analysis of the Kepler Cepheid V1154 Cyg: light curve modulation and detection of granulation** *Aliz Derekas (ELTE Gothard Astrophysical Observatory, HU)*
16:15		COFFEE BREAK
16:45	OC	**New insight on ultimate stage of stellar evolution with the Kepler white dwarf pulsators** *Noemi Giammichele (IRAP/OMP, FR)*
17:05	OC	**Understanding Rogue waves on pulsating white dwarfs** *J. J. Hermes (University of North Carolina at Chapel Hill, USA)*

S11.
SYNERGIES: STELLAR EVOLUTION AND GALACTIC POPULATIONS

Chairperson: *Conny Aerts*

17:25	IR	**Galactic asteroseismology** *Andrea Miglio (University of Birmingham, UK)*
18:00	OC	**Probing the deep end of the Milky Way with new oscillating Kepler giants** *Savita Mathur (Space Science Institute, USA)*
18:20	OC	**Ensemble asteroseimology as a tool for stellar population inference** *Caitlin Jones (University of Birmingham, UK)*
18:40		END OF THE WORKING DAY!
18:40		HELAS BIRTHDAY CELEBRATION (cake for all)
19:30		*HELAS Board meeting and dinner* (members only)

FRIDAY, 15 JULY 2016

08:30	IC	**Asteroseismology and chemodynamical models of the Milky Way** *Cristina Chiappini (Leibniz-Institut fuer Astrophysik Potsdam, DE)*
08:55	OC	**Formation history of open clusters constrained by detailed asteroseismic analysis of red giant stars observed by Kepler** *Enrico Corsaro (CEA Saclay, FR)*
09:15	OC	**Stellar population synthesis based modelling of the Milky Way using asteroseismology of 13000 Kepler red giants** *Sanjib Sharma (University of Sydney, AU)*
09:35	OC	**Testing asteroseismology with APOGEE star clusters** *Marc Pinsonneault (Ohio State University, USA)*
09:55		COFFEE BREAK

S12.
SYNERGIES: BINARIES

Chairperson: *Ennio Poretti*

10:25	IR	**Dynamic Asteroseismology: towards improving the theories of stellar structure and (tidal) evolution** *Andrew Tkachenko (KU Leuven, BE)*
11:00	IC	**Binary populations: what have we learned from Kepler and K2?** *Andrej Prsa (Villanova University, USA)*
11:25	OC	**Solar-like oscillators in binary systems: a way to put tight constraints on stellar physics** *Paul Beck (CEA-Saclay, FR)*
11:45	OC	**Asteroseismic modelling and orbital analysis of the triple star system HD 188753** *Frédéric Marcadon (IAS, FR)*
12:05	OC	**Asteroseismic detection of invisible companions to intermediate--mass stars** *Simon Murphy (University of Sydney, AU)*
12:25		LUNCH
14:00	OC	**The Toby Shake: Pulsations affected by precession and nutation in a close binary** *Roy Østensen (Missouri State University, USA)*

S13.
SYNERGIES: PLANETS

Chairperson: *Laurent Gizon*

14:20	IR	**Update on latest Kepler exoplanet results** *Natalie Batalha (NASA Ames, USA)*
14:55	OC	**Asteroseismology of exoplanet host stars using Kepler SC data** *Mia Sloth Lundkvist (University of Heidelberg, DE)*
15:15	OC	**Using asteroseismology to understand exoplanet orbits** *Vicent Van Eylen (Leiden University, NL)*

15:35 OC **A simple model to describe intrinsic stellar noise for exoplanet detection around red giants**
Thomas North (University of Birmingham, UK)

15:55 COFFEE BREAK

16:30 IR **Stellar magnetic activity and their effects on planetary environments**
Aline Vidotto (Trinity College Dublin, IR)

17:05 IC **K2 observations of Neptune**
Patrick Gaulme (New Mexico State University, USA)

S14.
CLOSING SESSION

Chairperson: *Jørgen Christensen-Dalsgaard*

17:30 SR **What future we may expect?**
Katrien Kolenberg (KU Leuven & University of Antwerp, BE)

18:20 FAREWELL DRINKS

20:00 END OF THE CONFERENCE

SATURDAY, 16 JULY 2016

DEPARTURE AND/OR HOLIDAYS IN AZORES!

ADDITIONAL MEETINGS

MONDAY, 11th, FROM 12:45 TO 14:00

MEETING OF THE TASC STEERING COMMITTEE (MEMBERS ONLY)
Location: small room

TUESDAY, 12th, FROM 13:00 TO 13:50

TASC WG7 (RED GIANTS) MEETING
Location: auditorium

TASC WG8 (COMPACT PULSATORS) MEETING
Location: small room

WEDNESDAY, 13th, FROM 13:00 TO 13:50

TASC WG0 (TASOC DATA PREPARATION) MEETING
Location: multimedia room

TASC WG3 (CLUSTERS) MEETING
Location: small room

TASC WG4&5 (O-B-A-F) MEETING
Location: auditorium

THURSDAY, 14th, FROM 13:00 TO 13:50

TASC WG1&2 (SOLAR-LIKE) MEETING
Location: auditorium

TASC WG6 (RR LYRAE) MEETING
Location: small room

THURSDAY, 14th, FROM 19:30

HELAS BOARD MEETING (MEMBERS ONLY)

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POSTER GROUP PB

TALKS

TASC Overview: From KASC to TASC

Hans Kjeldsen (Aarhus University)

SpaceInn overview: Results and impact

Markus Roth (Kiepenheuer-Institut für Sonnenphysik), SPACEINN Board

The collaborative project “SpaceInn – Exploitation of Space Data for Innovative Helio- and Asteroseismolgy” is funded under the European Union’s Seventh Framework Programme from January 2013 – December 2016. The European Helio- and Asteroseismology Network (HELAS) has initiated this project with the mission to build on the existing European strength in the field of time-domain stellar physics. In the last three years SpaceInn activities aimed to secure optimal use of the existing and planned data, from space and from the ground, in helio- and asteroseismology in order to improve access and scientific exploitation of the existing data.

The main goals of the project include:

- Establish coordinated archives of space- and ground-based data, as well as of the results of the analyses of these data. This includes tools for efficient data access.
- Secured long-term preservation of these, often unique, data.
- Coordinated utilization of the data, resulting in a much improved understanding of solar structure, dynamics and activity, as well as of stellar structure and evolution
- An increased awareness of the field, amongst the general public and at all levels of the educational system, throughout Europe.

In this talk I will present all these activities and the main outcome of the project.

Gaia – Impact on stellar evolution

Laurent Eyer (Geneva Observatory, University of Geneva)

First scientific results from BRITE-Constellation

Gerald Handler (Nicolaus Copernicus Astronomical Center Warsaw), The BRITE Executive Science Team

BRITE-Constellation is a nanosatellite space mission designed to obtain time-resolved two-colour photometry of the brightest stars in the sky. As intrinsically luminous stars are overrepresented among apparently bright stars, BRITE is naturally very well suited for asteroseismic studies of hot stars. The basic outset of the mission and some initial problems that needed to be overcome are briefly described, followed by a presentation of the first scientific results obtained by BRITE.

Update on APOKASC results

Yvonne Elsworth (University of Birminham)

Rapid classification and coarse characterisation of cool stars in K2.

Guy Davies (University of Birmingham), Mikkel N Lund (University of Birmingham), Yvonne Elsworth (University of Birmingham), Bill Chaplin (University of Birmingham)

K2 is providing high-precision photometry on many, many stars. In addition to primary targets, many additional stars are observed in postage stamps and super stamps. Pipelines like K2P2 can easily extract light curves for these 'bonus' stars but provide little in the way of classification. We have developed a machine learning scheme based on easily extractable power-spectrum features to classify cool stars and provide a coarse characterisation. We have trained the scheme on both Kepler and K2 data sets. We find that the classification scheme outputs a metric that provides a good estimate of the probability that we will detect solar-like modes of oscillation. Furthermore, using the same power-spectrum features we have trained a supervised regression scheme to provide coarse estimates of global oscillation properties.

Breaking the bright limit: K2 photometry of the brightest stars in the ecliptic

Tim White (Stellar Astrophysics Centre, Aarhus University), Daniel Huber (University of Sydney), Victor Silva Aguirre (Aarhus University), Conny Aerts (KU Leuven), Tim Bedding (University of Sydney), et al.

The K2 Mission is providing golden opportunities to study scientifically interesting targets in the ecliptic. Many of the most exciting targets are also the brightest, but the cost in pixels, coupled with the limited download bandwidth, means these targets would go unobserved. To overcome this we have developed methods to perform photometry in the wings of the PSF of bright stars, allowing them to be observed inexpensively. I will present results from applying these methods to the brightest stars in the ecliptic, including members of the Pleiades and Hyades, allowing us to obtain high-precision, uninterrupted photometry of these well-studied stars, which has not been possible from the ground. Combining asteroseismology with observations from complementary methods, including spectroscopy and interferometry, will provide strong observational constraints for testing stellar models and set these stars as benchmarks for large stellar surveys.

200 nights with μ Herculis: early results from the SONG Hertzsprung telescope

Jørgen Christensen-Dalsgaard (Stellar Astrophysics Centre, Aarhus University), Frank Grundahl (Stellar Astrophysics Centre), Mads Fredslund Andersen (Stellar Astrophysics Centre), Hans Kjeldsen (Stellar Astrophysics Centre), Pere Palle (IAC), et al.

The SONG Hertzsprung telescope, at the Observatorio del Teide, Izana, Tenerife, is a prototype for the telescopes in the planned SONG (Stellar Observations Network Group) network for asteroseismology and exoplanet studies. It has an aperture of 1 m and is equipped with a high-resolution spectrograph, with an iodine reference, and a two-channel lucky-imaging camera. Operations are fully robotic. The telescope entered operation in the Spring of 2014 and, as one of the first extended observing programmes, has observed the V = 3.42 subgiant μ Herculis (HD 161797) for a total of 200 nights in 2014 and 2015. This has yielded excellent data on the oscillation frequencies, with a clear indication of mixed modes, and other oscillation properties. I present these observations, demonstrating the excellent quality of the telescope and instrumentation, and discuss the first inferences from the analysis of the results.

Update on asteroseismology with PLATO

Mariejo Goupil (Observatoire de Paris)

A brief description of the ESA PLATO2.0 project will be presented followed by a presentation of the expected seismic performances and scientific outputs of the mission.

Helioseismology with the Solar Orbiter Mission

Björn Löptien (Max-Planck-Institut für Sonnensystemforschung)

The Solar Orbiter mission, to be launched in October 2018, will carry a suite of remote-sensing and in-situ instruments, including the Polarimetric and Helioseismic Imager (PHI). PHI will deliver high-cadence images of the Sun in intensity and Doppler velocity suitable for carrying out novel helioseismic studies. The orbit of the Solar Orbiter spacecraft will reach a solar latitude of 28 deg (up to 33 deg during the extended mission). This will enable local helioseismic studies of the polar regions of the Sun. In addition, combined observations of Solar Orbiter and another instrument will enable stereoscopic helioseismology – helioseismology from two vantage points. This potentially will allow probing the deep interior of the Sun and can lead to a better understanding of the physics of solar oscillations in both quiet Sun and sunspots. Helioseismology with Solar Orbiter will be subject to challenges that are not relevant to current missions. Major constraints for helioseismoloy will be the probably short observing time (current baseline: 3 x 10 days per orbit) and the low telemetry (minimum: 52 Gbit/orbit), which will require the usage of lossy data compression. Recent results, however, suggest that both local helioseismology and feature tracking methods are robust regarding lossy data compression. In addition, helioseismology of the solar poles requires observations close to the solar limb, even from the inclined orbit of Solar Orbiter. This gives rise to systematic errors, such as the center-to-limb effect in local helioseismology. These systematics will show a time-dependency due to the eccentric and inclined orbit of Solar Orbiter.

TESS: Where we are one year before launch

David Latham (Harvard-Smithsonian Center for Astrophysics)

From K2/Kepler to TESS: Data preparation

Mikkel Lund (University of Birmingham), Mikkel N. Lund (University of Birmingham; Stellar Astrophysics Centre (SAC))

With data from the The Transiting Exoplanet Survey Satellite (TESS) the seismic community is faced with a new set of challenges concerning the preparation of data. The TESS Asteroseismic Science Operations Center (TASOC) is tasked with delivering light curves ready for asteroseismic analysis to the TESS Asteroseismic Science Community (TASC) for each target observed by TESS. This includes the extraction of data from full frame images (FFIs), obtained every 30 minutes, and preparation of a large number of targets observed with a 1 minute cadence. In this talk I will present the current status of the preparations for the delivery of data products, comparison to the products served for the Kepler and K2 missions, and an assessment of the differences that can be expected in terms of photometric quality.

The TESS Input Catalog and Exoplanet Target Selection Strategy

Daniel Huber (University of Sydney), William Chaplin (University of Birmingham), David Latham (Harvard-Smithsonian Center for Astrophysics), Joshua Pepper (Lehigh University), Keivan Stassun (Vanderbilt University), et al.

The TESS Input Catalog (TIC) will form the primary community resource for target selection for the TESS Mission, similar to the Kepler Input Catalog (KIC) for the Kepler Mission. In this talk I will describe the construction and current status of the TIC, as well as plans to augment the catalog with data from large-scale surveys such as Gaia. I will furthermore describe the current strategy for selecting targets for the TESS exoplanet program, which is focused on the discovery of small, rocky planets transiting bright main sequence stars. Finally, I will discuss potential synergies between the TESS target selection strategy for the exoplanet survey and asteroseismology.

Evolved compact pulsators with TESS

Stephane Charpinet (Observatoire Midi-Pyrénées)

The TESS mission will offer new opportunities to study pulsating stars in the late stages of stellar evolution. I will briefly recall the nature and properties of white dwarf and hot subdwarf pulsators and propose a first overview of potential targets for TESS as a starting point for the TASK/WG8 activities.

Asteroseismology of Exoplanet-Host Stars with TESS

Tiago Campante (University of Birmingham, UK)

New insights on stellar evolution and stellar interiors physics are being made possible by asteroseismology. Throughout the course of the Kepler mission, asteroseismology has also played an important role in the characterization of exoplanet-host stars and their planetary systems. The upcoming NASA's Transiting Exoplanet Survey Satellite (TESS) will be performing a wide-field survey for planets that transit bright nearby stars. In addition, its excellent photometric precision, combined with its fine time sampling and long intervals of uninterrupted observations, will enable asteroseismology of solar-type and red-giant stars. We developed a simple test to estimate the detectability of solar-like oscillations in TESS photometry of any given star. Based on an all-sky stellar and planetary synthetic population, we go on to predict the asteroseismic yield of the TESS mission, placing emphasis on the yield of exoplanet-host stars for which we expect to detect solar-like oscillations. This is done for both the cohort of target stars (observed at a 2-min cadence) and the cohort of full-frame-image stars (observed at a 30-min cadence). A similar exercise is also conducted based on a compilation of known host stars. With several tens of TESS target hosts (mainly F dwarfs and subgiant stars) and up to 200 full-frame-image hosts (at the low-luminosity end of the red-giant branch) for which asteroseismology will become possible, not to mention the over 100 known host stars, this equates to a threefold improvement in the asteroseismic yield of exoplanet-host stars when compared to Kepler's.

Global seismology: From the Sun to the stars through solar analogues

Rafael A. Garcia (SAp/CEA-Saclay), the SPACEINN global seismology team

Sun-as-a star observations put our star as a reference for stellar observations. In this talk we review the activities in which the SPACEINN global seismology team has worked during the past 3 years. In particular, we will explain the new deliverables available on the SPACEINN seismic+ portal. Moreover, special attention will be given to surface dynamics (rotation and magnetic fields). After characterizing the rotation and the magnetic properties of ~300 solar-like stars and defining proper metrics for that, we use their seismic properties to characterize 18 solar analogues for which we study their surface magnetic and seismic properties. This allows us to put the Sun into context of its siblings.

SpaceInn local helioseismology

Laurent Gizon (Max Planck Institute for Solar System Research)

The purpose of SpaceInn local helioseismology activities is to maintain an archive of selected data cubes, modeling tools, data analysis tools, and technical information about HMI observations. These are openly available at http://www.mps.mpg.de/projects/seismo/SpaceInn/. Current topics of investigation include meridional circulation, medium- and large-scale convection, magnetic flux emergence, and active region dynamics. Local helioseismology, in combination with realistic numerical simulations of solar magnetoconvection, enables us to construct physics-based models of the interaction of oscillations with convection (essential to understand near-surface effects) and to characterize the seismic signature of sunspots and active regions, two examples that are relevant to global helioseismology and asteroseismology.

Solar Cycle Dependence of the Deep Meridional flow

Zhi-Chao Liang (Max Planck Institute for Solar System Research), Laurent Gizon (Max Planck Institute for Solar System Research, Germany)

In this study, we apply time-distance helioseismology to the medium-degree Dopplergrams observed by SOHO/MDI and SDO/HMI, in order to measure meridional circulation in the deep convection zone. The results are averaged over the same observation period (May 2010 to Apr 2011) of the two data set and then compared with each other. After the removal of the known center-to-limb variation and a roll-angle uncertainty in MDI data by registering with HMI data, the travel-time results obtained from MDI and HMI data are consistent. Even the fluctuations due to realization noise in the travel time match closely. Furthermore, we analyse 4-year HMI data and exclude the active regions from our analysis. The travel-time measurements of the meridional flow using the HMI data show a time variation in the convection zone similar to that using MDI data measured by Liang & Chou (2015).

Pinsker estimators for local helioseismology: inversion of travel times for mass-conserving flows

Damien Fournier (Institute for numerical and applied mathematics Göttingen), Laurent Gizon (Max-Planck-Institut for solar system Göttingen), Martin Holzke (Institut for numerical and applied mathematics Göttingen), Thorsten Hohage (Institut for numerical and applied mathematics Göttingen)

The reconstruction of the 3D velocity field of supergranules below the solar surface is a difficult task in time-distance helioseismology. In particular, the vertical component of velocity is generally poorly reconstructed. We investigate the difficulties of the classical inversion methods (RLS and SOLA) and propose a new method based on the Pinsker estimator (Pinsker 1980), which minimizes the risk (mean square error) of the estimator. To compare the methods, we use synthetic travel times generated by convolving Born kernels with a model of the averaged supergranule. A realistic noise level corresponding to 4 days of observations is added. We focus on the inversion procedure and do not discuss possible bias in the forward modeling. We show that all inversion methods can recover the horizontal part of the velocity but RLS and SOLA fail to reconstruct the vertical velocity vz. The Pinsker method is better but does not recover properly the amplitude of vz. Implementing a mass conservation constraint in the Pinsker inversion method improves the reconstruction, giving the correct amplitude of the vertical velocity down to a depth of 5.5 Mm.

Promoting the access to and use of seismic data in a large scientific community: The data handling and archiving Work Package of the SPACEInn Programme.

Eric Michel (Observatoire de Paris-LESIA), WP3 participants (SPACEInn project)

The growing amount of seismic data available from space missions (SOHO, CoRoT, Kepler, SDO,...) but also from ground-based observations (GONG, Bison, ground-based large programmes...), stellar modelling and numerical simulations, creates new scientific perspectives e.g. to characterize stellar populations in our Galaxy or to characterize planetary systems by giving model-independent global properties of stars such as mass, radius, and surface gravity within several percent accuracy, as well as to constrain the age. These applications address a broad scientific community beyond the solar and stellar one and require combining indices elaborated with data from different data bases (e.g. Space seismic archives and ground-based spectroscopic surveys). It is thus a basic requirement to develop a simple and efficient access to these various data resources and dedicated tools. In the framework of the European project SPACEInn (FP7), several data sources have been developed or upgraded. The Seismic Plus Portal has been developed, where synthetic descriptions of the most relevant existing data sources can be found, as well as some tools allowing to locate existing data for given objects or period and helping the data query. This project has been developed in the Virtual Observatory (VO) framework. In this talk, we will give a review of the various facilities and tools developed within this programme. The SpaceInn project ("Exploitation of Space Data for Innovative Helio- and Asteroseismology") has been initiated by the European Helio- and Asteroseismology Network (HELAS).

A new method for extraction of seismic indices and stellar granulation parameters: application to all stars observed by CoRoT and Kepler.

Raphaël Peralta (Observatoire de Paris – LESIA), Raphaël Peralta (Observatoire de Paris), Réza Samadi (Observatoire de Paris), Eric Michel (Observatoire de Paris)

In the framework of the SPACEInn project, a Stellar Seismic Indices (SSI – http://ssi.lesia.obspm.fr/) database was developed in order to provide oscillations ($\Delta\nu$, ν_{max}, Henv) and granulation (τ_{gran}, σ_{gran}) characterization for a large set of red-giant type stars, for the stellar community and beyond. For this purpose, we have developed a new method taking advantage of the MLE (maximum likelihood estimate) algorithm combined with the parametrized representation of the red giants pulsation spectrum following the Universal Pattern (Mosser et al. 2011), in order to measure simultaneously the oscillations and the granulation signature. This method has been tested in terms of precision and accuracy, using Monte Carlo simulations. We applied this new method, called MLEUP, to all stars observed by CoRoT and Kepler. In total, we yield seismic indices and granulation parameters for about 5,000 stars for CoRoT and more than 17,000 for Kepler, increasing the number of known red giant observed by Kepler by ~10%. First, we will briefly present the method and its performances. Then, we will present our results obtained with CoRoT and Kepler dataset.

Surface effects in solar-like oscillators

Warrick Ball (Institut für Astrophysik Göttingen)

Inaccurate modelling of the near-surface layers of solar models causes a systematic difference between modelled and observed solar mode frequencies. This difference—known as the “surface effect” or “surface term”—presumably also exists in other solar-like oscillators and must somehow be corrected to accurately relate mode frequencies to stellar model parameters. After briefly describing the various potential causes of surface effects, I will review recent progress along two different lines. First, various methods have been proposed for removing the surface effect from the mode frequencies and thereby fitting stellar models without the disproportionate influence of the inaccurate near-surface layers. Second, three-dimensional radiation hydrodynamics simulations are now being used to replace the near-surface layers of stellar models across a range of spectral types, leading to predictions of how some components of the surface effect vary between stars. Finally, I shall briefly discuss the future of the problem in terms of both modelling and observation.

Interaction of Oscillations with Near Surface Convection

Jesper Schou (Max Planck Institute for Solar System Research), Björn Löptien (MPS)

In helio- and asteroseismology there are several large but unexplained signals. Examples include the so called surface effect which offsets the observed mode frequencies relative to those expected and an apparent phase shift of solar oscillations depending on the center to limb distance. These two effects are most likely both caused by the interaction of the oscillations with the near surface convection. Here we will investigate this problem by examining how the observed oscillations depend on where in the granulation they are observed and analyze simulations to see if they agree with the observations and can shed light on the details of the interaction mechanism.

Generation of internal gravity waves by penetrative convection

Charly Pinçon (Paris Observatory), K. Belkacem (Paris Observtaory), M.J. Goupil (Paris Observatory)

The space-borne missions CoRoT and Kepler provide seismic data of thousands of stars from the main sequence to the red giants branch. The detection of mixed-modes in subgiants and red giants enabled us to show that their core rotate much more slowly than expected. In this context, internal gravity waves (hereafter, IGW) can play a role since they are known to be able to transport angular momentum in the radiative zone of the stars. The efficiency of the transport of angular momentum by IGW depends on their driving mechanism. Two different kinds of mechanism of excitation are usually invoked. The first one, due to the turbulent pressure through the convective bulk, has already been theoretically investigated. The second one, due to the penetration of convective plumes into the stably stratified region at the edge of the base of convective zone, has already been observed in numerical simulations and studied in geophysics, but a theoretical estimate was still missing. We develop a semianalytical model in order to estimate the energy of the plumes transferred into the waves at the base of the convective zone. We also investigate the effect of the steepness of the Brunt-Väisälä frequency at the base of the convective zone on the transmission of the waves into the propagative region. For the solar case, we show that IGW are generated more efficiently by penetrative convection than by turbulent pressure, and that a smooth thermal transition at the base of the convective zone can significatively enhances the transmission of the wave energy flux into the core. We expect this mechanism to work in evolved stars, which will be subject to future investigations.

Evolution of solar intermediate-scale convection

Jan Langfellner (Max Planck Institute for Solar System Research Göttingen), Laurent Gizon (Max Planck Institute for Solar System Research), Aaron C. Birch (Max Planck Institute for Solar System Research)

We study the near-surface solar convection on the length scale of supergranulation and larger, making use of observations from the Solar Dynamics Observatory (SDO) spacecraft. On a given length scale, the time series of flow maps for the average convective feature shows a complex evolution with an oscillatory component. Such an evolution pattern is also visible in maps of the continuum intensity contrast and of the magnetic field. Finally, we discuss the fingerprint of supergranulation in disk-integrated intensity and radial velocity signals, with stellar applications in mind.

Calibrating linear damping rates with Kepler linewidths

Günter Houdek (Stellar Astrophysics Centre, Aarhus University), Günter Houdek (SAC, Aarhus University)

Linear damping rates of radial oscillation modes in selected Kepler stars are estimated with the help of a nonadiabatic stability analysis. The convective fluxes are obtained from a nonlocal, time-dependent convection model. The mixing-length parameter is calibrated to the surface convection zone of a stellar model obtained from fitting adiabatic frequencies to the observations. The anisotropy parameter of the turbulent velocity field and the remaining nonlocal convection parameters are calibrated to 3D simulation results and to obtain a 'good' agreement with the Kepler linewidths measurements. Results for selected Kepler stars are presented.

Differential rotation and angular momentum distribution of stars

Tamara Rogers (Newcastle University)

2D dynamics of radiative zone of low-mass stars

Delphine Hypolite (CEA), Stéphane Mathis (CEA), Michel Rieutord (IRAP)

The internal rotation of low-mass stars all along their evolution is of primary interest when studying their rotational dynamics, internal mixing and magnetic fields generation. In this context, helio- and asterosismology probe angular velocity gradients deep within Solar-type stars. Still the rotation of the close center of such stars on the main-sequence is hardly detectable and the dynamical interactions of the radiative core with the surface convective envelope is not well understood. Among them, the influence of the differential rotation profile sustained by convection and applied as a boundary condition to the radiation zone may be very important leading to the formation of tachoclines. Indeed, in the Solar convective region, the equator is rotating faster than the pole while anti-solar rotation can also be expected in other low-mass stars envelopes since numerical simulations predict a bistable state. In this work, we therefore build for the first time 2D hydrodynamical models of solar-type stars radiation zone providing a full 2D description of their dynamics and studying the influence of a general shear boundary condition accounting for a solar or anti-solar differential rotation in the convective envelope. We compute coherently differential rotation and the associated meridional circulation using the anelastic approximation which is compared to the simplest Boussinesq one. Analytically, we demonstrate that the imposed shear implies a cylindrical differential rotation. Moreover, flux of angular momentum both in the radial and latitudinal directions are proportional to the shear and the radial flux is concentrated near the surface to counterbalance its action. The core to the surface rotation ratio decreases as the shear increases. These results will be discussed in the framework of seismic observables while perspectives to improve our modeling by including magnetic field or transport by waves will be presented.

Kepler's eye on stellar spin-down

Jennifer van Saders (Carnegie Observatories), Travis Metcalfe (Space Science Institute), Orlagh Creevey (Université de la Côte d'Azur, CNRS), Rafael Garcia (Laboratoire AIM, CEA/DRF – CNRS), Marc Pinsonneault (Ohio State University), et al.

Rotation is a ubiquitous feature of stellar populations, and has the potential to be a powerful tool in the study of stellar systems. Kepler and K2 data now make it possible to combine cluster, field, and asteroseismic datasets for a unique view into the physics of stellar angular momentum evolution, and to better refine rotation-based tools, such as gyrochronology. I will present updated results regarding the observed anomalously rapid rotation in old Kepler asteroseismic targets: we have doubled the sample of well-modeled asteroseismic target stars used in the previous analysis, and tested our conclusions against new data from K2 observations of the open cluster M67. Both the cluster and astereoseismic data support the presence weakened magnetic braking in old and intermediate age stars, a result that has implications for both the underlying physical mechanisms of angular momentum loss and the use of rotation as a tool to measure ages. I will discuss prospects for further testing this physical model in future missions, both with seismic targets and large field samples of rotation periods.

Rotation and Oblateness of KIC11145123

Takashi Sekii (NAOJ), L. Gizon (MPS), T. Sekii (NAOJ), M. Takata (University of Tokyo), D.W. Kurtz (University of Central Lancashire), et al.

KIC11145123 is a delta Scuti-gamma Doradus hybrid pulsator, whose pulsation frequencies have been measured by Kepler to very high precision (Kurtz et al 2014). The star rotates with a period of about 100 days, as indicated by rotational splitting frequencies. Unequal splittings in azimuthal multiplets inform us about differential rotation and structural asphericities. Here we report that the star is oblate, using multiplets in the p-mode frequency band. However, its measured oblateness is only about a third of what is expected from rotational oblateness alone. Guided by the results of helioseismology, we conjecture the presence of a magnetic field.

A theoretical insight on pulsations in fast, intermediate-mass rotators

Rhita-Maria Ouazzani (SAC – Aarhus University), Sébastien Salmon (ULg – Liège University), Victoria Antoci (SAC – Aarhus University), Tim Bedding (SIfA – Sydney University), et al.

The g modes which occur in γ Doradus stars, allow to reveal the innermost structure of stars on the lower main sequence, which is not even possible for the Sun. With four years of nearly-continuous photometry from Kepler, we are finally in a good position to apply asteroseismology to γ Dor stars. In particular several analysis (Bedding et al. 2015; Van Reeth et al. 2015) have demonstrated the possibility to detect non-uniform period spacings, which a theoretical study (Bouabid et al. 2013) has predicted to be directly related to rotation. Based on the non uniformity of their period spacings, we provide a univoque relation between an observable and the internal rotation, which applies all over the instability strip of γ Dors when the stars are too rapidly rotating to present rotational splittings.

Non-adiabatic pulsations in ESTER models

Daniel Reese (LESIA, Paris Observatory), Daniel R. Reese (LESIA, Paris Observatory), Marc-Antoine Dupret (Université de Liège), Michel Rieutord (IRAP, Observatoire Midi-Pyrénées)

One of the greatest challenges in interpreting the pulsations of rapidly rotating stars is mode identification, i.e. correctly matching theoretical modes to observed pulsation frequencies. Indeed, the latest observations as well as current theoretical results show the complexity of pulsation spectra in such stars, and the lack of easily recognisable patterns. In the present contribution, I will describe the latest results on non-adiabatic effects in such pulsations, and show how these come into play when identifying modes. These calculations fully take into account the effects of rapid rotation, including centrifugal distortion, and are based on models from the ESTER project, currently the only rapidly rotating models in which thermal equilibrium, a prerequisite for calculating non-adiabatic effects, is achieved. Non-adiabatic effects determine which modes are excited and play a key role in the near-surface pulsation-induced temperature variations which intervene in multi-colour amplitude ratios and phase differences, as well as line profile variations.

Constraining the near-core rotation rate in gamma Doradus stars

Timothy Van Reeth (Instituut voor Sterrenkunde, KU Leuven)

Gamma Doradus stars are located in possibly one of the most intriguing regions of the Hertzsprung-Russell diagram. They cover the transition from low-mass stars with a convective envelope to intermediate-mass stars with a convective core. The surrounding physical conditions in these stars can lead to either a growing or a shrinking convective core, but are currently not well understood. The gravity-mode oscillations in gamma Doradus stars predominantly probe the near-core regions, and can help us to constrain the properties of the stellar structure in the deep interior of the stars. Using the traditional approximation, we have developed methodology to derive the near-core rotation rate from observed gravity-mode pulsation periods and identify the mode geometry. We succesfully applied our technique to 40 out of 50 targets in our sample of gamma Doradus stars, allowing us to do ensemble modelling of these stars. For the majority of the observed period spacing patterns we found the corresponding pulsations are prograde dipole modes, while the derived rotation rates cover a large range of possible values. In five of the stars, our analysis has also led to the identification of a solitary pulsation mode, which we suspect to be retrograde dipole modes. Currently, the main limitation of the method is that it cannot be applied directly to retrograde pulsations in moderate to fast rotating stars, due to the neglect of the centrifugal force. This analysis forms the first step towards detailed seismic modelling of observed period spacing patterns in individual gamma Dor stars. We illustrate this for a few well chosen stars from our sample, for which we can determine the shape and size of the convective core.

Seismic diagnosis based on gravity modes strongly affected by rotation

Vincent Prat (CEA-Saclay), Stéphane Mathis (CEA-Saclay)

Most of the information we have about the internal rotation of stars comes from modes that are weakly affected by rotation, for instance thanks to rotational splittings. In contrast, we present here a method (based on the asymptotic theory of Prat et al. 2016, A&A, 587, A110) which allows us to analyze the signature of rotation where its effect is the most important, that is in low-frequency modes that are strongly affected by rotation.

The impact of differential rotation on gravito-inertial modes and applications to fast-rotating stars.

Giovanni Mirouh (IRAP / OMP), Jérôme Ballot (IRAP/OMP), Clément Baruteau (IRAP/OMP), Michel Rieutord (IRAP/OMP)

While slowly rotating stars are well described through asteroseismology, Kepler data show that the oscillation spectra of fast differentially rotating stars are much more complicated. The interpretation of such spectra typically requires an expensive forward-modelling approach and a good understanding of mode properties.
Using a simplified model, we studied the effects of a differential rotation on the low-frequency spectrum of fast rotating stars, which corresponds to gravito-inertial modes probing the deep layers of the stellar radiative zone. We solve the oscillation problem (i) by computing the paths of characteristics in the non-dissipative limit and (ii) by solving the fully-dissipative eigenproblem numerically. I will present how the non-dissipative study allows us to determine the frequency range in which gravito-inertial modes can exist, predict the extent of the propagation domain, the appearance of attractors, wedge trapping, or critical layers. The simulations give us scaling laws for the damping rates, unveil modes unstable to baroclinic instabilities, and show the existence of quasi-regular modes. I will finally discuss how the results of this study give diagnostics that can be applied to more realistic models of rapidly and differentially rotating stars, and lead to accurate mode identification.

Seismological insights into solar and stellar magnetic activity cycles

Anne-Marie Broomhall (University of Warwick)

The Sun's magnetic activity cycle varies primarily on a time scale of approximately 11yrs from minimum to maximum and back again. It is well-known that the properties of the Sun's acoustic oscillations are affected by the near-surface internal magnetic field: Frequencies, damping rates, and powers are all known to vary systematically with solar cycle. Careful observation of these variations, therefore, allows aspects of the Sun's internal magnetic field to be inferred. However, the Sun is just one star and with the advent of CoROT and Kepler, oscillations can now be observed for thousands of other stars. However, despite many stars showing signs of magnetic activity in their lightcurves, to date, activity cycle-like variations in the properties of asteroseimic oscillations are sparse. I will discuss recent observations of solar cycle associated variations in helioseismic oscillation parameters, demonstrating connections with other stars and implications for our understanding of solar and stellar magnetic fields. I will finish with a discussion on how seismology can provide insights into a star's magnetic field, without necessarily observing activity cycle-like behaviour.

Dynamos and Differential Rotation: Advances at the Crossroads of Observations, Analytics, and Numerics

Kyle Augustson (CEA/DRF/IRFU Service d'Astrophysique)

The recent observational, theoretical and numerical progress made in understanding stellar magnetism is discussed, with an emphasis on the mechanisms behind its short and long term variability. Particularly, this review will cover the physical processes thought to be at the origin of these magnetic fields and their variability, namely dynamo action arising from the interaction between convection, rotation, radiation and magnetic fields. Some care will be taken to cover recent analytical advances regarding the dynamics and magnetism of radiative interiors, including new mixing theories and topological magnetic stability criterion. Some thoughts on the role of a tachocline will be visited, looking both at analytical and numerical results. Moreover, recent and rapidly advancing numerical modeling of convective dynamos will be discussed, looking at rapidly rotating convective systems, grand minima and scaling laws for magnetic field strength. These topics are then linked to observations and or their observational implications.

Signatures of magnetic activity discovered in the oscillation parameters of 22 solar-like stars observed by Kepler

René Kiefer (Kiepenheuer Institute for Solar Physics), René Kiefer (Kiepenheuer-Institut für Sonnenphysik), Ariane Schad (Kiepenheuer-Institut für Sonnenphysik), Guy Davies (School of Physics and Astronomy, University of Birmingham), Markus Roth (Kiepenheuer-Institut für Sonnenphysik)

Context. The Sun and solar-like stars undergo activity cycles for which the underlying mechanisms are not well understood. The oscillations of the Sun are known to vary with activity cycle and these changes provide diagnostics on the conditions below the photosphere. Kepler has detected oscillations in hundreds of solar-like stars but as of yet, no widespread detection of signatures of magnetic activity cycles in the oscillation parameters of these stars have been reported. Aims. We analyse the photometric short cadence Kepler time series of a set of 24 solar-like stars, which were observed for at least 960 days each, with the aim to find signatures of stellar magnetic activity in the oscillation parameters. Methods. We analyse the temporal evolution of oscillation parameters by measuring mode frequency shifts and changes in the height of the p-mode envelope. Results. For 22 of the 24 investigated stars, we find significant frequency shifts in time, indicating stellar magnetic activity. For the most prominent example, KIC 8006161, we find that, similar to the solar case, frequency shifts are smallest for the lowest and largest for the highest p-mode frequencies. Conclusions. These findings show that magnetic activity can be routinely observed in the oscillation parameters for solar-like stars. The large proportion of stars for which this is the case opens up the possibility to place the Sun and its activity cycle in the context of other stars.

Investigating the origin of flares in A-type stars

May Gade Pedersen (Institute of Astronomy, Leuven University, Belgium), Victoria Antoci (SAC, Aarhus University), Heidi Korhonen (Dark Cosmology Centre, University of Copenhagen)

Recent studies show evidence of flare-like features in 36 Kepler A-type stars which were interpreted to be intrinsic, contradicting theory. Flares in late-type stars are generated through the reconnection of magnetic field lines in stellar atmospheres. For magnetic fields to be sufficiently strong to emerge at the surface and form flares a dynamo is required, which is operated by a convective envelope. A-type stars only possess shallow convective envelopes of the order of 1-3% of the total stellar radius and therefore are not expected to support flaring. On the other hand X-ray flares have been observed in strongly magnetic A- and B-type stars and through colliding winds in massive binary systems. Strong stellar winds vanish for late B-type stars and normal A-type stars only have weak global magnetic fields. Therefore, neither reconnection or strong stellar winds should support flaring in A-type stars. We analyse the 36 A-type stars previously found to be flaring, setting specific criteria in order to identify these features. Our results strongly disagree with the numbers found in literature. However, the positive detections follow the expected correlation between flare duration and intensity. We present results on our investigation of the origin of these flares, considering effects from contamination and combined light as well as study binarity from spectroscopy and possible circumstellar disks.

Magnetic fields inside red giants

Dennis Stello (University of Sydney), Matteo Cantiello (KITP, UCSB, USA), Jim Fuller (Caltech, USA), Rafael Garcia (CEA, Saclay, France), Lars Bildsten (KITP, UCSB, USA), et al.

In this talk I will present recent results on the prevalence of strong magnetic fields in the cores of red giant stars. In addition to presenting already published results, I will discuss more recent progress on both theoretical and observational fronts.

On the oscillation spectrum of magnetized core of giant stars

Michel Rieutord (IRAP), Rieutord Michel (IRAP), Deheuvels Sébastien (IRAP)

The spectrum of gravito-acoustic modes is depleted in dipolar modes for a significant fraction of the giant stars observed by Kepler, a feature that can be explained by the presence of magnetic fields in the core of these stars (Fuller et al. 2015, Cantiello et al. 2016). We further investigate this scenario by considering first the oscillation spectrum of the core of a giant star modeled by a stably stratified, self-gravitating fluid sphere pervaded by a uniform and/or toroidal magnetic field. First results show a great sensitivity of the g-mode spectrum to the strength of the magnetic field. This result leads us to further investigate the possibility of using the observed spectra to determine the dissipative properties of the core and the strength of the magnetic field when modeled by a simple large-scale distribution (i.e. uniform and/or toroidal). Results of these investigations will be presented.

Asteroseismic Signature of Evolving Internal Stellar Magnetic Fields

Matteo Cantiello (Kavli Institute for Theoretical Physics), Jim Fuller (Caltech), Lars Bildsten (KITP, UCSB), Dennis Stello (University of Sydney), Rafa Garcia (Irfu, CEA)

Recent asteroseismic analyses indicate the presence of strong (greater than 105 G) magnetic fields in the cores of many red giant stars. We examine the implications of these results for the evolution of stellar magnetic fields, and we make predictions for future observations. In particular, we show how current and future asteroseismic data can be used to test the survival of strong internal magnetic fields across convective phases of evolution (e.g. the He-flash) and into the compact remnant phase. We will discuss the important implications for internal angular momentum transport and the incidence of magnetic White Dwarfs and Neutron Stars.

Putting A and F stars into perspective

Victoria Antoci (Stellar Astrophysics Centre, Aarhus University), Victoria Antoci (Stellar Astrophysics Centre, Aarhus University)

A and F type stars occupy a region in the HRD where several physical processes occur: it is in the classical instability strip where the transition between deep and efficient to shallow convective envelopes takes place. This has an impact not only on pulsational stability but also on stellar evolution, activity and transport of angular momentum. In this talk I will give an overview over recent results with a special focus on pulsators such as delta Scuti, gamma Doradus and rapidly oscillating Ap stars. Additionally I will discuss the importance of A and F stars with respect to other scientific fields presented during this conference.

Can we do asteroseismology on F stars?

Tim Bedding (University of Sydney), D. Compton (University of Sydney), J. Guzik (Los Alamos National Laboratory), W. Ball (University of Sydney), S. Murphy (University of Sydney), et al.

Procyon (F5 IV-V) was the first star in which solar-like oscillations were detected (Brown et al 1991). It has been observed at least ten times since then but after 25 years, we still are not able to identify which modes are being observed. This is because the mode lifetimes are significantly shorter than in the Sun, causing the pattern in the Fourier spectrum to be blurred to the extent that adjacent l=0 and l=2 modes overlap. This "F-star problem" was further highlighted by HD 49933 (F3 V), which was the first CoRoT star to be published (Appourchaux et al. 2008). Many other F stars have now been observed with CoRoT and Kepler, and some progress has been made (e.g., White et al. 2012), but it is still unclear whether we will ever be able to apply asteroseismology to them. An important example is theta Cyg (F3 V), which is the brightest star to fall on the Kepler detectors (Guzik et al. 2016). There are surely great possibilities to apply the power of seismology to F stars, if only we could solve the problem of mode identification. Meanwhile, at slightly hotter temperatures on the main sequence, many early F stars show beautiful gamma-Dor g modes. Four years of Kepler observations have revealed a stunning variety of behaviour, including regular and irregular period spacings, as well as rotationally split multiplets (Kurtz et al 2014, Bedding et al 2015, van Reeth et al 2015, etc.). These stars show no sign of solar-like high-order p modes, but perhaps there is a transition region? In F stars that show solar-like oscillations, how can we decide which modes are which? The so-called surface correction term appears to be very different than in Sun-like stars, but surely there must be a gradual transition as we move up in temperature? We can also ask at what temperature the solar-like modes shut off, and become replaced by g modes. What about the granulation background that drives the solar-like modes? Is there any overlap with the g-mode pulsators, or is this a sudden discontinuity? This talk will review our progress in answering these questions, and will include new observational results (e.g. theta Cyg) and new theoretical models, in an attempt to address some of these issues.

What CoRoT tells us about δ Scuti stars and their pulsational pattern

Eric Michel (Observatoire de Paris-LESIA)

Inspired by the so appealing example of the red giants, where going from a handful of stars to thousands revealed the structure of the eigenspectrum, we inspected a large homogeneous set of 1900 δ Scuti stars observed with CoRoT. This unique data set reveals a common regular pattern which looks in agreement with island modes featured by theoretical non-perturbative treatment of fast rotation. This pattern can be characterized at first order by a few parameters which might play the role of seismic indices for δ Scuti stars, as $\Delta\nu$ and ν_{max} did for red giants. This pattern offers an observational support for guiding further theoretical works on fast rotation. It provides a framework for further investigation of the observational material collected by CoRoT and Kepler. It sketches out the perspective of using δ Scuti stars pulsations for ensemble asteroseismology.

The potential of space observations for pulsating pre-main sequence stars

Konstanze Zwintz (Institute for Astro- and Particle Physics, University of Innsbruck)

Asteroseismology of pre-main sequence (pre-MS) stars has the power to constrain the interior structure of stars in their earliest evolutionary phases and, hence, allows to address some of the yet open questions of early stellar evolution. Depending on their masses, pre-MS stars can show four different types of pulsations: (i) g-mode Slowly Pulsating B star pulsations, (ii) delta Scuti type p-mode pulsations, (iii) gamma Doradus like g-mode pulsations and (iv) stochastic solar-like oscillations. Within the past ~15 years, several dozens of pre-MS SPB, delta Scuti and gamma Doradus type pulsators were investigated using data obtained from ground and from space (i.e., using MOST, CoRoT and recently K2). Pre-MS solar-like oscillators are theoreticall predicted, but are still lacking the first observational detection. I will discuss the current observational status of pre-MS pulsators and the potential of TESS observations which can significantly advance the field of pre-MS asteroseismology in particular for the coolest young objects.

Modelling the binary F-type g-mode pulsator KIC10080943

Valentina Schmid (Institute for Astronomy, KU Leuven)

Pulsating binary stars are ideal targets for testing the theory of stellar structure and evolution. Fundamental parameters can be derived from binary modelling to high precision and provide crucial constraints for seismic modelling. High-order gravity modes are sensitive to the conditions near the convective core and therefore allow for a determination of parameters describing interior physics, especially the convective-core overshooting parameter. KIC 10080943 is a binary system, which contains two gravity and pressure hybrid pulsators. A detailed observational study has provided fundamental and seismic parameters for both components. In our study, we have used the stellar evolution code MESA and the seismic code GYRE, to compare theoretical properties to the observed mean period spacing and position in the Hertzsprung-Russell diagram. Additional constraints imposed by the binarity, are the mass ratio, equal age and composition. We present here the first consistent seismic modelling of a binary F-type g-mode pulsator. Our best models have masses below the values estimated from binarity, which is a consequence of the low observed mean g-mode period spacing. We find that strength of overshooting and turbulent diffusion can be well constrained by the equal-age requirement for the two stars. However, we find no significant difference for different shapes of the overshooting. Furthermore, when we aim to explain the morphology of the period spacing pattern, we lose the agreement with the binary parameters. Our models present a fruitful starting point for more detailed studies, which also take the tidal interactions into account.

Accurate mean density and surface gravity of δ Scuti stars using Asteroseismology

Antonio García Hernández (Instituto de Astrofísica e Ciências do Espaço, U.Porto), Mário J. P. F. G. Monteiro (Instituto de Astrofísica e Ciências do Espaco, Universidade do Porto, CAUP), Zhao Guo (Center for High Angular Resolution Astronomy and Department of Physics and Astronomy, Georgia State University), Daniel R. Reese (School of Physics and Astronomy, University of Birmingham / LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités), et al.

In the work we present here, we empirically demonstrate that a simple relation exists between a periodic pattern present in the frequency spectra of Delta Scuti stars and their mean density. This relation is homologous to that of solar-type stars. But the most important result is that this relation is indeed independent of the rotational velocity, becoming an ideal tool to constrain the pyhisical parameters of the star, even at high rotation rates. Moreover, we pushed the data one step further. Using also an estimation of the luminosity of each object, we demonstrate that it is possible, once the periodic pattern is determined, to derived the surface gravity of the star. The typical uncertainty we found for this quantity is the same as with high resolution spectroscopic data. This result might settle the degeneracy problem of the surface gravity determination with the spectra of A-type stars.

The first K2 roAp star: HD 24355 pulsating in a distorted quadruploe mode

Daniel Holdsworth (University of Central Lancashire), D.L. Holdsworth (University of Central Lancashire), D.W. Kurtz (University of Central Lancashire), B. Smalley (Keele University), H. Saio (Tohoku University), et al.

We present an analysis of the first K2 observations of a rapidly oscillating Ap (roAp) star, HD 24355. The star was discovered to be a roAp star by Holdsworth et al. (2014), with a frequency of 224.31 c/d (2596.18 microHz; P = 6.4 min) and an amplitude of 1.51 mmag in SuperWASP broadband photometry. Spectroscopic analysis of low-resolution spectra show the star to be an A5 Vp SrEu star. The high precision K2 data allow us to identify 13 rotationally split sidelobes to the main pulsation frequency. This is the largest number of sidelobes seen in a roAp star to date. We also see an unusual pulsational phase variation as the star rotates, showing this star to be the most distorted quadrupole roAp pulsator yet observed. Modelling of this star confirms its quadrupole nature, and allows us to constrain the magnetic field strength, angle of inclination and the angle of obliquity. This is currently the only roAp star observed with the Kepler satellite in Short Cadence mode that has a photometric amplitude detectable from the ground, thus allowing comparison between the mmag amplitude ground-based targets and the micromag spaced-based discoveries.

Asteroseismic inversions in the Kepler era: application to the Kepler Legacy sample

Gaël Buldgen (AGO, Université de Liège), Gaël Buldgen (Université de Liège), Daniel Roy Reese (LESIA-Observatoire de Paris-Meudon), Marc-Antoine Dupret (Université de Liège)

In the past few years, the CoRoT and Kepler missions have carried out what is now called the space photometry revolution. This revolution is still ongoing thanks to K2 and will be continued by the Tess and Plato2.0 missions. However, the photometry revolution must also be followed by progress in stellar modelling, in order to lead to more precise and accurate determinations of fundamental stellar parameters such as masses, radii and ages. In this context, the long-lasting problems related to mixing processes in stellar interior is the main obstacle to further improvements of stellar modelling. In this talk, we will apply structural asteroseismic inversion techniques to targets from the Kepler LEGACY sample and analyse how these can help us constrain the fundamental parameters and mixing processes in these stars. Our approach is based on previous studies using the SOLA inversion technique (Pijpers & Thompson 1994) to determine integrated quantities such as the mean density (Reese et al. 2012), the acoustic radius, and core conditions indicators (Buldgen et al. 2015a, Buldgen et al. 2015b), and has already been successfully applied to the 16Cyg binary system (Buldgen et al. 2016, Buldgen et al. in prep). We will show how this technique can be applied to the Kepler LEGACY sample and how new indicators can help us to further constrain the chemical composition profiles of stars as well as provide stringent constraints on stellar ages.

Asteroseismic Constraints on Evolutionary Models of Hot Subdwarfs

Jan-Torge Schindler (Steward Observatory, Department of Astronomy, University of Arizona), Schindler, Jan-Torge (Steward Observatory, Department of Astronomy, University of Arizona), Arnett, W. David (Steward Observatory, Department of Astronomy, University of Arizona), Green, Elisabeth M. (Steward Observatory, Department of Astronomy, University of Arizona)

Hot subwarfs are helium core burning stars with very thin hydrogen envelopes located at the extreme horizontal branch. Many of these hot (Teff =20,000-40,000K) and compact (log g = 5.0-6.2) objects exhibit pressure(p)-mode (100-400s) and/or gravity(g)-mode (2000-14000s or longer) stellar pulsations. Pulsational frequencies in both regimes have been observed using ground-based and space-borne (e.g. CoRot and Kepler) instruments. Asteroseismic analyses of these p- and g-mode pulsations led to strong constraints on surface properties, such as effective temperature, gravitational acceleration and rotation, and inferences on the inner structure, convective core sizes and composition. In my talk I will give a general overview over these results and then focus on a comparison of the inner structure and the convective core with evolutionary models. Especially subdwarf B star convective core sizes inferred from asteroseismology (0.22-0.28 Msun, ~45% of the total mass) challenge our current implementation of convection in standard stellar evolution. On our road to a more accurate treatment of convection we turn towards three-dimensional simulations of turbulent convection in stars for further insight.

Modelling of Red Giant Stars: The state-of-the-art

Santi Cassisi (INAF – Astronomical Observatory of Teramo)

We review the main evolutionary and structural properties of Red Giant Stars. The most important achievements in the theoretical evolutionary framework for these fundamental stellar objects are discussed. We mention the still-existing uncertainties in the their modelling as well as the important benchmarks provided by seismology.

Are observed mixed modes able to slow-down the core of red-giants?

Kevin Belkacem (Paris Observatory), K. Belkacem (Observatoire de Paris), J.P. Marques (Institut d)

The detection of mixed modes in subgiants and red giants by the CoRoT and Kepler space-borne missions allowed us to investigate for the first time the internal structure of evolved low-mass stars. These results indicate that the mean core rotation rate was much lower than expected, and that it slowed down with age as the star climbs the RGB. Although a number of physical processes have been proposed, no clear answer emerged. The quest for a mechanism efficient enough to transport the required angular momentum from the core of red giants is still ongoing. In this talk, we will consider the ability and efficiency of the observed mixed modes to slow-down the core of red giants.

What red giant seismology is teaching us about stellar physics

Sébastien Deheuvels (IRAP (Toulouse, France)), Sebastien Deheuvels (IRAP (Toulouse, France))

Since the detection of non-radial oscillations in over 10,000 red giants by space missions CoRoT and Kepler, the seismology of these objects has rightfully gained interest among the stellar physics community. The detection of mixed gravity-pressure modes has indeed made it possible to peer into the cores of red giants. This is currently bringing stringent constraints on several physical processes in stellar interiors that remain poorly understood but play a central role in stellar evolution, such as the nature and efficiency of mixing beyond boundaries of convective regions, or the way angular momentum is transported inside stars. We here give an overview of what the seismology of red giants has already taught us about such processes, and highlight the potential of dipole mixed modes in red giants for new advances in stellar physics.

Testing Asteroseismic Scalings for Red Giants with Eclipsing Binaries Observed by Kepler

Jean McKeever (New Mexico State University), Patrick Gaulme, Jason Jackiewicz, Meredith Rawls

Given the potential of ensemble asteroseismology for understanding fundamental properties of large numbers of stars, it is critical to determine the accuracy of the scaling relations on which these measurements are based (e.g. Stello et al. 2009, White et al. 2011, Miglio et al. 2013, Huber et al. 2011, Huber et al. 2012, Silva-Aguirre et al. 2012). From several powerful validation techniques, all indications so far show that stellar radius estimates from the asteroseismic scaling relations are accurate within a few percent. Eclipsing binary systems hosting at least one star with detectable solar-like oscillations constitute the most ideal test objects for validating asteroseismic radius and mass inferences. By combining radial-velocity measurements and photometric time series of eclipses, it is possible to determine the masses and radii of each component of a double-lined spectroscopic binary. So far, all published stars known to both display solar-like oscillations and belong to an eclipsing binary are red giants, all having been detected by the Kepler mission (Hekker et al. 2010, Frandsen et al. 2013, Gaulme et al. 2013, 2014, 2016 (submitted), Beck et al. 2014, 2015, Brogaard et al. 2016). Here we report the results of a four-year radial-velocity survey performed with the echelle spectrometer of the Astrophysical Research Consortium's 3.5-m telescope at Apache Point Observatory. We compare the masses and radii of 10 red giants, obtained by combining radial velocities and eclipse photometry with the estimates from asteroseismic scalings. We find that asteroseismic scalings overestimate red-giant radii by about 5% on average and masses by about 15% for stars at various stages of red-giant evolution. While these results are very encouraging in some specific cases, systematic overestimation of mass leads to underestimation of stellar age, which can have important implications for ensemble asteroseismology used for galactic studies.

Period and light curve analysis of the Kepler Cepheid V1154 Cyg: light curve modulation and detection of granulation

Aliz Derekas (ELTE Gothard Astrophysical Observatory), Plachy, E. (Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences), Molnar, L. (Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences), Sodor, A. (Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences), et al.

We present a detailed analysis of the bright Cepheid-type variable star V1154 Cygni using 4 years of continuous observations by the Kepler space telescope. The light curve was extracted by applying aperture photometry of the Kepler pixel data, then a detrending process. The frequency analysis revealed 28 frequencies and we identified modulation of the main pulsation frequency and its harmonics with a period of ~159 days. In addition, we detected another modulation with a period of about 1200 days. In addition, the Fourier parameters of the light curve and the O–C data show the 159 day modulation. The star also shows significant power in the low-frequency region that we identified as granulation noise. The effective timescale of the granulation agrees with the extrapolated scalings of red giant stars. Non-detection of solar-like oscillations indicates that the pulsation inhibits other oscillations. We obtained new radial velocity observations which are in a perfect agreement with previous years data, demonstrating that the 159 days modulation is not caused by the presence of a companion star. Finally, we discuss the possible origin of the detected frequency modulations.

New insight on ultimate stage of stellar evolution with the Kepler white dwarf pulsators

Noemi Giammichele (IRAP-CNRS/OMP), Stéphane Charpinet (IRAP-CNRS/OMP), Gilles Fontaine (Université de Montréal), Pierre Brassard (Université de Montréal)

White dwarf stars can be seen as stellar fossiles that keep buried in their interior many features from their past evolution. By studying their internal chemical compositions, and more precisely the carbon-oxygen profiles, we can place constraints on key processes in stellar physics such as nuclear burning, convection, and mixing, that shape this stratification over time. We present the asteroseismic analyses of a selected sample of white dwarf stars in the Kepler and Kepler2 fields. We precisely establish their internal structures using the forward method based on physically sound models. This opens up interesting perspectives on better constraining the physical processes occurring during the prior evolution of the star.

Understanding Rogue Waves on Pulsating White Dwarfs

J.J. Hermes (University of North Carolina at Chapel Hill)

Kepler and K2 have uncovered a completely unexpected new physical phenomenon in pulsating stars: large-amplitude outbursts in the coolest ZZ Cetis (hydrogen-atmosphere pulsating white dwarfs). The outbursts are essentially rogue waves, sporadically increases the overall stellar brightness by up to 15%. We have now discovered four outbursting white dwarfs, all confined to a narrow range of temperatures at the red edge of the ZZ Ceti instability strip. These outbursts are providing fresh insight into pulsation energy transfer via nonlinear resonances, as well as the eventual cessation of pulsations in cool white dwarfs.

Galactic asteroseismology

Andrea Miglio (University of Birmingham)

In the last few years asteroseismology has proven to be a main asset to the study of the structure and evolution of the Milky Way. In this talk I will summarise the recent progresses in this fast growing field, focussing primarily on the reliability of the asteroseismic age scale. I will then discuss future prospects and synergies with Gaia, and whether with K2, TESS, and PLATO we should expect incremental changes or breakthroughs in Galactic asteroseismology.

Probing the Deep End of the Milky Way with New Oscillating Kepler Giants

Savita Mathur (Space Science Institute), R. A. Garcia (CEA Saclay), D. Huber (University of Sydney), C. Regulo (Instituto de Astrofisica de Canarias), D. Stello (University of Sydney), et al.

The Kepler mission has been a success in both exoplanet search and stellar physics studies. Red giants have actually been quite a highlight in the Kepler scene. The Kepler long and almost continuous four-year observations allowed us to detect oscillations in more than 15,000 red giants targeted by the mission. However by looking at the power spectra of ~45,000 stars classified as dwarfs according to the Q1-16 Kepler star properties catalog, we detected red-giant like oscillations in ~850 stars. Even though this is a small addition to the known red-giant sample, these misclassified stars represent a goldmine for galactic archeology studies. Indeed they happen to be fainter (down to Kp~16) and more distant (d>10kpc) than the known red giants, opening the possibility to probe unknown regions of our Galaxy. The faintness of these red giants with detected oscillations is very promising for detecting acoustic modes in red giants observed with K2 and TESS. In this talk, I will present this new sample of red giants with their revised stellar parameters derived from asteroseismology. Then I will discuss about the distribution of their masses, distances, and evolutionary states compared to the previously known sample of red giants.

Ensemble Asteroseimology as a Tool for Stellar Population Inference.

Caitlin Jones (University of Birmingham), William J. Chaplin (University of Birmingham), Yvonne P. Elsworth (University of Birmingham), Andrea Miglio (University of Birmingham)

Using a simple metric we have defined based on a band-pass-filtered estimate of the variance of Kepler light curves for red giant stars, I present the results of work designed to determine the fraction of stars which reside in binary systems in a given population. Simulated power spectra have been created for synthetic Kepler fields, with populations of stars across a range of binary fractions generated by the TRILEGAL code. Using fundamental stellar parameters output by this code, I construct power spectra using existing relations for oscillation amplitudes, frequencies, granulation background and shot noise, and also consider the contribution of mixed modes and $l = 1$ suppression. I will discuss the decisions we have made with regards to the complexity of the simulated power spectra, and the considerations we have had to make in implementing a more realistic model. Analyses of the artificial data are being used to guide my interpretation of the real data, and, although subject to the limitations of our simulations and our understanding of the some properties of the real population, I will present the results of using this ensemble approach to infer the proportion of the real Kepler red giant branch stars which exist in binary systems. While asteroseismology is already used in detecting individual binary systems, this ensemble approach may provide a useful tool for the study of stellar populations as a whole. We also find that our variance metric discriminates between the red giant branch and red clump stars in the real population, implying that the different physics of stars in these two evolutionary states impacts on the observed oscillation power in a way which is detectable even using this simple metric. I will discuss the success of simulating these two evolutionary states, and our plans for future analysis of this phenomenon.

Asteroseismology and chemodynamical models of the Milky Way

Cristina Chiappini (Leibniz Institute for Astrophysics Potsdam (AIP))

Formation history of open clusters constrained by detailed asteroseismic analysis of red giant stars observed by Kepler

Enrico Corsaro (Service d'Astrophysique – CEA Saclay), Yueh-ning Lee (Service d), Savita Mathur (Space Science Institute), Paul Beck (Service d), et al.

Stars originate by the gravitational collapse of a turbulent molecular cloud of a diffuse medium, and are often observed to form clusters. Stellar clusters therefore play an important role in our understanding of star formation and of the dynamical processes at play. However, investigating the cluster formation is difficult because the density of the molecular cloud undergoes a change of many orders of magnitude. Hierarchical-step approaches to decompose the problem into different stages are therefore required, as well as reliable assumptions on the initial conditions in the clouds. In this talk we report for the first time the use of the full potential of NASA Kepler asteroseismic observations coupled with 3D numerical simulations, to put strong constraints on the early formation stages of open clusters. Thanks to a Bayesian peak bagging analysis of about 60 red giant members of NGC 6791 and NGC 6819, the two most populated open clusters observed in the nominal Kepler mission, we derive a complete set of detailed oscillation mode properties for each star, with thousands of oscillation modes characterized. We therefore show how these asteroseismic properties lead us to a discovery about the rotation history of stellar clusters. Finally, our observational findings will be compared with hydrodynamical simulations for stellar cluster formation to constrain the physical processes of turbulence, rotation, and magnetic fields that are in action during the collapse of the progenitor cloud into a proto-cluster.

Stellar population synthesis based modelling of the Milky Way using asteroseismology of 13000 Kepler red giants.

Sanjib Sharma (University Of Sydney), Dennis Stello (University Of Sydney), Joss Bland-Hawthorn (University Of Sydney), Daniel Huber (University Of Sydney), Tim Bedding (University Of Sydney)

With current space-based missions it is now possible to obtain age-sensitive asteroseismic information for tens of thousands of red giants. This provides a promising opportunity to study the Galactic structure and evolution. We use asteroseismic data of red giants, observed by Kepler, to test the current theoretical framework of modelling the Galaxy based on population synthesis modeling and the use of asteroseismic scaling relations for giants. We use the open source code Galaxia to model the Milky Way and find the distribution of the masses predicted by Galaxia to be systematically offset with respect to the seismically-inferred observed masses. The Galactic model overestimates the number of low mass stars, and these stars are predominantly old and of low metallicity. Using corrections to the $\Delta\nu$ scaling relation suggested by stellar models significantly reduces the disagreement between predicted and observed masses. For a few cases where non-seismic mass estimates are available, the corrections to $\Delta\nu$ also improve the agreement between seismic and non-seismic mass estimates. Altering the star formation rate in order to suppress stars older than 10 Gyr improves the agreement for mass but leads to inconsistent color distributions. We conclude that either the scaling relations and/or the Galactic models need to be revised to reconcile predictions of theory with asteroseismic observations.

Testing Asteroseismology with APOGEE Star Clusters

Marc Pinsonneault (Ohio State University), et al.

The APOGEE survey has obtained high resolution H band spectra for Kepler red giants and for large numbers of star cluster members. We explore the cluster data, both within and outside of the Kepler fields, as a test of asteroseismic surface gravity and mass measurements. Clusters provide independent checks on surface gravity (from cluster age, distance, and extinction), the mass dependence of the first dredge-up (as measured by C and N), and asteroseismic / spectroscopic inferences about evolutionary state. We discuss the current state of agreement between the two and prospects for improvement using upcoming data, including K2.

Dynamic Asteroseismology: towards improving the theories of stellar structure and (tidal) evolution

Andrew Tkachenko (Institute of Astronomy, KU Leuven)

Many fields in (stellar) astrophysics have been revolutionized with the launch of space missions like MOST, CoRoT, Kepler/K2, and soon TESS. Asteroseismology and binary star research areas are among domains that have benefited from high-quality space-based photometric data the most. An observational probe of the near core regions, as well as the measurements of the surface-to-core rotation have recently become available for MS stars of spectral types B to F. Space-based data provided us with new insights into stellar objects at advanced evolutionary stages, revolutionized our understanding of evolved red-giant stars exhibiting stochastically excited solar-like oscillations, and significantly improved our understanding of stars during early, pre-main-sequence stages of their evolution. On the other hand, dynamical measurements of fundamental properties of individual binary components to precisions approaching 1% became available for many systems and in large mass and age ranges. Many A- to B-type stars in binaries are found to exhibit both self-excited and tidally induced stellar oscillations. Although intended to improve the current theories of stellar structure and evolution (SEE), asteroseismology is itself a model-dependent research field, with the dependency being significantly larger for intermediate- and high-mass stars than for sun-like stars. Insufficient quality of observations is no longer a limiting factor for a new series of progressions in asteroseismology, but the shortcomings in the current theories of SEE become a real bottleneck. Likely, many pulsating stars are found in binary systems across the whole HR-diagram which gives us the unique opportunity to supply asteroseismic investigations with additional, model-independent observational constraints in terms of the dynamical masses and radii of stars. In this talk, I will focus on the advantages of combining the two complenetary research areas, asteroseismology and binary stars, and on the role of K2 and TESS missions in providing us with high-quality observational input.

Binary populations: what have we learned from Kepler and K2?

Andrej Prsa (Villanova University)

The original Kepler mission (Borucki et al. 2011) provided us with an unprecedented look into the statistical properties of EBs: the satellite's original field of view contains some 2800 close binaries for which we have 4 years of essentially uninterrupted data with unparalleled photometric precision (Kirk et al. 2016). This data-set allowed us to derive fundamental parameter distributions and multiplicity rates of EBs across the field (Pr¨a et al. 2011, Conroy et al. 2014a, Kirk et al. 2016). The Kepler EB catalog (http://keplerEBs.villanova.edu) represents the most complete census of close eclipsing binaries that is available to date. The crucial advantage of K2 over the original Kepler mission is the survey of the ecliptic. That implies probing inherently different stellar populations since the ecliptic spans galactic latitudes between -70-deg and 70-deg. These parts (the bulge, thick disk, thin disk, halo) feature distinct stellar populations, and understanding the properties of those populations is an ongoing effort. Studying these properties relies on reliable fundamental parameters of stars: their masses, radii, temperatures and luminosities. Eclipsing binary stars lend themselves naturally to this task, since their favorable geometrical orientation and basic laws of gravity enable us to determine fundamental parameters to a ~1% accuracy. In this review talk I will present what we learned from studying binaries with Kepler and K2, and look to TESS to fill in the blanks in our coverage of the bright end.

Solar-like oscillators in Binary systems: a way to put tight constraints on stellar physics.

Paul Beck (CEA, Paris-Saclay), P.G. Beck (Service d), P. Gaulme (New Mexico State University, Department of Astronomy, USA), T. Kallinger (Institut fuer Astrophysik, Vienna University, Austria), A. Palacios (LUPM – Université de Montpellier), et al.

The growing number of binary stars with oscillating components from Kepler space photometry (Beck et al. 2014, Gaulme et al. 2014) or ground-based spectroscopy (Beck et al. 2015) provides a large sample of rewarding objects to study stellar physics. In this case study we discuss a detailed analysis of a particular binary system, nicknamed 'Asterix & Obelix', hosting two oscillating giant components. Besides mass and radius, we confront the rotational rates from seismology with the surface rotation. Judged from the period of spot modulation some systems have stellar rotation rates close to (nearly) the orbital period, such as this system, others do not show signs of synchronization at all. For a good understanding of the system, a detailed light curvemodel is discussed and compared to other well-studied systems. Such an analysis clearly benefits from the spectral disentangling of both stellar components from the time series of high-resolution spectroscopy, which enables us to constrain the mass ratio to about 1% as well as the individual stellar fundamental parameters and metallicities. In particular, confronting the so derived lithium abundance for both components with model predictions us to constraint the history of mixing and angular-momentum transport inside the stars. We also propose new ways how double-lined binaries can serve as a tool to calibrate the scaling relations by rewriting the relations with spectroscopic terms. We furthermore present a substantial extension to the dataset of known binary systems hosting solar-like oscillating components on the main sequence or the red-giant phase from photometry and spectroscopy.

Asteroseismic modelling and orbital analysis of the triple star system HD 188753

Frédéric Marcadon (IAS), F. Marcadon (IAS), T. Appourchaux (IAS), J. P. Marques (IAS)

HD 188753 (HIP 98001, HO 581 or KIC 6469154) is known as a close visual binary discovered by Hough in 1895 and characterized by an orbital period of 25.7 years. In the late 1970s, it was established that the secondary is itself a spectroscopic binary with a period of 155 days. HD 188753 is therefore a hierarchical triple star system consisting of a close pair (Ba and Bb) in orbit at a distance of 12.3 AU from the primary (A). The triple star system was observed by Kepler in short-cadence mode during quarters Q13 and Q14. We report in this study the detection of solar-like oscillations for the brightest star HD 188753A. We perform the first asteroseismic analysis of HD 188753A using state-of-the-art stellar models in order to derive its fundamental parameters. We obtain the age and initial chemical composition of the star, which are assumed to be the same for the three members of the system, as well as a precise but model-dependent estimate of its mass. We then combine micrometric, interferometric and radial velocity measurements from almost a century of observations to determine the orbital masses of the three stars. We get direct constraint on the mass of HD 188753A which allows us to test different input physics in our stellar models. The full characterization of the triple stars HD 188753 is essential for better understanding the formation mechanisms and evolutionary processes of binaries and multiple stellar systems in our Galaxy.

Asteroseismic detection of invisible companions to intermediate-mass stars

Simon Murphy (SIfA, University of Sydney), Hiromoto Shibahashi (U. Tokyo), Tim Bedding (USyd), et al.

We present the latest results from the Phase Modulation method, which utilises the phases of stellar oscillations to detect changes in the path length between Earth and the observed star due to motion in a binary system. The companions detected with this method include planets, brown dwarfs, main-sequence stars with masses between 0.1 and 2.5 Msun, and possible compact objects such as neutron stars and black holes. Statistically robust distributions of the orbital parameters are discussed, exploring such phenomena as the circularisation of orbits as a function of orbital period. We will look at the most extreme systems found, some of which have eccentricities above 0.9, and discuss the implications for brown dwarf and planet formation given the distribution of mass functions of the systems.

The Toby Shake: Pulsations affected by precession and nutation in a close binary

Roy Østensen (Missouri State University), John Telting (Nordic Optical Telescope), Andrzej Baran (Krakow Pedagogical University), Mike Reed (Missouri State University)

The eclipsing sdb+dM binary KIC 9472174 = 2M1938+4603 is one of the few targets which was observed in short-cadence mode for the entire duration of the main Kepler mission. Its exceptionally complex pulsation spectrum contains periods ranging from around 200 seconds to 5 hours. The pulsation spectrum of both p-modes and g-modes has defied analysis by regular means due to the effects of fast rotation induced by the 0.25 d binary period. Analysing the entire Kepler dataset we have discovered strong amplitude modulation with a period of about 400 days in a majority of the pulsation modes, as well as more rapid modulations with a period of 39 days, which is associated with a strong frequency/phase modulation signal. A spectacular zoo of diverse modulation effects in amplitude and frequency/phase, some showing complete periodic phase inversion, may promise a new method for asteroseismic mode identification in close binaries.

Kepler's Exoplanet Legacy

Natalie Batalha (NASA Ames Research Center)

The scientific community recently celebrated twenty years exploring the diversity of planets and planetary systems orbiting main sequence stars. Today, the discoveries spill into the thousands, and the sensitivity boundaries continue to expand. NASA's Kepler Mission unveiled a galaxy replete with small planets and revealed populations that don't exist in our own solar system. The discovery catalog is sufficient for computing planet occurrence rates as a function of size, orbital period, and host star properties. We've learned that every late-type star has at least one planet, that terrestrial-sized planets are more common than larger planets within 1 AU, and that the nearest, potentially habitable earth-sized planet is likely within 5 pc.

After four years of continuous observations, the Kepler prime mission ended in May 2013 with the loss of a second reaction wheel. Thanks to innovative engineering, the spacecraft gained a second lease on life and emerged as the ecliptic surveyor, K2. In many regards, K2 is a distinctly new mission, not only by pointing at new areas of the sky but also by focusing on community-driven goals that diversify the science yield. For exoplanets, this means targeting bright ($V < 13$) and low mass (M dwarfs) stars -- the populations harboring planets amenable to dynamical and atmospheric characterization. To date, the mission has executed 9 observing campaigns lasting ~80 days each and has achieved a 6-hour photometric precision of 30 ppm. Dozens of planets have been confirmed, including nearby (< 50 pc) systems on the watch-list for future observing campaigns with the James Webb Space Telescope. While Kepler prime is setting the stage for the direct imaging missions of the future, K2 is easing us into an era of atmospheric characterization.

Asteroseismology of exoplanet host stars using Kepler SC data

Mia Sloth Lundkvist (LSW, University of Heidelberg), Hans Kjeldsen (Stellar Astrophysics Centre, Aarhus University), Simon Albrecht (Stellar Astrophysics Centre, Aarhus University), Guy Davies (University of Birmingham / Stellar Astrophysics Centre, Aarhus University), Camilla Agentoft (Stellar Astrophysics Centre, Aarhus University), et al.

We present a coherent asteroseismic analysis of all 280 exoplanet candidates host stars brighter than magnitude 13.5 for which short cadence Kepler data exist. We find that 102 of these candidates show a clear asteroseismic detection allowing measurement of the large frequency separation for p-modes. This in turn allows us to compute very precise radii and incident fluxes for the exoplanets. Using this information, we can detect a hot-super-Earth desert; a region in the radius-flux parameter space completely void of exoplanets. This implies that evaporation plays a role in sculpting the observed exoplanet population. All these exoplanet host stars represent the best characterized exoplanet systems and we discuss the stellar properties and improvement in the quality of the measurements of the exoplanet properties such as radius and incident flux. Most of the p-mode detections are of low signal-to-noise ratio and we can therefore use those results to estimate the implications for TESS asteroseismology of exoplanet host stars. In addition, this study emphasizes the importance of asteroseismology in order to obtain highly precise exoplantary parameters and that it is crucial for TESS to also observe the fainter stars.

Using asteroseismology to understand exoplanet orbits

Vincent Van Eylen (Leiden University), Simon Albrecht (Aarhus University)

Eccentricity is a fundamental orbital parameter which holds information about planet formation and evolution as well as habitability. Surprisingly, many massive gas giant planets travel on highly elliptical orbits, in contrast to the orbits of solar system planets which are nearly circular. So far, the orbital shape of smaller, more terrestrial, exoplanets remained largely elusive, because the stellar radial velocity caused by these small planets is extremely challenging to measure. I sidestepped this problem by using photometry from the Kepler satellite and utilizing a method relying on Kepler's second law, which relates the duration of a planetary transit to its orbital eccentricity, if the stellar density is known. Here, asteroseismology is key to delivering this stellar parameter with the required precision and accuracy. This approach enabled me to measure the eccentricity of planets even smaller than Earth, much smaller than what was previously possible. I present eccentricity measurements for 74 planets in multi-planet systems, and 50 systems with a single transiting planet. The multi-planet systems are nearly circular, in full agreement with solar system eccentricities, but in contrast to the eccentricity distributions previously derived for exoplanets from radial velocity studies. The systems with a single transiting planet have significantly higher eccentricities. I link these findings to planet formation and evolution theory and argue that the eccentricity of systems with a single transiting planet may be related to the presence of non-transiting planets on an inclined orbit. I also compare the eccentricities with stellar parameters derived from asteroseismology for this "gold standard" sample.

A simple model to describe intrinsic stellar noise for exoplanet detection around red giants

Thomas North (University of Birmingham), William Chaplin (University of Birmingham), et al.

In spite of the huge advances in exoplanet research provided by the NASA Kepler Mission, there remains a dearth of transit detections around evolved stars. Here we present a reformulation of the noise properties of red-giant stars, where the intrinsic stellar granulation and oscillations present the dominant noise sources. This noise model is then used to make transit signal-to-noise predictions for a 6400-strong cohort of Kepler stars that have already been identified as evolved stars on the red-giant branch. We discuss predictions of the fraction of red-giant targets that might have detectable planets. Subject to different assumptions for the underlying planet population our results suggest it may be possible to double the number of detected transiting planets around red giants, using current Kepler data.

Stellar magnetic activity and their effects on planetary environments

Aline Vidotto (Trinity College Dublin)

In this talk I will review some recent works on the magnetic activity of Sun-like stars, their winds and potential impact on surrounding exoplanets. Stellar magnetic fields drive space weather on (exo)planets, being responsible for the ejection of stellar winds and bursty events, such as flares and coronal mass ejections. Therefore, understanding the host star magnetism is a key step towards characterisation of exoplanetary environments. Although these environments may be potentially dangerous for a planet's atmosphere, the interaction between exoplanets and the host star winds can provide other avenues for planet detection and maybe even assess planetary properties, which would otherwise remain unknown.

K2 observations of Neptune

Patrick Gaulme (New Mexico State University)

We proposed to observe Neptune with K2 for three reasons: 1) studying the evolution of cloud features by monitoring the rotational photometric variability; 2) studying its interior structure through the possible detection of global acoustic oscillations; 3) detecting the solar acoustic oscillations imbedded in the Sun's reflected light to understand how Kepler would see the Sun. As regards clouds, we compare results extracted from the light curve with contemporaneous disk-resolved imaging of Neptune from the Keck 10-m telescope at 1.65 microns and Hubble Space Telescope visible imaging acquired nine months later. We conclude that a single large discrete storm seen in Keck imaging dominates the K2 and Hubble light curves, and that smaller or fainter clouds likely contribute to short-term brightness variability. As regards seismology of Neptune, the observation principle stipulates that Neptune behaves as a mirror for solar light and that slight distortions of its disk caused by the oscillations would lead to detectable photometric fluctuations. This is very challenging and K2 was the first opportunity ever to test this approach. Even though a low amplitude periodic signal is detected by autocorrelation of the time series in the frequency range where we expect oscillations, it is likely to be a artifact related to instrumental noise. Finally, the detection of the solar oscillations is the major result of these observations as it is the first time that solar oscillations are detected in photometry on any other planet (including the Moon). This is another great performance of Kepler, K2 in particular. We clearly identify eight mode overtones with degrees l=0,1,2, which we compare to SOHO's VIRGO and GOLF data, as well as BiSON. We also measure the frequency at maximum amplitude and mean large spacing, from which we infer the solar mass and radius as Kepler would have estimated it. Uranus was observed by K2 in early 2016. Depending on the date we get the data, we might be able to show some first results.

POSTERS

POSTER GROUP PO

PO.S1.1 – SPACEINN – Exploitation of Space Data for Innovative Helio- and Astero-seismology

Mario J P F G Monteiro (Instituto de Astrofisica e Ciencias do Espaço, U.Porto & DFA/FCUP), M. Roth (Kiepenheuer-Institut für Sonnenphysik), The SPACEINN Board

The European Helio- and Asteroseismology Network (HELAS) has initiated the project "Exploitation of Space Data for Innovative Helio- and Asteroseismology" (SpaceInn) with the mission to build on the existing European strength in the field of time-domain stellar physics. SpaceInn activities, which are organized around the themes of data access, scientific expertise and existing coordination, aim to secure optimal use of the existing and planned data, from space and from the ground, in helio- and asteroseismology.

POSTER GROUP PA
S2. Space Missions & Data

PA.S2.2 – LAMOST observations in the K2 fields: project and observation progress

Jianning Fu (Beijing Normal University), J.N. Fu (Beijing Normal University), M.C. Smith (Shanghai Astronomical Observatory), R.Y. Zhang (Beijing Normal University), A.B. Ren (Beijing Normal University), et al.

To complement the time-series observations of the Kepler space mission in the K2 fields, spectroscopic observations for hundreds of thousands of stars in these fields are hugely important. LAMOST, a Chinese 4-meter class telescope equipped with 4000 fibers on the focal plane, is an ideal facility to fulfill this task. The LAMOST-K2 project was approved in the autumn of 2015 and observations commenced during the 2015-2016 winter season. The project will initially cover 6 of the first 8 observed K2 campaigns, and may be extended to include later K2 campaigns. We shall describe the project and introduce the current progress of observation with the poster presentation.

PA.S2.3 – LAMOST observations in the Kepler field. Analysis of the stellar parameters measured with the LASP based on the low-resolution spectra

Anbing Ren (Beijing Normal University), Jianning Fu (Department of Astronomy, Beijing Normal University, No. 19 Xinjiekouwai Street, Haid- ian District, Beijing 100875, China), Peter De Cat (Royal observatory of Belgium, Ringlaan 3, B-1180 Brussel, Belgium), Ruyuan Zhang (Department of Astronomy, Beijing Normal University, No. 19 Xinjiekouwai Street, Haid- ian District, Beijing 100875, China), et al.

All of the 14 subfields of the Kepler field have been observed at least once with the Large Sky

Area Multi-Object Fiber Spectroscopic Telescope (LAMOST, Xinglong Observatory, China) during the 2012-2014 observation seasons. The raw spectral data were reduced by the LAMOST 2D pipeline to obtain the flux- and wavelength-calibrated, sky-subtracted spectra. There are 88,628 reduced spectra with SNRg (signal-to-noise ratio in g band) ≥ 6 after the first round (2012-2014) of observations for the LAMOST-Kepler project (LK-project). They will be released publicly in the third data release of LAMOST (DR3). By adopting the upgraded version of the LAMOST Stellar Parameter pipeline (lasp), we have determined the atmospheric parameters (Teff, log g, and [Fe/H]) and radial velocity (Vrad) for 51,406 stars with 61,226 spectra. Compared with atmospheric parameters derived from both high-resolution spectroscopy and asteroseismology method for common stars in Huber et al. (2014), an external calibration of lasp atmospheric parameters was made, leading to the determination of external errors for the giants and dwarfs, respectively. Multiple spectroscopic observations for the same objects of the LK-project were used to estimate the internal uncertainties of the atmospheric parameters as a function of SNRg with the unbiased estimation method. The lasp atmospheric parameters were calibrated based on both the external and internal uncertainties for the giants and dwarfs, respectively. Fitting formulae are obtained segmentally for both the calibrated atmospheric parameters of the LK-project and the KIC parameters with the common stars. We obtained more than 97,600 and 99,700 reduced spectra for the LK-project and K2-project during the 2015.09-2016.02 observations seasons, respectively. The Teff, log g, [Fe/H] and Vrad and their errors are determined for more than 79,300 and 66,300 reduced low-resolution spectra in the LK-project and K2-project, respectively. These parameters will be calibrated by using both the linear relationships derived from the external comparisons and their internal uncertainties. Combing with the high-precision time-series photometric data provided by the Kepler mission, the calibrated atmospheric parameters and radial velocities of the two projects will be very useful for studying stars in the Kepler field and K2 fields.

PA.S2.4 – Differences in the frequencies and error estimates of p-modes between different fitters - a problem for model fitting

Ian Roxburgh (Queen Mary University of London)

Not infrequently the frequencies for a given star determined by different fitters do not agree with each other - the differences can be larger than the error estimates so that were one to find a model that fitted one frequency set it may well not fit an alternative set. I illustrate this by comparing frequency sets for 21 stars from the Kepler Legacy project with alternative frequency estimates from Davies (2015), Appourchaux (2014) and myself.
I explore the origin of the differences and compare with estimates from an independent fitting routine, concentrating on 16CygA and 16CygB. I find that there is some error in the Legacy determination of some of the frequencies of 16CygA, and that for 16CygB, whilst on using the kasoc weighted power spectrum I reproduce the Legacy frequencies, except for modes with low signal/noise, I do not reproduce these frequencies using a power spectra derived from the kasoc light curve. I find much better agreement with Davies's frequencies (except for modes with low signal/noise) on using his power spectrum, a power spectrum derived from his time series, and power spectra derived from the kasoc light curve.
Other factors that affect fitted mode parameters include different fitting techniques, different constraints on the fitting procedure, large variations in estimates at low and high frequencies where the mode power is small compared to the background, and estimates of rotational splitting. In my opinion, given that there is no known "correct" procedure, the differences between values obtained using different techniques should be included in estimates of the uncertainties in the frequencies.

PA.S2.5 – The Corot legacy: final data release available!

Frederic Baudin (IAS), F. Baudin (IAS, Orsay, France), H. Ballans (IAS, Orsay, France), A. Baglin (LESIA, Meudon, France), S. Chaintreuil (LESIA, Meudon, France), et al.

The CoRoT mission was operated for 6 years, from 2007 to 2012. It has gathered more than 160000 stellar light-curves aiming at planet detection and stellar physics objectives. Based on the experience acquired since the launch, a final version of the CoRoT data (light curves and other products) has been released. Instrumental problems in light curves have been thoroughly filtered out. In particular most of the discontinuities caused by impacts on the detectors have been cleaned. In addition, a new and deeply improved version of the Exodat catalog providing a characterization (spectral type) of the targets has also been released. Some examples will be shown together with an assessment of the quality of Exodat data.

PA.S2.6 – The SONG Project

Victoria Antoci (Stellar Astrophysics Centre, Aarhus University), SONG team (Stellar Astrophysics Centre, Aarhus University, Denmark)

SONG (Stellar Observations Network Group) is a Danish-led collaborative project set to design and build a global network of small telescopes that should specifically target the study of stars and planetary systems around stars. The objective was to develop a prototype of a new ultra-modern robotic telescope that would be inexpensive and efficient to run. The Hertzsprung SONG Telescope, i.e. the prototype of the SONG network, is located at the Observatorio del Teide (OT) of the Instituto de Astrofisica de Canarias (IAC) in Tenerife. The telescope is equipped with a high-resolution spectrograph aiming at ultra-precise radial velocity measurements and will have the capability of performing photometry using the Lucky Imaging technique. Here we present technical details and summarise our experience of 1.5 years of operations.

PA.S2.7 – First-Light Observations Using the Multi-Band Lucky Imaging Cameras at SONG

Victoria Antoci (Stellar Astrophysics Centre, Aarhus University), SONG team (Stellar Astrophysics Centre, Aarhus University, Denmark)

About fifty years ago, in the middle of the 20th century, lucky imaging cameras became popular for making beautiful images of planets in the Solar System. Nowadays, lucky imaging is a well-established observing strategy that is used to produce high cadence, sharp images of stars in visible wavelengths. During each observing run, from the hundreds of images taken every night the sharpest ones are selected, shifted, and added to produce a high signal-to-noise and high spatial resolution combined image, that would not be possible to obtain by means of ground-based long-exposure observations. One of such system that simultaneously operates in both red and visible wavelengths, has been mounted at the 1m Hertzsprung SONG (Stellar Observations Network Group) Telescope on Tenerife. Here we present how the lucky imaging system operates at SONG, along with our first-light observations.

PA.S2.8 – New opacity tables for asteroseismology

Sylvaine Turck-Chièze (CEA/Saclay), the OPAC team

Two new opacity tables are now available for stellar use. They have been computed respectively by the french OPAS team (Blancard et al. 2012) for the solar applications and by the Los Alamos team (Colgan et al. 2015, 2016) for stellar general use. The calculations leading to these tables have been studied in details by the OPAC consortium during the last 5 years. They have been partially checked by experiments and through detailed calculation comparisons (Bailey et al. 2015, Turck-Chièze et al. 2015, 2016). Some of them could be checked also thanks to coming future experiments (Lepennec et al. 2015) on large laser facilities (OMEGA, NIF, LMJ). The poster will summarize the different steps of validation of these calculations and discuss the limits of the present or past calculations.

S3. Special Session: TASC & KASC

PA.S3.9 – The Kepler LEGACY project: the best and brightest of the main-sequence solar-like oscillators

Victor Silva Aguirre (Aarhus University), Mikkel Lund (University of Birmingham), Sarbani Basu (Yale University), William Chaplin (University of Birmingham), et al.

The nominal Kepler mission produced a true revolution in our understanding of solar-like oscillations in main-sequence stars. From the hundreds of these stars where excess power in the light curve was detected, we selected those with more than one year of short-cadence observations to use as a benchmark set. These 66 unique stars comprise the Kepler LEGACY sample, and the aim of this project is to provide the most accurate set of stellar properties possible using 7 different methods of asteroseismic fitting. In this talk I present the results of this effort and stellar properties for these benchmark stars that can be used by the community for a number of different applications, and comment on the actual precisions in asteroseismically derived parameters and their accuracy when independent constrains are available. The results of this comparison have important implications for large scale surveys where automated analysis methods are mandatory, such as TESS and PLATO.

PA.S3.10 – Stellar Properties for 138,600 Targets Observed by the K2 Mission

Daniel Huber (University of Sydney), Stephen T. Bryson (NASA Ames), Michael R. Haas (NASA Ames), Tom Barclay (NASA Ames), Geert Barentsen (NASA Ames), et al.

Unlike the Kepler Input Catalog (KIC) for the Kepler Mission, the Ecliptic Plane Input Catalog (EPIC) for the K2 Mission does not include estimates of stellar properties for each cataloged source. Here we present a full set of stellar properties for 138,600 K2 targets in Campaigns 1-8 (~88% of the full target sample) derived from colors, proper motions, spectroscopy, parallaxes, and galactic population synthesis models, with typical uncertainties for G-type stars of ~3% in Teff , ~0.3 dex in log(g), ~40% in radius, ~10% in mass, and ~40% in distance. We show that stars targeted by K2 are dominated by K-M dwarfs (~41% of all selected targets), F-G dwarfs (~36%) and K giants (~21%), consistent with key K2 science programs to search for transiting exoplanets and galactic archeology studies using oscillating red giants. However, we find a significant variation of the fraction of cool dwarfs with galactic latitude, indicating a target selection bias due to interstellar reddening and the increased contamination by giant stars near the galactic plane. We discuss possible systematic errors in the derived stellar properties, and differences to published classifications for K2 exoplanet host stars. The EPIC stellar properties are available through the Mikulski Archive for Space Telescopes (MAST, http://archive.stsci.edu/k2/epic/search.php) and the NASA Exoplanet Archive (NExScI, http://exoplanetarchive.ipac.caltech.edu).

PA.S3.11 – Observational inputs on the solar/stellar connection from the Kepler satellite and the Hermes spectrograph: activity, rotation, lithium of solar analogs

Paul Beck (CEA, Paris-Saclay), D. Salabert (CEA, Paris-Saclay), P.G. Beck (CEA, Paris-Saclay), R.A. Garcia (CEA, Paris-Saclay), J. Do Nascimento (CfA, Harvard, USA / Universidade Federal do Rio, Brazil), et al.

The unprecedented quality of the continuous 4-yr photometric observations collected by the Kepler satellite allowed the measurements of acoustic oscillations in hundreds of solar-like stars. The addition of asteroseismic data was proven to provide the most accurate fundamental properties that can be derived from stellar modeling today. Moreover, the length of the Kepler dataset

provides a unique source of information for detecting magnetic activity. In this poster, we will present our latest results on the solar/stellar connection by studying oscillating 18 solar analogs that we identified among the Kepler seismic sample. We measured their magnetic activity properties using the observations collected by the Kepler satellite and ground-based, high-resolution Hermes spectrograph. The photospheric (Sph) and chromospheric (S index) magnetic activity levels of these seismic solar analogs are compared in relation to the solar activity. We show that the activity of the Sun is actually comparable to the activity of the seismic solar analogs. Furthermore, we will discuss the fundamental parameters and lithium abundances derived from the Hermes observations.

PA.S3.12 – Kepler – K2: A Search for very red variables

Erich Hartig (University of Vienna, Astrophysics), E. Hartig (University of Vienna, Department of Astrophysics), T. Lebzelter (University of Vienna, Department of Astrophysics), K. Hinkle (National Optical Astronomy Observatories, Tucson, AZ 85726 USA)

The NASA Kepler K2 mission offers new opportunities to search for long period variables (LPVs) along the ecliptic plane. We present first results of our observing proposals for 'Super-Red-Targets' in the Kepler K2 Campaigns 0 to 3 (GO0083, GO1003, GO2089, GO3089). The proposal aims at finding and characterizing very red variable objects in the Kepler K2 fields. Selection criteria were 2MASS colours J-Ks greater than 0.8 and Ks less than 8.0 mag plus the availability of some basic information from Simbad, GSC 2.3, 2MASS, and AAVSO data bases to ensure that we select stellar objects only. A main group of stars found with these selection criteria are long period variables (LPV). To focus on these objects we set a lower period limit of 10 days. The usability of K2 for this search is limited since the observation period of an individual target is limited to 80 days. However, this time scale allows detecting LPVs and making an estimate of the period length. Even more than for the Kepler primary mission (see Hartig et al., 2014) the data reduction had to be done with care to extract the true stellar signal. This data reduction is discussed in this poster. For the data preparation we adjusted our pipeline software for TPD, which we used in the Kepler primary mission and modified it to the K2 requirements. While the 6 hours signal caused by the firing of the thrusters for correcting the telescope's pointing could be easily corrected, a non-linear flux increase over each observation period had to be removed up to campaign C2. This had to be done very carefully since any long time instrumental signal would interfere with a possible long period signal of the star. Furthermore, it turned out that stars with magnitudes < 8.5 Kepmag typically show elongated pixel formats. This has been handled by an appropriate pixel aperture, and so we could improve the light curve's signal to noise ratio significantly. Some examples are shown. Finally, we compare our results of Campaign 3 with the officially supplied light curves, e.g. Armstrong, et al., 2016, and present our first preliminary results here. Ref.: Armstrong, D. J., Kirk, J., Lam, K. W. F., et al., 2016, MNRAS, 456, 2260 Hartig, E., Cash, J., Hinkle, K. H., et al., 2014, AJ, 148, 123

PA.S3.13 – Back-up to the Future: Creating the Kepler/K2 long-term "living archive"

Rasmus Handberg (Stellar Astrophysics Centre, Aarhus University), R. Handberg (Stellar Astrophysics Center (SAC), Department of Physics and Astronomy, Aarhus University, Denmark), A. S. Conrad (The Royal Library, Copenhagen, Denmark), M. Svendsen (The Royal Library, Copenhagen, Denmark)

What if something horrible happens in the future? Great Scott! Do we have a backup? Is a backup even enough? At the Kepler Asteroseismic Science Operations Center (KASOC) we have a goal that all data and information from Kepler and KASC is preserved for the future. The benchmark is that the data should be useful for, at least, the next 50 years. But how do we ensure that hundreds of terabytes of data is understandable or even readable in half a century? In close collaboration with The Royal Library we have created Data

Management Plans, strategies and requirements for how such an archive should operate. Data is stored in formats that are easily readable by both humans and computers. Regarding the actual hosting of such a long-term archive we are currently in dialogue with national facilities in Denmark that can ensure its operation on timescales of many decades. The idea of the archive is to have a "living archive" where the contents of the archive is in continuous usage in active research, and new research results can be incorporated continuously and seamlessly throughout its lifetime. This is in contrast to the traditional philosophy of data archives where, in metaphorical terms, all research data is put into neatly labeled boxes and lock them in the basement for safe keeping. The archive is overall aimed at the researchers of the future who wants to continue to use the Kepler/K2 data in active research and discover new things we haven't even begun to think off...

S4. Special Session: SpaceInn & HELAS

PA.S4.14 – Computational local helioseismology in the frequency domain

Chris Hanson (Max-Planck-Institut für Sonnensystemforschung), The MPS-INRIA Collaboration (Max-Planck-Institut für Sonnensystemforschung and INRIA Bordeaux), et al.

Forward problems in local helioseismology have thus far been addressed in a semi-analytical fashion using the Born approximation and normal mode expansions. However, it has proven difficult to take into account geometrical and instrumental effects. To avoid these difficulties we employ a numerical method to determine the impulse response of a solar model in a 2.5D geometry. Solving the wave equation in the frequency domain avoids the difficulties (instabilities) faced in the time domain. This framework is flexible, computationally efficient, and produces solar-like power spectrum and cross-covariance that match accurately with observations, including the high-frequency continuous spectrum. Additionally, we present accurate travel-time sensitivity kernels for perturbations to the solar medium which hint at the promising potential of this framework in future forward and inversion problems.

PA.S4.15 – Accurate numerical solutions to the forward problem of local helioseismology

Chris Hanson (Max-Planck-Institut für Sonnensystemforschung), Michael Leguebe (Max-Planck-Institut für Sonnensystemforschung), MPS and INRIA Collaboration (Max-Planck-Institut für Sonnensystemforschung and INRIA Bordeaux)

We compute acoustic Green's functions in an axisymmetric solar background model, which may include a meridional flow and differential rotation. The wave equation is solved in the frequency domain using a finite element solver.

A transparent boundary condition for the waves is implemented in the chromosphere, which represents a great improvement in computational efficiency compared to implementations based on 'sponge layers'. We perform various convergence studies that demonstrate that wave travel times can be computed with an accuracy of 0.001 s. This high level of numerical accuracy is required to interpret travel times in the deep interior, and is achieved thanks to a refined mesh in the near surface layers and around the source of excitation. The wave solver presented here lays the ground for future iterative inversion methods for flows in the deep solar interior.

PA.S4.16 – Measuring active region inflows with local correlation tracking

Björn Löptien (Max-Planck-Institut für Sonnensystemforschung), B. Löptien (Max-Planck-Institut für Sonnensystemforschung), A. C. Birch (Max-Planck-Institut für Sonnensystemforschung), T. L. Duvall Jr. (Max-Planck-Institut für Sonnensystemforschung), L. Gizon (Max-Planck-Institut für Sonnensystemforschung, Institut für Astrophysik Göttingen), et al.

Active regions are surrounded by large converging inflows with typical velocities of 20-30 m/s that extend up to 10 deg around the active region. These inflows are important for the evolution of active regions because models suggest that they inhibit active region dispersal. The inflows have so far only been studied using local helioseismology. Here we study the flows around active regions by applying local correlation tracking of granulation on continuum intensity images provided by the Helioseismic and Magnetic Imager (HMI). We show examples of full disk Carrington maps of the horizontal flow velocity at the solar surface. These exhibit inflows to the active regions with the typical flow velocities and the radial extend being comparable to the results from local helioseismology.

PA.S4.17 – Combined spectroscopic calibration for FGK-dwarfs and GK-giants

Mario J P F G Monteiro (Instituto de Astrofisica e Ciencias do Espaço, U.Porto & DFA/FCUP), G. D. C. Teixeira (IA & FCUP, Universidade do Porto), S. A. G. Sousa (IA, Universidade do Porto), M. J. P. F. G. Monteiro (IA & FCUP, Universidade do Porto), N. C. Santos (IA & FCUP, Universidade do Porto), et al.

We use spectra from a joint sample of 708 stars, compiled from 451 FGK-dwarfs and 257 GK-giant stars. We used homogeneously determined spectroscopic stellar parameters to derive temperature calibrations using a set of selected EW line-ratios, and [Fe/H] calibrations using a set of selected FeI lines. We have derived 322 EW line-ratios and 100 FeI lines that can be used to compute Teff and [Fe/H], respectively. These calibrations are shown to be effective, simultaneously, for FGK-dwarfs and GK-giant stars in the following ranges: 4500 K < Teff < 6500 K , 2.5 < logg < 4.9 dex, -0.8 < [Fe/H] < 0.5 dex. The new calibration has a standard deviation of 74 K for Teff and 0.07 dex for [Fe/H]. Four independent samples of stars are used to test and verify the new calibration: a sample of 56 giant stars, a sample composed of GAIA FGK benchmark stars, a sample of 36 GK giant stars of the DR1 of the GAIA-ESO survey, and a sample of 582 FGK dwarfs stars. We also provide a new computer code, GeTCal, to automatically produce new calibration files based on any new sample of stars.

PA.S4.18 – Activities in the SpaceInn project: the HARPS archive of the CoRoT mission

Ennio Poretti (INAF-OA Brera), Monica Rainer (INAF-OA Brera), Angelo Mistò (INAF-OA Brera), Maria Rosa Panzera (INAF-OA Brera), et al.

A large number of high-resolution spectra have been taken with different echelle spectrographs in order to complement the asteroseismological observations of the CoRoT satellite. In the framework of the EU FP7 collaborative project SpaceInn, 7103 HARPS spectra have been stored in a VO-compliant database along with the CoRoT photometric data of the same

objects. Several useful variability parameters (mean line profiles; indicators of differential rotation, activity and emission lines) together with v sin i and radial velocity measurements have been extracted from the spectra. The atmospheric parameters Teff, log g and [Fe/H] have been computed following a homogeneous procedure. The sample of 261 targets contained in the database aims at being a resource for in-depth studies of a wide range of classes of variable stars.

PA.S4.19 – SIGS – Seismic Inferences for Glitches in Stars

Filipe Pereira (Instituto de Astrofísica e Ciências do Espaço, U.Porto), L. Filipe Pereira (Instituto de Astrofísica e Ciências do Espaço), Mario J. P. F. G. Monteiro (Instituto de Astrofísica e Ciências do Espaço), Joao P. Faria (Instituto de Astrofísica e Ciências do Espaço)

A new set of codes, to become publicly available, are presented. These use the frequencies of oscillation of solar-type stars, together with some of the stellar atmospheric parameters, to automatically measure and characterize acoustic glitches in these stars. Both the glitch at the base of the convective zone and at the helium ionization zones are simultaneously measured, using low-degree data.

PA.S4.20 – The Stellar Seismic Indices (SSI) data base

Eric Michel (Observatoire de Paris-LESIA), R. Samadi (Observatoire de Paris-LESIA, France), R. De Assis Peralta (Observatoire de Paris-LESIA, France), K. Belkacem (Observatoire de Paris-LESIA, France)

In the framework of the SPACEInn project financed by the European Union under the Seventh Framework Programme (FP7), a data base named The Stellar Seismic Indices (SSI) has been developed. This data base aims at containing stellar seismic indices of solar-like oscillating stars as well as other stellar indices such as the main characteristics of stellar granulation. These stellar parameters are extracted using an automatic analysis method that is able to derive simultaneously the seismic indices and the parameters characterizing the granulation signature of solar-like pulsators (De Assis Peralta et al, in prep). This analysis method was applied on all Kepler long-cadence light-curves and all the targets observed from the CoRoT faint stars fields. A total of about 330 000 targets have been analyzed, among which seismic indices and granulation parameters have been extracted for about 25 000 of them. This poster presents the data base content and its interface. The SSI data base will be accessible soon at http://ssi.lesia.obspm.fr/.

PA.S4.21 – The Seismic Plus

Kevin Belkacem (Paris Observatory), Kévin Belkacem (Observatoire de Paris – LESIA)

The wealth of seismic data available from space borne missions (SOHO, CoRoT, Kepler, SDO,...), and from ground-based observations (GONG, Bison, ground-based large programmes...), is stimulating solar and stellar structure and evolution studies but is also opening new scientific perspectives (e.g. characterization of planetary systems, stellar population in our galaxy, etc...). These applications address a broad scientific community within and beyond the solar and stellar communities. They thus require combining data of various types and from various sources. The Seismic Plus Portal intends to help this development by providing, at a well-identified place, a homogeneous description and access for sources of solar and stellar seismic data as well as for sources of complementary and ground-based data. The Seismic Plus portal is now open and available at http://voparisspaceinn.obspm.fr/seismicplus/. It is currently being developed in the framework of the SPACEInn project (Exploitation of Space Data for Innovative Helio- and Asteroseismology) financed by the European Union under the Seventh Framework Programme (FP7). We describe here the Seismic Plus portal and provide a short description of its main functionalities.

PA.S4.22 – WP4 Spaceinn helioseismology

Kaori Nagashima (Max Planck Institute for Solar System Research), Spaceinn collaboration

S6. Physics: Convection and Mode Behaviour

PA.S6.23 – Modelling the effect of Meridional Flows in Time--Distance Helioseismology: Born vs. Ray approximation

Vincent Böning (Kiepenheuer-Institut für Sonnenphysik), Markus Roth (Kiepenheuer-Institut für Sonnephysik, Freiburg, Germany), Jason Jackiewicz (Department of Astronomy, New Mexico State University, Las Cruces, NM, USA), Shukur Kholikov (National Solar Observatory, Tucson, AZ, USA)

Accurate meridional flow measurements are important for understanding the solar dynamo. Recent inversions for meridional flows have not yet reached a consensus on the nature of the meridional flow in depths greater than about 0.9 solar radii. In time-distance helioseismology, current modelling of the solar interior for meridional flow inversions is performed using ray kernels, which assume that waves propagate along infinitely thin ray paths. The Born approximation may constitute a more accurate approach as it models the first order perturbation to the wave field in the whole solar interior. We present the current status of an undergoing validation of a recently developed model for computing spherical Born approximation sensitivity functions suitable for inferring meridional flows. In addition, we compare Born and ray approximations using flow models.

PA.S6.24 – Sub-Inertial Gravity Modes in the B8V Star KIC 7760680 Reveal Moderate Core Overshooting and Low Vertical Diffusive Mixing

Ehsan Moravveji (Institute of Astronomy, KU Leuven), Richard H. D. Townsend (University of Wisconsin-Madison), Conny Aerts (KU Leuven, Radbound Nijmegen), Stephane Mathis (CEA, Paris Observatory)

KIC 7760680 was discovered by Papics et al. (2015) to be the richest known Slowly Pulsating B star, by exhibiting 36 consecutive dipole prograde (ell=1, m=+1) gravity (g-) modes. Moreover, the monotonically decreasing period spacing of the series, in addition to the local dips in the pattern confirm that this star is a moderate rotator, with clear mode trapping in chemically inhomogeneous layers. This star, thus, constitutes a great laboratory to probe mixing and transport processes in pulsating rotating massive stars. We compute a dense MESA (Paxton et al. 2011, 2013, 2015) grid of evolutionary tracks by varying initial mass, metallicity, overshooting and diffusive non-standard mixing in the radiative envelope. We employ GYRE (Townsend & Teitler 2013) to compute high-order dipole prograde g-mode frequencies using the traditional approximation of rotation to incorporate the effects of the Coriolis acceleration on g-mode frequencies. This detailed forward asteroseismic modelling reveals that KIC 7760680 is a moderately rotating B star with a mass ~3.25 Msun. By simultaneously matching the slope of the period spacing, and the number of modes in the observed frequency range, we deduce that the equatorial rotation frequency of KIC 7760680 is 0.4805 1/day, which is 26% of its Roche break up frequency. The relative deviation of the model frequencies and those observed is less than one percent. We succeed to tightly constrain the convective core overshooting. We demonstrate that an exponentially-decaying model with its parameter fov=0.024 ± 0.001 allows a better agreement than those with a classical step-function overshoot. This also means that convective core overshooting can coexist with moderate rotation. Finally, we constrain the best value for diffusive non-standard mixing in the radiative stable envelope to be confined to log Dext=0.75 ± 0.25, where Dext (in cm2/sec is the effective diffusivity. This is three to ten orders of magnitude smaller than the current theoretical predictions. This can be the signature of a weak differential rotation and of an efficient transport of angular momentum in the vertical direction.

PA.S6.25 – An opaque Sun?

Regner Trampedach (Stellar Astrophysics Centre, Aarhus, Denmark/Space Science Inst., Boulder, Colorado, USA)

Last year Bailey et al. announced their measurement of iron opacity that increases

the Rosseland mean at the base of the solar convection zone by 7%. I ask what happens if the absorption by other elements is also stronger than predicted: Having the increase be proportional to the number of bound electrons in the absorber (reflecting our remaining ignorance of atomic physics) gives an opacity increase for a solar model, that has the potential to solve the solar abundance problem. Conclusion: Opacities are the likely source of the solar abundance problem, and the solar abundances are likely closer to those of Asplund et al (2009) than the alternative modern set, offered by Caffau et al. (2011).

PA.S6.26 – Physical formulation of the eigenfrequency condition of mixed modes of stellar oscillations

Masao Takata (University of Tokyo)

The frequency condition for eigenmodes of mixed character, which have been extensively detected in red giants and sub giants, is generally examined by a simple physial model, which is based on a running-wave picture. The coupling coefficient between the gravity-wave oscillation in the core and the acoustic-wave oscillation in the envelope is expressed in terms of the reflection coefficient at the intermediate evanescent region. This relation is different from the conventional asymptotic expression (Shibahashi 1979; Tassoul 1980) in the case of the strong coupling. The expression for the amplitude ratio between the core and envelope oscillations is also derived. The upper and lower bounds of the ratio are found to be determined by the reflection coefficient at the intermediate region. It is also argued that the eigenmode condition should appropriately be modified if the wave generated near the surface and transmitted to the core is (partially) lost either by damping or scattering in the core. The derived formulae should be helpful in understanding the physics of mixed modes in general, the origin of the red giants with depressed dipolar modes, and the effect of radiative damping in the core of the red giant stars.

S7. Physics: Rotation

PA.S7.27 – The influence of rotation on the asteroseismic fingerprint of slowly pulsating B (and Be) stars in the Kepler field

Peter Papics (Institute of Astronomy, KU Leuven (Belgium)), Andrew Tkachenko (Institute of Astronomy, KU Leuven (Belgium)), Conny Aerts (Institute of Astronomy, KU Leuven (Belgium))

Slowly pulsating B (SPB) stars are main sequence stars with a mass between 2.5 and 8 Solar mass that show non-radial heat-driven gravity-mode oscillations (see, e.g., Aerts et al. 2010, Chapter 2). Although it has been a quarter century since their discovery by Waelkens (1991), the first actual seismic modelling based on the high-order g-modes was only achieved recently for KIC 10526294 by Pápics et al. (2014). Even though these objects are not massive stars according to the classical definition, they share the same internal structure by having a convective core and a radiative envelope. This means that SPB stars are ideal asteroseismic probes of ill-understood internal mixing processes that have a significant influence on the lifetime of the metal factories of the Universe, such as core overshooting, diffusive mixing, or internal differential rotation. Therefore these stars hold the key to the precise calibration of stellar structure and evolution models of massive stars. We present five new SPB stars in the Kepler field that show unambiguous long series of gravity modes of the same degree l with consecutive radial order n. In comparison with similar stars that have been presented until now (KIC 10526294 by Pápics et al. 2014, Moravveji et al. 2015, and Triana et al. 2015; KIC 7760680 by Pápics et al. 2015), the rotation rates of these SPBs are clearly faster, with vsini values up to 240 km/s. Moreover, the fastest rotator shows weak Be signatures both in photometry and in spectroscopy. In-depth modelling of these stars will provide significant input (in terms of rotation and mixing properties) to a new generation of stellar structure models of massive stars, while some interesting conclusions can already be drawn from the shape of the detected period spacing patterns combined with fundamental parameters from high-resolution spectroscopy.

S8. Physics: Magnetic Field and Activity

PA.S8.28 – Asteroseismic signature of a starspot

Emanuele Papini (Max-Planck-Institut für Sonnensystemforschung), Laurent Gizon (Max-Planck-Institut für Sonnensystemforschung)

Stellar acoustic oscillations are affected by magnetic activity, however it is unclear how a single starspot would affect the power spectrum of oscillations. Since the starspot rotates with the star, it causes a perturbation that is unsteady in the observer's frame. Each (n,l) multiplet appears as (2l + 1)2 blended peaks in the power spectrum, whose amplitudes depend on the star's inclination and on the latitude of the starspot. We simulate example power spectra using both perturbation theory and numerical simulations.

PA.S8.29 – Starspot signature on the light curve: learning about the spot distribution

Ângela Santos (Instituto de Astrofísica e Ciências do Espaço, U.Porto), M. S. Cunha (Instituto de Astrofísica e Ciências do Espaço), P. P. Avelino (Instituto de Astrofísica e Ciências do Espaço), S. Mathur (Space Science Institute), R. A. García (CEA Saclay)

Starspots are cooler/darker than the stellar surface. Therefore, the total flux of a star changes when spots are visible on its surface. The presence of spots together with the stellar rotation leads to a periodic modulation on the light curve. By studying that modulation one can then learn about the stellar rotation and also magnetic activity. Recently, Reinhold & Arlt (2015) proposed a method based on the analysis of the Lomb Scargle Periodogram (LSP) of the light curve to identify the sign of the differential rotation, i.e. weather the equator rotates faster than the poles or the opposite. In this work, we study in detail the spots' impact on the light curve and on the resulting LSP. We find that, under some conditions, the LSP can actually provide an estimate of the true spot latitudes and/or the stellar inclination angle. Moreover, we find that the impact of the spot on the ratio between the heights of the second and first harmonics of the main peaks in the LSP can be described by a single parameter, the visibility time of the spot. Finally, we also identify possible sources of false positives/negatives for the sign of the differential rotation.

PA.S8.30 – Short- and mid-term activity-related variations in the solar acoustic frequencies

Ângela Santos (Instituto de Astrofísica e Ciências do Espaço, U.Porto), M. S. Cunha (Instituto de Astrofísica e Ciências do Espaço), P. P. Avelino (Instituto de Astrofísica e Ciências do Espaço), W. J. Chaplin (University of Birmingham), T. L. Campante (University of Birmingham)

The activity-related variations in the solar acoustic frequencies have been known for 30 years. However, the importance of the different contributions is still not well established. With this in mind, we developed an empirical model to estimate the spot-induced frequency shifts, which takes into account the sunspot properties, such as area and latitude. The comparison between the model frequency shifts obtained from the daily sunspot records and those observed suggests that the contribution from a stochastic component to the total frequency shifts is about 30%. The remaining 70% is related to a global, long-term variation. We also propose a new observable to investigate the short- and mid-term variations of the frequency shifts, which is insensitive to the long-term variations contained in the data. On the shortest time scales the variations in the frequency shifts are strongly correlated with the variations in the total area covered by sunspots. However, a significant loss of correlation is still found, which cannot be fully explained by ignoring the invisible side of the Sun when accounting for the total sunspot area. We also verify that the times when the frequency shifts and the sunspot areas do not vary in a similar way tend to coincide with the times of the maximum amplitude of the quasi-biennial variations found in the seismic data.

S9. Seismology: Stars Near and in the Main Sequence

PA.S9.31 – Small convective cores on the main sequence

Michael Bazot (New York University Abu Dhabi), Michaël Bazot (New York University Abu Dhabi), Jørgen Christensen-Dalsgaard (Aarhus University), Laurent Gizon (Max-Planck-Institut für Sonnensystemforschung), Othman Benomar (New York University Abu Dhabi)

Convective cores are extremely interesting objects in stellar physics. On one hand they are good age markers. On the other hand they offer ways of testing the physics of our models. One such instance is the search of small convective cores in main-sequence stars. The precise modelling of the stellar structure may strongly impact the outcome of the detection process. As a test case, we will discuss alpha Cen A, a prototypal example of star with a potential small convective core, for which we have large set of good observations (including seismic data). We will discuss the results of a thourough Bayesian analysis of this star and show the impact of overshooting, nuclear reaction rates and diffusion on the physical state at the centre of the star (does it have a convective core ? which nuclear process powers it ? what is the precise evolutionary phase of the star ?). We will show that, in probabilistic terms, it remain a very uncertain picture. We will use our conclusions to discuss the impact of Kepler data (and other space missions) for the search of small convective cores in other stars.

PA.S9.32 – Characterizing solar-type stars from full-length Kepler data sets using the Asteroseismic Modeling Portal

Orlagh Creevey (Observatoire de la Cote d'Azur), Travis Metcalfe (Space Science Institute, Boulder), David Salabert (CEA, Saclay), Frederic Thevenin (Universite Cote d), et al.

The Kepler space telescope yielded unprecedented data for the study of solar-like oscillations in other stars. The large samples of multi-year observations posed an enormous data analysis challenge that has only recently been surmounted. Asteroseismic modeling has become more sophisticated over time, with better methods gradually developing alongside the improved observations. We apply the latest version of the Asteroseismic Modeling Portal (AMP) to the full-length Kepler data sets for 57 stars, and we use the results to investigate the amplitude and character of surface effects within the sample. We find that the empirical correction for surface effects suggested by Kjeldsen and coworkers is adequate for solar-type stars that are not much hotter or significantly more evolved than the Sun. Precise parallaxes from the Gaia mission and future observations from TESS and PLATO promise to improve the reliability of stellar properties derived from asteroseismology.

PA.S9.33 – Validity of the Traditional Approximation for Gamma Doradus pulsators

Francois Lignieres (IRAP), Jérôme Ballot (IRAP)

Recent asteroseismic analysis of g modes in Gamma Doradus stars have been conducted in the framework of the Traditional Approximation. Using the TOP code, we investigate the range of validity and the accuracy of this approximation for a typical Gamma Doradus stellar model. The presence of convective layers is expected to play an important role that was not taken into account in our previous investigation (Ballot et al. 2012). The influence of the full treatment of the Coriolis effects on the period spacing will be emphasized.

PA.S9.34 – Amplitude modulation in delta Scuti stars: statistics from an ensemble of Kepler targets

Dominic Bowman (University of Central Lancashire), Donald W. Kurtz (Jeremiah Horrocks Institute, University of Central Lancashire, Preston PR1 2HE, UK), Michel Breger (Department of Astronomy, University of Texas, Austin, TX 78712, USA), Simon

J. Murphy (Sydney Institute for Astronomy (SIfA), School of Physics, The University of Sydney, NSW 2006, Australia), Daniel L. Holdsworth (Jeremiah Horrocks Institute, University of Central Lancashire, Preston PR1 2HE, UK)

Kepler data provide unprecedented views of light variability in pulsating stars. Intermediate-mass pulsators, such as delta Scuti stars, lie in a transition region between radiative cores and thick convective envelopes in low-mass stars, and large convective cores and thin convective envelopes in high-mass stars. Mode coupling and nonlinearity are predicted in delta Scuti stars, which give rise to variable pulsation amplitudes. The delta Scuti star KIC 7106205 was shown to have a single amplitude-modulated pulsation mode that decreased in amplitude by more than a factor of 20 over 6 yr, whilst all other pulsation mode frequencies remained constant in amplitude and phase (Bowman et al. 2015). A thorough and statistical search for amplitude modulation in approximately 1000 delta Scuti stars that were continuously observed by Kepler for 4 yr has been carried out. We present these results and demonstrate that diverse pulsational behaviour, in particular amplitude modulation, is common among delta Scuti stars with the majority of these stars exhibiting at least one pulsation mode that varies significantly in amplitude over 4 yr (Bowman et al. 2016). We construct models and use case studies to distinguish among different scenarios: beating of close-frequency pulsation modes; pure amplitude modulation; mode coupling and nonlinearity. Our study shows that time spans of years and decades are important for delta Scuti stars and that amplitude modulation is not restricted to a small region of the HR diagram. The study of approximately 1000 delta Scuti stars using the Kepler data set by Bowman et al. (2016) will be useful for studying similar stars with K2 and TESS, as the 4-yr time span will not be surpassed for some time.

PA.S9.35 – Revisiting the Instability Strip for rapidly oscillating Ap stars

Margarida Cunha (Instituto de Astrofísica e Ciências do Espaço, U.Porto), Luis Balona (South African Astronomical Observatory), Daniel Holdsworth (University of Central Lancashire), Guenter Houdek (Stellar Astrophysics Centre, Aarhus University), Karrine Perraut (IPAG, University of Grenoble), et al.

Chemically peculiar stars are stage to a wide variety of physical phenomena. Progress in the understanding of these objects, through the study of their oscillations, can help us characterize these physical phenomena and better understand the way they are coupled in stars. More than 60 Ap stars are today known to exhibit high frequency oscillations. Despite this, the mechanism responsible for driving these oscillations is still under debate. Currently, the most widely accepted theory states that oscillations in this class of pulsators are excited by the opacity mechanism acting on the hydrogen ionization region, in an envelope where convection has been suppressed by a strong magnetic field. Nevertheless, this theory has been challenged in a number of ways, particularly for its difficulty in reproducing the observed red edge and the very high frequencies observed in some of the well studied pulsators.
In this study we revisit the theoretical instability strip proposed by Cunha (2002) and compare the results with the observations for over 60 roAp stars, including 5 stars with exquisite luminosity and effective temperature determinations, derived from a combination of interferometry, parallax, and bolometric flux. The main differences with respect to the previous theoretical work is the exploitation of a larger parameter space and different input physics for the non-adiabatic models. The results show that there is an overall consistency between the position of the known roAp stars in the HR diagram and the predicted Instability strip. However, hints of disagreement are seen when comparing the range of frequencies excited in stellar models and those observed in some stars. This, in turn, points towards the need to re-think the excitation mechanism at work, at least in a sub-group of roAp stars.

PA.S9.36 – Nonradial oscillations in classical pulsators. Prospects for seismology.

Wojtek Dziembowski (Copernicus Astronomical Center, Polish Academy of Sciences), R. Smolec (Nicolaus Copernicus Astronomical Center)

We have now a good evidence that nonradial modes of moderate degrees (l=7-9) are excited in a large number of 1O Cepheids and RR Lyrae (RRc) stars. The first detected signature of the presence of these modes was the periodicity at (0.6-0.65)P_1O, which is due to harmonics that are associated with spherically symmetric changes of radiative flux. Only recently, thanks to precise space-based observations and extensive ground-based OGLE photometry, the signal at mode frequencies has been detected. The excited modes are very well trapped in stellar envelopes and very similar in terms of driving properties to the first two radial modes. It is unlikely that they play any essential role in the development of pulsation. Rather, they are passive contaminants useful as a source of new constraints on star parameters.

PA.S9.37 – A comparison of model fitting using separation ratios, epsilon fitting and phase matching

Ian Roxburgh (Queen Mary University of London)

I discuss the properties of 3 surface layer independent model fitting techniques – comparison of model and observational data on separation ratios, comparison of epsilon values and phase matching. I conclude that epsilon matching is the simplest to implement. Both separation ratios and epsilon matching only require knowledge of model and observed frequencies which are stored with a model set, and both only interpolate in model values, but the errors in separation ratio fitting are strongly correlated requiring the evaluation of covariance matrices, whereas the errors are uncorrelated in epsilon matching. Phase matching is in principle similar to epsilon matching but requires the calculation of the inner pause shift of the models at the observed frequencies. I give some examples.

PA.S9.38 – Improving 1D Stellar Models with 3D Atmospheres

Jakob Mosumgaard (Aarhus University), Victor Silva Aguirre (Aarhus University), Achim Weiss (Max Planck Institute for Astrophysics), Jørgen Christensen-Dalsgaard (Aarhus University), et al.

One of the basic ingredients in astrophysics is the understanding of stellar structure and evolution. This understanding is primarily based on one-dimensional numerical models and the comparison of these with observations. Many of today's stellar models share common issues; amongst these are the use of an artificial grey atmosphere to describe the outer layers of the star and the use of the mixing-length formulation to describe convection. I am working on using the results from three-dimensional radiation-coupled hydrodynamics (3D-RHD) simulations in one-dimensional stucture models; I have implemented 3D-RHD results into the GARching STellar Evolution Code (GARSTEC). My implementation substitutes the non-physical grey atmosphere with more appropriate T-tau-relations, depending on the physical properties of the star (i.e. position in the HR-diagram), to set up more realistic outer boundary conditions. Furthermore, the mixing-length parameter changes as the star moves in the HR-diagram (calibrated from the 3D atmospheres) to refine the treatment of convection. Moreover, my implementation is consistent and takes modification of the thermal gradients properly into account, as well as correctly scaling the mixing-length parameter to the solar calibrated value. Finally, I have generated custom opacity tables to fully match the microphysics of the atmospheric simulations.

PA.S9.39 – A theoretical tool for the study of radial velocities in the atmospheres of roAp stars

Paola Quitral (Instituto de Astrofísica e Ciências do Espaço, U.Porto), Margarida S. Cunha (nstituto de Astrofísica e Ciências do Espaço, U.Porto)

Studies of high-resolution spectroscopy of rapidly oscillating Ap (roAp) stars show that the pulsations in these stars have a complex behavior in the atmospheric region, which results from their magnetoacoustic nature. Aiming at a better understanding of these pulsations, we developed a theoretical tool for the computation of the integrated radial velocities in roAp stars, as a function of depth. In the computation, we consider that the star is permeated by a dipolar magnetic field. The displacement at each latitude and depth is obtained with the MAPPA code (Cunha 2006) and we verify that the solutions for the outer atmosphere tend to the decoupled acoustic and magnetic analytic solutions valid for an isothermal atmosphere (Sousa & Cunha 2011). We explore the amplitude and phase behaviour derived from the theoretical radial velocities, for different mode degrees and different inclinations of the observer.

PA.S9.40 – A fitting LEGACY – modelling Kepler's best stars

Magnus Johan Aarslev (Aarhus University), Jørgen Christensen-Dalsgaard (Stellar Astrophysics Centre, Aarhus University), The LEGACY team (TBA) (Various)

The LEGACY sample represents the best solar-like stars observed in the Kepler mission. The 66 stars in the sample are on the main sequence and have more than one year's data in short cadence, allowing for precise extraction of individual frequencies. We present model fits using the ASTFIT procedure and employing the Ball & Gizon (2014) near-surface effect correction. This correction is based on calculations by Douglas Gough (1990) and includes two terms; one representing a frequency shift corresponding to the increase in pressure scale height that would arise from better modeling of convection and another term correcting for a frequency shift caused by magnetic fields affecting the sound speed without changing the density stratification. Furthermore the correction of each frequency is weighted by the inertia of the corresponding mode. The ASTFIT methods combines the Aarhus stellar evolution code with the Aarhus adiabatic oscillation package to fit individual model frequencies. When combined with the aforementioned correction we produce frequency fits of unprecedented quality – even for stars where the surface term differ significantly from that of the Sun. Our ability to model observations in a precise manner helps constrain the physical parameters of the observed stars as well as pinpoint the aspects of stellar models that still need improvement.

PA.S9.41 – Validation and application of the seismic tool SIGS, to measure acoustic glitches in solar-type stars observed by Kepler

Filipe Pereira (Instituto de Astrofísica e Ciências do Espaço, U.Porto), L. F. Pereira (Instituto de Astrofísica e Ciências do Espaço), M. J. P. F. G. Monteiro (Instituto de Astrofísica e Ciências do Espaço), J. P. Faria (Instituto de Astrofísica e Ciências do Espaço)

In order to validate TAGS, a tool for measuring acoustic glitches in solar-type stars, several sets of p-mode frequencies of solar-like stars observed with Kepler are used. We compare the results obtained with TAGS, in both modes of operation, with the results from Mazumdar et al. (2014) and Verma et al. (2014). Applications to other stars are also included in an attempt to expand the sample of solar-type stars with known precise constraints on acoustic glitches.

PA.S9.42 – The more the merrier: grid based modeling of Kepler dwarfs with 5-dimensional stellar grids.

Aldo Serenelli (Instituto de Ciencias del Espacio (ICE/CSIC-IEEC)), Daniel Huber (Institute for Astronomy, University of Sydney), William Chaplin (School of Physics and Astronomy, University of Birmingham)

Most of the work done so far on determination of stellar parameters based on global seismology (Dnu and numax) has employed the simplest possible grids of stellar models where age, [Fe/H] and mass define the parameter space. We extend the grid used in BeSPP in two additional dimensions: initial helium abundance and mixing length parameter. This opens up the possibility of determining stellar parameters in a less constrained way compared to was is generally done. Also, such new grid of models allows simple testing of, for example different galactic chemical enrichment laws (DY/DZ), results on mixing length parameter obtained from 3D RHD stellar envelope models. This can be done simply by including appropriate priors in the statistical extraction of stellar parameters. Here, we present initial results of such type of analysis for the sample of Kepler dwarfs and subdwarfs.

PA.S9.43 – Deciphering the period spacing pattern in the oscillation spectrum of the SPB star KIC 7760680

Wojciech Szewczuk (Astronomical Institute of the Wroclaw University), Jadwiga Daszynska-Daszkiewicz (Astronomical Institute of the Wroclaw Uniwersity), Przemyslaw Walczak (Astronomical Institute of the Wroclaw Uniwersity)

KIC 7760680 is the Slowly Pulsating B-type star identified in the Kepler photometry in which Papics et al. (2015) found a series of 36 frequencies quasi-equally spaced in period. The star rotates at a rate of at least 62 km s-1. Based on the zero-rotation asymptotic theory and slope of this series, the authors attributed these frequency peaks to prograde dipole gravity modes of high orders. Taking into account in an appropriate way the effects of rotation, we show that the slope of the period spacing series can be explained also by other high-order g modes. Our seismic modelling is based on evolutionary calculations with MESA code and on the traditional approximation for including the effects of the Coriolis force on g-mode pulsations. Additionally, the effect of various mixing processes (e.g., convective overshooting, diffusion, rotationally induced mixing) are investigated.

PA.S9.44 – On possible explanations of pulsations in Maia stars

Jadwiga Daszynska-Daszkiewicz (Uniwersytet Wroclawski), Przemyslaw Walczak (Uniwersytet Wroclawski), Alosha Pamyatnykh (Copernicus Astronomical Center, Warsaw)

The long-time photometric surveys in a few young open clusters allowed to identify the light variability in stars located between the well defined δ Scuti variables and Slowly Pulsating B-type stars (Mowlavi et al, 2013, 2015). The period of these changes is in the range of about 0.1 – 0.7 [d] corresponding to the frequencies of about 1.4 – 10 [d-1]. Several objects of this type were suggested also from the analysis of the Kepler data (Balona et al. 2015). Assuming the pulsational origin of this variability, we test the two hypotheses. The first and the old one involves the very high rotation which, both, enhances the pulsational instability and causes the shift of unstable modes to the higher frequency range. We perform the pulsational computations in the framework of the traditional approximation and compare them with the results from the literature. In the second and the new scenario, we modify the opacity profile in order to excited pulsational modes in the required frequency range. We show that by increasing opacity at certain depths (log T) and considering modes with the harmonic degree up to 6, it is also possible to get the pulsational instability. This scenario works for, both, slow and fast rotating stars of B8-A2 type.

POSTER GROUP PB S10. Seismology: Stars Beyond the Main Sequence

PB.S10.45 – Nonlinear asteroseismology: insight from amplitude and frequency modulations of oscillation modes in Kepler compact pulsators

Weikai Zong (IRAP, CNRS/Universite de Toulouse), Stéphane Charpinet (IRAP, Université de Toulouse/CNRS, France), Gérard Vauclair (IRAP, Université de Toulouse/CNRS, France), Noemi Giammichele (1. IRAP, Universite dé Toulouse/CNRS, France; 2. Département de Physique, Université de Montréal, Canada), et al.

Nonlinear mode interactions are difficult to observe from ground-based telescopes as the typical periods of the modulations induced by those nonlinear phenomena are on timescales of weeks, months, even years. The launch of space telescopes, e.g., Kepler, has tremendously changed the situation and shredded new light on this research field. In this talk, I will present results from Kepler photometry showing evidence that nonlinear interactions between modes occur in the two compact pulsators KIC 08626021, a DB white dwarf, and KIC 10139564, a short period hot B subdwarf. KIC 08626021 and KIC 10139564 had been monitored by Kepler in short-cadence for nearly two years and more than three years without interruption, respectively. By analyzing these high-quality photometric data, we found that the modes within the triplets induced by rotation clearly reveal different behaviors: their frequencies and amplitudes may exhibit either periodic or irregular modulations, or remain constant. These various behaviors of the amplitude and of the frequency modulations of the oscillation modes observed in these two stars are in good agreement with those predicted within the amplitude equation formalism.in the case of the nonlinear resonant mode coupling mechanism.

PB.S10.46 – Using Kepler data and machine learning to help improve constraints on global parameters of red giants observed with K2 and TESS

James Kuszlewicz (University of Birmingham), Guy R. Davies (University of Birmingham)

The wealth of red giant stars observed with Kepler enables us to extract a great deal of information on their stellar structure and dynamics. By using machine learning techniques we can use results from the nominal Kepler mission to constrain the stellar properties of both lower signal-to-noise and shorter length datasets, as it is under these situations where the determination of the background parameters (and more importantly, global seismic parameters) can be much more difficult. We employ Bayesian statistics and a supervised machine learning scheme to derive a set of priors from background fits to high signal-to-noise APOKASC red giants, which are used as a training set. With this newly extracted information the resultant priors were then applied in similar fits to help constrain K2 C1 and C3 data, paving the way to further explore models of the Milky Way using asteroseismology.

PB.S10.47 – The K2 RR Lyrae survey

Robert Szabo (Konkoly Observatory, MTA CSFK)

We have initiated a large survey with K2, to observe thousands of RR Lyrae stars along the ecliptic. The high photometric precision and the 80-90-day continuous coverage will allow us to investigate the light variation of these galactic structure tracer variable stars with an unprecedented detail. The survey will help us to conduct a thorough statistical study of RR Lyrae pulsation dynamics including old and recently discovered dynamical phenomena, like resonances, non-radial modes, period-doubling and the Blazhko-effect. We describe the survey, present the first results and discuss the prospects in the light of what the combination of the survey and LSST (and also Gaia) will have to offer in the context of galactic structure studies.

PB.S10.48 – Toward a better understanding of red giants rotation

Charlotte Gehan (LESIA, Paris Observatory)

Red giant stars have proved to be asteroseismic targets of choice: conditions in their interior are met to couple pressure waves propagating in the envelope and gravity waves propagating in the core, so that we have a direct view on their core through mixed modes, which is not the case for main-sequence stars. In particular, asteroseismology of red giants gives us the opportunity to study their internal rotation, especially their core rotation. Rotation is known to deeply impact the evolution of stars, but including rotation in stellar evolution models is still challenging. Models predict central rotation rates at least ten times too large compared to asteroseismic measurements. This implies that angular momentum transport is at work in stellar interiors, whose physical mechanisms are not yet fully understood. It is thus of prime importance to know how internal rotation evolves in time. This is particularly true for red giants, in order to better characterise the physical processes operating in the deepest region of these stars. Such a study requires core rotation measurements for a maximum number of red giants. In this context, I have developed an automatic method to determine the mean core rotation of red giant stars presenting different evolutionary stages with Kepler data. In the future, obtaining mean core rotation rates for thousands of red giants will improve the characterisation of the physical mechanisms causing angular momentum transport in these stars, and therefore our understanding of stellar evolution. I will present preliminary results that I obtained with a new and promising method to determine automatically core rotation rates of red giants. Such an automated measurement of the core rotation of red giants will moreover be required to analyse the hundreds of thousands of oscillation spectra that PLATO should provide in a few years. Hence this automated method is paving the way for the future PLATO data.

PB.S10.49 – Observations of giant stars with SONG

Pere L. Pallé (Instituto de Astrofísica de Canarias), M.F. Andersen (SAC. Aarhus University), S. Frandsen (SAC. Aarhus University), F. Grundahl (SAC. Aarhus University), J. Christensen-Dalsgaard (SAC. Aarhus University), et al.

One of the outstanding and unforeseen results from the Kepler mission is our new insight and understanding of red giant stars. These highly evolved stars, which are in the last stages of their life, provide extremely useful information when trying to develop stellar evolutionary models. Furthermore, they show stochastically excited oscillations thus allowing to use asteroseismic techniques to derive conditions of the most internal layers. Bright giants stars are well suited to be studied with the 1m telescopes in the Stellar Observations Network Group project (SONG) using a high resolution echelle spectrograph performing high precision measurements of their the radial velocity. The prototype node- the Hertzsprung SONG telescope- was inaugurated in October 2014 and is located at the Teide Observatory on Tenerife and providing continuous and high quality observations since then, When selecting the best targets for SONG, a precision of 1-2 m/s per point is reachable using the iodine method and a number of red giants have been observed with the SONG telescope since scientific operation started. In this talk we present the first results of these specific campaigns for a few red giants in which eigenmodes have been identified and their global seismic parameters derived.

PB.S10.50 – Star quakes : a new tool to test the properties of red giant stars

Nadège Lagarde (Institut UTINAM Observatoire de Besançon), Bossini Diego (University of Birmingham), Miglio Andrea (University of Birmingham), Vrard Mathieu (LESIA, Observatoire de Paris), Mosser Benoit (LESIA, Observatoire de Paris)

In the context of the determination of stellar properties using asteroseismology, we study the influence of rotation and convective-core overshooting on the properties of red giant stars. We used stellar evolution models to investigate effects of these both mechanisms on the asymptotic period spacing of red-giant stars that ignite He burning in degenerate conditions (M≤2.0 Msun). We also compare the theoretical predictions with recent Kepler observations (Vrard et al 2016). We find that mixing processes have an impact on $\Delta\prod(l=1)$, hence on the determination of the stellar mass when $\Delta\prod(l=1)$ is used as a constraint. In the case of more evolved red-giant-branch stars and regardless of the transport processes occurring in their interiors, the observed $\Delta\prod_1$ can provide information as to their stellar luminosity, within ~ 10-20 per cent. In general, the trends of $\Delta\prod_1$ with respect to mass and metallicity that are observed in Kepler red-giant stars are well reproduced by the models.

PB.S10.51 – Evolutionary states of red-giants stars: how to obtained them from "short" time series data from K2 and Tess

Saskia Hekker (Max Planck Institute for Solar System Research), S. Hekker (Max Planck Institute for Solar System Research), S. Basu (Yale University), Y. Elsworth (University of Birmingham)

The long (~4 yrs) nearly-uninterrupted time series data obtained by the Kepler satellite during its nominal mission have revealed unprecedented features in the oscillation spectra of red-giant stars. Among these are the mixed-gravity-pressure modes, which probe both the inner as well as the outer parts of the star. These modes provide information from the stellar core making it possible to determine whether a star is in a state before or after the onset of Helium burning. Long time series data of at least hundred(s) of days are necessary to resolve the mixed modes. Hence for red-giants observed with the K2 mission and a large fraction of stars observed with the TESS satellite this will not be feasible. Here we present another way to determine evolutionary states of red-giant stars, which do not require the detection of mixed modes.

PB.S10.52 – Looking for Magnetic Fields in Kepler Red Giants

Jérôme Ballot (IRAP), Jérôme Ballot (IRAP)

Spectropolarimetric measurements allow us to detect and measure magnetic field through Zeeman effect in stellar photospheres. We observed with the spectropolarimeters Narval (at Telescope Bernard Lyot) and ESPADONS (at CFHT) a few Kepler Red Giants in 2012 and 2013, especially four stars showing depressed bipolar modes. Interestingly, recent seismic studies by Fuller et al. (2015) suggest these stars had a magnetic history. After presenting shortly the technique, I will detail the detections we did and the constraints we put in surface magnetic fields, then I will discuss the origin of these fields by comparing these observations to a broader sample of red giants observed by Aurière et al. (2015).

PB.S10.53 – Asteroseismology of 1400 new red giants from Kepler data

Jie Yu (Sydney Institute for Astronomy, School of Physics, University of Sydney), Daniel Huber (Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia), Timothy R. Bedding (Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia), Dennis Stello (Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia)

We report the discovery of solar-like oscillations in 1400 new Kepler red giants which have previously been misclassified as subgiants, with predicted numax values (based on the KIC) ranging between 280 μHz to 700 μHz. The sample enlarges the known number of oscillating low-luminosity red giants by 40% (from 1874 to 2630), and includes over a dozen new seismic planet-candidate host stars. About three quarters of our sample are classified as ascending red-giant-branch stars, while the remaining stars are red-clump stars. A novel scheme was applied to determine $\Delta\nu$ for 93 stars with ν_{max} close to the Nyquist frequency (240 μHz < ν_{max} < 320 μHz).

Additionally, we identified 47 stars residing in the super-Nyquist frequency regime up to 387 μHz using long-cadence light curves. We show that the misclassifications are most likely due to large random uncertainties in KIC surface gravities, and do not result from the absence of broadband colors or from different physical properties such as reddening, spatial distribution, mass or metallicity. The new sample allows us to study oscillations in low-luminosity red giants, and to characterize planet candidates around those stars.

PB.S10.54 – Analysis of a subdwarf B pulsator observed during Campaign 2 of K2

Laura Ketzer (Missouri State University), A.S. Baran (Krakow Pedagogical University), M.D. Reed (Missouri State University), J.H. Telting (Nordic Opitical Telescope), P. Nemeth (KU Leuven)

We present an analysis of the pulsating subdwarf B (sdB) star EPIC 203948264, observed during Campaign 2 of the extended Kepler mission. A time series analysis of the short cadence data set has revealed a rich g-mode pulsation spectrum with 16 independent pulsation periods between 0.5 and 2.8 hours. Most of the pulsations fit the asymptotic period sequences for ell=1 or 2, with average period spacings of 261.34+/-0.78 and 151.18+/-0.34 s, respectively. The pulsation amplitudes are below 0.77 ppt and vary over time. Radial velocity measurements give no indication for binarity in this star. We did not find rotationally induced pulsation multiplets, which indicates that the rotation period of the star is longer than about 45 days, which would make the data too short to resolve multiplets. By characterizing the various pulsation modes present in pulsating sdB stars, and by examining the time-dependence of pulsation amplitudes, we can constrain structural models of the interiors of sdB stars. This is a promising approach to enhancing our understanding of blue horizontal branch stars.

PB.S10.55 – The study of pulsating subdwarf B (extended horizontal branch) stars using K2 data

Mike Reed (Missouri State University), M. D. Reed (Missouri State University), A. S. Baran (Krakow Pedagogical University), R. H. Ostensen (Missour State University), J. H. Telting (Nordic Optical Telescope), et al.

Through the first seven K2 fields, 16 pulsating subdwarf B stars have been discovered. Most of these stars have yet to be fully analyzed and this poster will review the current status of our work. So far we have discovered several new short-period pulsators, which were lacking in K1; an ellipsoidal variable with no indications of frequency multiplets, even though its orientation and short binary period are well-suited for their detection; and asymptotic period spacings which are filling in evolutionary parameter space.

PB.S10.56 – EPIC 212707862, a pulsating subdwarf B star from Kepler K2 mission.

Szymon Bachulski (Pedagogical University of Cracow, Poland), A.Baran (The Pedagogical University of Cracow, ul. Podchorążych 2, 30-084 Kraków, Poland), R.Ostensen (Instituut voor Sterrenkunde, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium), J.Telting (Nordic Optical Telescope, Rambla José Ana Fernández Pérez 7, 38711 Breña Baja, Spain), M.Reed (Department of Physics, Astronomy, and Materials Science, Missouri State University, Springfield, MO 65804, USA)

We present our analysis of Kepler K2 data of EPIC 212707862, a pulsating subdwarf B star (sdBV). We extracted 12 significant pulsation modes from nearly 79 days of continuous data gathered during Campaign 6. In the case of this star we did not find any signs of multiplets which would enable us to derive a rotation period. We also searched for period-spacing sequences to perform a mode identification, and we successfully identified modal degrees of 11 of 12 detected modes.

PB.S10.57 – The additional-mode garden of RRab stars

Laszlo Molnar (Konkoly Observatory, MTA CSFK), Áron L. Juhász (Konkoly Observatoty, MTA CSFK, Budapest; Eötvös University, Budapest), Emese Plachy (Konkoly Observatoty, MTA CSFK, Budapest), Péter Klagyivik (Konkoly Observatoty, MTA CSFK, Budapest)

Space-based photometric missions revealed a surprising abundance of millimagnitude-level additional modes in RR Lyrae stars. The modes that appear in the modulated fundamental-mode (RRab) stars can be ordered into four major categories. Period doubling, caused by the resonant ninth overtone, and the mode at ~0.6 P0 that may potentially correspond to the second overtone, are relatively abundant in these stars. In more rare cases (including RR Lyr itself), the additional modes can be identified with the first overtone, and finally some fall outside the above mentioned categories, so they are most likely non-radial modes. Here we present a census of the additional modes based on Campaigns 0 to 6 of the K2 mission, the largest sample obtained with space-based photometry so far.

PB.S10.58 – Using phase shift to numerically characterize the mixed modes in post–main sequence stars

Chen Jiang (Instituto de Astrofísica e Ciências do Espaço, U.Porto), Joergen Christensen-Dalsgaard (SAC), Margarida Cunha (IA)

Mixed modes have been largely observed in post–main sequence stars by the Kepler and CoRoT space missions. The mixed nature of pressure and gravity modes leads to variations of some observable parameters of the oscillation modes, such as the mode frequency and amplitude. The level of the mixture of the p and g modes can be measured by the dimensionless coefficient q, the so-called cou- pling strength. Although the coupling strength varies with the mode frequencies, the difference between them is normally small within a star. Therefor, q is not optimal to characterize the behaviour of mixed modes. We discuss the utility of the phase shift θ as a tool to distinguish mixed modes from the theoretical as well as the practical point of view. The theoretical calculation of θ is very sensitive to the wave number K which is computed through series of approximations, nevertheless, it works well for high-radial-order mixed modes. Observed frequencies of a Kepler red giant star KIC 3744043 are used to test the method. We use the large frequency separation and the period spacing, which can be extracted from the power spectrum, to replace the theoretical integrals of K over different oscillatory cavities. The result is also very promising. Aside from the use of characterizing mixed modes, the computation of θ can also provide us better understanding of the pressure and gravity radial order of the mixed modes.

PB.S10.59 – Close encounters: Oscillating Kepler red giants with strange companions

Isabel Colman (The University of Sydney), Timothy Bedding (The University of Sydney), Daniel Huber (The University of Sydney)

We present an analysis of 93 oscillating red giants from NASA's Kepler mission which exhibit anomalous single-frequency peaks in their amplitude spectra. These peaks may be indicative of binary star systems, with frequencies such that the companion star's orbit would be within the red giant's convective envelope. Alternatively, the observed phenomenon may be due to a close binary orbiting a red giant in a triple system, or binary systems contaminating the pixels around the target star. We eliminate 46 stars in the sample as blends. However, we find that in 47 cases the anomalous peaks are indistinguishable from the target star to within a resolution of 4", the size of a Kepler pixel. This suggests that we are either observing contamination by a line-of-sight background or foreground binary system, or a physical association. We examine a Galaxia model of the Kepler field of view to estimate background star counts and find that it is highly unlikely that all targets can be explained by chance alignments. From this, we conclude that these stars may comprise a population of physically associated systems.

PB.S10.60 – Extended Aperture Photometry of K2 RR Lyrae stars

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We applied the method of Extended Aperture Photometry (EAP) to K2 RR Lyrae stars to minimize the instrumental variations of attitude control maneuvers. We present example light curves that are compared with the automated PDCSAP data and the K2SC-detrended light curves.

PB.S10.61 – A modulated RRd star observed by K2

Emese Plachy (Konkoly Observatory, MTA CSFK), László Molnár (Konkoly Observatory, MTA CSFK), Péter Klagyivik (Konkoly Observatory, MTA CSFK), Róbert Szabó (Konkoly Observatory, MTA CSFK)

We report the analysis of the double-mode RR Lyrae star EPIC 205209951, the first modulated RRd star observed from space. The amplitude and phase modulation are present in both modes and operate in opposite phases. The star was previously known as a strongly modulated RRab star: data from ground-based surveys revealed only the modulated fundamental mode that reaches higher amplitudes than the first overtone.

PB.S10.62 – Detecting the size of helium core of red giant: KIC 6928997

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For a low-mass star, it goes into red giants when the hydrogen has exhausted in its core and the burn hydrogen takes place in a surrounding shell. And then, the evolutionary state of red giants is almost characterized by the status of the helium core. Thanks to the spacing observations (such as CoRoT and Kepler), more and more red giants have been observed precisely. The mixed modes are clearly detected, especially for l=1 modes. It shows the property of p-mode in the outer cavity and of g-mode in inner cavity, respectively. In our published work (Wu & Li 2016), we found that, for a pure p-mode oscillations, the better candidate models seriously constrains the stellar acoustic parameter – acoustic radius. In the present work, we combine the radial modes and the non-radial modes (l=1) of KIC 6928997 to detect the status of its helium core. Finally, the calculations show that the radius of the helium core can be precisely detected.

PB.S10.63 – RR Lyrae Stars in the Globular Cluster M4

Charles Kuehn (University of Northern Colorado), Pawel Moskalik (Copernicus Astronomical Center), Jason Drury (University of Sydney)

Observations by Kepler/K2 have revolutionized the study of RR Lyrae stars by allowing DETECTION OF phenomena, such as additional modes and period doubling, which had not previously been seen from the ground. During campaign 2, K2 observed the globular cluster M4, providing the first opportunity to study a SIZEABLE group of RR Lyrae that belong to a single population; the other RR Lyrae that have been observed from space are field stars in the galactic halo and thus belong to an assortment of populations. In this poster we present the results from our study of the RR Lyrae in M4 from K2 photometry. We have identified additional, low amplitude pulsation modes in both observed RRc stars. In 3 RRab stars we have found the Blazhko effect with periods of 16.6 days, 22.4 days and 44.5 days.

PB.S10.64 – Looking into red giants in NGC 6819 using asteroseismology and vice versa

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We present an extensive peakbagging effort on Kepler light curves of 51 red giant stars in the open star cluster NGC 6819, a unique sample, because of the length of observations and their common distance, metallicity, and age. By employing sophisticated pre-processing of the time series and Markov Chain Monte Carlo (MCMC) techniques we extracted individual frequencies, heights and linewidths for hundreds of oscillation modes in the sample of stars. We show that the "average" asteroseismic parameter $\delta\nu_{02}$, derived from these, can be used to distinguish the stellar evolutionary state between the red giant branch (RGB) stars and red clump (RC) stars, without having to measure the often difficult dipole modes. The masses and radii of the giants are estimated using asteroseismic scaling relations, both empirically corrected to obtain self-consistency as well as agreement with independent measures of distance and age, and, alternatively, using updated theoretical corrections. Remarkable agreement is found, allowing the evolutionary state of the giants to be determined exclusively from the empirical correction to the scaling relations. Stars that are outliers relative to the ensemble reveal over-massive members that likely evolved via mass-transfer in a blue straggler phase. We also suggest that KIC 4937011, a low-mass Li-rich giant previously studied in the literature, is a cluster member in the RC phase that experienced very high mass-loss during its evolution. Such over- and under-massive stars need to be considered when studying field giants, since the true age of such stars cannot be known and there is currently no way to distinguish them from normal stars.

PB.S10.65 – Amplitudes and lifetime of radial modes in red giant star spectra observed by Kepler

Mathieu Vrard (Instituto de Astrofísica e Ciências do Espaço, U.Porto), Barban, C. (Observatoire de Paris), Mosser, B. (Observatoire de Paris), Baudin, F. (Institut d)

The space mission Kepler has provided seismic data of unprecedented quality which brought new ways to precisely measure the stellar seismic parameters in red giant star spectra. With now four years of observations, the precise characterization of the seismic mode parameters can be carried out. Here, we present the results of a large study realized on red giant and subgiant stars which aim to characterize precisely their pressure mode amplitude and linewidth in their spectra. We will detail the automated procedure used to determine these two parameters throughout the star spectra. We will then present the results and analyze them throughout the stellar evolution in function of the star physical parameters. Finally, the implications of the results on the physical processes behind the excitation and damping of the modes will be developed.

S11. Synergies: Stellar Evolution and Galactic Populations

PB.S11.66 – Stellar Parameters in an Instant with Machine Learning

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With the advent of dedicated photometric space missions, the ability to rapidly process huge catalogues of stars has become paramount. We introduce a new method based on machine learning for inferring the stellar parameters of main-sequence stars exhibiting solar-like oscillations. Our method makes precise predictions that are competitive with other methods, but with the advantage of costing practically no time. We validate our technique on a hare-and-hound exercise, the Sun, and 16 Cygni and then use it to predict the parameters of the Kepler objects-of-interest. Finally, we present novel insights into main-sequence evolution that have been extracted by the algorithm.

PB.S11.67 – Fundamental Parameters of Main Sequence Turn-off Star Candidates Observed with the LAMOST and Kepler

Yaqian Wu (Beijing Normal University), Maosheng Xiang (National Astronomical Observatories), Tandai Li (National Astronomical Observatories), Shaolan Bi (Beijing Normal University), et al.

Main sequence turn-off (MSTO) stars are advantaged indictors of Galactic evo- lution since their ages could be robustly estimated based on atmospheric parameters. A few hundred of thousands of MSTO stars have been selected from the LAMOST Galactic surveys to study the structure and evolution of the Milky disk by Xiang et al. (2015). In this work, we validate the age estimates, as well as examine the contamination rate of the MSTO sample of Xiang et al. with a sample of 179 stars that have asteroseismic parameters from analysis of the Kepler photometry. We determine accurate fundamental stellar parameters (M, R, Age, L, Teff, Z, log g) for 150 stars by combing the asteroseismic properties Δ, max and stellar atmospheric parameters yielded by the LSP3 from LAMOST spectra, utilizing a dense grid of evolutionary tracks we constructed. We find that for the majority of stars, the age esti- mates of Xiang et al. are basically consistent with our results, with a mean difference and standard deviation of 0.53 and 2.71 Gyr, respectively. Nevertheless, according to our results, a considerable fraction of the MSTO stars in Xiang et al's sample are prob- ably contaminations from either main sequence stars or sub giant stars, and ages for many of those contamination stars could be significantly overestimated. The contamination rate is especially higher for the older stars. The main cause of the high fraction of contaminations is the relatively large systematic bias of surface gravity yielded by the current LSP3.

PB.S11.68 – Isochrones of M67 with an Expanded Set of Parameters

Lucas Viani (Yale University), Dr. Sarbani Basu (Yale University)

We create isochrones of M67 using YREC (The Yale Rotating Stellar Evolution Code). In addition to metallicity, parameters that are traditionally held fixed, such as the mixing length parameter and initial helium abundance, also vary. The amount of convective overshoot is also changed in different sets of isochrones. Models are constructed both with and without diffusion. We examine limits on the age and distance to the cluster obtained by this wider set of isochrones.

PB.S11.69 – AIMS – Asteroseismic Inference on a Massive Scale

Andrea Miglio (University of Birmingham), Ben Rendle (University of Birmingham), Laura Scott (University of Birmingham), Arlette Noels (Universite de Liege), Daniel Reese (LESIA, Paris Observatory), et al.

The comparison of observational constraints with predictions from stellar models is a key aspect in the determination of stellar properties. AIMS is a code that relies on a Monte-Carlo-Markov-Chain approach to find a representative set of models which reproduce a given set of classical and asteroseismic constraints. These models are obtained by interpolation from a pre-calculated grid thereby increasing computational efficiency. Here we test the accuracy of the different operational modes within AIMS for two grids of stellar models computed with CLES (main sequence and giants), and compare the results to stars with well constrained parameters from the literature. A series of interpolation tests to determine frequencies around numax are analysed. Moreover, by using a set of artificial data generated from models within the grid, we show the impact of considering different combination of observational constraints (individual mode frequencies, period spacing, parallaxes, photospheric constrains,...) on the precision of the inferred stellar properties.

PB.S11.70 – Galactic archeology with TESS: prospects for testing the star formation history in the solar neighborhood

Andrea Miglio (University of Birmingham), Fabian Gittins (University of Birmingham), Alex Thomas (University of Birmingham), Emma Stevenson (University of Birmingham), Guy Davies (University of Birmingham), et al.

Uncertainties in the age distribution of stars in the solar neighbourhood have thus far limited the determination of the star formation history of the local galactic disk, which is one of key constraints to test competing models of formation and evolution of the Milky Way. It is hoped that this barrier may be overcome with the reception of all-sky asteroseismic data. In this contribution we investigate whether the TESS mission will be able to make a substantial contribution to the field of galactic archaeology. We use the TRILEGAL code to generate a set of synthetic stellar populations, and considered only stars which would display oscillations detectable by TESS. We then investigate the extent to which the mission would be able to distinguish between models generated assuming different star-formation-history models.

PB.S11.71 – Stellar Modeling of Oscillation Frequencies in a Sample of Red Giants

Jean McKeever (New Mexico State University), Jason Jackiewicz (New Mexico State University), Patrick Gaulme (New Mexico State University)

The study of red giants in eclipsing binaries has allowed for the best in-depth study of red giants to date. We are able to approach these stars from the perspective of asteroseismology, to learn what the oscillations tell us about the internal structure of the star, and see the star as a dynamical two-body system, where gravity tells us the size and density of the objects. The use of asteroseismology to predict masses and radii for large populations of stars is a powerful and widely used tool. However, discrepancies between the asteroseismically predicted and dynamically modeled masses and radii have been found to be rather large in many cases (Gaulme, et al. 2016). To better pin down where the differences come from we are conducting a detailed study of the individual pulsation frequencies for a sample of red giants in eclipsing binary systems. For a first look, we use the MESA stellar evolution code to create a model of a star, then use GYRE to compute adiabatic frequencies from the structure given in the models. Expected frequencies are computed for models of both the asteroseismic and dynamic masses. Specific models are selected to reproduce the large frequency spacing that is observed. Both models are compared to the observed echelle diagram and predicted radii. To perform a more detailed analysis we use the astero

module of MESA to run many sets models and compute many sets of frequencies while varying parameters such as mass, metallicity, overshoot, and mixing length. Individual oscillation modes are “peak-bagged” to find their exact frequency using the DIAMONDS code and then used as constraints to MESA’s astero module. Here we present the first results using this method for red giants in eclipsing binaries.

S12. Synergies: Binaries

PB.S12.72 – Peakbagging of red-giant stars in binary systems

Nathalie Themessl (Max Planck Institute for Solar System Research (MPS))

Red-giant stars show rich oscillation spectra comprising low-spherical degree pressure modes that follow a distinct pattern in Fourier space (Tassoul, 1980). The unambiguous identification of these modes provides rigorous constraints on stellar models, and allows the determination of the stellar parameters. Based on more than 4 years of Kepler observations we performed a thorough asteroseismic study of three red giants in eclipsing binary systems. In these stars we derived the central frequencies, mode widths and mode heights of detected l=[0,1,2,3] modes. This information is then used to constrain stellar models and ages of these stars.

PB.S12.73 – KIC 6220497: A New Algol-type Eclipsing Binary with Multiperiodic Pulsations

JaeWoo Lee (Korea Astronomy and Space Science Institute), Kyeongsoo Hong (Korea Astronomy and Space Science Institute), Seung-Lee Kim (Korea Astronomy and Space Science Institute), Jae-Rim Koo (Korea Astronomy and Space Science Institute)

We present both binarity and pulsation of KIC 6220497 from the Kepler observations. The light curve synthesis shows that the eclipsing system is a semi-detached Algol with parameters of $q = 0.243 \pm 0.001$, $i = 77.3 \pm 0.3$ deg, and $\Delta T = 3{,}372 \pm 58$ K, in which the detached primary component fills its Roche lobe by ~87%. A multiple frequency analysis of the eclipse-subtracted light residuals reveals 33 frequencies in the range of 0.75-20.22 d-1 with amplitudes between 0.27 and 4.56 mmag. Among these, four are pulsation frequencies in fundamental (f1, f5) and p(f2, f7) modes, and six are orbital frequency (f8, f31) and its harmonics (f6, f11, f20, f24), which can be attributed to tidally excited modes. For the pulsation frequencies, the pulsation constants of 0.16-0.33 d and the period ratios of P pul/Porb = 0.042-0.089 indicate that the primary component is a δ Sct pulsating star and, thus, KIC 6220497 is an oscillating eclipsing Algol (oEA) star. The dominant pulsation period of 0.1174051±0.0000004 d is significantly longer than that expected from empirical relations that link the pulsation period with the orbital period. The surface gravity of log g1 = 3.78±0.03 is clearly smaller than those of the other oEA stars with similar orbital periods. The pulsation period and the surface gravity of the pulsating primary demonstrate that KIC 6220497 would be the more evolved EB, compared with normal oEA stars.

PB.S12.74 – Kepler observation of HD 176465, a binary system with overlapping pulsation frequencies

Othman Benomar (New York University Abu Dhabi), Tim White (SAC, Aarhus University), Othman Benomar (Speaker) (Center for Space Science, New York University Abu Dhabi), Victor Silva Aguirre (SAC, Aarhus University), Warrick Ball (Institut für Astrophysik, Georg-August-Universität Göttingen), et al.

Binary stars systems are crucial to better understand the physics of stars, because they might share a common history, enabling us to assume that they have the same age and composition. Furthermore, using the kepler laws, the orbital parameters could provide tight constraints on their mass ratio. With the recent advent of asteroseismology it is also now possible to look for pulsating multiple stars, providing a new insight on their internal structure and dynamics. Yet, while 60% of stars are thought to be part of a multiple system, only a handful were detected with more than one component showing pulsations. I will present one of these rare cases, HD 176465. It is composed of two bright stars situated at 49.6 +/- 1.8 pc, that show pulsations at a similar frequency numax~3500 muHz. I will first describe our seismic analysis of the system, then discuss the orbits of the stars, their rotations and fundamental physical properties (masses, radii, ages, compositions), derived using various stellar models.

PB.S12.75 – Time-series spectroscopy of the eclipsing binary AB Cas with a pulsating component

Kyeongsoo Hong (Korea Astronomy and Space Science Institute), Jae Woo Lee (Korea Astronomy and Space Science Institute), Jae-Rim Koo (Korea Astronomy and Space Science Institute)

We present high resolution spectra of the eclipsing binary AB Cas with a δ Sct-type pulsating star, which were obtained using the Bohyunsan Optical Echelle Spectrograph in Korea. The radial velocities (RVs) for the primary and secondary components are measured from a total of 27 spectra, secured during 2 nights on October 2015. In order to obtain the accurate physical properties, we simultaneously analyzed our RV curves together with previously published uvby light-curves. Individual masses, radii, and effective temperatures of both components are determined to be M1=2.01±0.02 Msun, M2=0.37±0.02 Msun, R1=1.84±0.02 Rsun, and R2=1.69±0.03 Rsun, Teff,1=8,000±250 K and Teff,2=4,900±150 K, respectively. In addition, we investigate the evolutionary history of AB Cas using theoretical evolutionary models to give the best representation for their physical parameters. All of these indicates that AB Cas is an oscillating Algol-type eclipsing binary (oEA) with the less massive and cool secondary star filling its inner Roche lobe, which may have experienced rapid mass transfer.

PB.S12.76 – Time-series spectroscopy of the pulsating eclipsing binary XX Cephei

Jae-Rim Koo (Korea Astronomy and Space Science Institute), Jae Woo Lee (Korea Astronomy and Space Science Institute), Kyeongsoo Hong (Korea Astronomy and Space Science Institute), Seung-Lee Kim (Korea Astronomy and Space Science Institute), et al.

Oscillating Algol-type eclipsing binaries (oEA) are very interesting objects that have three observational features of eclipse, pulsation, and mass transfer. Direct measurement of their masses and radii from the double-lined radial velocity data and photometric light curves would be the most essential for understanding their evolutionary process and for performing the asteroseismological study. We present the physical properties of the oEA star XX Cep from high-resolution time-series spectroscopic data. The effective temperature of the primary star was etermined to be 7,946 +/- 240 K by comparing the observed spectra and the Kurucz models. We detected the absorption lines of the secondary star, which had never been detected in previous studies, and obtained the radial velocities for both components. With the published BVRI light curves, we determined the absolute parameters for the binary via Wilson-Devinney modeling. The masses and radii are M1 = 2.49 +/- 0.06 Msun, M2 = 0.38 +/- 0.01 Msun, R1 = 2.27 +/- 0.02 Rsun, and R2 = 2.43 +/- 0.02 Rsun, respectively. The primary star is about 45 % more massive and 60 % larger than the zero-age main sequence (ZAMS) stars with the same effective temperature. It is probably because XX Cep has experienced a very different evolutionary process due to mass transfer, contrasting with the normal main sequence stars. The primary star is located inside the theoretical instability strip of delta Sct-type stars on HR diagram. We demonstrated that XX Cep is an oEA star, consisting of a delta Sct-type pulsating primary component and an evolved secondary companion.

PB.S12.77 – KIC2696703, A Kepler Eclipsing binary system with Gamma Dor Pulsations

Aunia Samadi Ghadim (IVS KU Leuven), Andrew Tkachenko (Institute for Astronomy, KU Leuven), Timothy Van Reeth (Institute for Astronomy, KU Leuven)

Binary systems are the main source of precise fundamental properties of stars, such as their masses, radii, and to some extend chemical compositions. These stellar characteristics are the key ingredients in many applications in stellar astrophysics, in particular when it concerns internal structure and evolution of stars. The theories of stellar structure and evolution are best probed with asteroseismology, the study of oscillations of stars through interpretation of frequencies, amplitudes, and phases of their individual pulsation modes. It is thus natural to combine these two complementary fields, asteroseismology and binary stars, to test and improve the current theoretical models. We investigate a short-period (P ~ 6 d) eclipsing binary system consisting of two nearly twin F-type stars (m1/m2 ~ R1/R2 ~ 1) that are also found to exhibit intrinsic variability in terms of gamma Dor-type g-mode oscillations. The Kepler space-based photometric data are complemented with high-resolution ground-based spectroscopic observations to characterize the system as a whole as well as its individual stellar components. The two stars are found to rotate synchronously with the orbit of the binary system; the individual spectral line profiles experience strong variability near the periastron – the result which we interpret as an interaction between stellar pulsation and dynamical tide due to non-zero eccentricity of the system. Preliminary analysis of the pulsation signal encoded in the Kepler photometry reveals four series of pulsation periods. These may originate from the same star and can be identified as dipole, quadrupole and octopole modes, with two series belonging to the latter category.

PB.S12.78 – The First Quintuple Star Found with the Kepler K2 Mission

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We report on a quintuple star system found with the Kepler K2 mission. Its unusual architecture includes two stellar images separated by 11 arcsec on the sky. Our investigation is based on the analysis of the Kepler light curve complemented by adaptive optics (AO), speckle imaging, and radial velocity (RV) studies. It reveals that one image actually hosts two eclipsing binaries, 'A' and 'B', which are resolved within that image at 0.09 arcsec, while the other one appears to be single. The 'A' binary is circular with a 5.1-day period, while the 'B' binary is eccentric with a 13.1-day period. Spectral analysis together with Monte Carlo simulations based on the derived mass functions and observed relative fluxes allow us to place all stars into the Teff-log(g) diagram and to compare their positions with theoretic evolutionary tracks. Based on the derived difference in the systemic velocities of the two binaries and their projected separation, we derive most likely values for the period and separation of the orbit of the two binaries revolving about each other. The results show that motion within this orbit should be discernible via future RV, AO, and speckle imaging studies within a couple of years. The very small difference in RV and proper motion between the two binaries and the single object implies that all these objects are physically bound, making this at least a quintuple star system.

PB.S12.79 – Asteroseismic modelling of the Binary HD 176465

Benard Nsamba (Instituto de Astrofísica e Ciências do Espaço, U.Porto), M. J. P. F. G. Monteiro (Institute of Astronomy and Astrophysics, Portugal), T. L. Campante (School of Physics and Astronomy, University of Birmingham, UK)

The detection and analysis of oscillations in binary star systems is critical in understanding stellar structure and evolution. This is because such systems have the same initial chemical composition and age. Solar-like oscillations have been detected in both components of the asteroseismic binary HD 176465 by Kepler (White et al., 2016). This study presents an independent modelling of the two stars in this binary system. Stellar models generated using MESA (Modules for Experiment in Stellar Astrophysics) were fitted to both the observed individual frequencies and some spectroscopic parameters. The individual theoretical oscillation frequencies for the corresponding stellar models were obtained using GYRE as the pulsation code. A Bayesian approach was applied to find the Probability Distribution Functions of the stellar parameters using AIMS (Asteroseismic Inference on Massive Scale) as the optimization code. The age of the individual stars was found to agree with that obtained by White et al., (2016) of about 3.0 ± 0.5 Gyr old.

S13. Synergies: Planets

PB.S13.80 – The Asteroseismic potential of Exoplanet Host Stars With TESS

Mathew Schofield (University of Birmingham), W. J. Chaplin (University of Birmingham), T. L. Campante (University of Birmingham)

TESS has excellent potential for detecting solar-like oscillations in stars. Code was written to calculate the probability of detecting global solar-like oscillations. With this code, the faintest magnitude for detecting these oscillations was found for stars with different masses and at different evolutionary stages, from the Main Sequence to the Red Giant Branch. These results show that only the very brightest Main Sequence targets (Ic

PB.S13.81 – A Potentially Re-inflated Exoplanet Orbiting a Red Giant Star

Daniel Huber (University of Sydney), Samuel Grunblatt (University of Hawaii), Eric Gaidos (University of Hawaii), Benjamin Fulton (University of Hawaii), et al.

While most exoplanet surveys focus on main sequence stars, our understanding of planets orbiting red-giant branch (RGB) stars is limited. Due to their diversity in mass, luminosity, and chemical composition, RGB stars can help tackle unsolved questions in exoplanet science such as the puzzling radius inflation of gas-giant planets. We present first results from our Asteroseismology & Giants Orbiting Giants (AGOG) K2 program, including the discovery of an inflated (~1.4 RJ, ~1.1 MJ) planet in an 8.4 day orbit around a oscillating low-luminosity red giant star. The incident flux on the planet was near the inflation threshold while the star was on the main-sequence, providing tentative support for the proposal by Lopez & Fortney (2015) that post-main sequence stellar evolution can re-inflate planets through direct deposition of energy into the planetary interior.

PB.S13.82 – Observational evidence of deficit of planets at radius ~2 Rearth

Camilla Agentoft (Stellar Astrophysics Centre, Aarhus University), Mia Sloth Lundkvist (LSW, University of Heidelberg, Stellar Astrophysics Centre), Hans Kjeldsen (Stellar Astrophysics Centre, Aarhus University)

We present an extended study of 139 exoplanets, whose host stars were studied extensively through asteroseismology by Lundkvist et al. 2016. The combination of high precision stellar parameters from asteroseismology combined with high quality transit-fits produce the best characterized exoplanet-systems. Our analysis revealed a deficiency gap in the number of exoplanets with a radius ~2 Rearth, which is caused by the evaporation of the atmosphere of the exoplanets. The distinction between pure rocky planets, and planets with an envelope of water or gas was also clearly visible from density determinations.

NOTES