

Uncovering the Unknown

with

**Polarized
Spatially extended Lyman alpha**

Escape of Ly α from Galactic Labyrinths - Orthodox Academy of Crete - 11 Sep 2018

Marius Berge Eide (MPA)

&

Max Grönke (UCSB), Mark Dijkstra (Stitch Fix Inc) and Matthew Hayes (Stockholm U.)

1.

Resonant Lya

A Remarkable Probe
In Remarkable Times

2.

Spatially extended Lya

Potentially
Decoupling
CGM from ISM

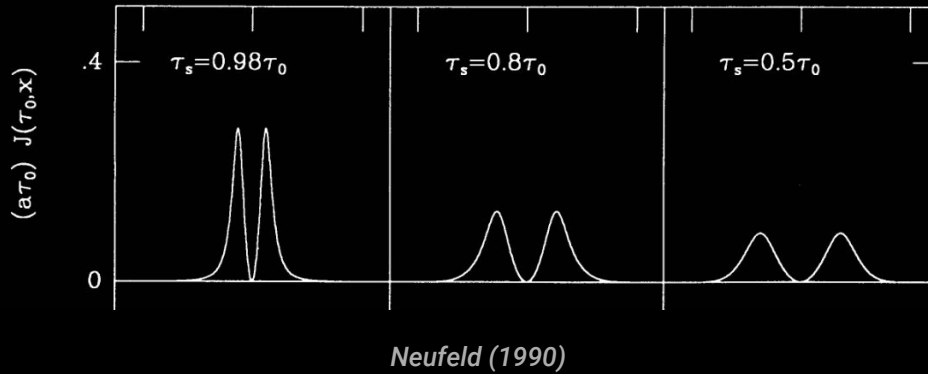
3.

Polarized Lya

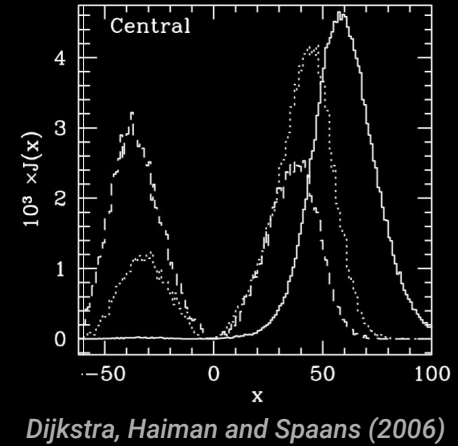
Even
More
Can
Be
Learned

A REMARKABLE PROBE

COLUMN DENSITY



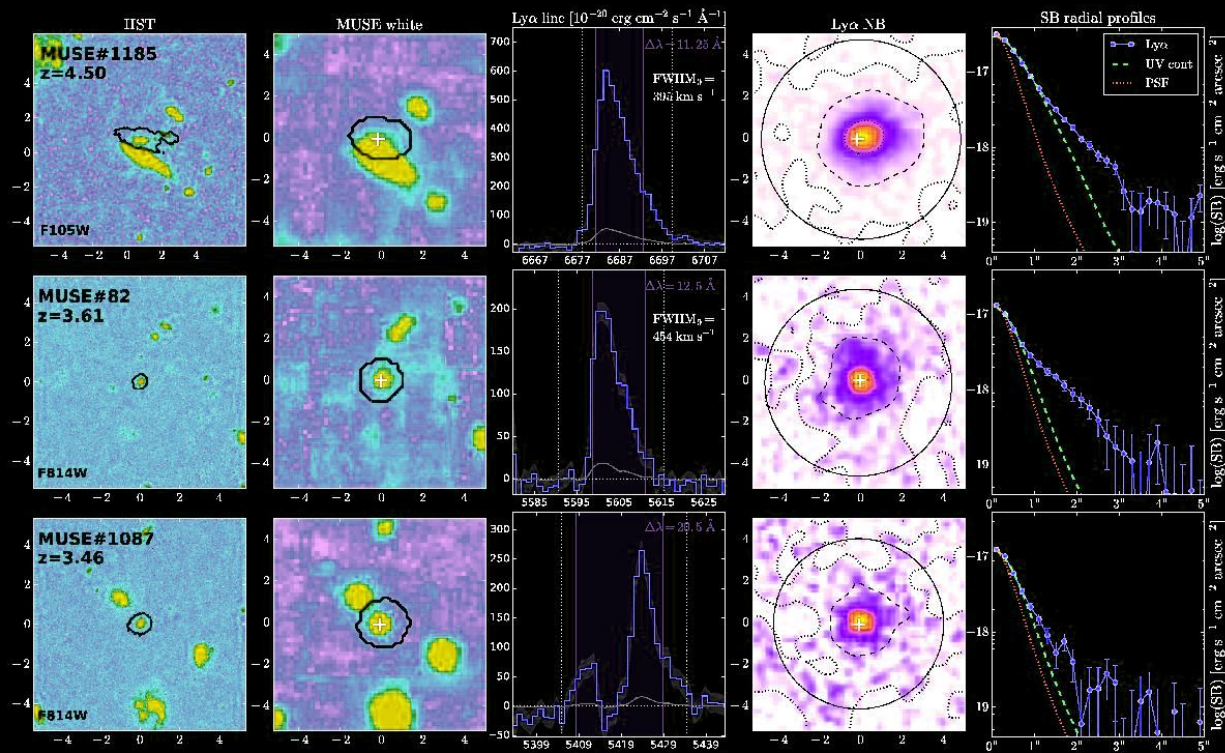
KINEMATICS



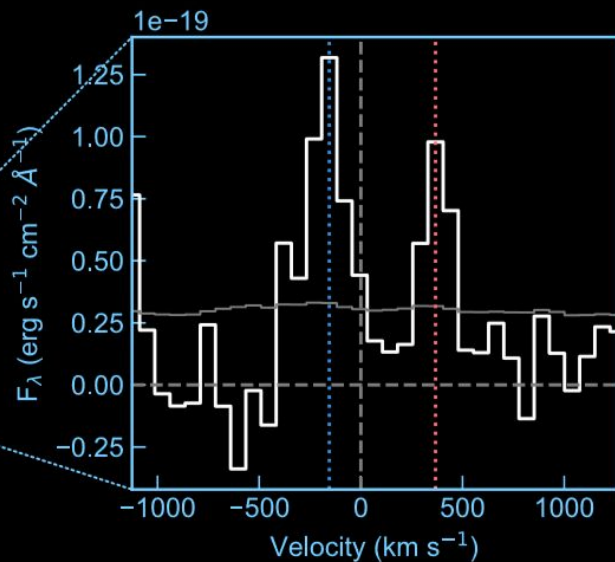
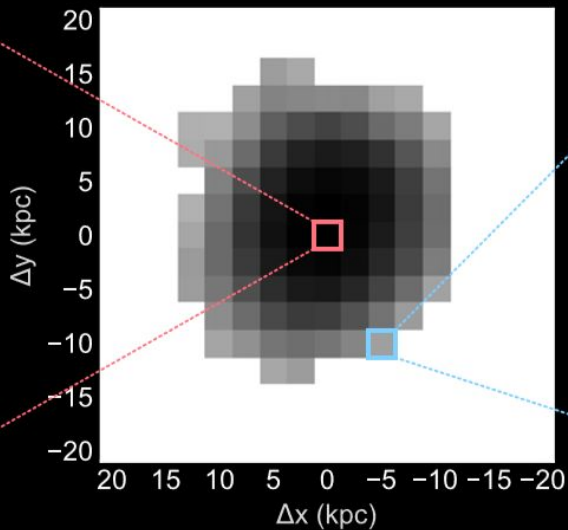
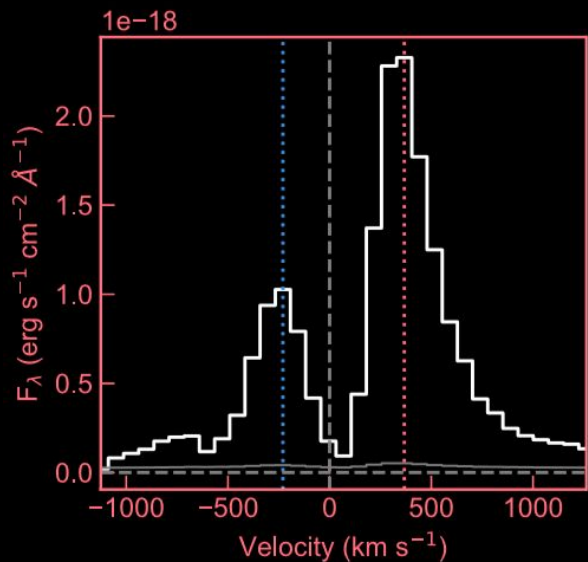
GEOMETRIES?

**EMISSION
MECHANISM?**

IN REMARKABLE TIMES!



WOW!



1.

Resonant Lya

A Remarkable Probe
In Remarkable Times

2.

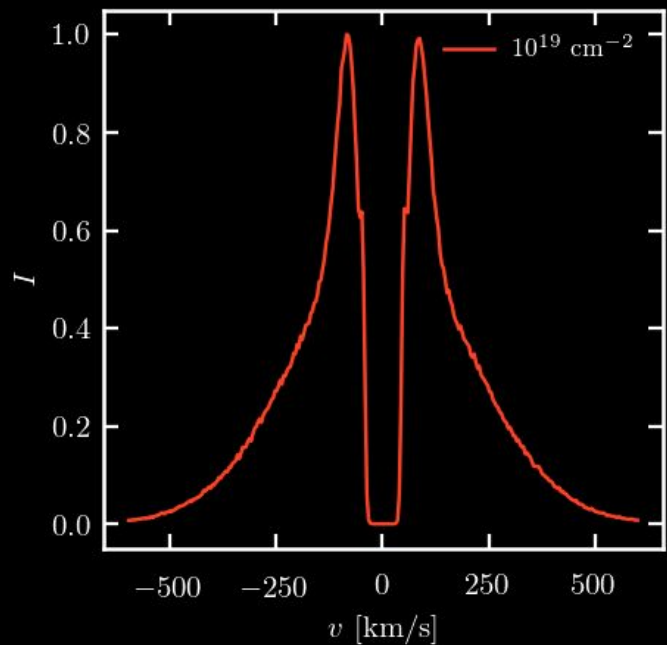
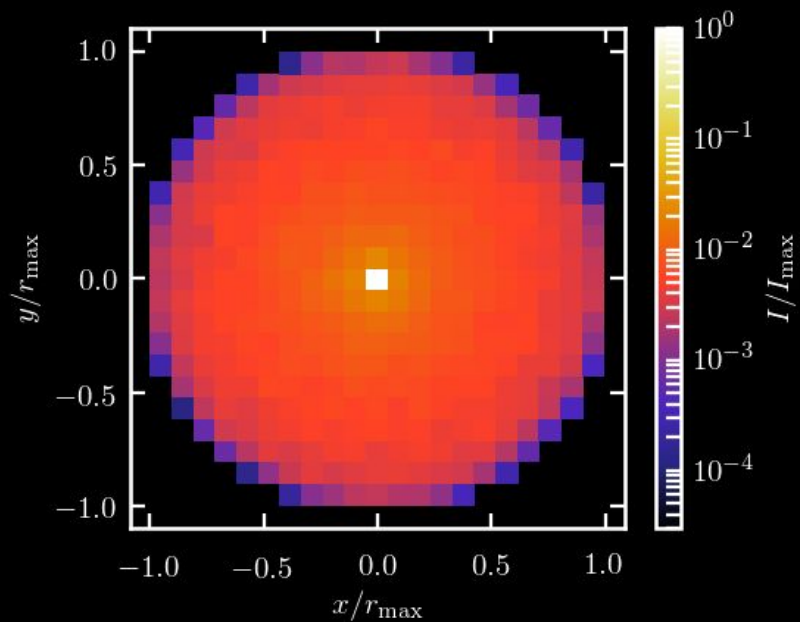
Spatially extended Lya

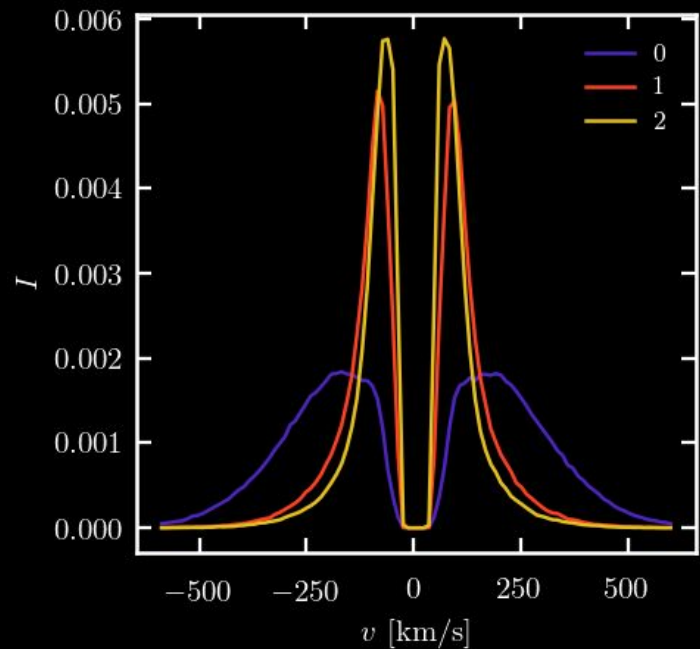
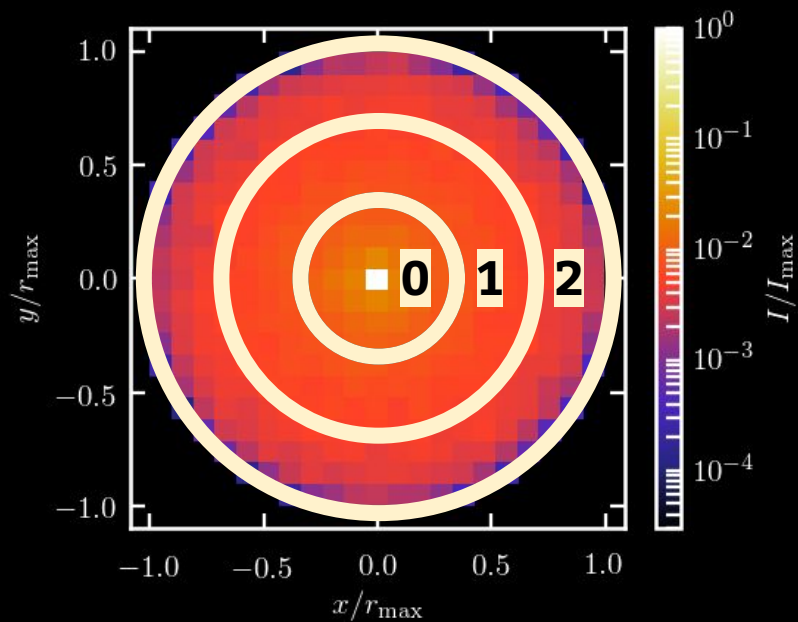
Potentially
Decoupling
CGM from ISM

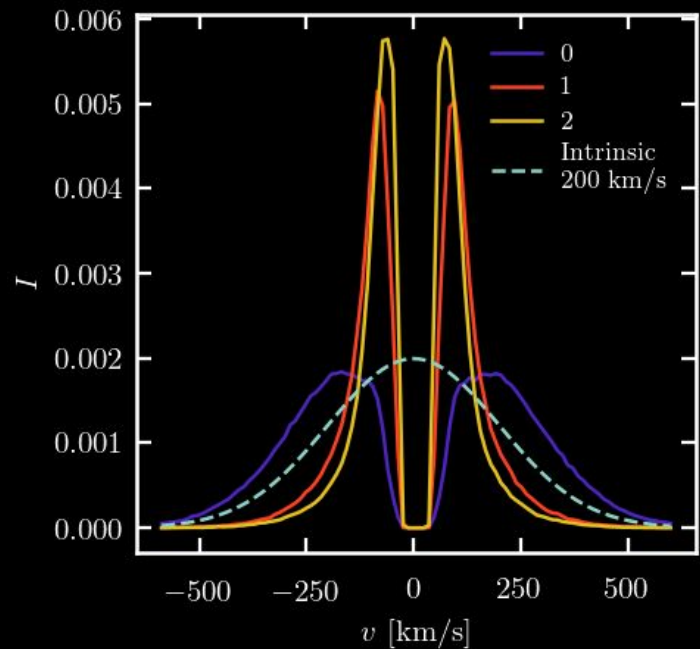
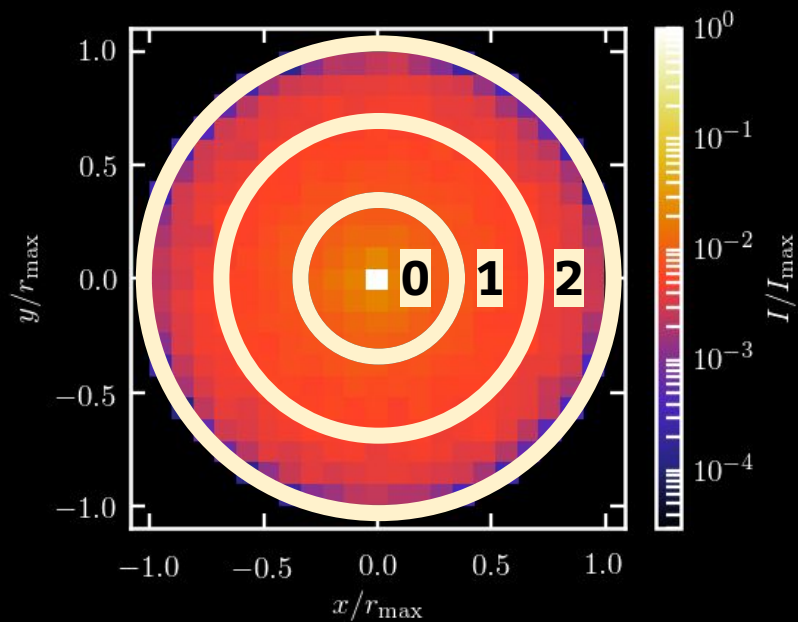
3.

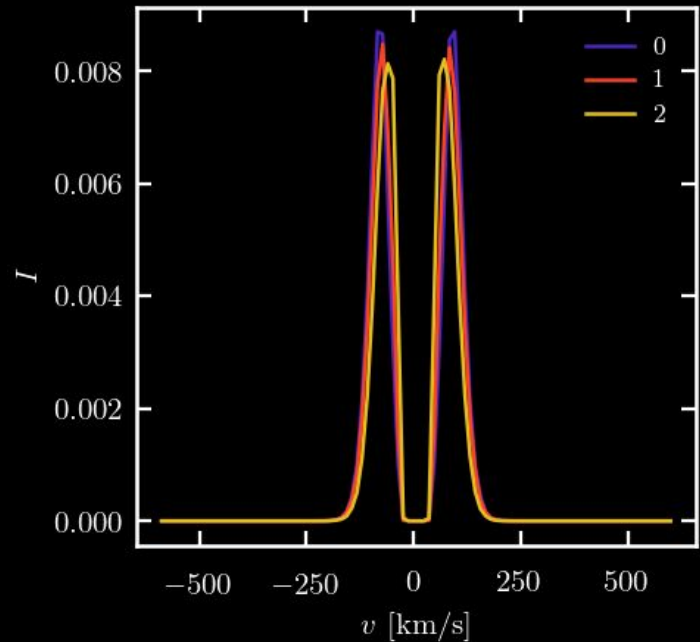
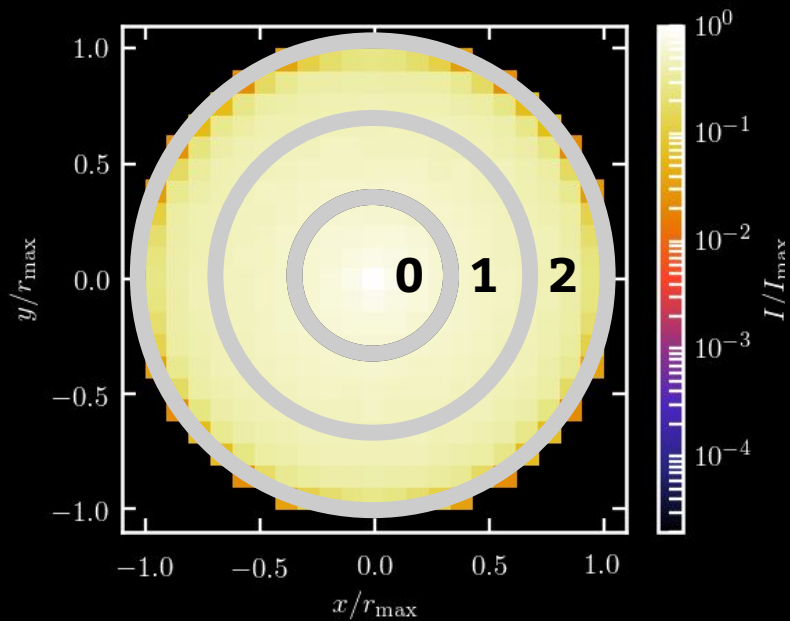
Polarized Lya

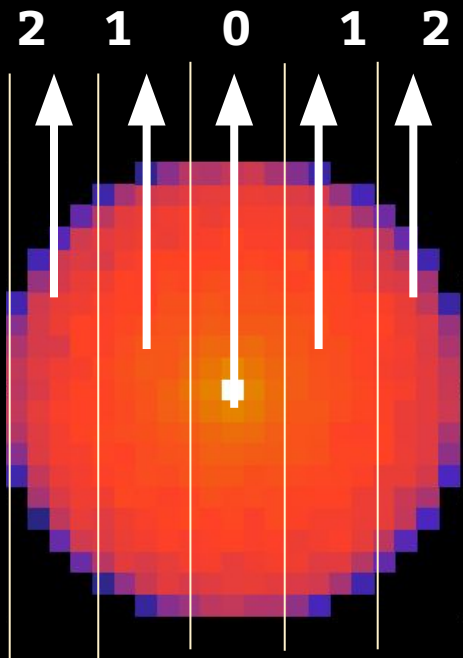
Even
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Innermost 0:

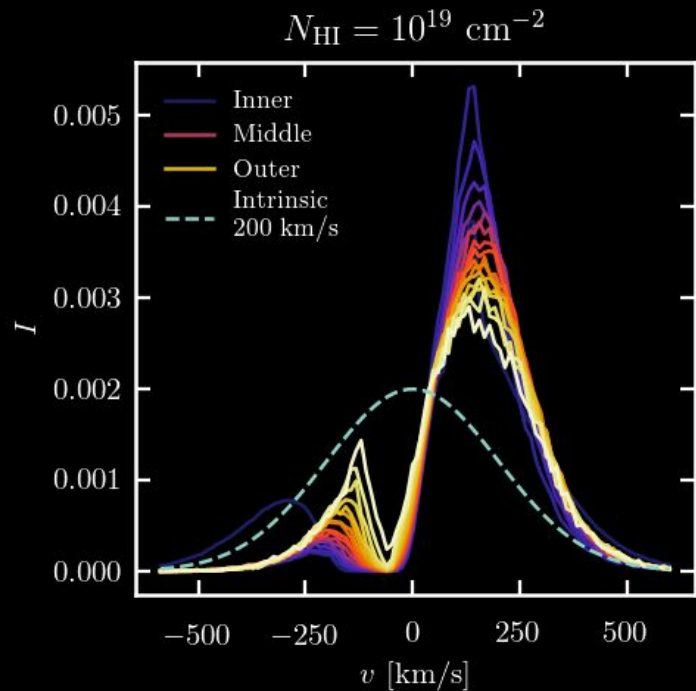
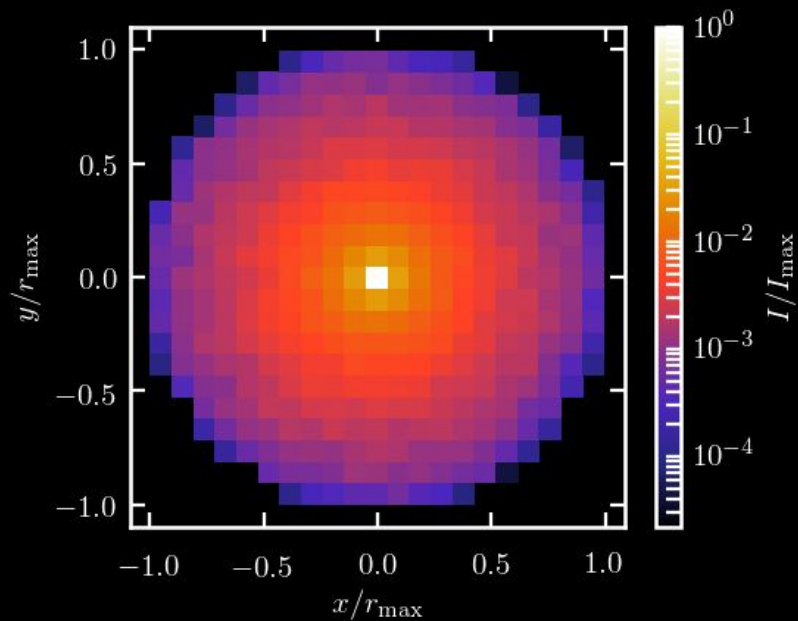
Significant contribution from ISM

Middle 1:

Scattered (line center) photons

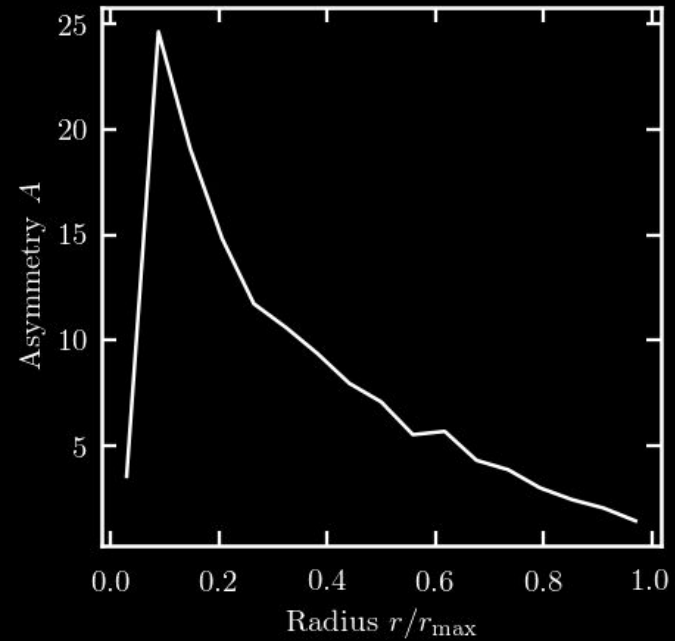
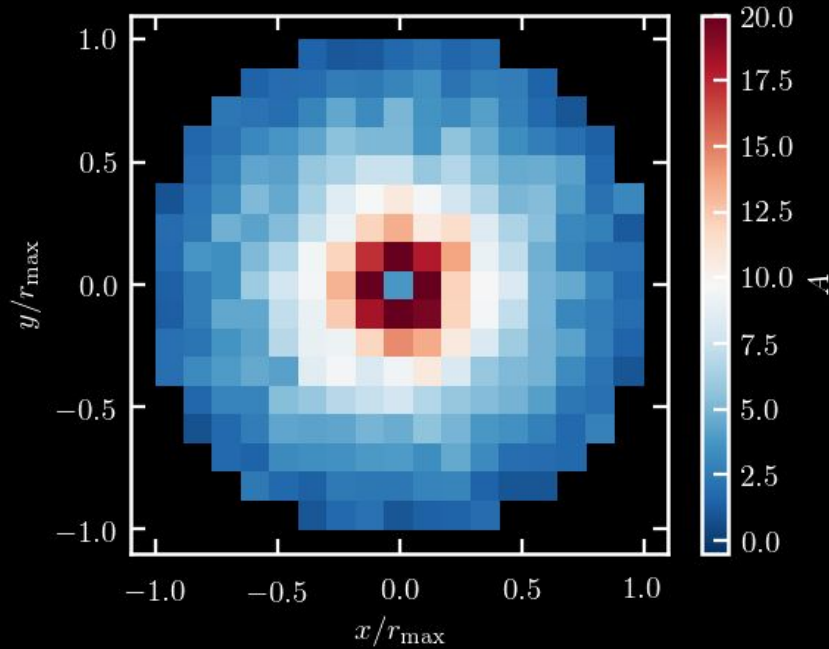
Outer 2:

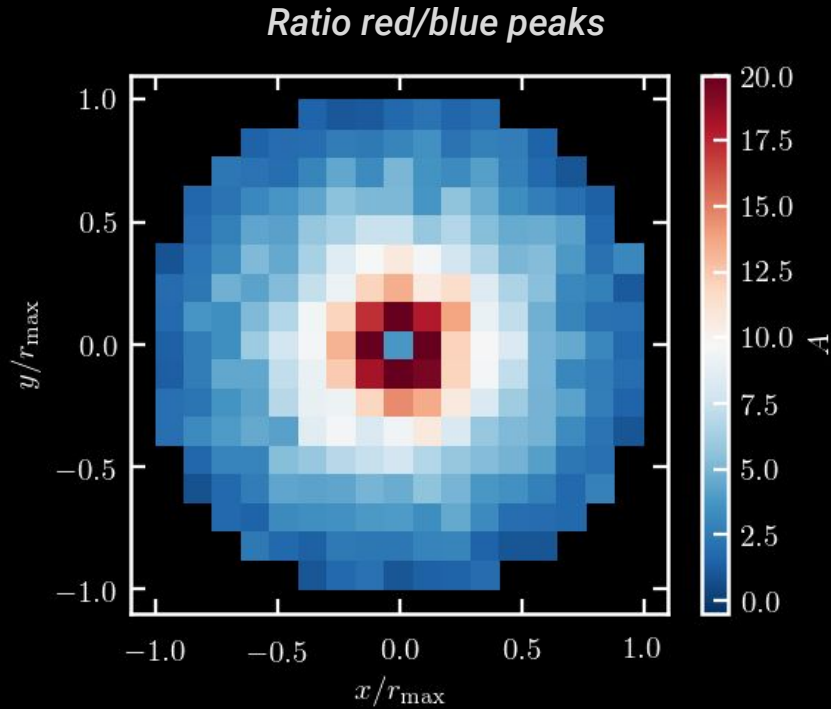
Traces CGM as 1



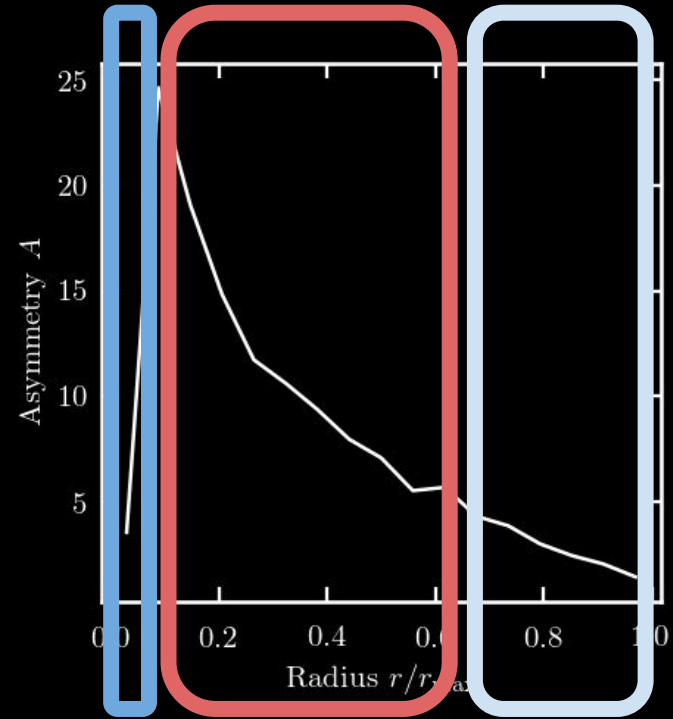
$$A = \frac{\int I(\text{red})}{\int I(\text{blue})} - 1$$

Ratio red/blue peaks

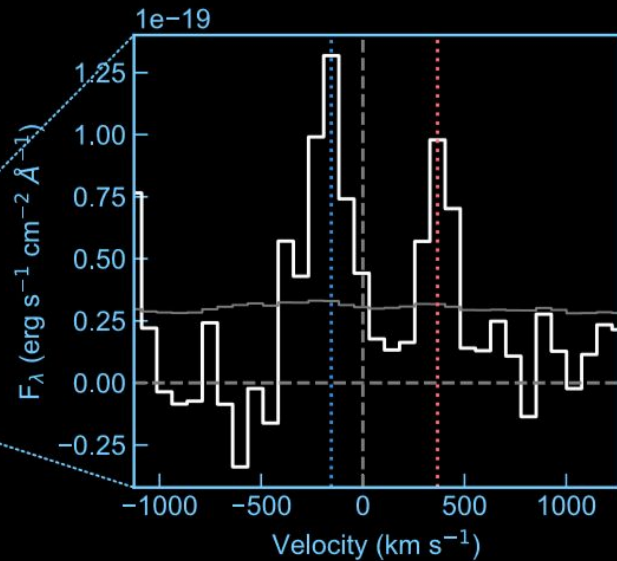
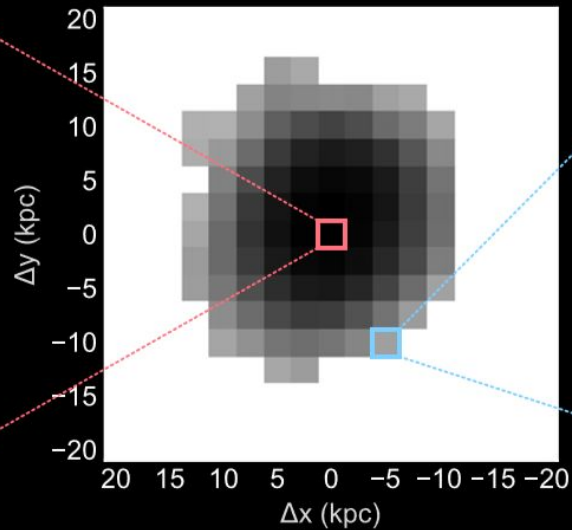
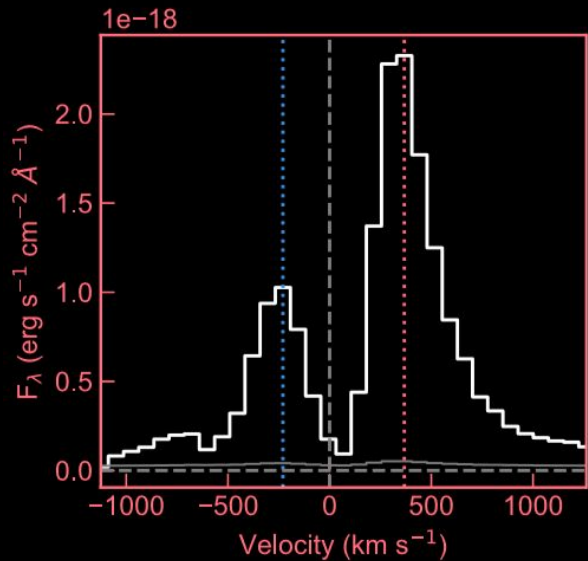


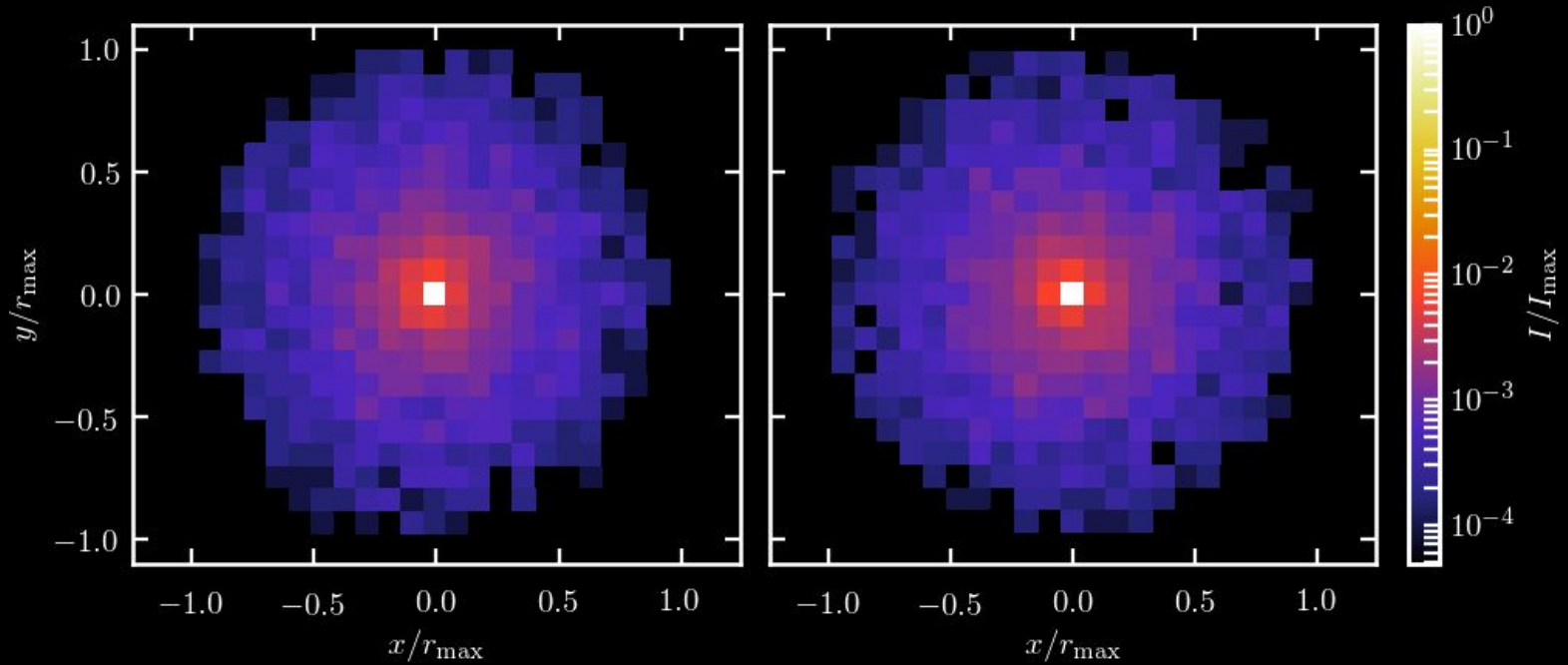


ISM wing photons *LOS along velocity dir* *Less velocity effect along LOS*



EXPANDING & HOMOGENEOUS

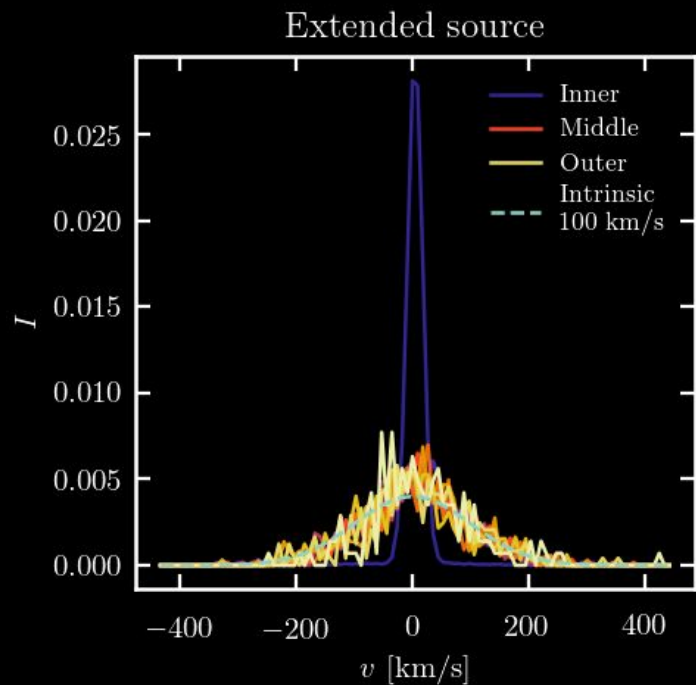
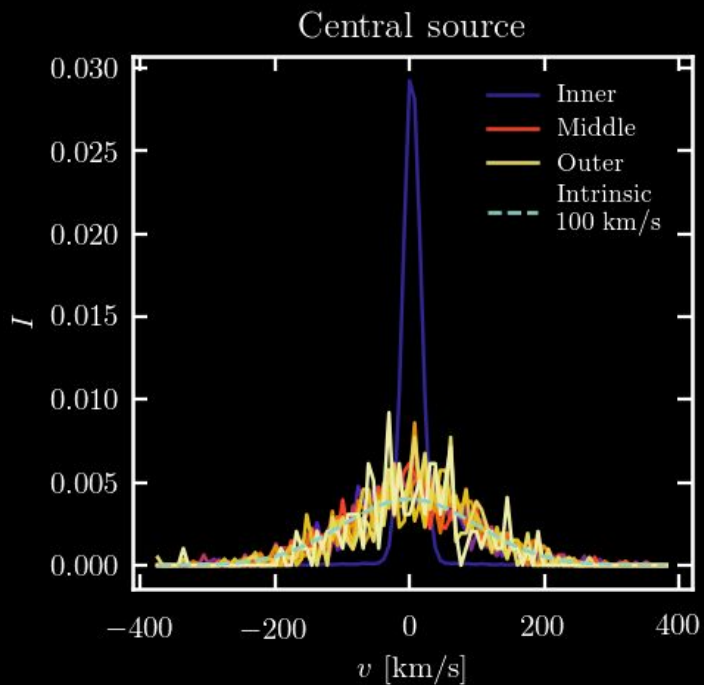




UNKNOWN EMISSION MECHANISM

in

MULTIPHASE MEDIA



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Resonant Lya

A Remarkable Probe
In Remarkable Times

2.

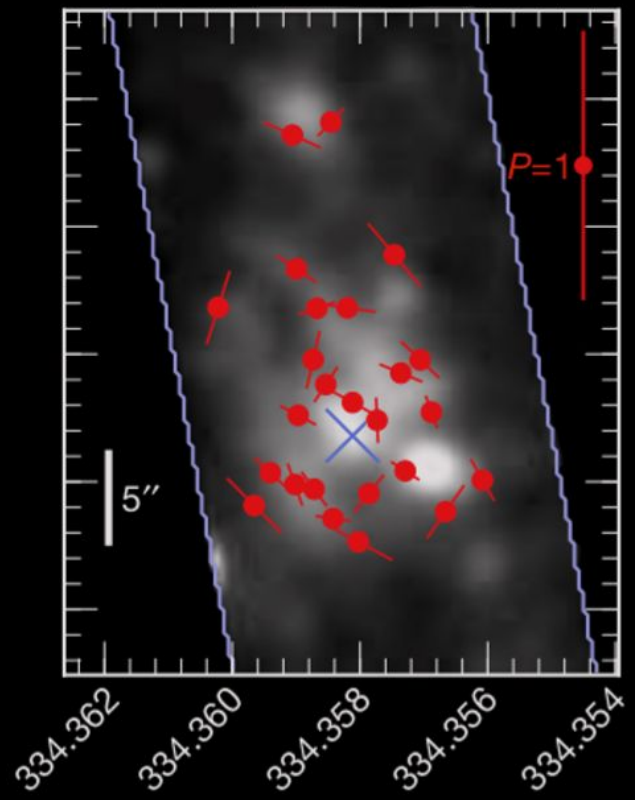
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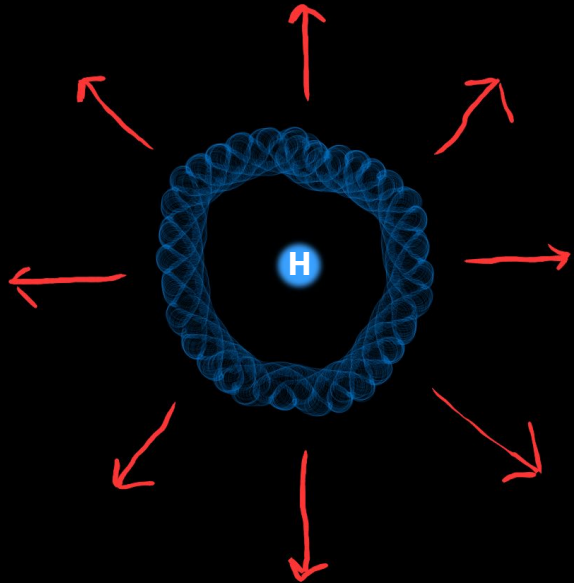


The polarization of Ly α :

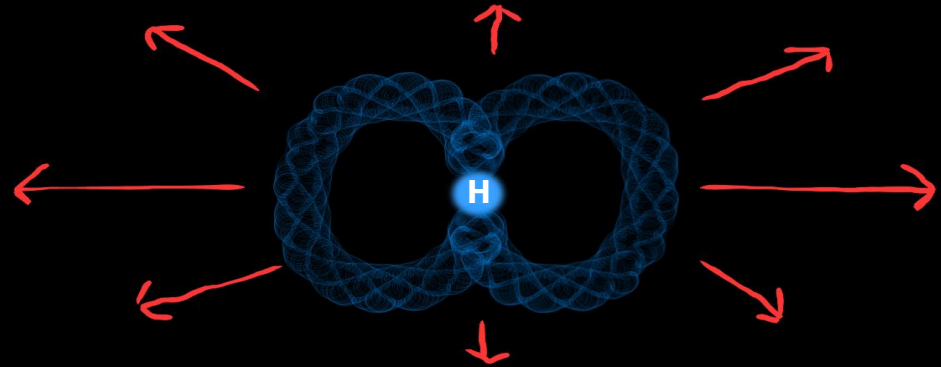
On a photon level:
depending on the type of transition

Ensembles of photons:
a statistical effect

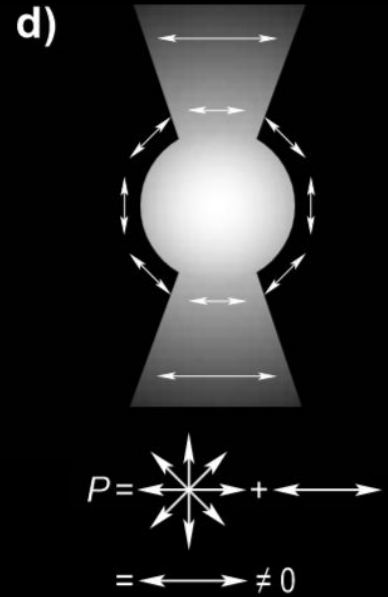
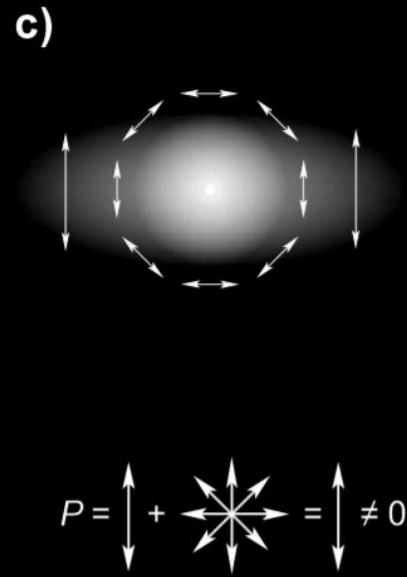
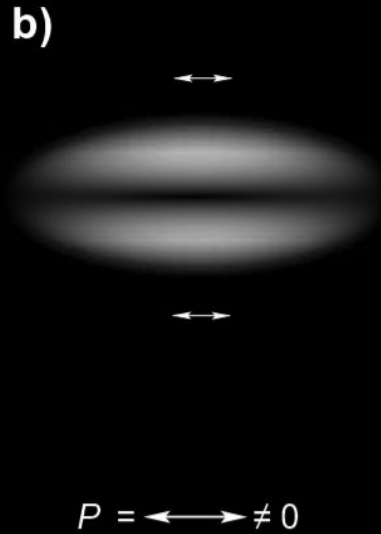
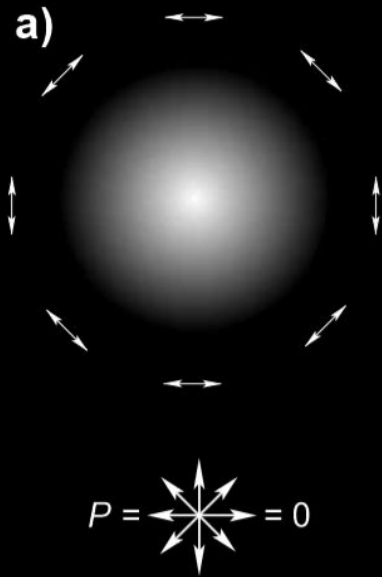
$2P_{1/2}$



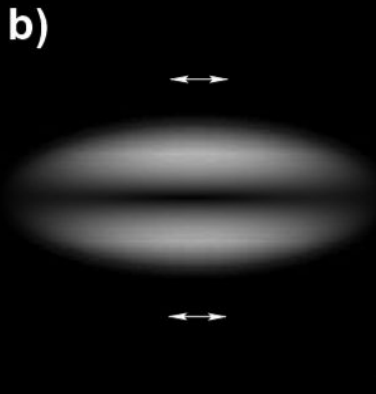
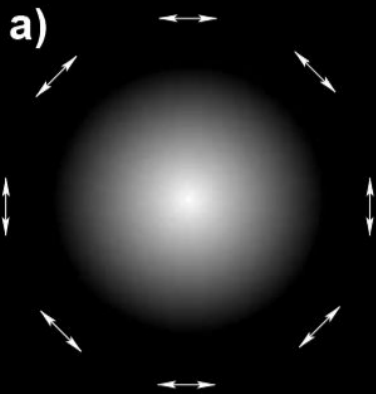
$2P_{3/2}$



*Far from line center: electron behaves as if free:
Dipole scattering (similar directional dep. as $2P_{3/2}$)*

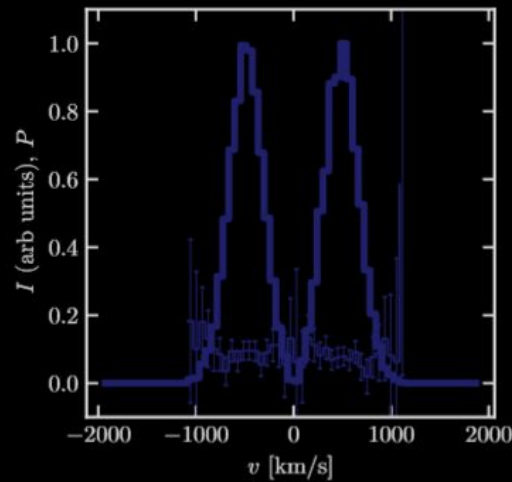
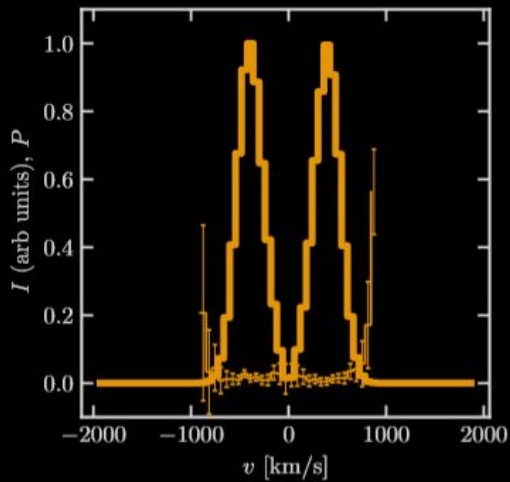


**P reveals
ASYMMETRIES**



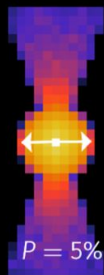
$P = \begin{matrix} \uparrow \\ \downarrow \\ \leftarrow \\ \rightarrow \\ \nearrow \\ \nwarrow \\ \searrow \\ \swarrow \end{matrix} = 0$

$P = \longleftrightarrow \neq 0$



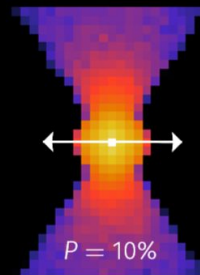
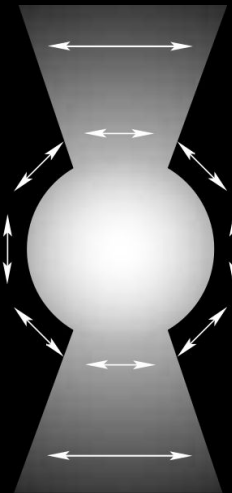
M Eide, M Gronke, M Dijkstra and M Hayes (1802.04280)

P aligns
TANGENTIALLY
to source

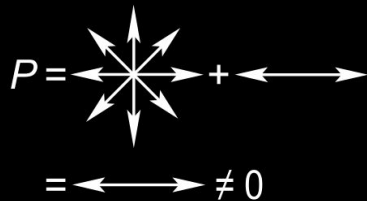
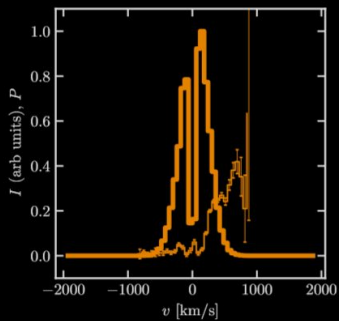


$P = 5\%$

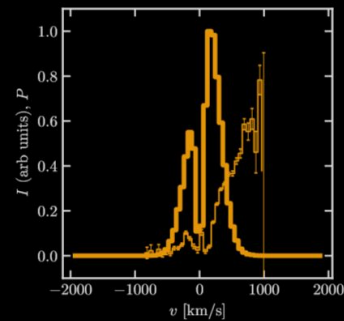
$N_{\text{HI}} = 10^{19} \text{ cm}^{-2}$



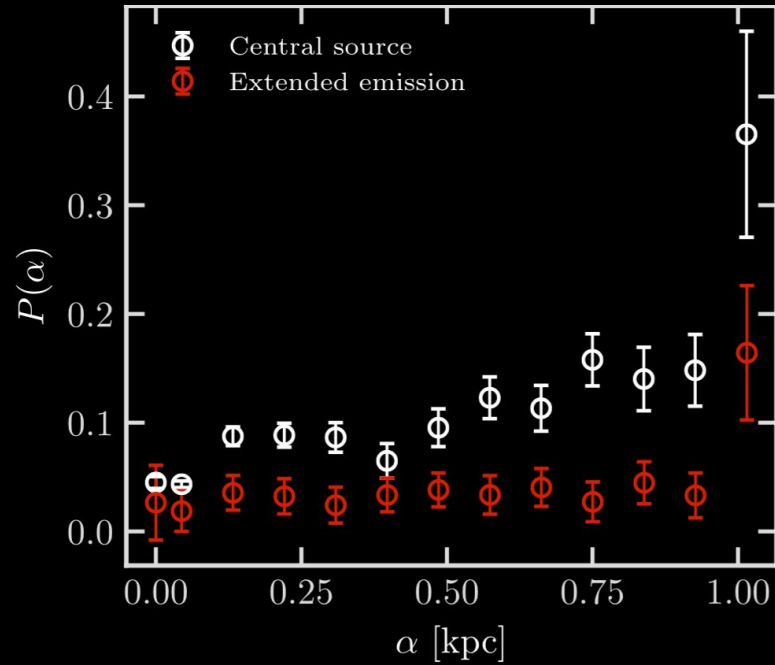
$P = 10\%$



$M, M, M \& M (1802.04280)$



P reveals
EMISSION
mechanism!



LYMAN FUTURE

Spatial Spectra:

Kinematics and geometry along LOS

ISM photons powers CGM

but

ISM photons also escape!

Polarized Spectra:

Scattering

(geometric or kinematic)

asymmetries at frequency

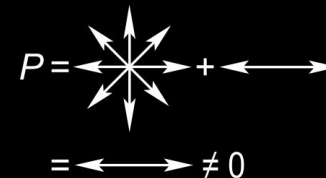
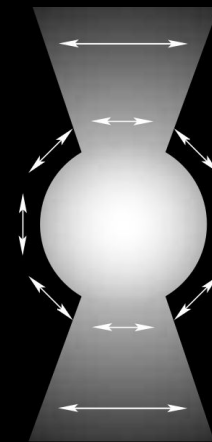
Total Polarization:

Reveals:

Overall asymmetry

Source orientation

Emission mechanism



$N_{\text{HI}} = 10^{19} \text{ cm}^{-2}$

