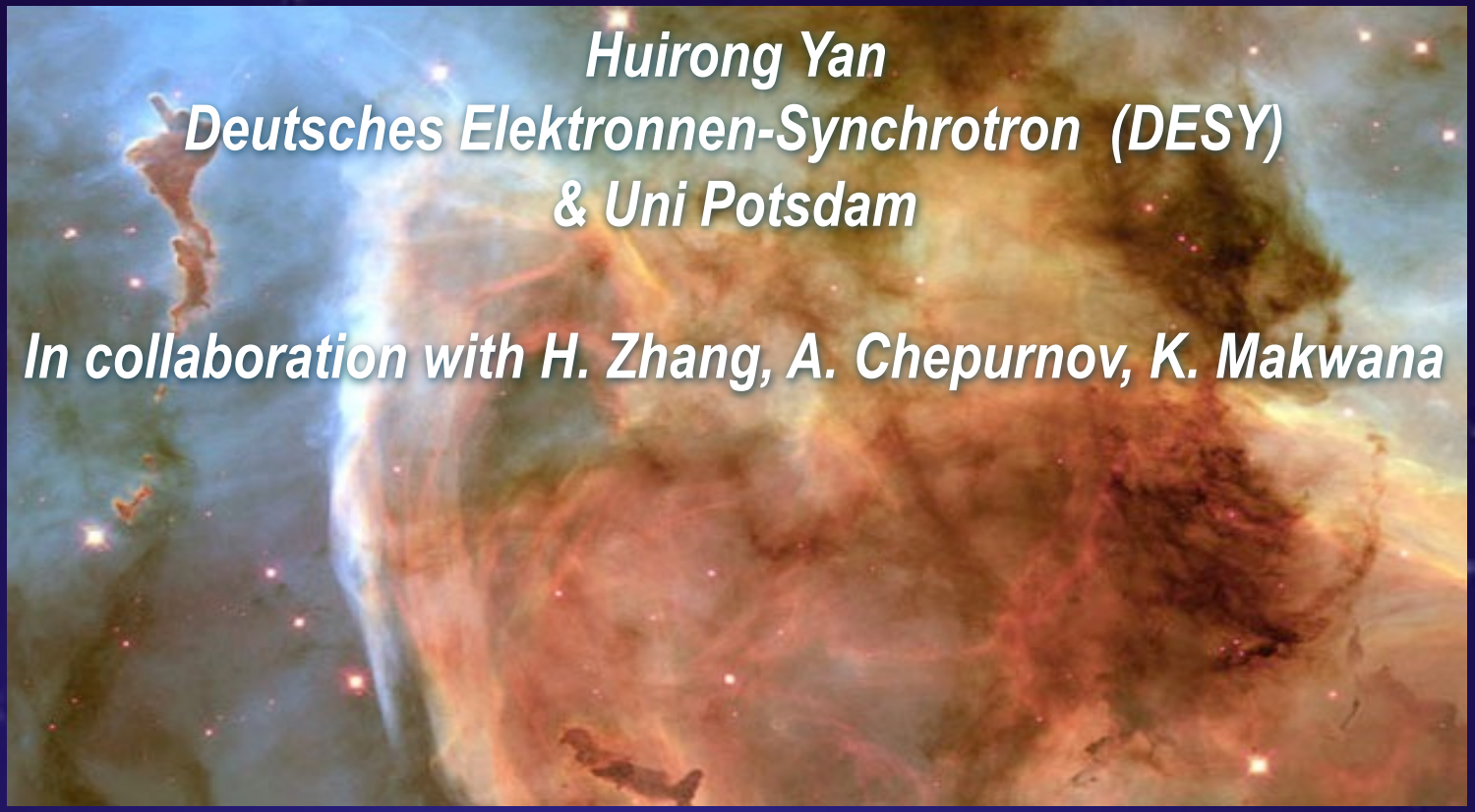
Identification of magnetosonic modes in Galactic turbulence



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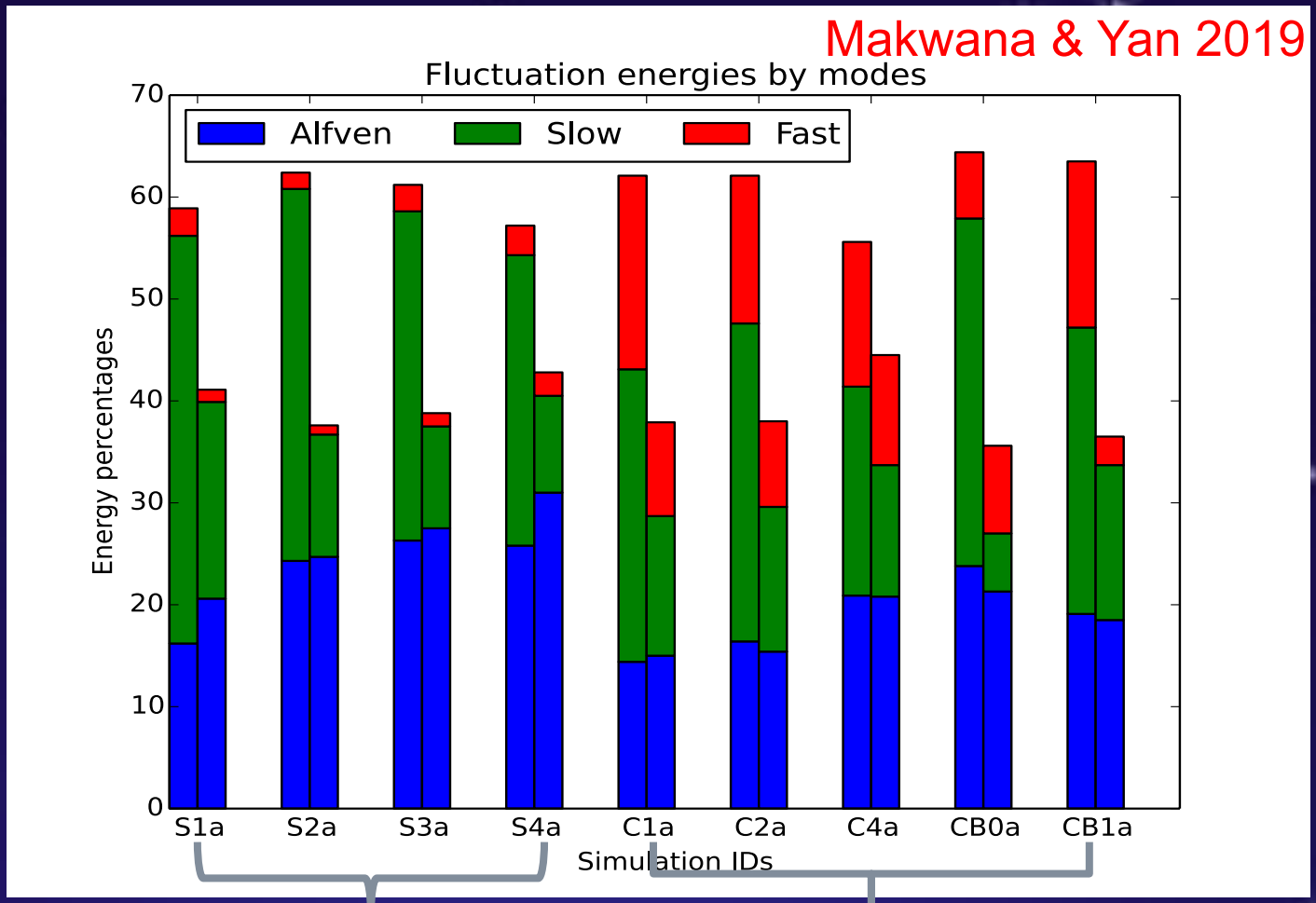
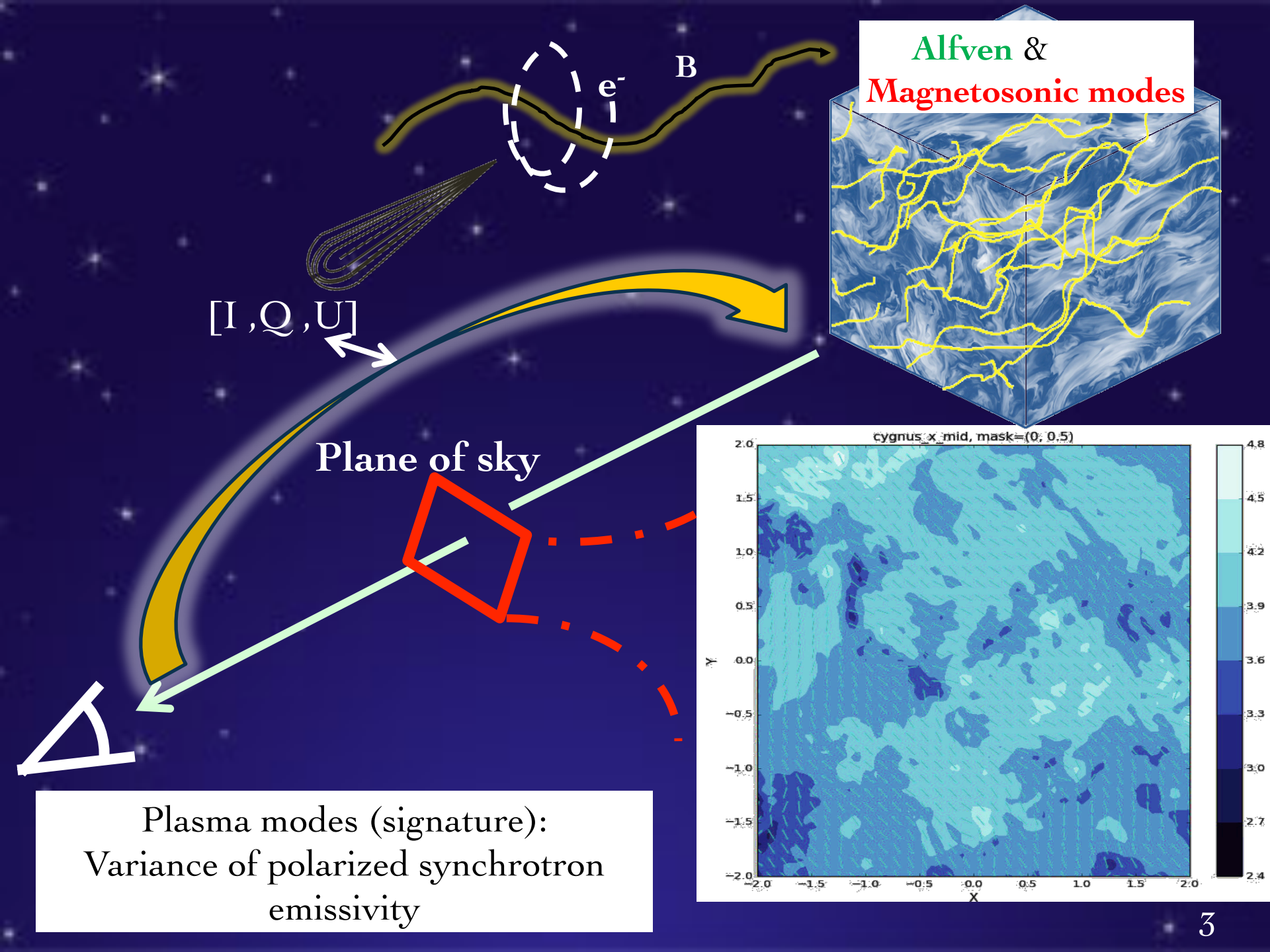
Energy fraction in each plasma modes

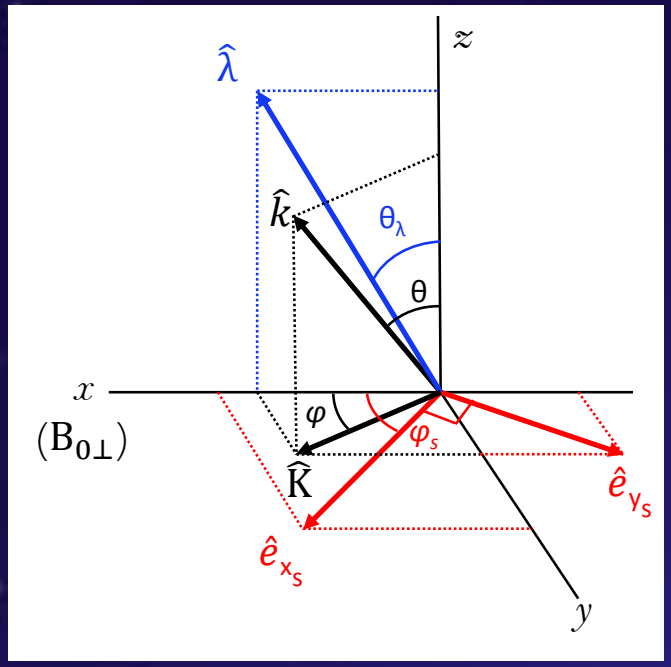


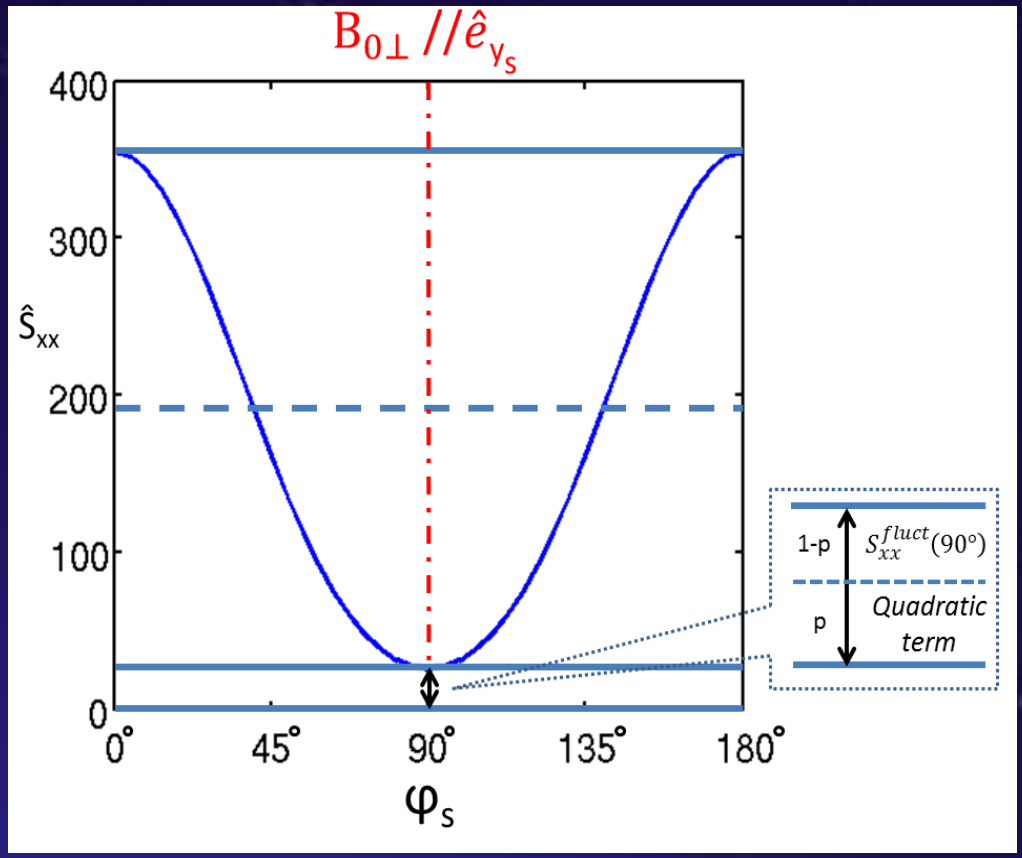
Composition of MHD turbulence depends on driving.



Plasma modes (signature):
Variance of polarized synchrotron emissivity

The expected signature from observations

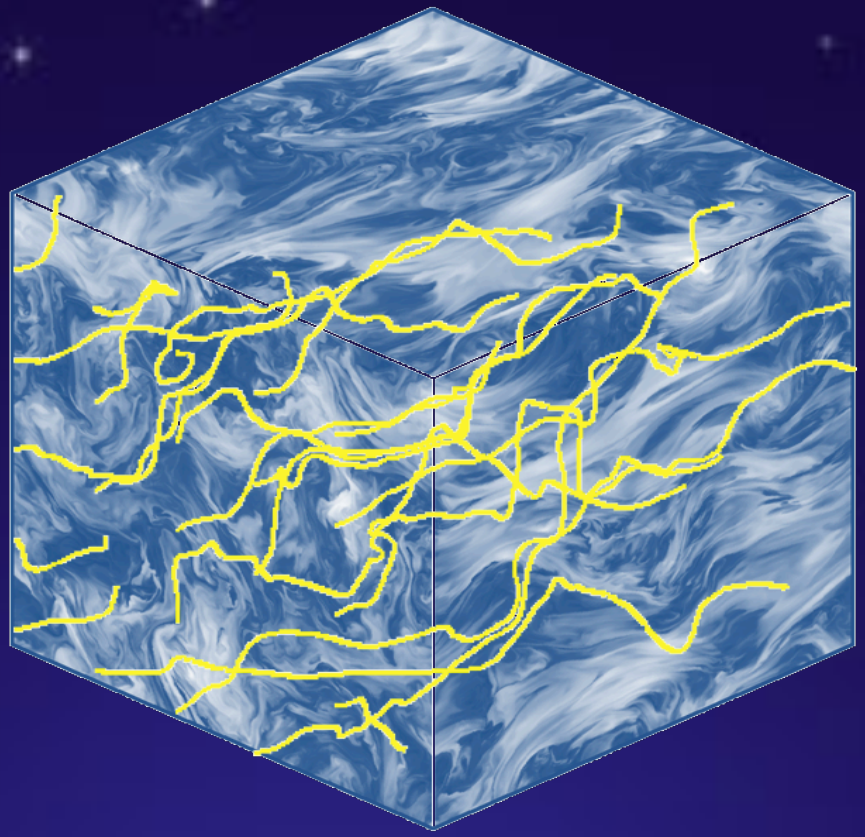




Variance of polarized emissivity I+Q

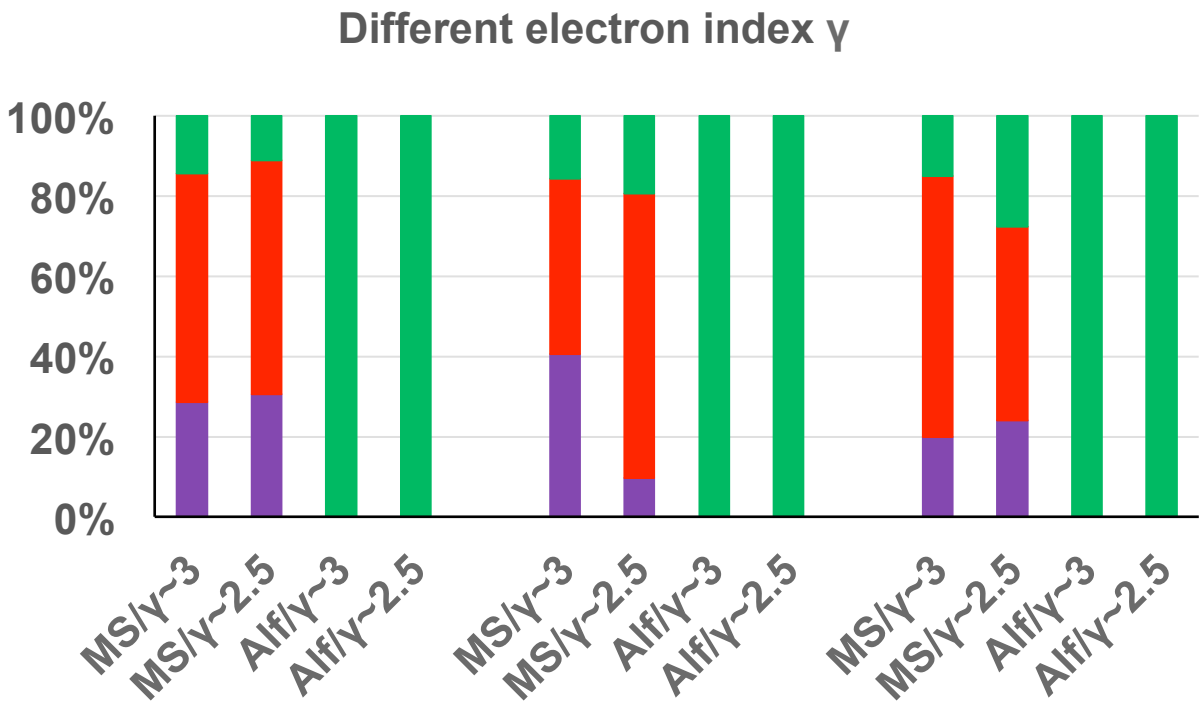
$$S_{xx}(\phi_s) = (a_{xx}\sin^2\phi_s + b_{xx})\cos^2\phi_s,\ r_{xx} \equiv a_{xx}/b_{xx}$$

Synthetic observations through simulated turbulence



Synchrotron polarization maps are generated from ray-tracing from 200 different lines of sight.

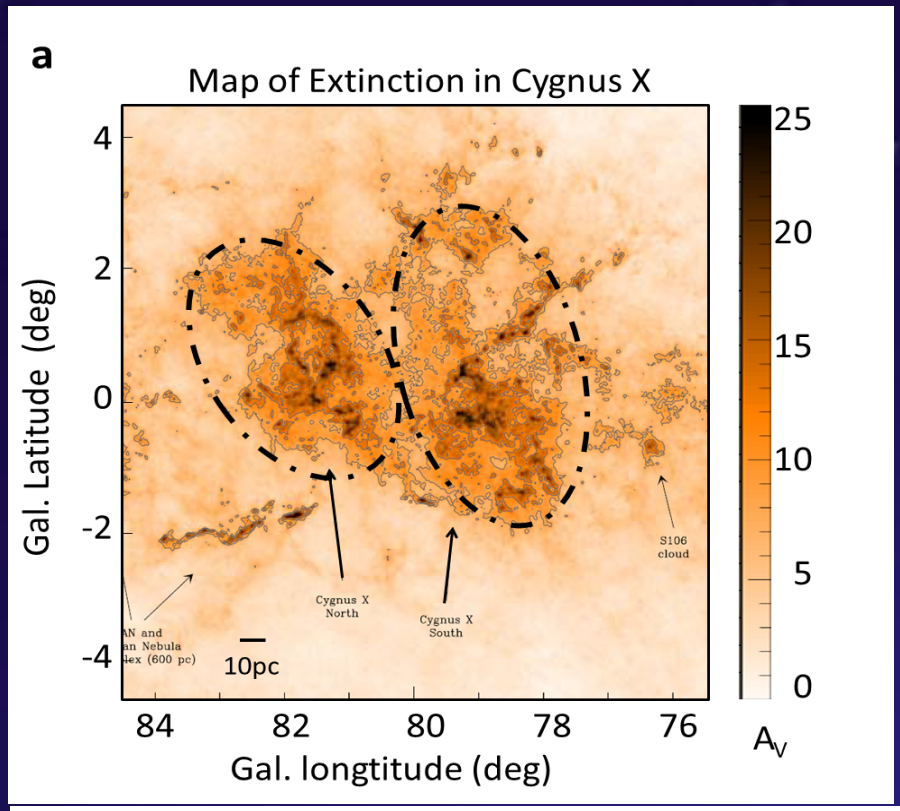
Alfven and MS modes are distinguishable from SPA

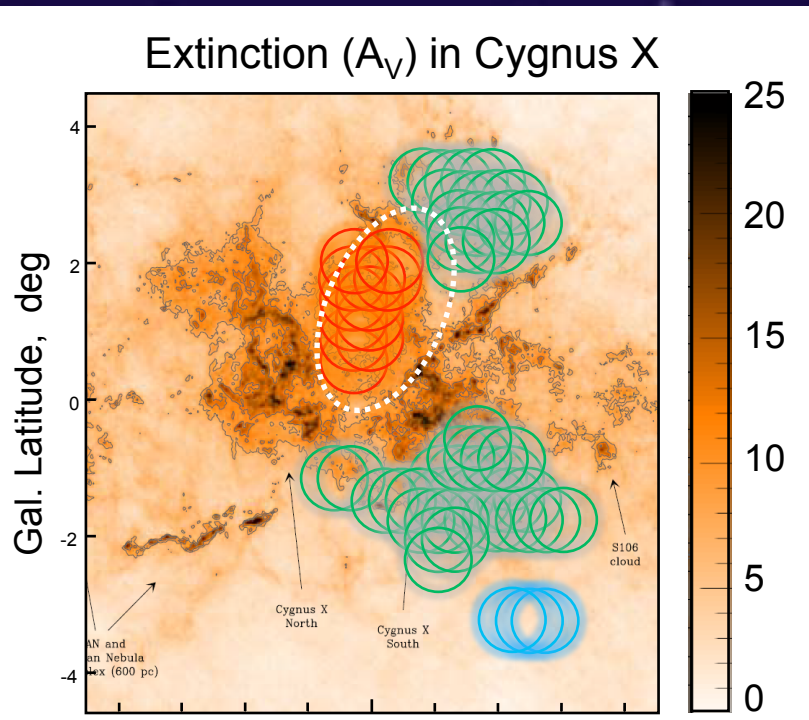


Red: MS signature, green: Alfven signature, Purple: ambiguous

Signatures detected from synthetic data cubes.

Detection of plasma modes in star forming area

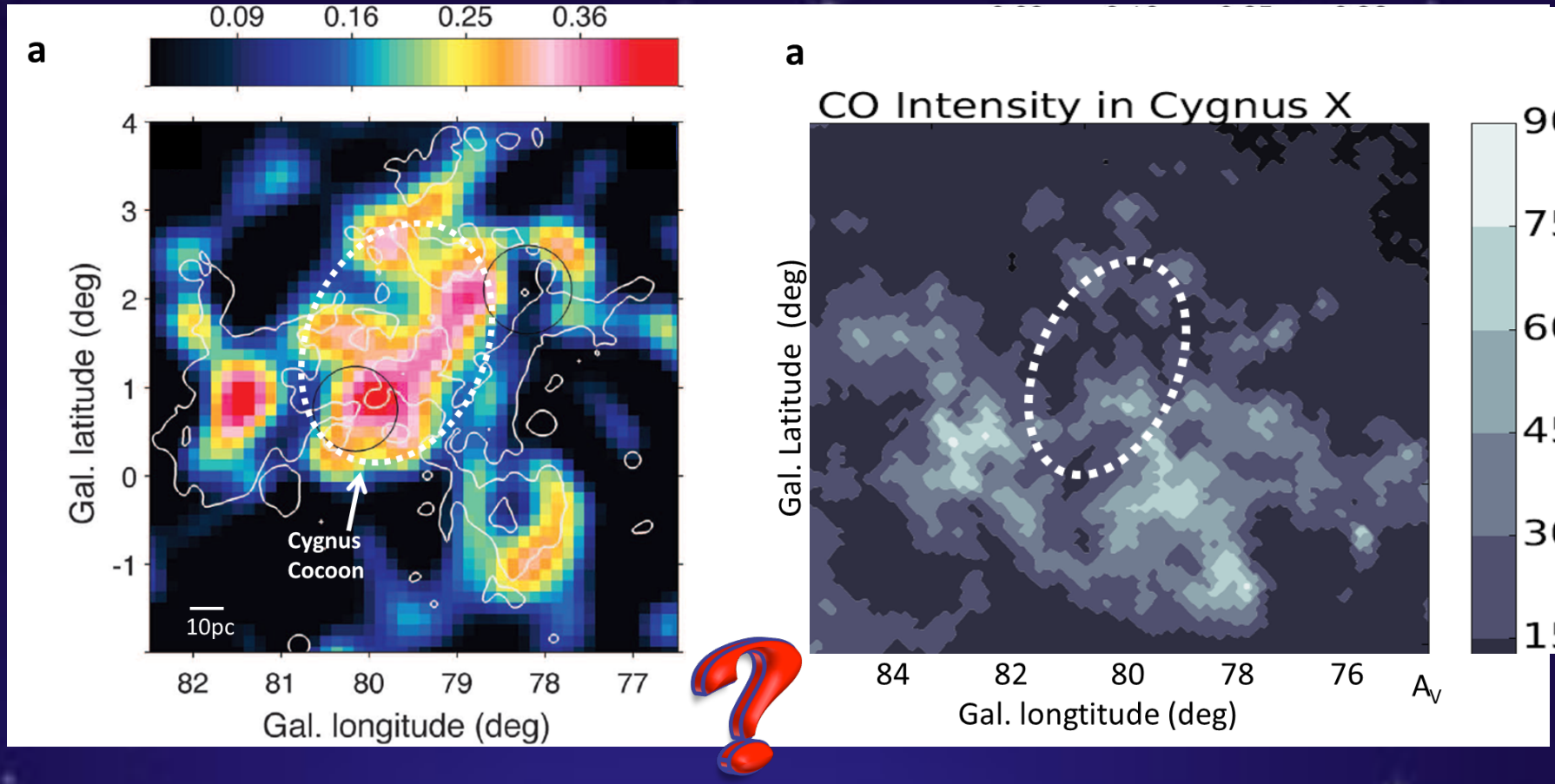




Red spots: MS modes dominant, green spots: Alfven modes dominant, Blue: isotropic turbulence

Synchrotron polarization analysis (SPA) reveals dominant plasma modes and driving mechanism (Zhang, Chepurnov & Yan+ 2020)

Gamma ray emission from Cygnus-X and its comparison with multi-messengers

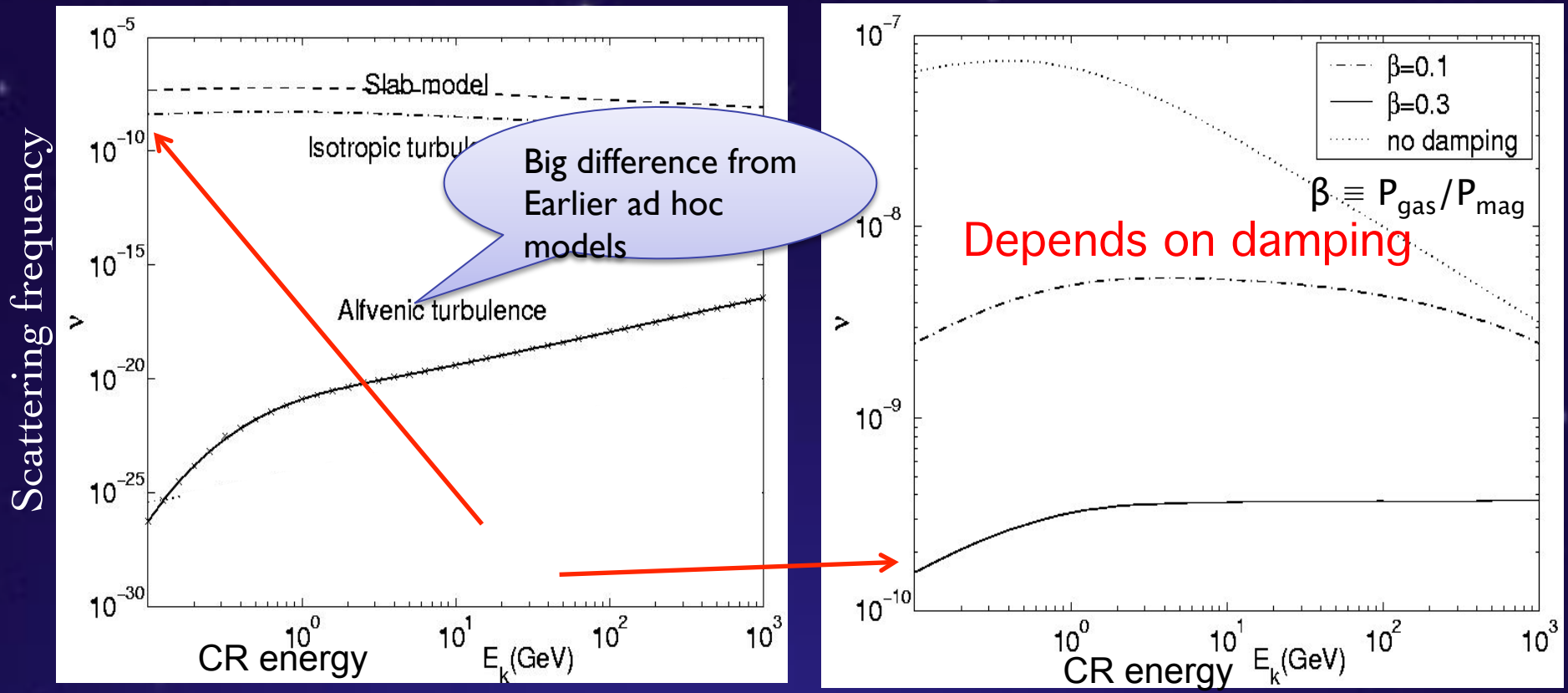


The gamma ray intensity correlates with neither the active star forming area nor the density distribution.

Fast modes dominate CR scattering!

Alfven modes

Fast modes



Alfven modes are useless. Fast modes dominate scattering in spite of damping (Yan & Lazarian 2002, 2004, 2008)

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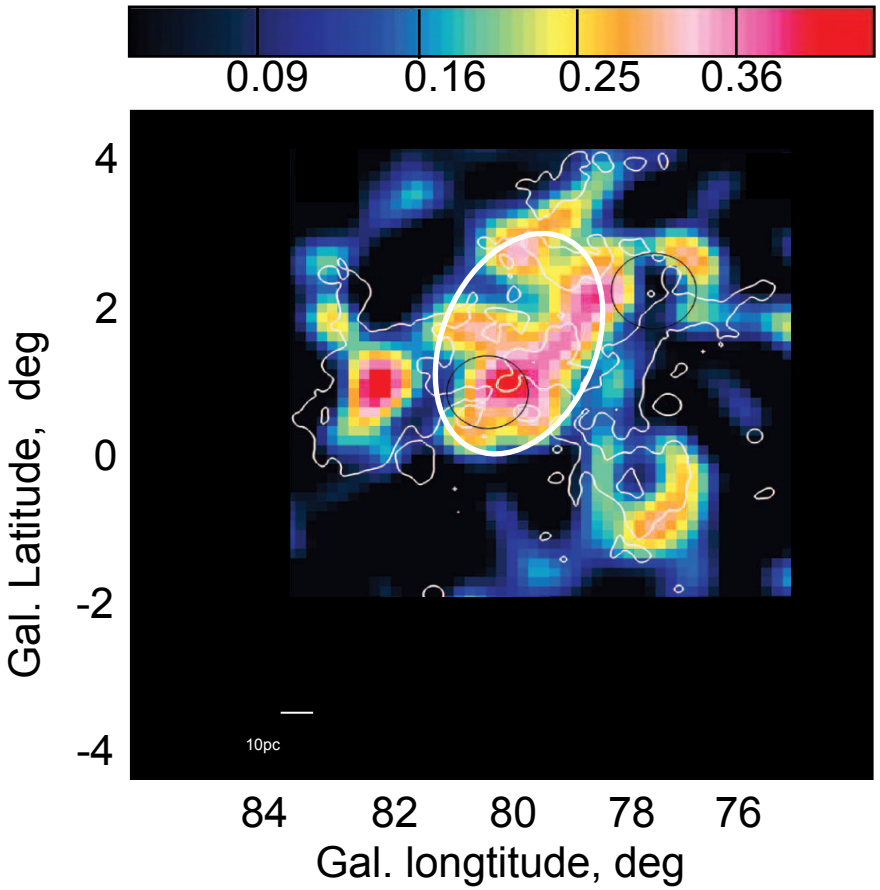
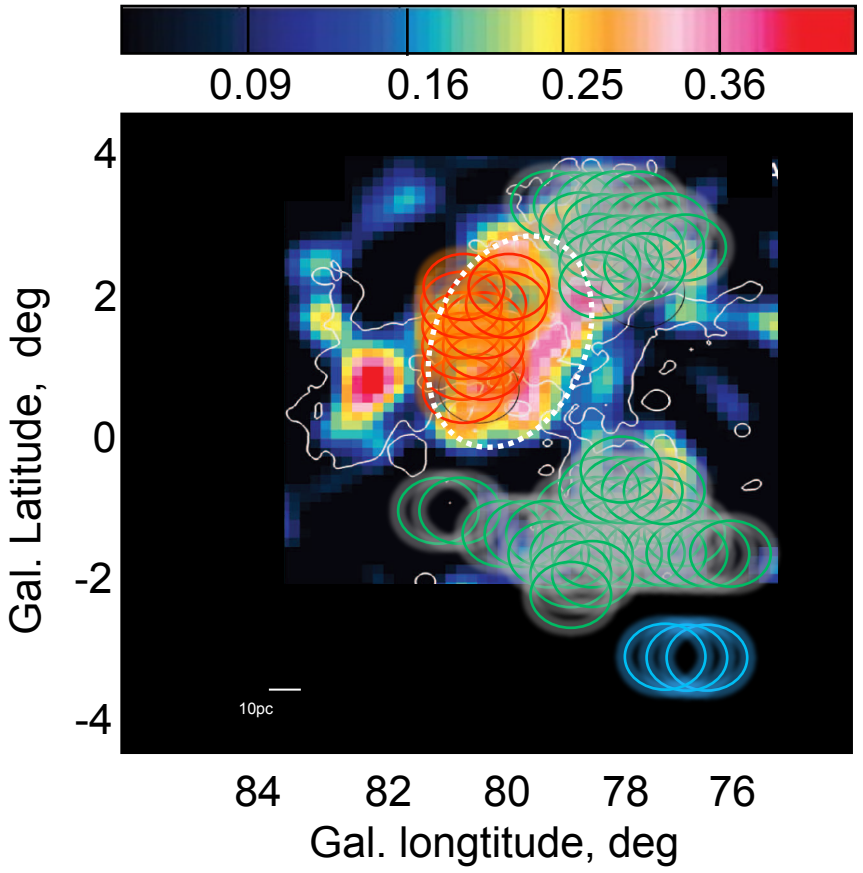
Detected plasma modes overlaid on the Fermi map

γ-ray residual from Fermi-LAT



Cygnus Cocoon vs plasma modes



The MS modes overlaps the Cygnus with a high degree consistency, completely in line with the theory (Zhang et al. 2020)

Summary

- The composition of MHD turbulence depends on the driving mechanism. Alfven modes dominate in the case of solenoid driving, whereas MS modes prevail with compressible driving.
- **Magneto-sonic modes are observed** for the first time in ISM.
- The intense diffuse γ-ray emission regions are **only** seen in MS modes dominant region, completely in line with the theoretical prediction on the dominant role of MS modes on CR transport.
- Both Alfven and MS modes are detected in star-forming area and SNRs.
- **Synchrotron Polarization Analysis (SPA)** is a powerful technique to identify turbulence modes distribution in the Galactic medium.