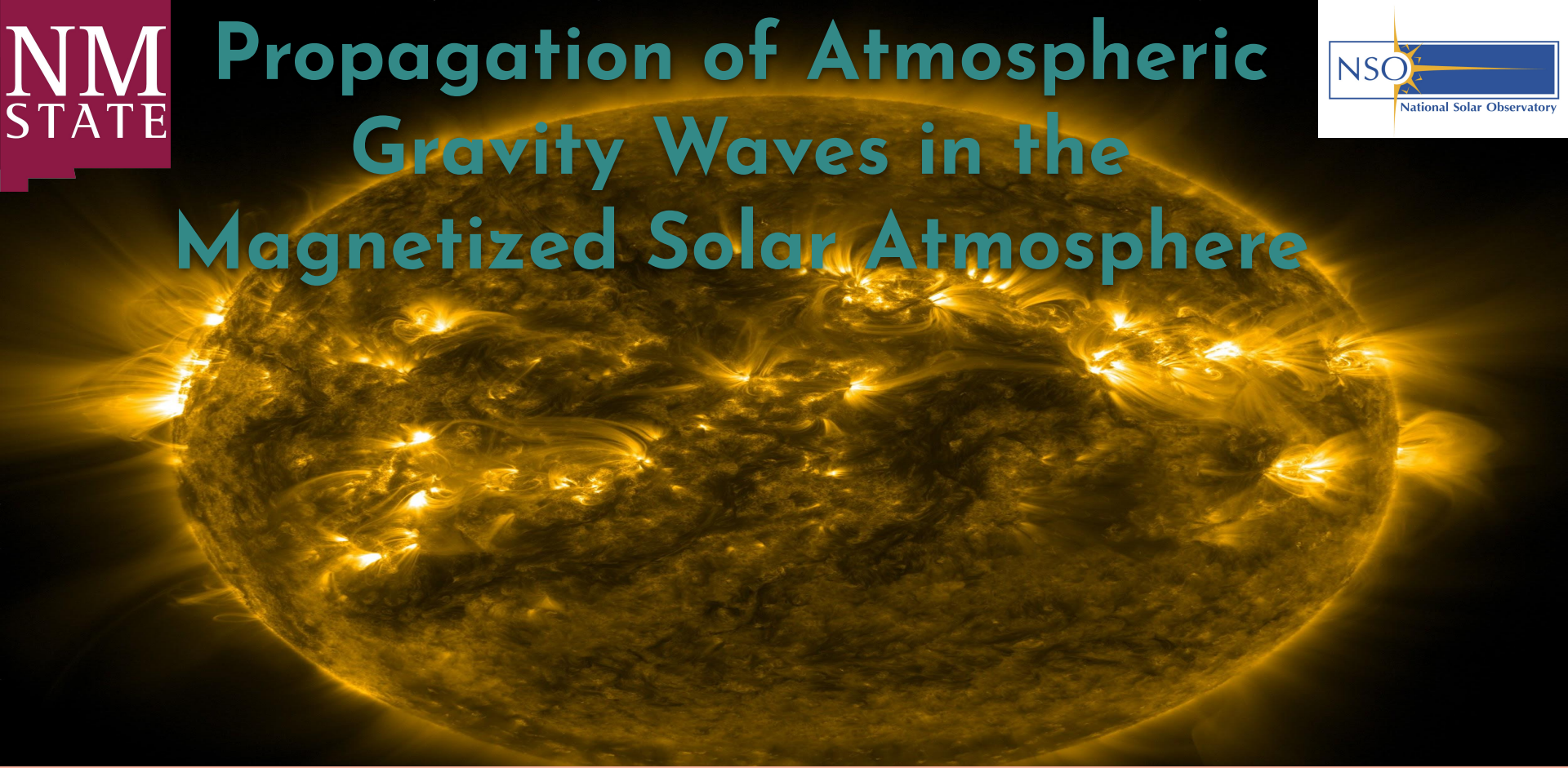
NM STATE

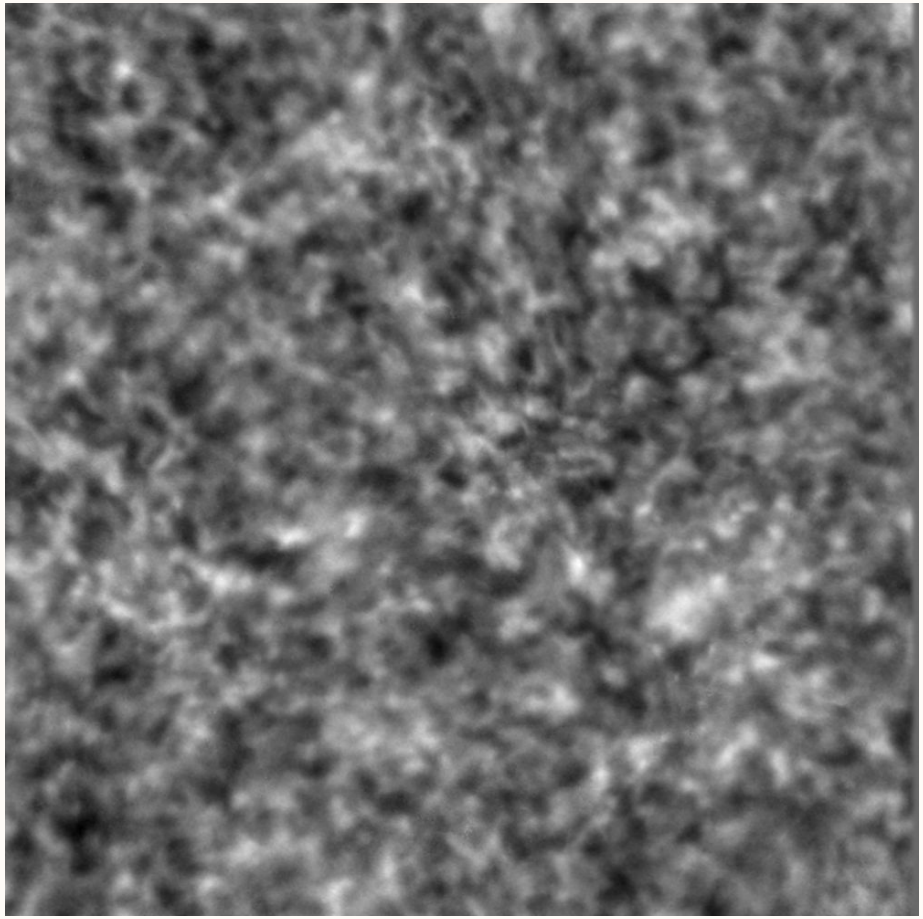
Propagation of Atmospheric Gravity Waves in the Magnetized Solar Atmosphere

NSO National Solar Observatory

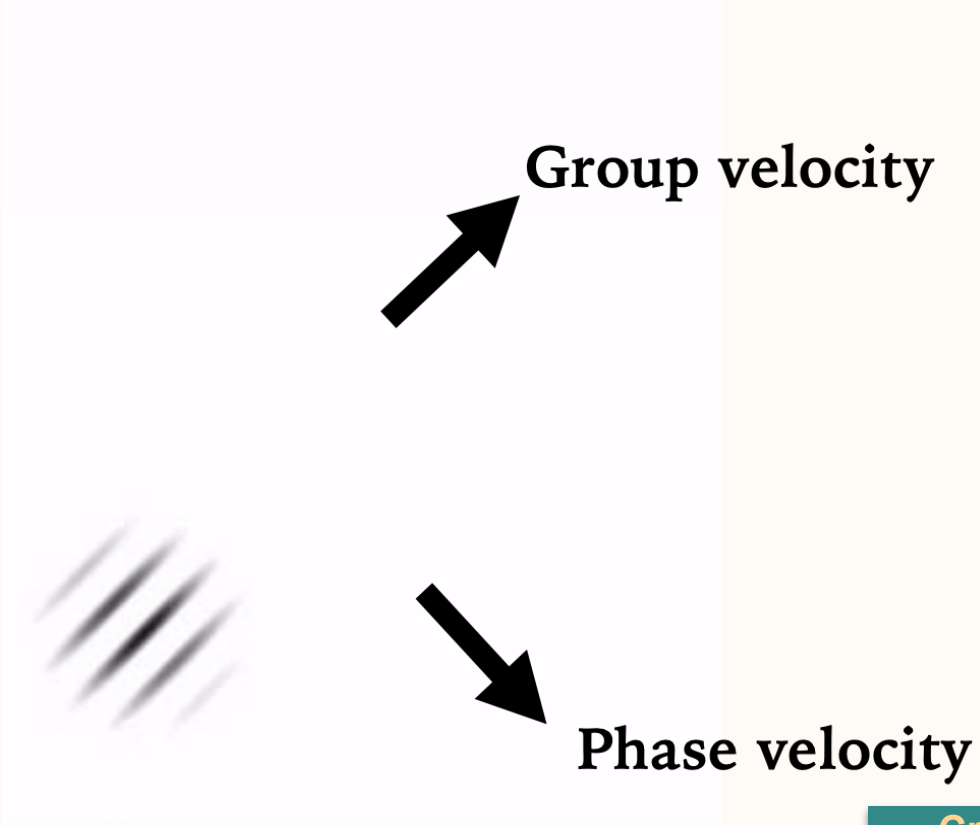


Oana Vesa, Jason Jackiewicz, & Kevin Reardon

- Comprehensive study on the behavior of atmospheric gravity waves (AGWs)
- Waves provide atmospheric & magnetic field diagnostics
- Mechanism for heating the upper atmosphere
- Excited by turbulent convection below surface

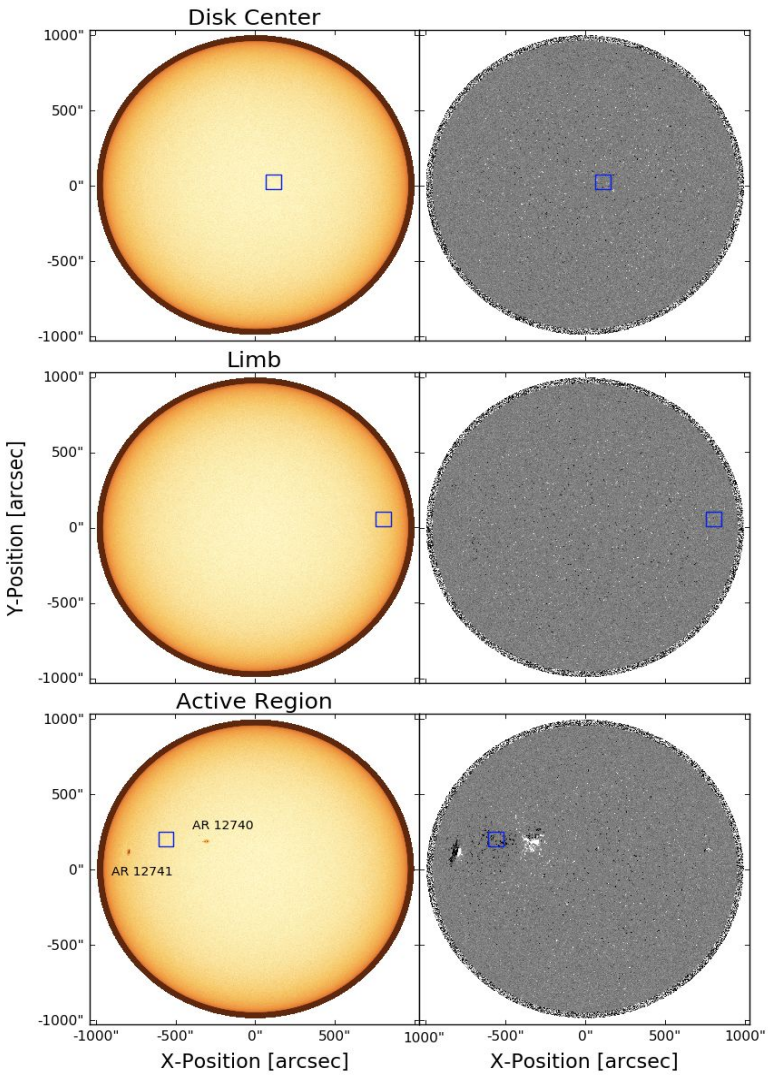


- Long period, low frequency waves
- Group and Phase velocities are orthogonal
  - Group velocity carries energy



Credit: G. Vigeesh

- IBIS: Fabry Perot Interferometer Imaging Spectropolarimeter
  - AO
  - Fe I 7090, Fe I 5434, K I 7699, Ca II 8542
- SDO space based data
  - Fe I 6173, AIA 1600, AIA 1700
- Multi-height observations
  - From 150 km to > 1000 km
- Different locations on the Sun



25 April 2019

Spectral Data

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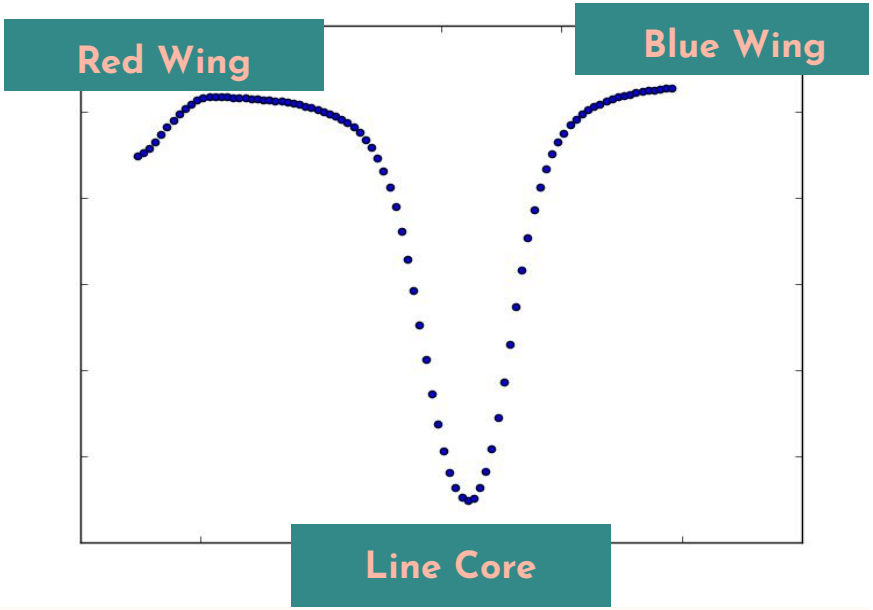
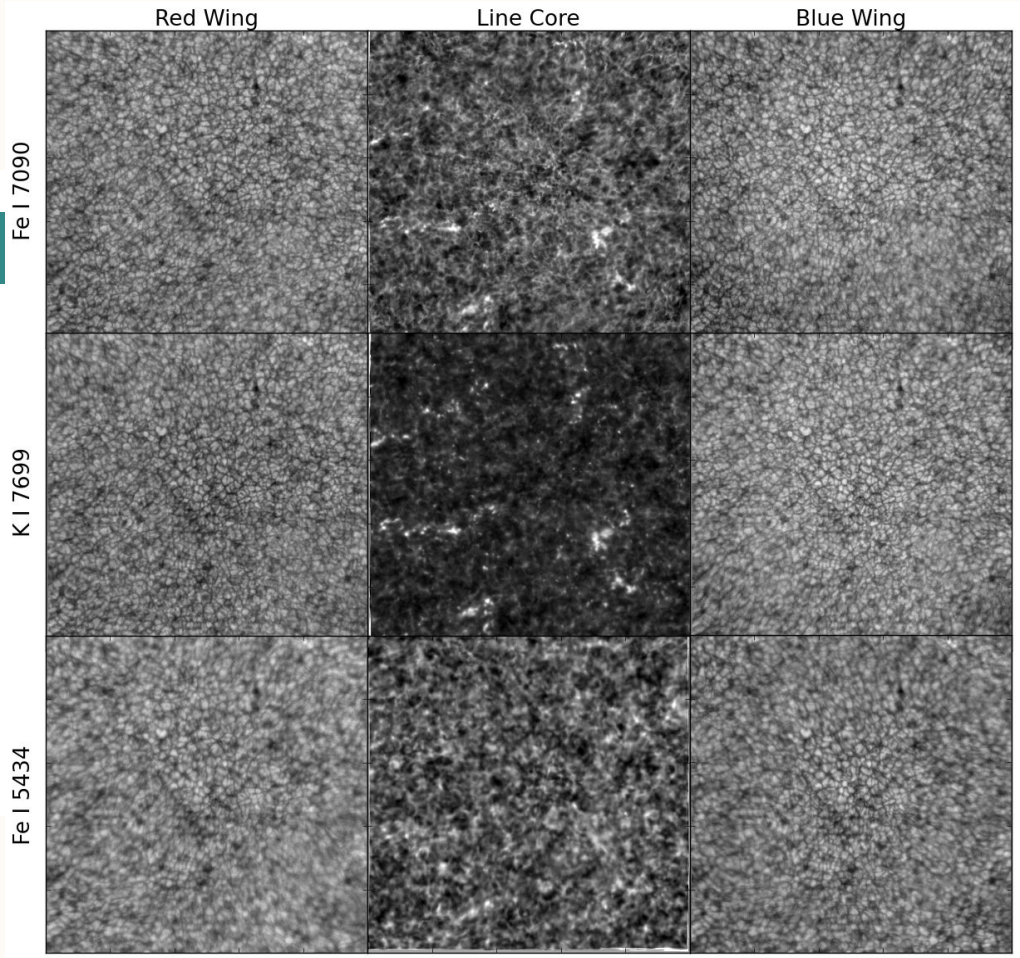
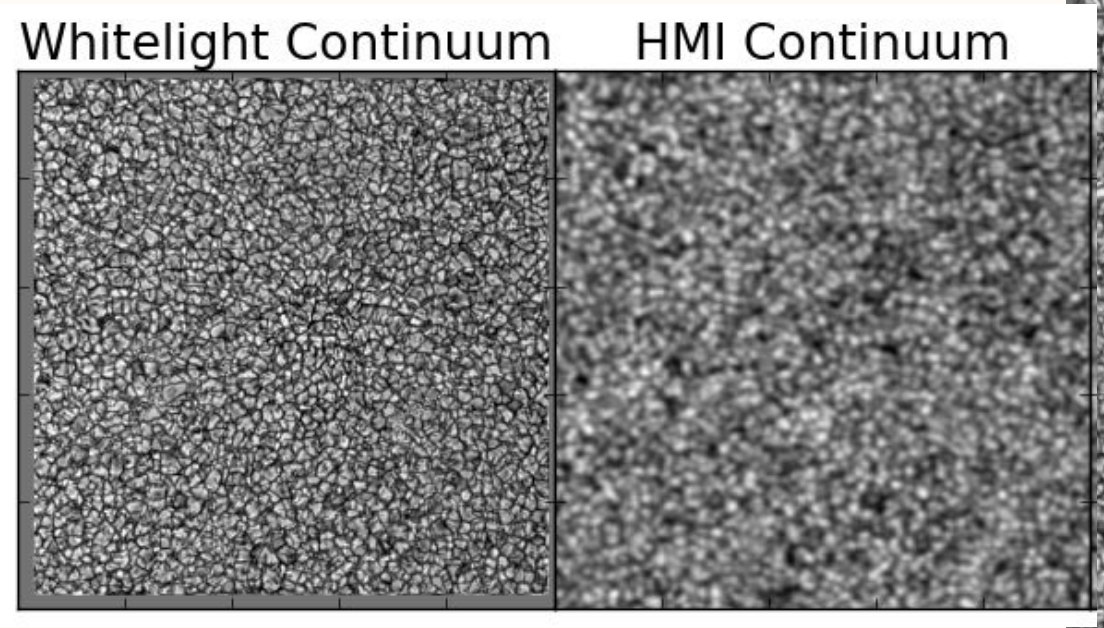
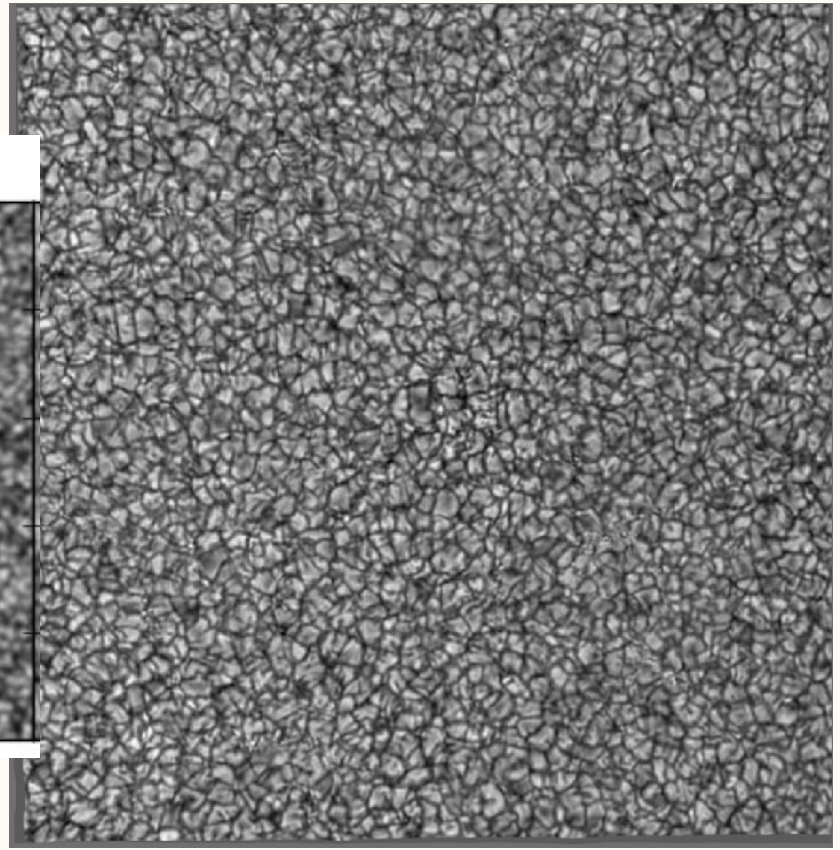




25 April 2019



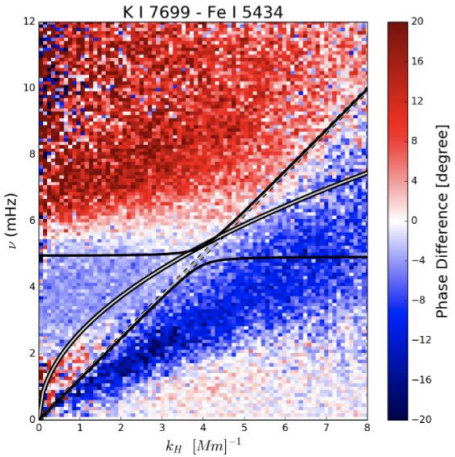


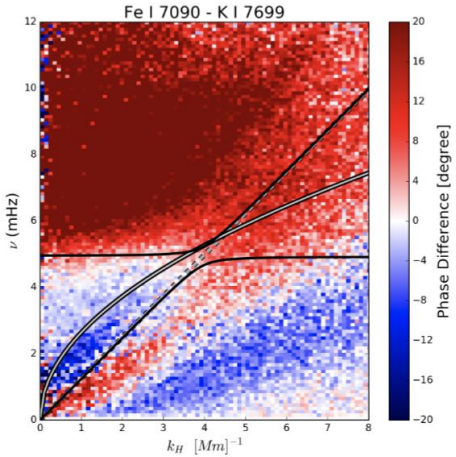
Velocity - Velocity Phase Spectra

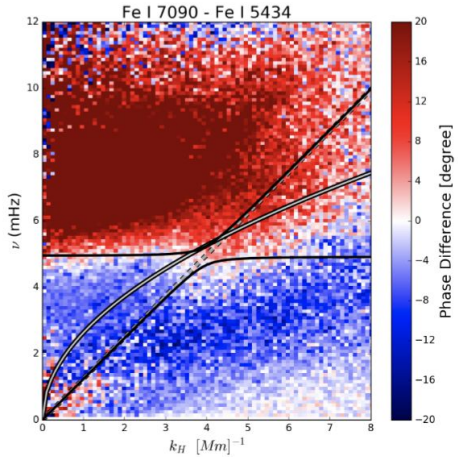
Δz = ~100 km
Upper photosphere

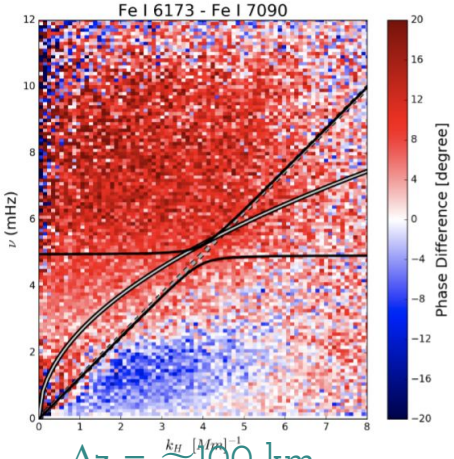
Δz = ~220 km

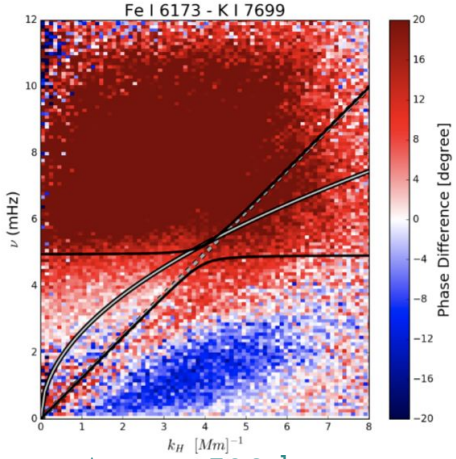
Δz = ~320 km

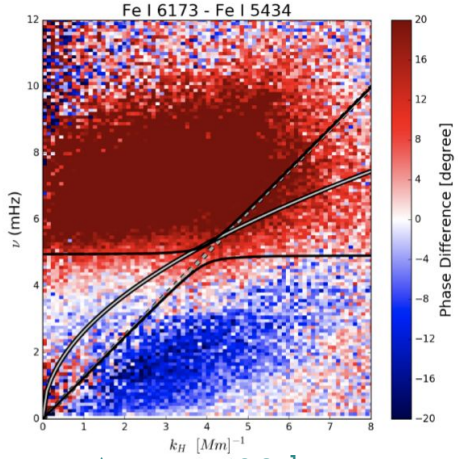












Δz = ~100 km
Lower photosphere

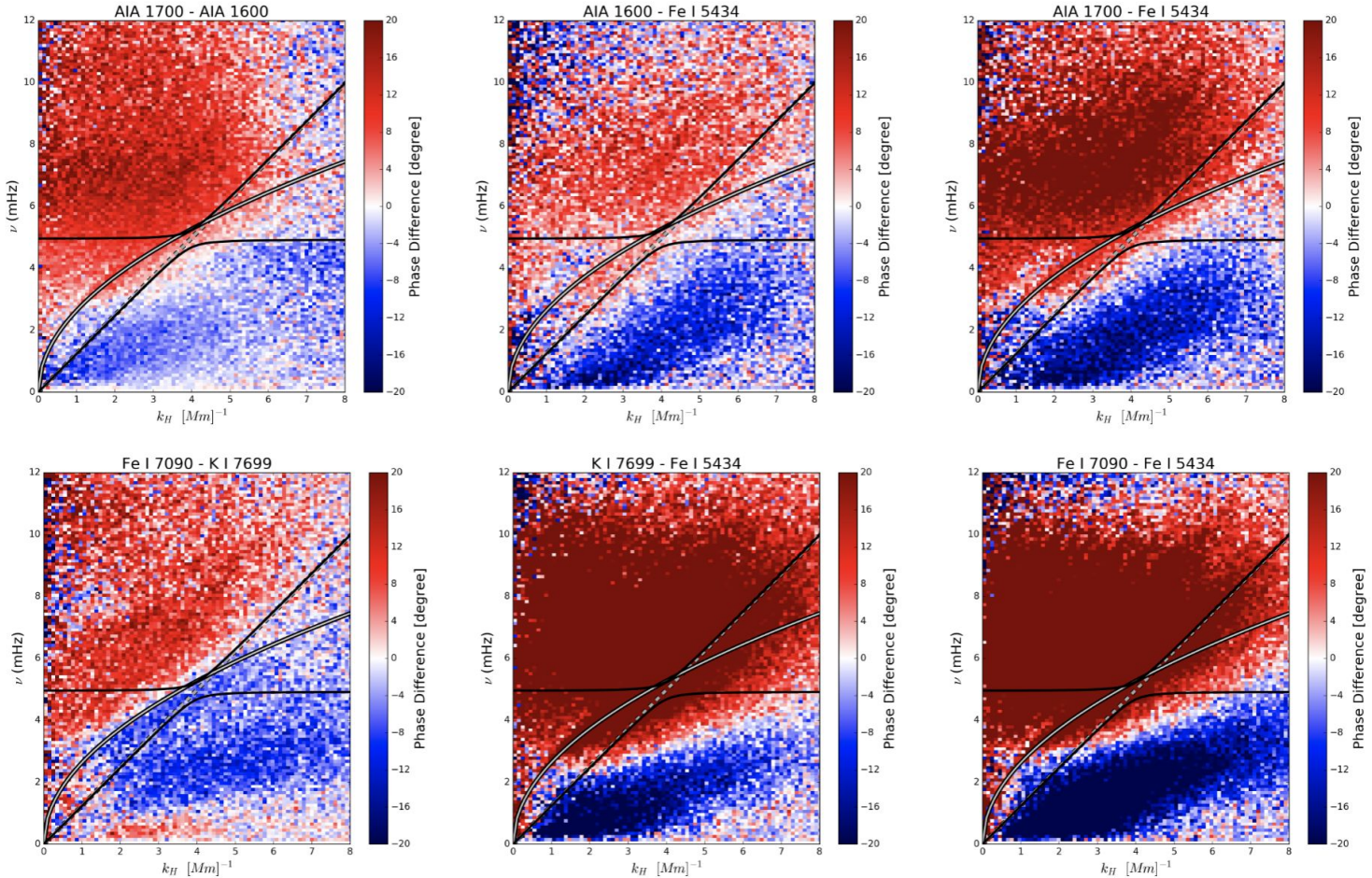
Δz = ~320 km

Δz = ~420 km

- AGW: lower curve
- Acoustic Waves: upper curve
- Negative phase differences (blue): upwardly propagating AWGs
- Pinpoint Height of Formation
  - Fe I 5434 > K I 7699 > Fe I 7090 > Fe I 6173

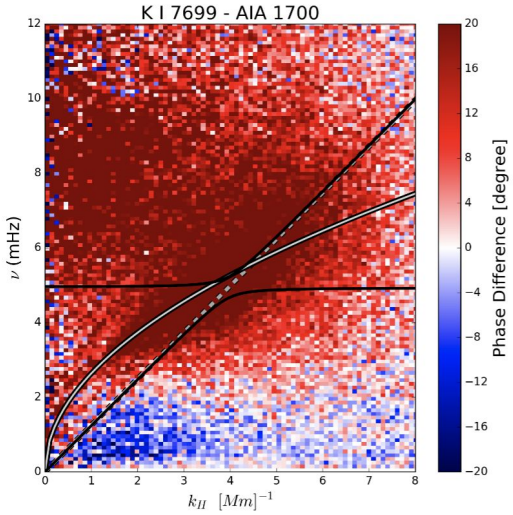
Δz = 70 km
Upper photosphere

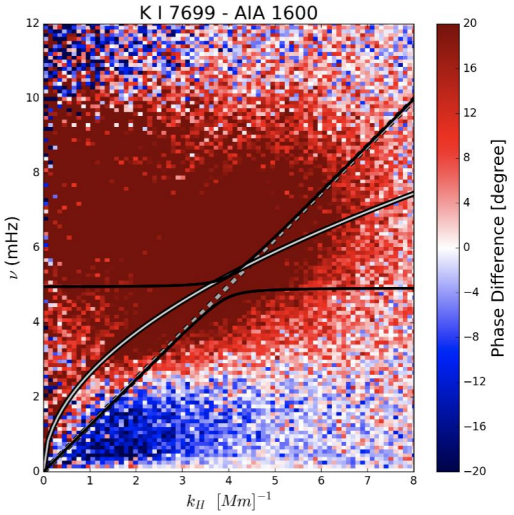
Δz

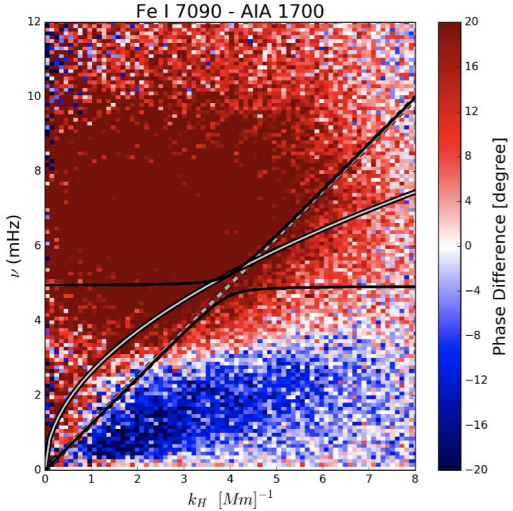


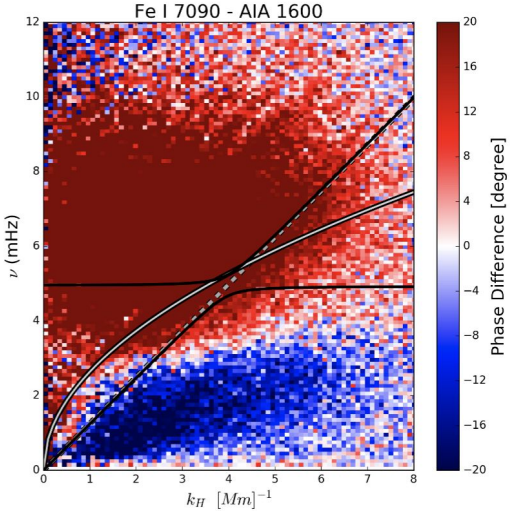
Lower photosphere

- Larger phase differences
- F-mode signal is strong
- AIA 1600 & AIA 1700 form at 430 and 360 km.









- KI 7699 forms at ~200 km
  - NLTE effects
- Pinpoint Heights of Formation
  - Fe I 5434 > AIA 1600 > AIA 1700 > K I 7699 > Fe I 7090

Conclusions

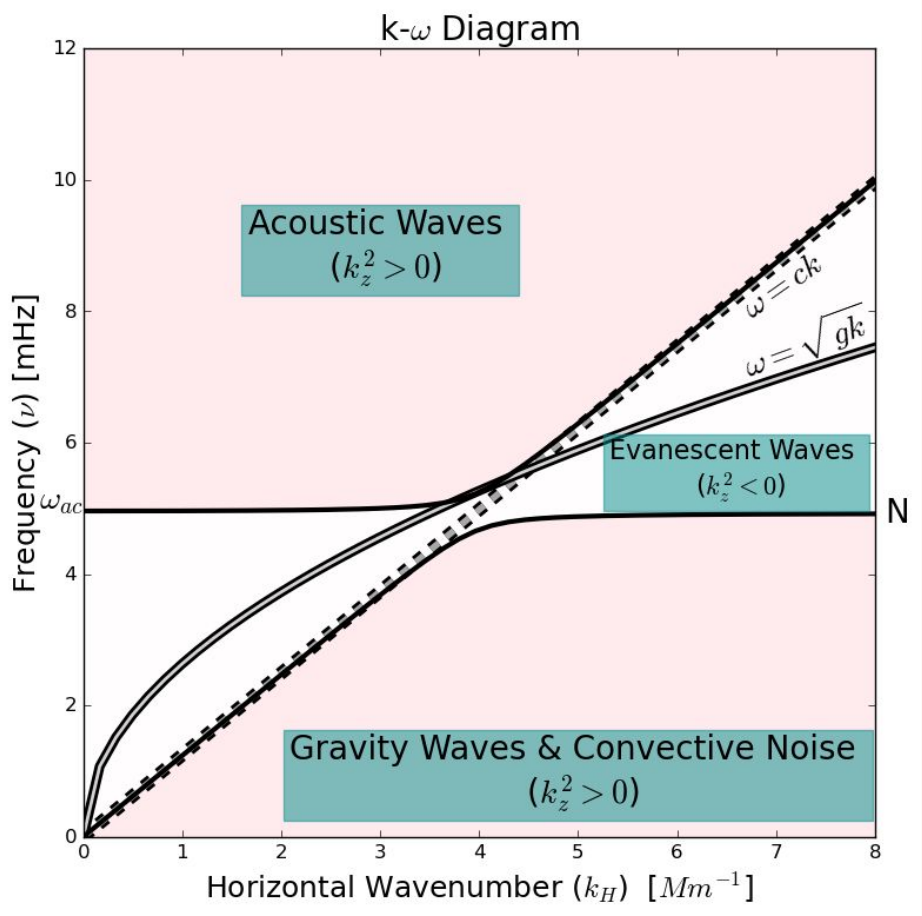
- Detect propagating AGWs at disk center in both V-V & I-I phase spectra
  - As high up as ~500 km
- Determined relative formation heights
- Significant signals in intensity data
- Strong f-mode signal in intensity data

Future Work

- Limb and Active Region (AR 12740 & 12741) datasets in the reduction process
  - Never explored areas for gravity waves
  - Explore horizontal velocities
  - Explore behaviors in more magnetic environments
- MCMC to fit hard to observe atmospheric parameters

Questions?

Credit: NSO/NSF/AURA

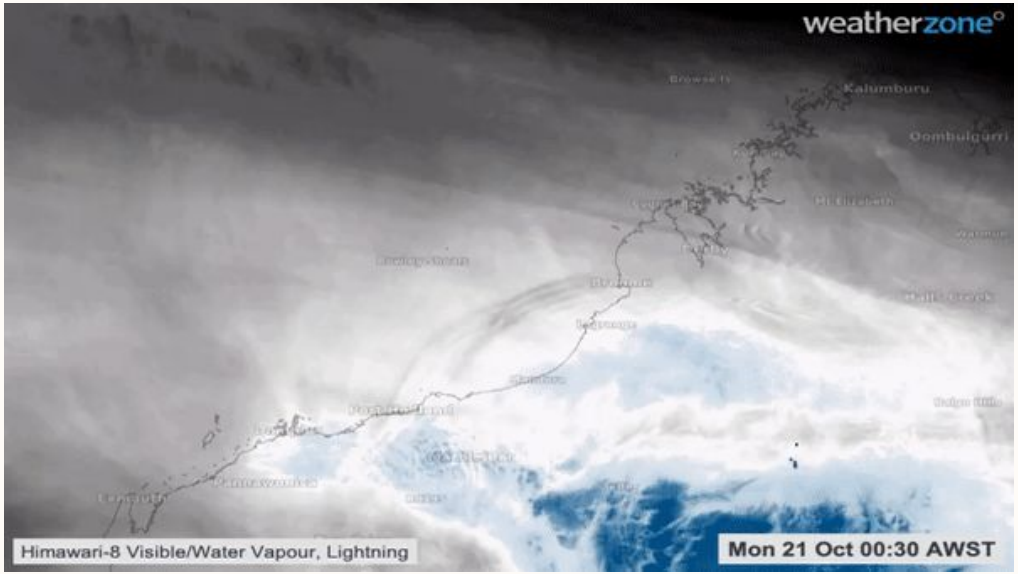


Wave Dispersion Equation

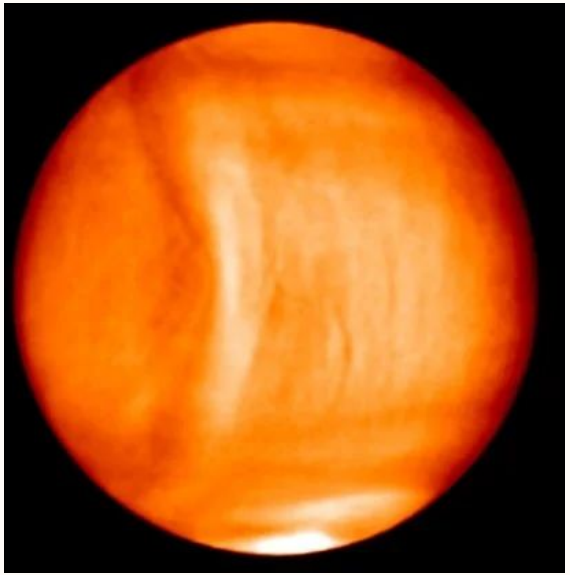
$$k_z^2 = \frac{\omega^2 - \omega_{ac}^2}{c_s^2} - \frac{(\omega^2 - N^2)k_h^2}{\omega^2}$$

Brunt-Väisälä frequency

$$N = \sqrt{-\frac{g}{\rho}\frac{\partial \rho}{\partial z}}$$

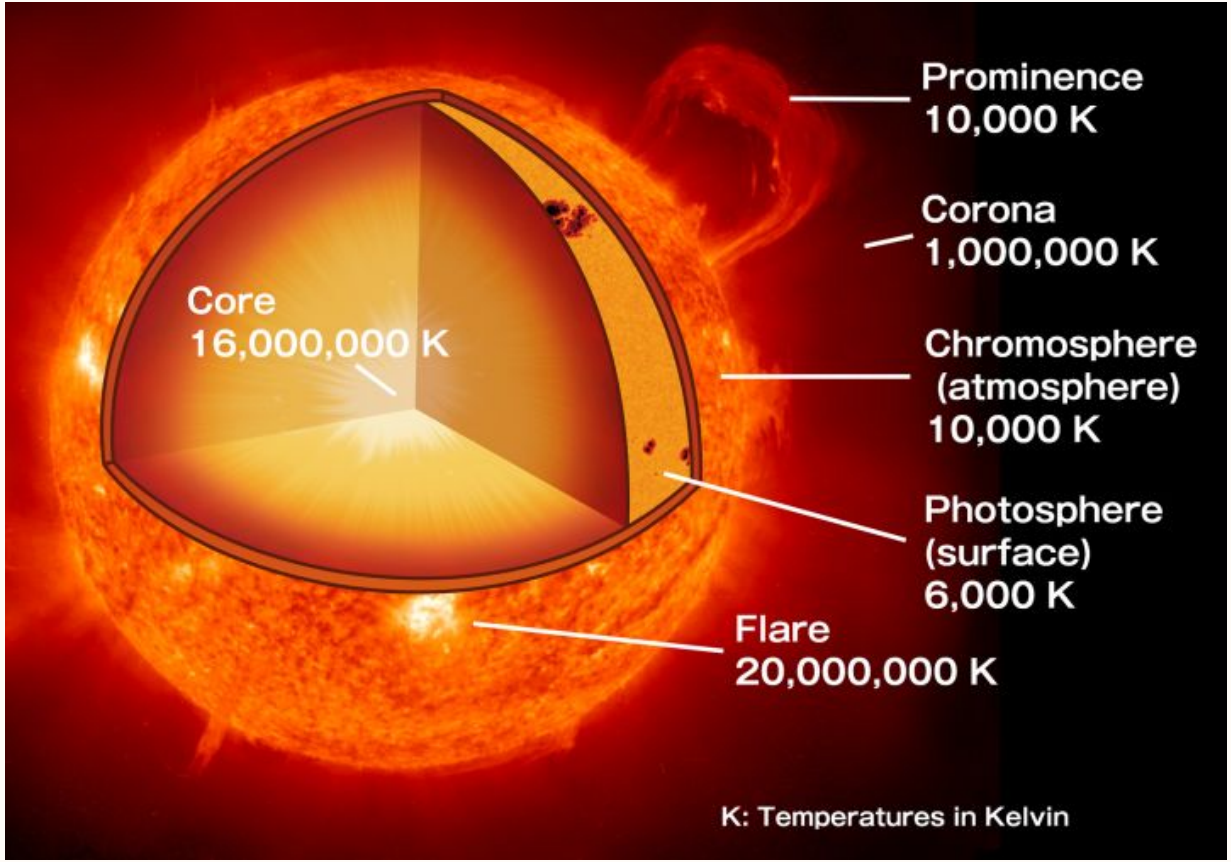


Credit: Weather Zone



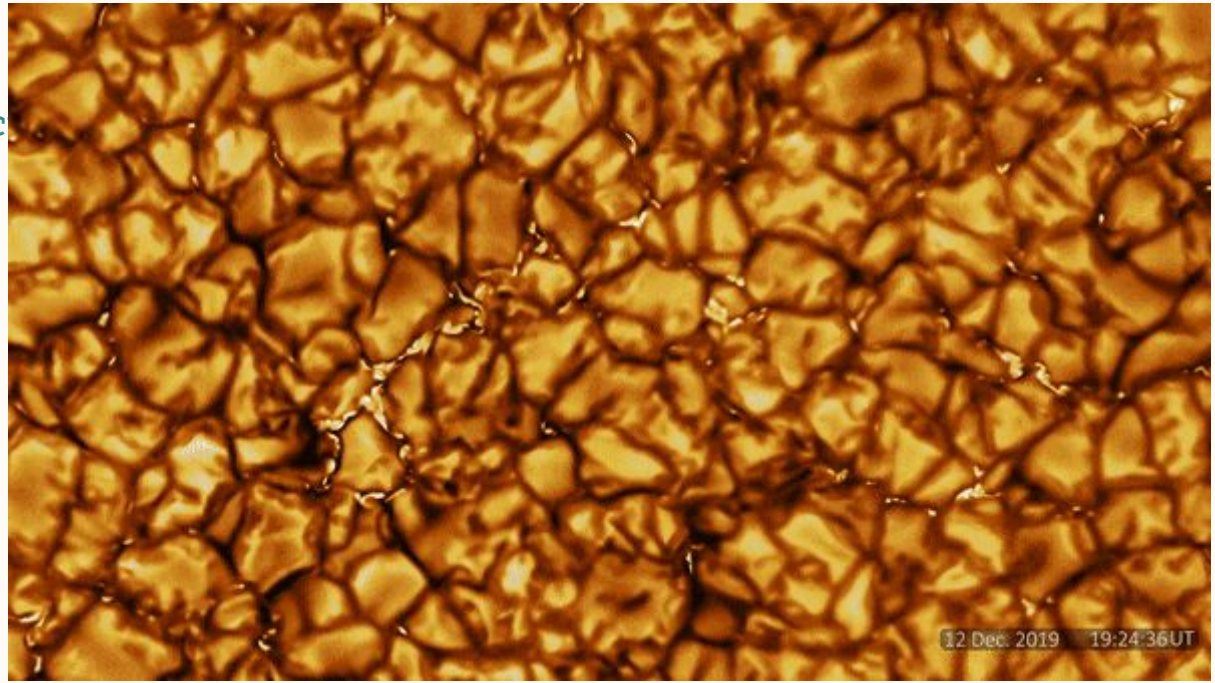
Atmospheric Gravity Waves on Venus.

Credit: JAXA



Credit: NASA/TRACE

- Stably stratified medium
- Excited by turbulent convec
- Restoring force: buoyancy
- Propagate horizontally and



Credit: NSO/NSF/AURA