Effects of Magnetic Drag on Doppler Shifts of High Resolution Emission Spectra of Ultrahot Jupiter WASP-76b
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Abstract

Background: Ultrahot Jupiters

- Gas giants (like our own Jupiter) that orbit much closer to their host star and therefore have different atmospheric composition and conditions
- Ultrahot Jupiters defined as gas giants with equilibrium temperatures greater than 2000 K
- Atmospheres are heavily influenced by the extreme radiation regime they live in
- Because of short orbital period, ultrahot Jupiters are tidally locked into synchronous orbits
  - This means a permanent day side and night side, which differ strongly in temperature and chemical composition
  - These factors make it important to take into account regional conditions to make more accurate drag models instead of global average
  - This makes them a great choice for 3D models that more accurately describe spatial variation around the planet

Methods

- Because UHJs are tidally locked, the dayside and nightside show strongly different temperature profiles, resulting in emission and absorption features respectively
- Each wavelength range has a different main absorber: $\lambda_1$: CO, $\lambda_2$: H$_2$O

Drag time scale

- $\tau = \frac{\rho \phi}{B \eta}$
- $\rho$ = density
- $\phi$ = latitude
- $B$ = global magnetic field strength
- $\eta$ = magnetic resistivity

How we get peak Doppler shift:

- Cross correlate Doppler on (spectra broadened from winds and rotation) with Doppler off at the same phase
- Velocity at peak cross-correlation gives net Doppler shift of the spectra

Different observed behaviors for of active drag vs uniform drag models

- Active drag models are more physically consistent than uniform drag models because they vary spatially
- Different drags results in different temperature profiles, resulting in different emission spectra
- Each model has different net Doppler shifts across orbital phase and wavelengths, since wavelengths are probing different absorbers which differ in concentration throughout the planet

Results: Comparing Models

- We tested 3 models of magnetic drag:
  - 0 G: no magnetic drag
  - Uniform: single drag time scale throughout model
  - 3 G: active model with time scale varying with temperature and pressure throughout the model
- We look at the net Doppler shift in planet’s frame of reference
- Dayside (180 degrees) and nightside (0 degrees) structure look vastly different, causing large variations in Doppler shifts
- Different wavelengths show us effects of different absorbers (see Methods section)

Conclusion

- Different observed behaviors for of active drag vs uniform drag models
- Active drag models are more physically consistent than uniform drag models because they vary spatially
- Different drags results in different temperature profiles, resulting in different emission spectra
- Each model has different net Doppler shifts across orbital phase and wavelengths, since wavelengths are probing different absorbers which differ in concentration throughout the planet
- Because of different concentrations of the absorbers, we’re probing different heights, which is why we have different Doppler shifts
  - Example: $\lambda_1$ and $\lambda_2$ at same phase are different heights in the atmosphere

Works Cited:

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