Spitzer Variability Properties of Free-Floating Exoplanet Analogs

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Young brown dwarfs are excellent exoplanet analogs

Gravity influences cloud properties:

- Young low-gravity brown dwarfs and directly-imaged exoplanets are redder and less luminous than old, higher gravity field dwarfs due to enhanced condensate clouds
- Spitzer photometric variability monitoring directly probes the presence of condensate clouds as they rotate in and out of view

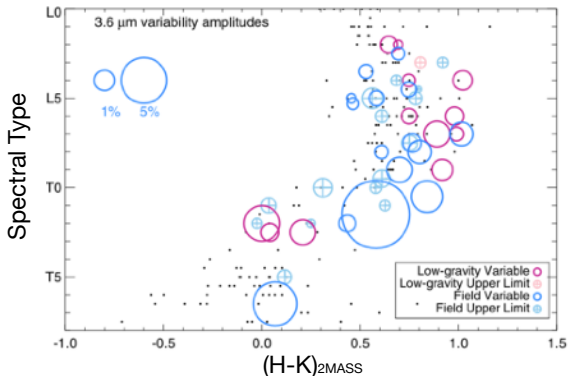

Figure 1: Current sample of low-gravity and field brown dwarfs with Spitzer variability measurements

Photometric monitoring with Spitzer has already revealed the variability properties of a large sample of field brown dwarfs, and a small but growing sample of young, low-gravity objects

In this work we combine the variability properties of young and field L dwarfs from the literature to explore the influence of youth/gravity on condensate clouds.

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Brown Dwarfs Spin Up Over Time

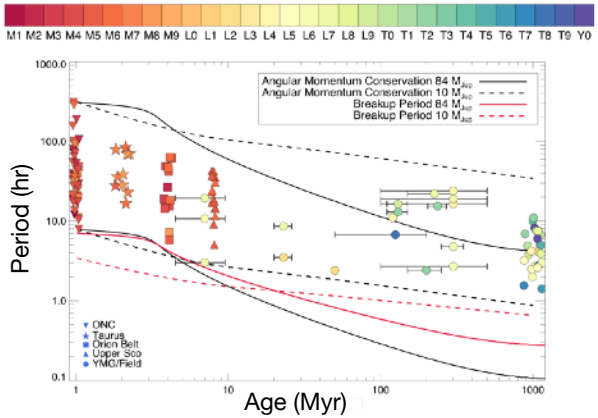


Figure 2: Rotation rates of brown dwarfs as a function of age. Field dwarfs are plotted at 1 Gyr. Black lines show the expected rotation period evolution assuming angular momentum conservation. Breakup periods are plotted in red. **The population of brown dwarfs with measured rotation periods agree with the limits set by evolutionary models.**

Increase in variability amplitude for late-Ls

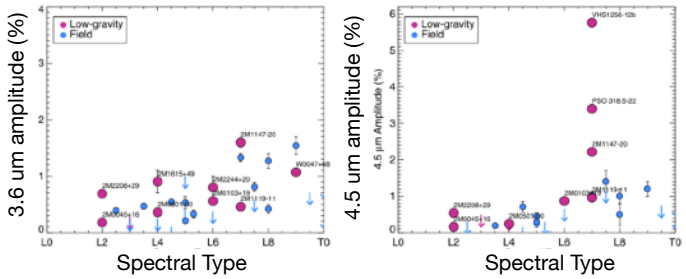


Figure 3: Peak-to-peak variability amplitudes at 3.6 μm (left) and 4.5 μm (right). Low-gravity objects are shown in purple and field dwarfs are shown in blue. **The young, late-L objects show a possible enhancement in variability amplitude at 4.5 μm.**

Brown dwarfs viewed equator-on appear redder than the median

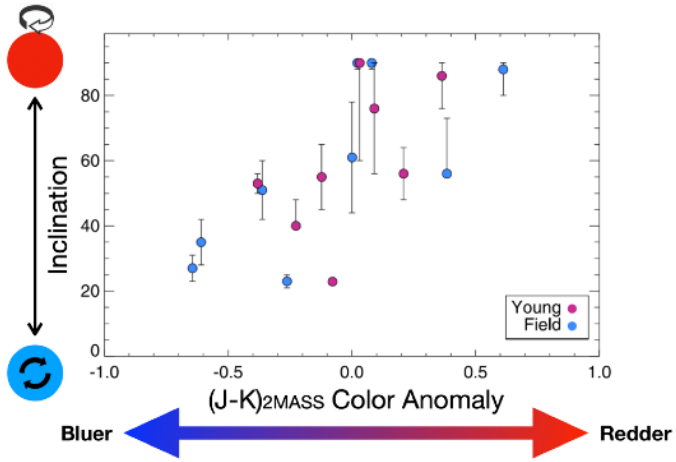
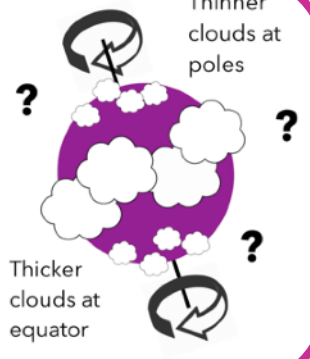


Figure 4: Inclination plotted against near-IR color anomaly for young and field brown dwarfs. The color anomaly of a brown dwarf is the median $(J-K)_{2MASS}$ color of brown dwarfs with the same spectral type and gravity class subtracted from the color of the object.

An inclination-dependent color may be explained by thicker clouds accumulating at the equator relative to the poles, as recently predicted by atmospheric dynamical simulations (Tan & Showman 2020)



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