Let the Great World Spin: Revealing the Turbulent, Stormy Atmospheres of Giant Planet Analogs

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A large Spitzer survey for variability in young brown dwarfs

Young, low-mass brown dwarfs act as powerful analogs to the directly-imaged exoplanets.

The colours of the young, low-mass brown dwarfs form a distinct sequence in the color-magnitude diagram (Fig 1) — they are consistently redder and less luminous that the field brown dwarfs at a given spectral type. Their colors and spectra and remarkably similar to those of the directly-imaged exoplanets discovered to date.

Models generally invoke disequilibrium chemistry and thicker, high altitude clouds to explain their observed colors and spectra.

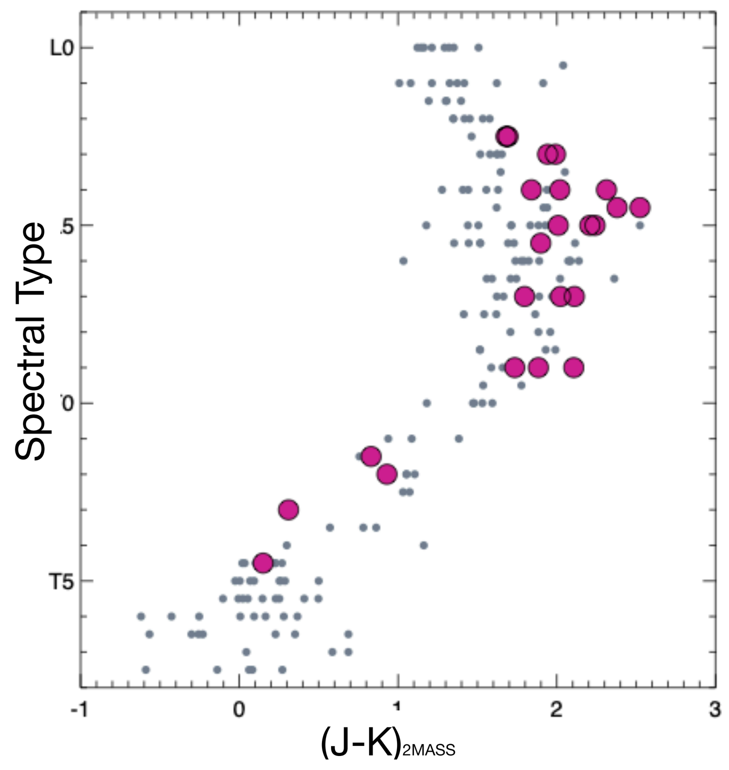

Figure 1: Field brown dwarfs (grey) compared to our low-gravity sample (pink)

We present preliminary results from the largest, most sensitive survey for photometric variability in isolated giant planet analogs with the Spitzer Space Telescope.

Our unique sample of 26 young L2-T5 brown dwarfs allows us to probe the effects of surface gravity and youth on the variability properties, by comparing with the field sample published in Metchev et al. (2015).

We detect a large number of new low-mass variables

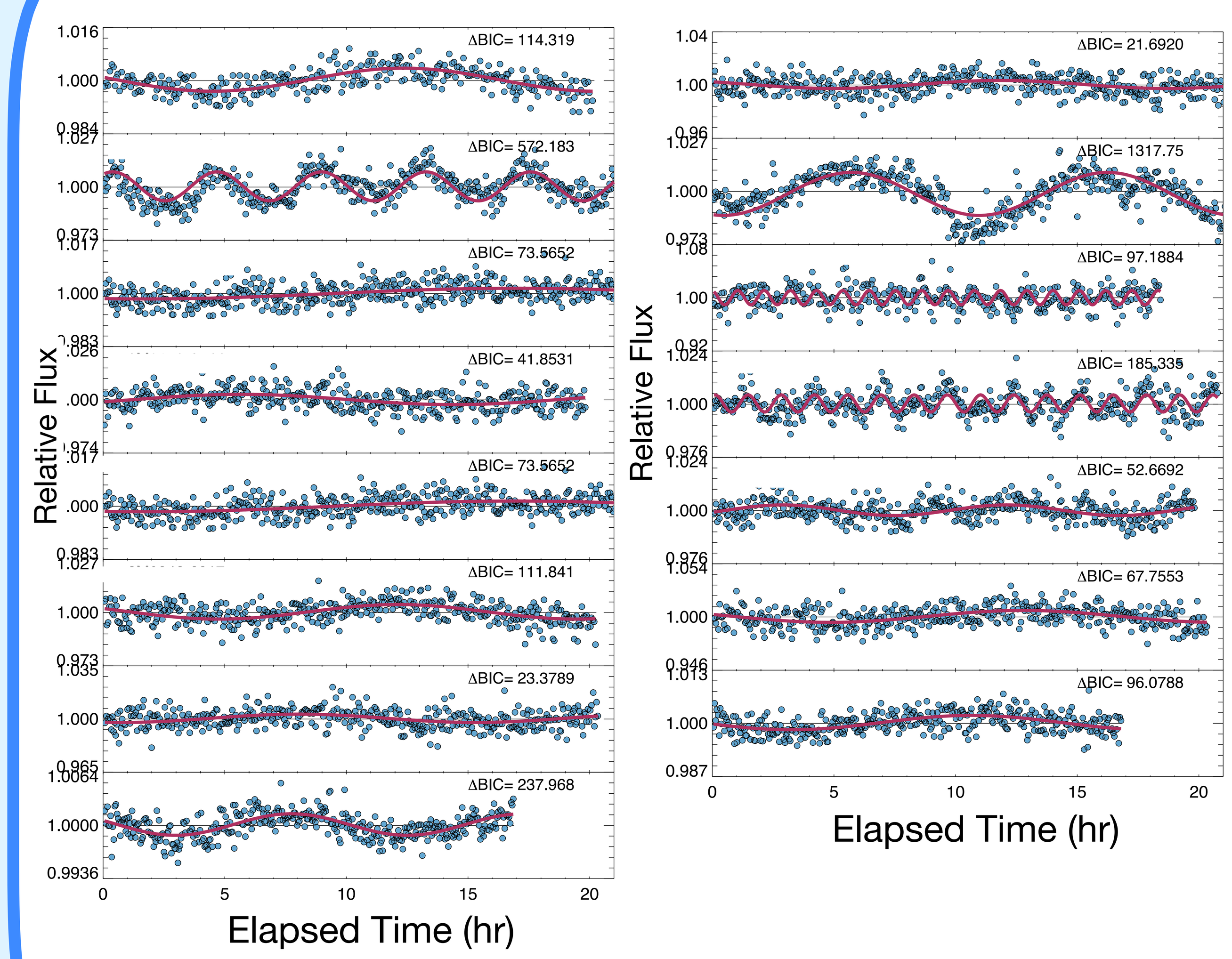

Figure 2: Variability detections from our survey. Blue points show 2.5 min cadence. ΔBIC values show that a variable, sinusoidal model is favoured over a non-variable model.

We detect photometric variability at 3.6 μm in 15/26 objects in our sample.

We correct for intrapixel sensitivity variations using a cubic function of the *x* and *y* coordinates. We identify variable light curves using a periodogram method and using the Bayesian Information Criterion (BIC). These techniques are outlined in Vos et al. (2020).

The variability is sometimes sinusoidal and sometimes shows rapidly evolving light curves. These variations are likely due to condensate clouds rotating in and out of view.

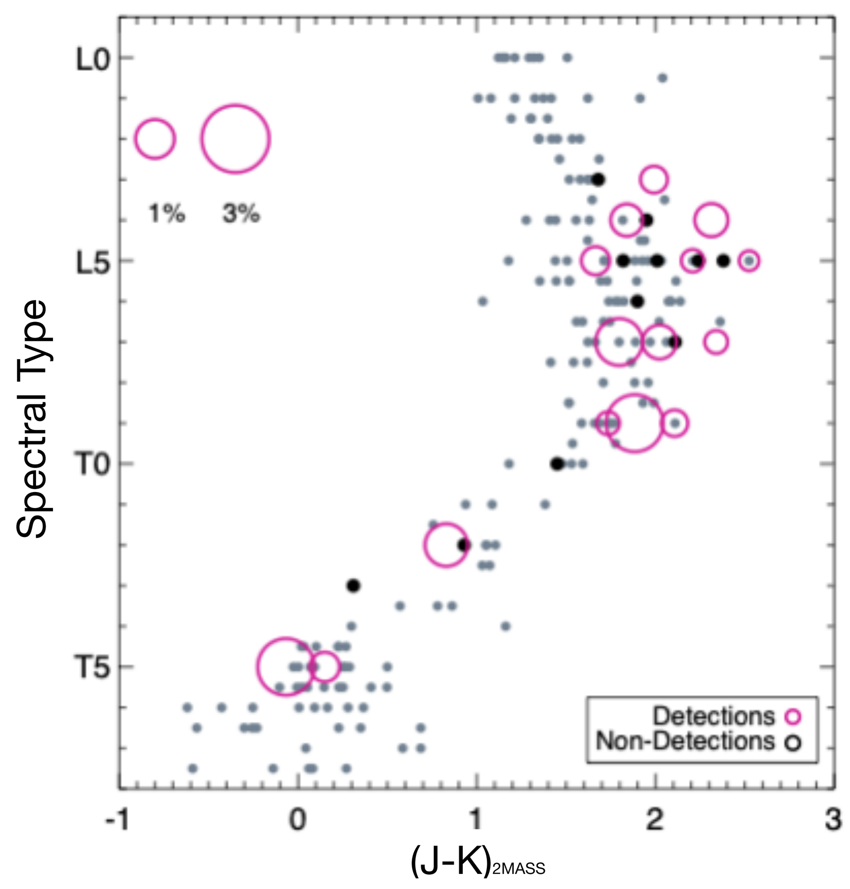

Figure 3: Variability detections (pink) and non-detections (black) of our variability survey. For variable objects, the symbol area is proportional to the variability amplitude

Evidence for variability enhancement for low-mass objects

3.6 μm Variability Amplitudes

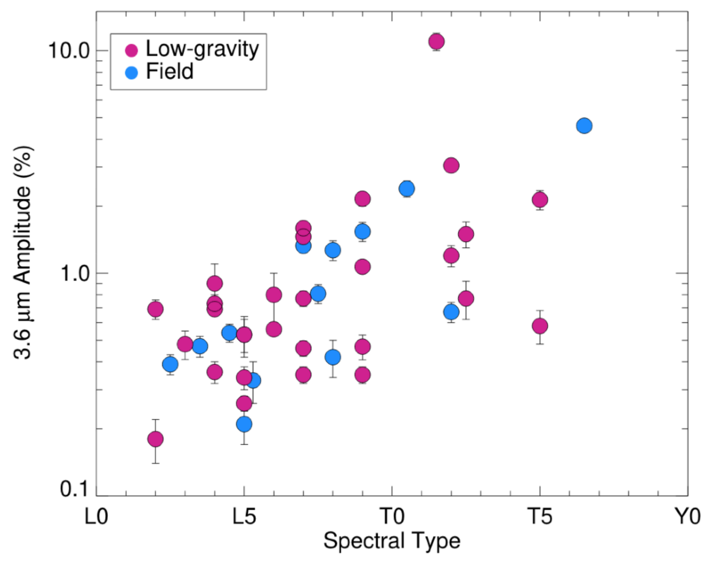

Figure 4: Variability amplitudes of low-mass objects (pink) and field dwarfs (blue) as a function of spectral type.

Main Takeaways:

1. For each spectral bin, the max variability amplitudes occurs for young objects, suggesting a relation between low-gravity and high-amplitude variability
2. However this does not mean that all young brown dwarfs exhibit high-amplitude variability — their range of observed amplitudes is likely affected by viewing angle, the relative size of storms etc.

3.6 μm Variability Occurrence Rates

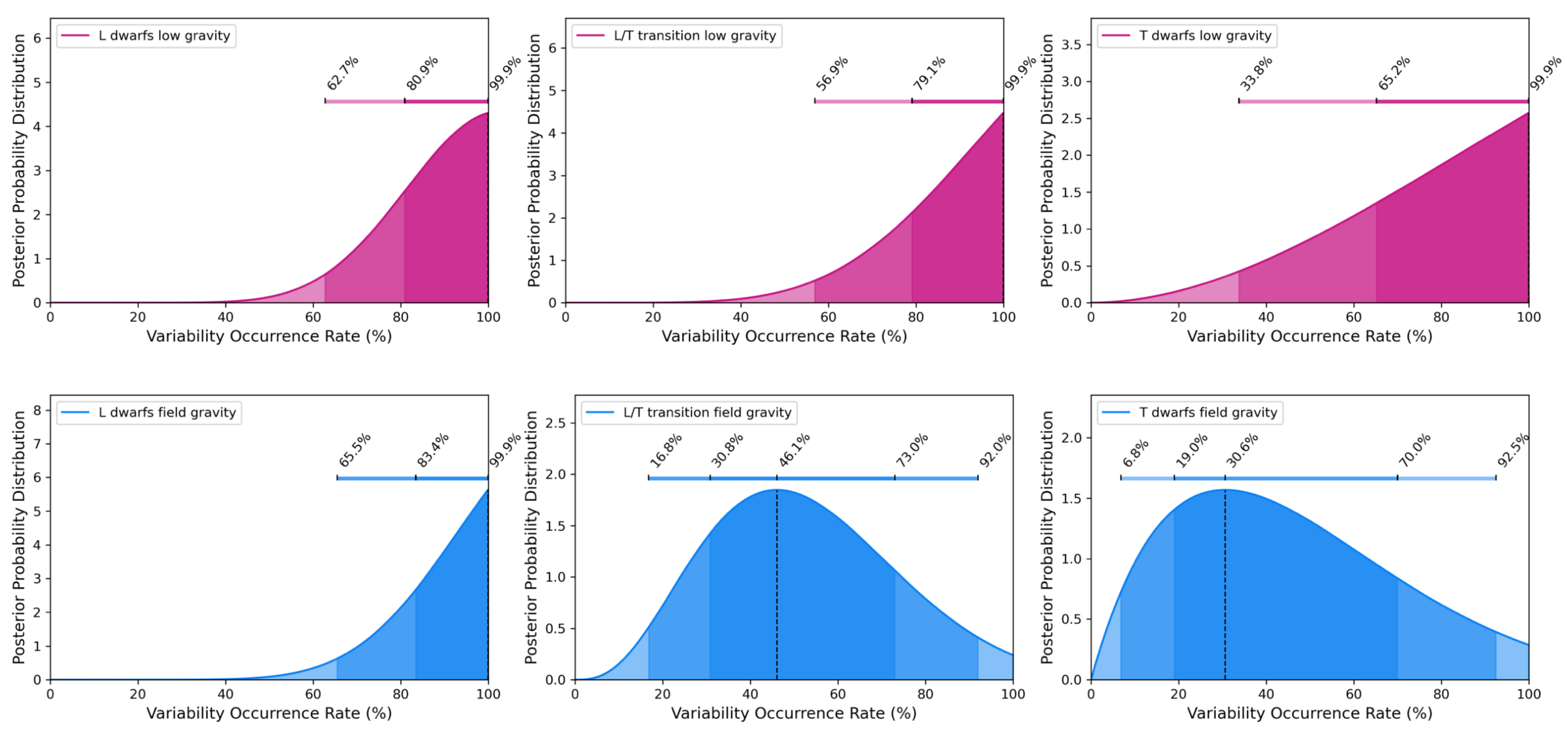

Figure 5: Variability occurrence rates for young objects (pink) and field objects (blue).

Key Takeaways:

1. The variability occurrence rates of young objects remains high, from L to T spectral types.
2. We observe no difference in variability occurrence rate across the L/T transition for either sample.

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