Are models accurate in a relative sense?

We have measured the first direct, individual masses for a substellar binary in the L/T transition by combining high-precision astrometry from Keck LGS AO (resolved, relative) and CFHT/WIRCam (unresolved, absolute).

This allowed us to perform the first test of the mass—luminosity relation for substellar objects in the process of losing their clouds. Evolutionary models that do not account for changing clouds (e.g., Dusty) do not match our data, but “hybrid” models adopting a simple, ad hoc prescription for cloud clearing agree well (right). Age is a free parameter for this field binary system.

Are models accurate in an absolute sense?

To test the accuracy of evolutionary models in an absolute sense requires binary systems of known age. We now have determined dynamical masses for two such substellar binaries that are companions of young, solar-type stars having very similar gyrochronology ages of ~800 Myr.

Keck LGS AO orbital monitoring $\rightarrow$ Dynamical masses

Substellar evolutionary models $\rightarrow$ Estimated masses

Given these binaries’ observed luminosities and known ages, evolutionary models predict masses that are much higher ($\approx$60–70 $M_{\text{Jup}}$) than our directly measured dynamical masses ($\approx$50–55 $M_{\text{Jup}}$).

This discrepancy is apparently due to evolutionary models underpredicting substellar luminosities by a factor of $\approx$2x, at least at this mass and age. A physical explanation for this luminosity problem is still lacking.

Take-away #1
Clouds strongly influence the substellar mass—luminosity relation, and this is not reproduced in widely used evolutionary models, like Dusty.

Take-away #2
Without dynamical mass information, masses estimated from substellar evolutionary models likely harbor large ($\approx$25%) systematic errors. These errors could be even larger for young planets or L/T transition objects.