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Molecules, Dust and Ices in Brown Dwarf Atmospheres

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Jupiter-sized brown dwarfs are found in the solar neighborhood with effective temperature $T_{\rm eff}$ as low as 250 K [1]. Iron, silicates, chlorides and sulfides condense in the atmospheres of the $T_{\rm eff} \approx 2000$ K L-type and $T_{\rm eff} \approx 1000$ K T-type dwarfs [2]. At the T-/Y-type boundary, $T_{\rm eff} \approx 500$ K and atmospheres are clear [3]. The next species to condense are H_2O at $T_{\rm eff} \approx 350$ K and NH_3 at $T_{\rm eff} \approx 200$ K [4]. We have obtained near-infrared spectra of the Y0 WISEP J173835.52+273258.9 and the Y1 WISE J035000.32−565830.2 using Gemini Observatory. We compare these to models with updated H_2, NH_3 and CH_4 opacities, which include disequilibrium chemistry driven by vertical transport [5, 6]. Figure 1 shows the Y0 spectrum and the best fitting model. Mixing is important in Y dwarf atmospheres as it is for the warmer brown dwarfs and the cooler Jupiter [7], although remaining discrepancies show that the CH_4/CO and NH_3/N_2 balance needs further work. The new data are best fit by cloud-free models with a mixing diffusion coefficient $\log K_{zz} = 10^6\, {\rm cm^2 s^{-1}}$ and gravity $\log g = 4.0\, {\rm cm\, s^{-2}}$; the Y0 has $T_{\rm eff} = 425$ K and the Y1 $T_{\rm eff} = 350$ K. Evolutionary models [8] then give a mass of $5^{+4}_{-2}\, M_{\rm Jupiter}$ for both, and ages 0.15 − 1 Gyr and 0.3 − 3 Gyr for the warmer and cooler dwarf respectively.

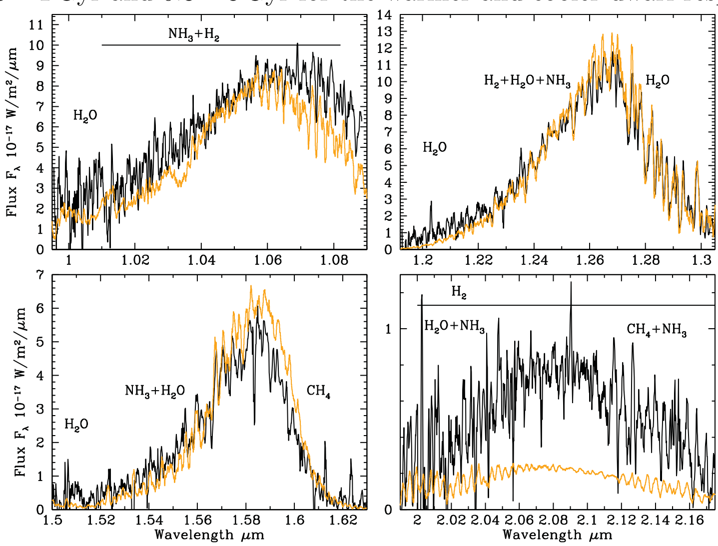

Figure 1. Spectrum of the Y0 WISEP J173835.52+273258.9 (black) and best fit model with $T_{\rm eff} = 425$ K, $\log g = 4.0$, $\log K_{zz} = 6$ (orange), scaled to the target distance and radius [8].

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