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Experimental and theoretical study of alkali lines broadening for astrophysical applications

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The visible and near infrared spectra of L and T-type brown dwarfs exhibit prominent features corresponding to atom resonance lines of alkali-metal atoms [1]. Similar features are expected to appear in the spectra of extraterrestrial giant planets (EGPs) [2,3]. The spectra of cool brown dwarfs are dominated by the resonance lines of Na at 590 nm and of K at 760 nm. Because of the large concentrations in these objects of gaseous H_2 and He at temperatures around 1000 K, the profiles of Na and K lines are strongly broadened by collisions up to 100 nm on each side of the line core. This broadening is pressure and temperature sensitive and consequently the ability to model precisely those alkali lines is a powerful tool to retrieve the atmospheric conditions of cool brown dwarfs and EGPs.

To improve the data available for modeling, we have designed a spectroscopic experiment to measure absolute absorption coefficients of alkali vapors colliding with H_2 and He at astrophysically relevant temperatures. The atomic densities are measured precisely using the anomalous dispersion ("hook") method. Investigating the spectral range 380-920 nm, we observed the broadening of the K 770 nm lines and we find the K 404 nm doublet exhibits a putative satellite feature on its blue wing. The theoretical calculations utilize accurate molecular potential energies and transition dipole moments and fully quantum-mechanical methods. Supported in part by NASA grant NNG06GF06G.

[1] A. Burrows et al., ApJ, 573 (2002), 394.
[2] S. Seager and D. D. Sasselov, ApJ, 537 (2000), 916.
[3] A. Sudarsky et al., ApJ, 588 (2003), 1121.