Theoretical Studies of Pressure Broadened Alkali-Metal Atom Resonance Lines

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Broadened absorption lines of alkali-metal atoms are prominent in the optical spectra of brown dwarfs (cf. Burrows *et al.,* 2001) and may be a source of opacity in extra-solar giant planet atmospheres (Seager and Sasselov, 2000; Brown, 2001). The pressure broadening of the resonance lines of Na and K by various perturbing gases is thought to be evident in M and L-dwarf optical spectra. Recently, absorption in the region of the Na resonance line has been detected in the transit of an extra-solar giant planet using the HST STIS spectrograph (Charbonneau *et al.,* 2001).

The pressure broadening of a resonance line is commonly represented in stellar atmosphere models as a Lorentzian shape arising from the van der Waals interaction between the alkali-metal atom and a perturbing atom or molecule (cf. Schweitzer *et al.,* 2001). An improved description results with the use of molecular potential energy surfaces describing the interaction between the alkali-metal atom and the perturber. Accurate calculations of the pressure-broadened line profiles are important in developing effective temperature and density diagnostics for brown dwarf and extra-solar giant planet atmospheres.

We report quantum-mechanical calculations of the absorption spectra of Na and K broadened by He and discuss the validity of various approximations for the pressure-broadened line shapes. The calculated spectra are compared to available experimental results and astrophysical applications are discussed.

References:

Burrows, A., Hubbard, W. B., Lunine, J. I., and Liebert, J., 2001, *The theory of brown dwarfs and extrasolar giant planets,*, *Rev. Mod. Phys.* **73**, 719-765.

Brown, T. M., 2001, *Transmission spectra as diagnostics of extrasolar giant planet atmospheres, Ap. J.* **553**, 1006-1026.

Charbonneau, D., Brown, T. M., Noyes, R. W., and Gilliland, R. L, 2001, *Detection of an extrasolar planet atmosphere,* preprint.

Seager, S., and Sasselov, D. D., 2000, *Theoretical transmission spectra during extrasolar giant planet transits, Ap. J.* **537**, 916-921.

Schweitzer, A., Gizis, J. E., Hauschildt, P. H., Allard, F., and Reid, I. N., 2001, *Analysis of Keck HIRES spectra of early L-type dwarfs, Ap. J.* **555**, 368-379.

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