Opacities of Molecules and Dust

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As progressively lower temperatures are encountered in a stellar atmosphere, first molecules and finally dust grains become important sources of opacity. The abundance of important molecular and solid absorbers depends upon temperature, pressure, and the chemical composition in complex ways which require detailed equation of state calculations. Molecular spectra, which usually contain thousands or millions of spectral lines, are usually treated statistically in the opacity sampling method. Because of the size of modern line lists and the computation time required to process them, efficient computation of molecular opacity requires careful selection of the wavelengths and the relevant lines. We will discuss these procedures, and the results obtained for important absorbers such as H_2O and TiO.

For temperatures below about 1,800 K, some materials begin to precipitate out of the gas phase as small solid particles. Because these small grains are very efficient absorbers and scatterers of light, they dominate the opacity whenever they exist. The thermodynamic and optical properties of these materials will be explored. Recent results show that even grains with relatively low abundances, such as Al_2O_3 and $CaTiO_3$, can have a dramatic impact on the structure of stellar atmospheres. Most atmospheres with $T_{eff} < 3,000\ K$, both giant and dwarf, have grains in their outer layers in sufficient quantity to affect the emergent spectrum.