Microwave, Millimeter, Submillimeter and Far Infrared Spectral Databases

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The spectrum of most known astrophysical molecules is derived from transitions between a few hundred to a few hundred thousand energy levels populated at room temperature. In the microwave and millimeter wave regions, spectroscopy is almost always performed with traditional microwave techniques. In the submillimeter and far infrared microwave technique becomes progressively more technologically challenging and infrared techniques become more widely employed as the wavelength get shorter. Infrared techniques are typically one to two orders of magnitude less precise but they do generate all the strong features in the spectrum. With microwave technique is generally impossible and rarely necessary to measure every single transition of a molecular species, so careful fitting of quantum mechanical Hamiltonians to the transitions measured are required to produce the complete spectral picture of the molecule required by astronomers. The fitting process produces the most precise data possible and is required in the interpret heterodyne observations.

The drawback of traditional microwave technique is that precise knowledge of the band origins of low lying excited states is rarely gained. The fitting of data interpolates well for the range of quantum numbers where there is laboratory data, but extrapolation is almost never precise. The majority of high-resolution spectroscopic data is millimeter or longer in wavelength and a very limited number of molecules have ever been studied with microwave techniques at wavelengths shorter than 0.3 mm. The situation with infrared technique is similarly dire in the submillimeter and far infrared because the black body sources used are competing with a very significant thermal background making the signal to noise poor. Regardless of the technique used the data must be archived in a way useful for the interpretation of observations.

The consequence to any archiving spectral database is that there is very limited high-resolution data available in the submillimeter and far infrared and the traditional infrared catalogs generally do not extend into the region. Additionally most astrophysical molecules are not very rigid further complicating the analysis and prediction of transitions. The JPL Submillimeter, Millimeter and Microwave Spectral line Catalog is an attempt to compile a complete and consistent set of spectroscopic data to support observations and observation planning.