Precise Laboratory Measurements of Line Frequencies Useful to Studies of Star and Planet Formation

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Precise molecular line frequencies are essential to studies of the motions and abundances in star-forming dense cores and in planet-forming circumstellar disks. The line frequencies in the millimeter- and submillimeter-wave bands for a number of molecular species used in these studies have not been measured accurately in the laboratory. Uncertainties in the line frequencies limit the study of dense cores forming sunlike stars, and will soon limit the study of the outer parts of circumstellar disks forming planets. Modern spectroscopic techniques can provide the needed improvement in precision, as demonstrated by our recent measurements of CS and $C^{34}S$ which yielded 1σ uncertainties in the velocities of < 0.02 km s^{-1} in the region from 50 to 500 GHz.

A program is now underway at the Smithsonian Astrophysical Observatory to improve the precision of rotational line frequencies for the principal isotopic species of those neutral and ionic molecules which probe motions and chemical processes in cores and disks. The species to be studied were selected according to three criteria: (a) relevance of the lines for studies of star and planet formation, (b) detectability of the species according to past astronomical observations, and (c) velocity precision significantly worse than 0.02 km s^{-1}. According to these criteria six neutral molecules and three molecular ions were identified for frequency measurement. Some recent observations in narrow-line astronomical sources by Lee *et al.* (1999, 2001) illustrate how the kinematic interpretation depends crucially on the adopted line frequency.

References:

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