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Progress report

OBSERVATIONS OF HCN HYPERFINE LINE ANOMALIES TOWARDS LOW AND HIGH MASS STAR-FORMING CORES

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HCN is becoming a popular molecule for studying star formation in both low and high mass regions and for other astrophysical sources from comets to high red shift galaxies. However, a major and often overlooked difficulty with HCN is that it can exhibit dramatic non-LTE behaviour in its hyperfine line structure. Individual hyperfine lines can be strongly boosted or suppressed. In low mass star forming cloud observations, this could possibly lead to large errors in the calculation of opacity and excitation temperature while in massive star forming clouds, where the hyperfine lines are partially blended due to turbulent broadening, errors will arise in infall measurements that are based on the separation of the peaks in a self-absorbed profile. This is because the underlying line shape is unknown if hyperfine anomalies are present. We present a first observational investigation of these anomalies across a wide range of conditions and transitions by carrying out a survey of low-mass starless cores (in Taurus and Ophiuchus) and high mass protostellar objects (in the G333 giant molecular cloud) using hydrogen cyanide (HCN) J=1-0 and J=3-2 rotational lines. We quantify the degree of anomaly in these two lines by considering ratios of individual hyperfine lines compared to LTE values (R_{02} and R_{12}, see figure). We find that all the cores observed demonstrate some degree of anomaly while many of the lines are severely anomalous. We conclude that HCN hyperfine anomalies are common in both lines in both low mass and high mass protostellar objects and we discuss the differing hypotheses for the generation of the anomalies in light of the results and the implications for the use of HCN as a dynamical tracer. We also present model fits to selected low mass starless cores in both HCN lines as well as the HCN J=1-0 observations of several of the high mass protostellar cores. The radiative transfer code that was used has been equipped with a newly calculated, self-consistent, set of hyperfine collisional rate coefficients complete with quasi-elastic rates. Our conclusion is that current 3D non-LTE radiative transfer codes are incapable of matching the observed anomalous hyperfine lines especially amongst HCN rotational transitions and that there is much need for development of a 3D non-LTE code that takes account of the overlap of molecular transition lines.