CCS - A TRACER OF EARLY STAR FORMATION

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We have conducted a survey of the CCS $J_N = 3_2 - 2_1$ line toward 11 dark clouds and star-forming regions at $30''$ spatial resolution and 0.054 km s^{-1} spectral resolution. Our results show that CCS can only be detected in quiescent clouds, not in active star-forming regions. The CCS distribution shows remarkable clumpy structure, and 25 clumps are identified in 7 clouds. The CCS clumps tend to exist around the higher density regions traced by NH_3 emission or submillimeter continuum sources, and the distribution is not spherically symmetric. Variation of the CCS abundance was suggested as an indicator of the evolutionary status of star formation. However, we can only find a weak correlation between N(CCS) and n(H_2), which suggests that the time scale for creating and destroying CCS may be very short compared to the lifetime of CCS. Therefore, we conclude that CCS clumps are unlikely to collapse into protostars, but rather transiently exist in the regions with density $\sim 10^4$-10^5 cm^{-3} as the cloud evolves. As a result, CCS traces pre-protostellar cores in the very early stage of star formation or traces the envelope of pre-protostellar cores in the later stage.

CCS is also an excellent probe of kinematic structure of dark clouds because of its lack of hyperfine splittings and its moderate optical depth. The velocity distributions of CCS clouds reveal that a systematic velocity pattern generally exists. The most striking feature in our data is a ring structure in the position-velocity diagram of L1544 with an well-resolved inner hole of 0.04 pc $\times$ 0.13 km s^{-1} and an outer boundary of 0.16 pc $\times$ 0.55 km s^{-1}. This position-velocity structure clearly indicates an edge-on disk or ring geometry, and it can be explained as a collapsing disk with an infall velocity $\sim$ 0.1 km s^{-1} and a very low rotational velocity (less than our spectral resolution). Non-thermal linewidth distribution is generally coherent in CCS clouds, which could be an evidence that the Larson's Law terminates at small scale $\sim$ 0.1 pc.

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