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MULTI-LEVEL STUDY OF C_3H_2: THE FIRST INTERSTELLAR HYDROCARBON RING

S. C. Madden, W. M. Irvine
Five College Radio Astronomy Observatory
University of Massachusetts

and

H. E. Matthews, L. W. Avery
Hezberg Institute of Astrophysics
National Research Council of Canada

Cyclic species in the interstellar medium have been searched for almost since the first detection of interstellar polyatomic molecules. It has been suggested that the relative abundance of rings might be related to the importance of reactions on grain surfaces as compared with that in the gas phase. Previous searches for rings, however, have only included stable closed shell molecules, and have not reached very low abundance limits. In contrast, the newly detected interstellar hydrocarbon ring, cyclopropenylidene (C_3H_2), is a di-radical, three-membered ring and was demonstrated by Matthews and Irvine (Ap. J. (Letters) 298, L61 1985) to be widespread throughout the Galaxy, originating in a variety of sources with a wide range of temperature and density. Since the serendipitious discovery of the easily detected ortho ground state transition, ($1_{10} \rightarrow 1_{01}$), followed by its identification by Thaddeus, Vrtikek, and Gottlieb (Ap. J. (Letters), 299, L63, 1985), we have made systematic Galactic surveys of several transitions and have concentrated in depth on the nearby dark dust cloud, TMC-1, which has shown an unusually high propensity toward C_3H_2. The fact that TMC-1 is also a dominant source of the carbon chain molecules, especially cyanopolyynes, leads to the speculation that the formation of this ring molecule may have some possible relationship to production of carbon chains.

We have detected 11 different C_3H_2 rotational transitions; 9 of them which have been studied in TMC-1 are shown in Figure 1. The $1_{10} \rightarrow 1_{01}$ and $2_{20} \rightarrow 2_{11}$ transitions were observed with the 43 m NRAO telescope, while the remaining transitions were detected with the 14 m antenna of the Five College Radio Observatory (FCRAO). The lines detected in TMC-1 have energies above the ground state ranging from 0.9 to 17.1 K and consist of both ortho and para species. Limited maps were made along the ridge for several of the transitions. Fortunately, we were able to map the HC_3N $J = 2 \rightarrow 1$ transition simultaneously with the C_3H_2 $1_{10} \rightarrow 1_{01}$ line and therefore can compare the distribution of this ring with a carbon chain in TMC-1. C_3H_2 is distributed along a narrow (< 2') ridge with a SE - NW extension which is slightly more extended than the HC_3N $J = 2 \rightarrow 1$. Gaussian fits gives a FWHP extension of 8'5 for C_3H_2 while HC_3N has a FWHP of 7'. Our data show variations of the two velocity components along the ridge as a function of transition. Most of the transitions show a peak at the position of strongest HC_3N emission while the $2_{21} \rightarrow 1_{10}$ transition shows a peak at the NH_3 position. The $3_{30} \rightarrow 2_{21}$ transition, which lies 17.1 K above the ground state, shows a weak, very narrow (~.28 km s^{-1}) component which seems to be sampling only one of the cloud components, perhaps indicating density variations throughout the source. The most surprising result was the detection of the $2_{20} \rightarrow 2_{11}$ transition in absorption against the 2.7 K background in TMC-1. Some results in other sources will also be presented.

C_3H_2 Detections in TMC-1

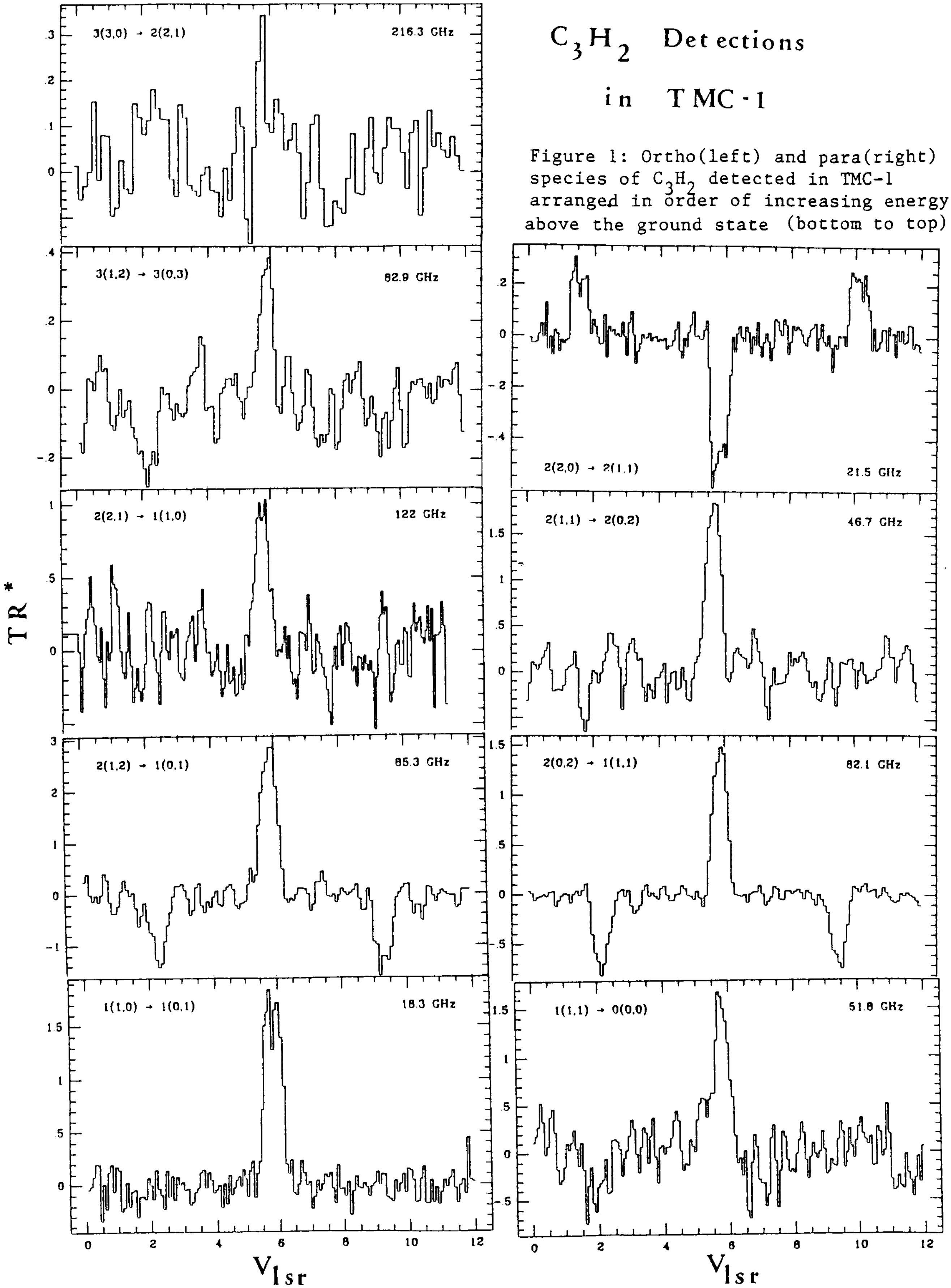

Figure 1: Ortho(left) and para(right) species of C_3H_2 detected in TMC-1 arranged in order of increasing energy above the ground state (bottom to top).