MULTI-LEVEL STUDY OF C\textsubscript{3}H\textsubscript{2}: THE FIRST INTERSTELLAR HYDROCARBON RING

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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\textsubscript{3}H\textsubscript{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 serendipitous discovery of the easily detected ortho ground state transition, (\textit{i}_\textit{10} * \textit{i}_\textit{0}1), 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\textsubscript{3}H\textsubscript{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\textsubscript{3}H\textsubscript{2} rotational transitions; 9 of them which have been studied in TMC-1 are shown in Figure 1. The \textit{i}_\textit{10} + \textit{i}_\textit{0}1 and \textit{2}_\textit{20} + \textit{2}_\textit{1} \textit{J} 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\textsubscript{3}N \textit{J} = 2 + 1 transition simultaneously with the C\textsubscript{3}H\textsubscript{2} \textit{i}_\textit{10} + \textit{i}_\textit{0}1 line and therefore can compare the distribution of this ring with a carbon chain in TMC-1. C\textsubscript{3}H\textsubscript{2} is distributed along a narrow (< 2') ridge with a SE – NW extension which is slightly more extended than the HC\textsubscript{3}N \textit{J} = 2 + 1. Gaussian fits gives a FWHP extension of 8'5 for C\textsubscript{3}H\textsubscript{2} while HC\textsubscript{3}N 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\textsubscript{3}N emission while the \textit{2}_\textit{21} + \textit{1}_\textit{10} transition shows a peak at the NH\textsubscript{3} position. The \textit{3}_\textit{30} + \textit{2}_\textit{21} transition, which lies 17.1 K above the ground state, shows a weak, very narrow (~ 28 km s\textsuperscript{-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 \textit{2}_\textit{20} + \textit{2}_\textit{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).