DARK CLOUD MODELING OF THE ABUNDANCE RATIO OF ORTHO-TO-PARA CYCLIC C_3H_2

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We present the first attempt to model the ortho and para forms of cyclic C_3H_2(c-C_3H_2) by reproducing the observed abundance ratio(o/p-C_3H_2) in dark clouds. The unusual three-carbon species c-C_3H_2 is relatively abundant in cold dense sources (10^{-8} with respect to H_2). According to observations for TMC-1C and L1527, the o/p-C_3H_2 ratio is 2.4 - 2.5 depending somewhat on density. This is only slightly lower than the statistical ratio of 3, which pertains to high temperature equilibrium.

In order to model the ortho-to-para abundance ratio in dense clouds, we used a large network of chemical reactions augmented by reactions that specifically consider the formation and depletion of ortho and para forms of the molecules c-C_3H_2 and c-$C_3H_3^+$. The reaction branching fractions were determined by a variety of considerations. We then investigated how the calculated ortho-to-para ratio for c-C_3H_2 depends on a number of factors such as the elemental C/O ratio, the depletion of metals from the gas, and the cosmic ray ionization rate. It turns out, however, that in order to reproduce the large observed ratio, it is necessary to use an extreme branching ratio between two channels for the dissociative recombination(DR) reaction ($C_3H_3^+ + e \rightarrow C_3H_2 + H$; $C_3H + H_2$) in which the the first channel is dominant.