THE DETECTION AND ANALYSIS OF THE ION H_2D^+ IN THE COLD PRE-STELLAR CORE L1544

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Deuterium fractionation in cold interstellar clouds yields detailed information about the temperature and composition of the object. We have recently run chemical models of objects known as pre-stellar cores (Aikawa et al. submitted), which are collapsing to form stars but are still quite cold (approx. 10 K). The chemical models include deuterium fractionation, which can occur via gas-phase chemistry and chemistry on the surfaces of dust particles. One strong prediction of the models is that the deuterium fractionation should be so strong near the center of pre-stellar cores that the deuterated ion H_2D^+ can be more abundant than its normal counterpart H_3^+ despite an elemental deuterium to hydrogen ratio of 10^{-5}. Recent observations on the well-studied pre-stellar core L1544 by Caselli et al. (submitted) show indeed that, towards its center, the abundance of H_2D^+ is so high that it is most likely the dominant ion in the source. Moreover, the abundance of ortho-H_2D^+ is probably as high as the para modification despite the low temperature. The predictions and observations imply that molecules heavier than H_2 are strongly depleted from the gas phase at the high densities associated with the central core of L1544. This implication is strongly confirmed by recent observations on the depletion of heavy molecules in L1544.