

Deuterium Fractionation and Ion-Molecule Reactions at Low Temperatures

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Abstract. More than 20 different deuterated molecules and several multiply deuterated species have been detected in interstellar clouds. The relative abundance of these molecules with respect to their hydrogenated analogues can be several orders of magnitude higher than one would expect due to the cosmic D/H ratio of 1.5×10^{-5} , see e.g. Millar (2002). In typical molecular clouds HD is the main reservoir for deuterium. Reactions of HD with three reactants, H_3^+ , CH_3^+ , and C_2H_2^+ , have been found as primary sources for deuterated species. Differences in the Zero-Point-Energies favor the deuterated reaction products, namely H_2D^+ , CH_2D^+ , and C_2HD^+ . In secondary reactions the isotopic enrichment is passed on to other species. In fact these reactions are one limitation for deuterium fractionation of the primary ions based on the actual cloud composition.

However, many more reactions and in particular inelastic collisions can influence the amount of deuterated species. In this contribution current models of deuterium fractionation in different astrophysical environments will be discussed. Experimental work on some reactions involved will be reviewed (Gerlich, Herbst & Roueff (2002), Gerlich & Schlemmer (2002), Asvany, Schlemmer & Gerlich (2004)). One key to unravelling the nature of isotopic fractionation lies in the ortho to para ratios of H_2 and the associated ortho to para ratio of H_2D^+ , CH_2D^+ etc. Dedicated experiments will be described where laser induced reactions are used to determine the rotational population and thus the ortho to para ratio of H_2D^+ under laboratory conditions. Preliminary results from these experiments will be compared to calculations from simple reaction models describing the chemical network. The role of scrambling collisions and nuclear spin conservation as well as the influence on current interstellar cloud models will be discussed.

Keywords. astrochemistry - ISM: molecules, methods: laboratory

References

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