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Theoretical models of deuterated H_3^+ in proto-planetary disks

Cecilia Ceccarelli[1]**& Carsten Dominik**[2]

[1]Laboratoire d'Astrophysique, Observatoire de Grenoble - BP 53, F-38041 Grenoble cedex 09, France
email:Cecilia.Ceccarelli@obs.ujf-grenoble.fr

[2]Sterrenkundig Instituut "Anton Pannekoek", Kruislaan 403, NL-1098SJ Amsterdam, The Netherlands
email:Dominik@science.uva.nl

Abstract. Probing the gas and dust in proto-planetary disks is central for understanding the process of planet formation. In disks surrounding solar type protostars, the bulk of the disk mass resides in the outer midplane, which is cold ($\leqslant$20 K), dense ($\geqslant 10^7$ cm^{-3}) and depleted of CO. Observing the disk midplane has proved, therefore, to be a formidable challenge. Ceccarelli et al. (2004, ApJ 607, L51) detected H_2D^+ emission in a proto-planetary disk and claimed that it probes the midplane gas. Indeed, since all heavy-elements bearing molecules condense out onto the grain mantles, the most abundant ions in the disk midplane are predicted to be H_3^+ and its isotopomers. In this poster, we show the results of a theoretical study of the chemical structure of the outer midplane of proto-planetary disks. Using a self-consistent physical model for the flaring disk structure, we compute the abundances of H_3^+ and its deuterated forms across the disk midplane. We also provide the average column densities across the disk of H_3^+, H_2D^+, HD_2^+ and D_3^+, and line intensities of the ground transitions of the ortho and para forms of H_2D^+ and HD_2^+ respectively. We discuss how the results depend on the cosmic ray ionization rate, dust-to-gas ratio and average grain radius, and general stellar/disk parameters. An important factor is the poorly understood freeze-out of N_2 molecules onto grains, which we investigate in depth. We finally summarize the diagnostic values of observations of the H_3^+ isotopomers.

Keywords. ISM: abundances – ISM: molecules – Stars: formation –ISM: