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Interruption of ion acceleration by collisions with neutrals in a cometary coma: a 1D model applied to 67P/Churyumov-Gerasimenko

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We present a 1D model of a cometary ionosphere with the main purpose to investigate the ability of the neutrals to hamper ion acceleration along electric fields in the radial direction. Because ion-neutral reaction cross-sections are energy dependent, the distance from a cometary nucleus within which ions remain collisionally coupled to the neutrals is dictated not only by the comet's activity level but also by the electromagnetic fields in the coma. As electron cooling is inefficient due to low neutral gas density and density decays with cometocentric distance a significant ambipolar electric field may develop. In the model we treat charge transfer processes as replacing a fast ion and a slow neutral with a fast neutral and a slow ion. For a given neutral background and electric field profile, the model, which in essence is based on the multiplication principle of probabilities, calculates observables such as the total ion number density, the H_3O^+/H_2O^+ number density ratio, the mean ion drift speed and the ion energy distribution function, as a function of cometocentric distance. The model is applied to different conditions encountered by Rosetta during its mission to comet 67P/Churyumov-Gerasimenko. Our findings include i) that the activity, even near perihelion, was probably not high enough for an efficient ion-neutral coupling all the way to the spacecraft location, and ii) that model runs using electric field profiles that give ion number densities and mean flow speeds within limits constrained by RPC observations tend to give H_3O^+/H_2O^+ number density ratios higher than typically observed by ROSINA/DFMS (e.g., [1]). We discuss also the influence on the results of including the ion motion in large-amplitude plasma waves into the model. Finally we highlight some reactions for which determinations of cross-sections at low collision energies would be valuable.

[1] Fuselier, S.A., et al. 2016, MNRAS, 462, S312