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Multifluid modelling of cometary coma for diverse range of parent volatile compositions

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Comets show a general diversity in their parent volatile composition, but in most cases H_2O is observed to be the dominant volatile in terms of abundance. This is followed by CO and CO_2, and trace amounts of other species such as CH_4, CH_3OH, O_2, and NH_3 are also present. However, the observed ratio of n_x/H_2O varies considerably from one comet to another (n_x represents any parent species other than water).

We aim to study how the chemistry and dynamics of the cometary coma changes for varying abundances of the major parent volatiles. We have constructed a fluid model, using the principles of conservation of mass, momentum and energy, for our study. Parent volatiles sublimating from the nucleus undergo photolytic reactions due to the solar UV radiation field, resulting in the formation of secondary neutral and ionic species and photoelectrons. Active chemistry occurs in the coma, and some of the chemical reactions taking place are ion-neutral rearrangement, charge exchange, dissociative recombination, electron impact dissociation and radiative de-excitation. The energy that is released due to these chemical reactions is non-uniformly distributed amongst all the species, resulting in different temperatures. Hence, for a complete description of the coma, we have used a multifluid model whereby the neutrals, ions and electrons are considered as three separate fluids. Apart from chemical reactions, we have also considered the exchange of energy between the three fluids due to elastic and inelastic collisions.

We consider different initial compositions of the comet, and then use our model to generate the temperature and velocity profiles of the coma, for varying cometocentric distances. We also obtain the number density profiles of the different ionic and neutral species that are created in the coma. We see that changes in the initial parent volatile abundance will modify the temperature profile, and there are significant changes in the ionic abundances. Hence, the parent volatile composition of the comet drives the physico-chemical attributes of the coma.