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Coupled modeling of neutral and ionized sodium in the exosphere and magnetosphere of Mercury

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Because of its bright emission that allows remote observations, the existence of a sodium exosphere on Mercury has been known for more than 20 years. Produced by photo-ionization, Na^+ is the most abundant heavy ion species of the exospheric origin entering the magnetosphere. As a result, the study of sodium (both neutral and ionized) can help to link the dynamical processes occurring in the exosphere and magnetosphere to in situ and remote observations. This consideration makes sodium one of the most interesting species present in the vicinity of Mercury.

A coupled modeling of neutral and ionized sodium is a challenging problem. A large mean free path and gyro radius makes it important to account for kinetic effects. Furthermore, the interaction of the magnetosphere with the solar wind defines the distribution of the electric and magnetic fields that act upon these ions and has to be considered also.

Our exospheric Monte Carlo model preserves the kinetic nature of the evolution of the neutral/ionized sodium population. In the numerical approach implemented for this work, we separate the simulation of the sodium ions distribution from the calculation of the electric/magnetic fields, which are obtained from the Michigan global MHD model of Mercury's magnetosphere. Such an approach cannot be considered as completely self-consistent because the charge and current densities associated with Na^+ are neglected in the calculation of the fields.

With our model we will study both recycling of the neutral sodium atoms in order to determine its escaping fraction as well as formation of the neutral tail, which will be used to constrain the total source rate. By modeling Na^+ ions we will derive their energy distribution for further comparisons with in situ measurements.