Self-consistent modelling of Mercury's surface composition and exosphere by solar wind sputtering

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A Monte-Carlo model of exospheres was extended by treating the solar wind ion induced sputtering process, quantitatively in a self-consistent way starting with the actual release of particles from the mineral surface of Mercury. Mercury is a body without a significant atmosphere, thus, the surface is effected by different processes that are mainly related to the radiation and plasma environment of the Sun and to micrometeorites, which are delivered to Mercury's surface. In such a case it can be assumed that the composition of Mercury's thin collisionless atmosphere, the exosphere, is related to the composition of the planetary crustal materials. If so, then inferences regarding the bulk chemistry of the planet can be made from a study of atoms and molecules in the exosphere after they are released from the mineral surface by a variety of release processes. One difficult challenge is the identification of the main source of some elements like H, He, Na or K. Generally it is believed that H and He come primarily from the solar wind, while Na and K originate from volatilized materials partitioned between Mercury's crust and impacts from meteorites. Besides the before mentioned elements corresponding to spectroscopic observations and experiments with soil analogues, other elements such as O, Na, Mg, Al, Si, P, S, K, Ca, Ti, Cr, Fe, Ni, Zn, OH should also be related with Mercury's surface soils (Wurz et al., 2010, and references therein). Based on available observational data and literature data we established a global model for the surface mineralogy of Mercury and from that derived the average elemental composition of the surface. Compositional data analysis has been employed for Mercury's surface minerals recently by (Sprague et al., 2009). In these cases the applied method was based on simple correlation methods, which do not exploit the full potential of the available data. In addition, the closed nature of compositional data, i.e., the assumption that component concentrations have to sum up to 100% in an analysis, bears important implications for the statistical analysis of compositional data, which do not seem to have been sufficiently appreciated until now. To investigate the default of the classical additive analysis method our research group applied recently a more realistic multiplicative method (Aitchison, 1986) based on the Euclidean space geometry of the simplex (see the chapter Elements of simplicial linear algebra and geometry). Our recent results presented in detail in Wurz et al., (2010) for Mercury will be discussed. This model serves as a tool to estimate densities of species in the exosphere depending on the release mechanism and the associated physical parameters quantitatively describing the particle release from the surface.

References

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