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Comparison of models for Mercury's pickup ions with MESSENGER measurements for northward and southward IMF

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Measurements obtained during the first and second MESSENGER flybys of Mercury reveal that ions of planetary origin extend beyond Mercury's magnetosphere and into the upstream solar wind. Prominent among these ions are those of sodium and magnesium. We investigate the distribution of these two ionic species during the flybys by means of single-particle tracing, using magnetospheric fields obtained from a magnetohydrodynamic simulation and models for the sources of neutral sodium and magnesium corresponding to photodesorption, impact vaporization, and ion sputtering. From the perspective of exosphere-magnetosphere connection, the main difference between the two flybys was a change from northward to southward interplanetary magnetic field (IMF) conditions. At high altitudes, the planetary ions respond to the –V x B electric field applied by the solar wind in a cometary manner. These MESSENGER observations are reproduced by model calculations showing penetration of pickup ions into the dusk (dawn) magnetosphere for northward (southward) IMF. The results of this new model of planetary ion pickup and the spatial distribution of ions measured by MESSENGER are used to constrain the neutral exospheric morphology and to assess the role of planetary ions in magnetospheric processes.