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On the dynamic influence of Na+ in Mercury's magnetotail

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Although initially ionized at low (<10 eV) energies in Mercury's dayside magnetosphere, Na+ ions can become energized via non-adiabatic motion in the plasma sheet to energies as high as several keV. Although present in sufficient abundance to contribute to both plasma pressure and mass density, the collective influence of Na+ has not yet been confirmed. Here, observations by the Fast Imaging Plasma Spectrometer and Magnetometer on the MErcury Surface Space Environment, GEochemistry, and Ranging spacecraft demonstrate that Na+ can contribute substantially to the total pressure in Mercury's plasma sheet. We identify several examples of sustained high fluxes of Na+ particle flux that are shown to contribute to the diamagnetic depressions measured in the plasma sheet. The three-dimensional distribution functions of Na+ for these events are consistent with hot, nearly isotropic Maxwell-Boltzmann distributions. The relative pressure contribution of Na+ to the total plasma sheet content at Mercury is highly asymmetric, increasing from $\sim$1-30% from dawn to dusk. We further identify an increase in magnetic fluctuations near the Na+ gyro-frequency at the dusk-side magnetopause when the Na+ content of the plasma sheet exceeds 1/cc. These fluctuations are non-linear and highly compressive and do not appear to be the simple left-hand-polarized ion cyclotron wave mode. Instead, these waves transition from left-hand near the magnetopause to right-hand polarization deeper inside the magnetosphere, penetrating up to high latitudes.