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Cold ionospheric ions in the magnetosphere: Why they are important

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Cold (eV) ions of ionospheric origin dominate the number density of most of the volume of the magnetosphere during most of the time. This affects large scales, including the Alfve´n velocity and thus energy transport with waves and the magnetic reconnection rate. This also affects small-scale kinetic plasma physics, including the Hall physics and wave instabilities associated with magnetic reconnection. Concerning large scales, we summarize observations from several spacecraft and show that a typical total outflow rate of ionospheric ions is 10^{26} ions/s and that many of these ions stay cold also after a long time in the magnetosphere. Concerning small scales, we show examples of how cold ions modify the Hall physics of thin current sheets, including magnetic reconnection separatrices. On small kinetic scales the cold ions introduce a new length-scale, a gyro radius between the gyro radii of hot (keV) ions and electrons. The Hall currents carried by electrons can be partially cancelled by the cold ions when electrons and the magnetized cold ions ExB drift together. Also, close to a reconnection X-line an additional diffusion region can be formed (regions associated with hot and cold ions, and with electrons, total of three). In addition, in thin current sheets, the relative drift between hot (unmagnetized) and cold (magnetized) ions can cause lower hybrid waves, heating the initially cold ions. We present recent estimates of the effects of cold ions, using observations from the Cluster and MMS spacecraft.