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Outflow of Ions: From eV to keV Energies

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Ions apparently originating from the same source, the ionospheric polar cap, can either end up as energized to keV energies in the high-altitude cusp/mantle, or as cold ions in the magnetotail lobes. Cluster observations show that the cusp is a main source of oxygen ion outflow, whereas the polar cap is a main source for cold ions observed in the lobes. Such cold positive ions with energies less than tens of eV are complicated to detect onboard sunlit spacecraft at higher altitudes, which often become positively charged to several tens of volts. We use two Cluster spacecraft and study low-energy ions with a technique based on the detection of the wake behind a charged spacecraft in a supersonic ion flow. We find that low-energy ions usually dominate the density and the outward flux in the geomagnetic tail lobes during all parts of the solar cycle. The global outflow is of the order of 10^{26} ions/s and often dominates over the outflow at higher energies. The outflow increases by a factor of 2 with increasing solar EUV flux during a solar cycle. This increase is mainly due to the increased density of the outflowing population, while the outflow velocity does not vary much. Thus, the outflow is limited by the available density in the ionospheric source, rather than by the energy available in the magnetosphere to increase the velocity.