Ion distributions in the Earth's foreshock region: hybrid-Vlasov simulations and spacecraft observations

Y. Kempf[1,2,*], O. Gutynska[3], D. Pokhotelov[1], L.B. Wilson III[3],
B. Walsh[3], S. von Alfthan[2], D. Sibeck[3], M. Palmroth[2]

1. Department of physics, University of Helsinki, P.O. Box 64, 00014 University of Helsinki, Finland
yann.kempf@fmi.fi, dimitry.pokhotelov@fmi.fi

2. Earth observation unit, Finnish Meteorological Institute, P.O. Box 503, 00101 Helsinki, Finland
sebastian.von.alfthan@fmi.fi, minna.palmroth@fmi.fi

3. NASA Goddard Space Flight Center, Code 674, Greenbelt, Maryland 20771, USA (except L.B. Wilson: Code 672)
olga.gutynska@nasa.gov, lynn.b.wilson@nasa.gov, brian.m.walsh-1@nasa.gov, david.g.sibeck@nasa.gov

We present the ion distribution functions in the terrestrial foreshock, simulated by the hybrid-Vlasov model called Vlasiator and observed by the THEMIS and Cluster spacecraft. In the hybrid-Vlasov description, the ion distribution function is propagated in up to three spatial and three velocity dimensions and electrons are modelled as a massless charge-neutralising fluid. Vlasiator was used to model self-consistently the terrestrial bow shock and foreshock regions in the ecliptic plane (two spatial, three velocity dimensions). The simulations were run for tens of ion gyroperiods over hundreds of ion inertial lengths. Vlasiator provides, for the first time, a large-scale picture of the ion distribution in the foreshock with a quality comparable to or even better than spacecraft data thanks to the uniform velocity space sampling and the absence of statistical noise. This allows us to study the interaction between the backstreaming ions and the solar wind, which can trigger instabilities leading to waves in the foreshock.

This poster will feature a simulation snapshot on a large scale including the simulated ion distribution functions at high spatial resolution, as well as comparison to spacecraft data. Beam and ring-beam distributions are present near the foreshock edge. The distributions become progressively more intermediate/cap-shaped with increasing distance from the foreshock edge, including occurrences of multiple-cap distributions. At the same time the drift speed relative to the solar wind decreases deeper in the foreshock. Diffuse distributions are present near the quasi-parallel bow shock.

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