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Large-Scale Structures in Earth Foreshock Waves during Radial IMF

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Wave instabilities in the foreshock region of Earth's bow shock lead to formation of magnetic field and density fluctuations, commonly observed by spacecraft as 30-second waves. These waves are oblique to the interplanetary magnetic field, with the mechanism leading to oblique propagation still under discussion.

Using the VLASIATOR (http://vlasiator.fmi.fi) global hybrid-Vlasov simulation code, we performed runs of radial and near-radial IMF conditions and were able to reproduce the development of these oblique foreshock wave instabilities, revealing a peculiar global structure, in which waves with different wave-vector directions are arranged around central spines, which are spatially offset from the bow shock's nose.

We present analysis of the waves' growth behaviour and combine them with artificial observations, comparing to in-situ spacecraft data. Furthermore, we employed a test particle approach to investigate the formation mechanism of the instabilities' large-scale structure, and found that a coupling between the microphysics of wave-particle interaction and global-scale shock and foreshock geometry is essential to explain them.