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Multi-spacecraft measurement of spatial scales of foreshock Langmuir waves

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Langmuir waves in planetary foreshocks are usually observed in the form of localized short wavepackets. This observation is often interpreted as a projection of small scale spatial structure of the wavepackets being convected over the spacecraft by the solar wind flow. Multi-spacecraft Cluster observations offer a unique opportunity to distinguish between spatial and temporal effects and to estimate the spatial dimensions of wavepackets by direct measurement. In our study we derived such multi-spacecraft estimates of the spatial scales of foreshock Langmuir wavepackets using data from the WBD wave instrument. As the scales of Langmuir wavepackets are of the order of tens of kilometers, at very small spacecraft separations (100 km) signatures of the same wavepacket on two different satellites could sometimes be identified. To overcome instrumental constraints, we developed a spectral matching technique and evaluated the results in a statistical sense. The analysis shows, that typical scale of Langmuir wavepackets in the direction transverse to the magnetic field falls between 40 and 100 km and their size in the parallel direction is larger than 150 km. We also conclude that convection of wavepackets may contribute to the large scale temporal modulation of Langmuir waves observed in previous spacecraft studies, but the small scale structure of the modulation must be attributed to other effects.