URSI AP-RASC, Sydney, Australia, 17-22 August 2025

Prediction of the Shape and Orientation of Foreshock Radio Sources at Earth and Elsewhere

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Radio emission produced in Earth's foreshock is due to the bow shock reflecting and accelerating some electrons back upstream into the foreshock, where they produce Langmuir waves and radio emissions near the electron plasma frequency f_p and near $2f_p$. Here we make new predictions about the source shape and flux of Earth's foreshock radio emissions, with associated implications for other sources of radio emission at multiples of f_p. We use a recently extended model for Earth's foreshock radiation to calculate throughout the foreshock the electron distributions and the energy flows into Langmuir waves and radio emissions produced by specific linear and nonlinear emission processes. One extension is the addition of linear mode conversion of Langmuir waves into f_p radio emission at density gradients, a process that is found to produce ~ 10-30% of the total radio flux near f_p. We predict images for the shape, size, and location of Earth's foreshock radio sources for f_p and $2f_p$ radiation observed remotely from the first Lagrange point and other locations. The intrinsic radio sources should be elongated along the shock surface perpendicular to the plane containing the upstream magnetic field and plasma flow velocity vectors. These calculations confirm the qualitative prediction by Gurnett and colleagues for the 2-3 kHz outer heliospheric radiation. Although angular scattering by density irregularities also needs to be considered, which will tend to change the shape and size of the source increasingly as the observing distance increases, this prediction is also applied to type II solar and interplanetary radio bursts as well as other foreshock-like radio sources. Once again, when sufficiently close to the radio source, the intrinsic source shape is expected to be elongated perpendicular to the (macroscopic) magnetic field direction in the source, projected into the plane of the sky, and along the shock surface.