Radiation efficiency of electromagnetic wave modes from beam-generated solar radio sources

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Résumé

During type III solar radio bursts, electromagnetic waves are radiated at the plasma frequency and its harmonics by electrostatic wave turbulence generated by electron beams ejected from the Sun in randomly inhomogeneous solar wind and coronal plasmas. These emissions, detected for decades by spacecraft and radiotelescopes, are split by the plasma magnetic field into three modes, X, O and Z, with different dispersion, polarization and radiation properties. Here, using three independent and converging approaches-particle-in-cell simulations, a theoretical model of waves in a random medium and analytical calculations in the framework of turbulence theory-we demonstrate that only a small fraction of electromagnetic energy radiated at the plasma frequency escapes from beam-generated radio sources, mainly as O-mode waves and, depending on plasma conditions, as X-mode waves. Most energy is radiated in the Z-mode and can therefore be observed only close to sources. The results provide strong support for interpretation of observations performed up to close distances from the Sun by spacecraft such as Parker Solar Probe and Solar Orbiter. This work, based on general approaches requiring few assumptions, makes it possible to study the properties of radio emission under realistic solar conditions, and thereby provides a solid basis for the development of theoretical tools for probing space and time variations of beam–plasma systems in the solar wind.

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