Electromagnetic radiation from upper-hybrid wave turbulence driven by electron beams in solar plasmas

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Solar radio bursts of Type III are believed to result from a sequence of physical processes ultimately leading to electromagnetic wave emissions near the electron plasma frequency $\omega_p$ and its harmonic $2\omega_p$. The radiation bursts are due to energetic electron beams accelerated during solar flares. When propagating in the solar corona and the interplanetary wind, these fluxes excite Langmuir and upper-hybrid wave turbulence, which can be further transformed into electromagnetic radiation near the frequencies $\omega_p$ and $2\omega_p$.

It is believed that, in a homogeneous plasma, Langmuir turbulence evolves due to three-wave interaction processes, such as the fusion of Langmuir waves $L$ with sound waves $S$ leading to the formation of electromagnetic waves $T_{\omega_p}$ at $\omega_p$ or the decay of $L$-waves into $S$-waves and $T_{2\omega_p}$-waves. On the other hand, the electromagnetic waves radiated at $2\omega_p$ should arise from the coalescence $L + L' \rightarrow T_{2\omega_p}$ of Langmuir waves $L$ generated by the beam with Langmuir waves $L'$ coming from the electrostatic decay $L \rightarrow L' + S$.

Large-scale 2D3V Particle-In-Cell simulations have been performed with the fully kinetic code Smilei [Derouillat et al., 2018], using parameters typical of Type III solar radio bursts. The excitation of upper-hybrid wave turbulence by energetic electron beams propagating in magnetized plasmas leads ultimately to electromagnetic emissions near the fundamental and the harmonic plasma frequencies.
