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Efficient photon-stimulated scattering of fast electrons in solar flares

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Understanding the dynamics of flaring magnetic structures, in active regions of the Sun surface, is of prime importance for space weather forecasts. The mechanisms of acceleration and confinement of fast electrons, in a flare magnetic-loop, determine the flare energetics [1, 2], yet they still remain elusive so far.
A striking energy-height dependence of accelerated fast electrons was observed in a large number of flares. In these so-called Masuda flares [3], combined microwave and hard X-ray observations indicate the presence of a fast electron population above the flare loop-top, which is interpreted as resulting from enhanced fast electron scattering [4, 5, 6, 7].
Turbulent wave-particle scattering is usually pointed out as the dominant mechanism at play. A variety of observations [8] and theoretical works [9] support the occurence of small-scale turbulence, as well as turbulent mirrors, that may enhance the fast electron scattering in flares. However, the magnetic fluctuation spectrum is poorly known [11], which introduces a large uncertainty in the models and makes the predicted flare dynamics very sensitive to the turbulence parameters. In that respect, the solar Parker Probe and solar orbiter spacecrafts may soon bring a better characterization of these turbulent spectrum.
Here we show that another mechanism should be considered to explain the enhanced fast electron scattering, namely, Bremsstrahlung-induced scattering off the plasma ions, stimulated by the flaring Sun radiation. We demonstrate that the thermal radiation spectrum of the Sun corona in the microwave range can boost the Bremsstrahlung scattering of fast electrons by orders of magnitude. This is due to the fact that stimulated Bremsstrahlung scattering possesses two infrared divergences. These divergences, which occur both in the Bremsstrahlung cross-section and in the photon occupation number, cumulate at the lowest frequencies, close to the corona plasma frequency. By estimating the radiation intensity in the microwave range, for a well-documented Masuda flare [10, 5], we show that the proposed mechanism is sufficient to explain the anomalously high fast electron scattering inferred from the observations.

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