Electron transport in a radiation-dominated plasma, application to solar corona brightenings

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Résumé

Bremsstrahlung scattering of fast electrons on ions can be enhanced by the microwave radiation present in the solar corona.
It can account for the electron diffusive transport along magnetic loops and high precipitation rates (Duclous et al., PoP, 31, 2, 022904, (2024)).
This process can also dominate the transport of thermal electrons confined in such loops, which calls for a dedicated study.

The influence of stimulated Bremsstrahlung scattering on the electron transport is studied here, with focus on the return current induced by the fast electron population trapped in magnetic loops. From a more general standpoint, transport coefficients need to be reevaluated in the radiation-dominated plasma, characterized by the stimulated action of radiation on the Bremsstrahlung electron-ion collision frequency, down to thermal velocities.

We develop a theoretical framework for electron transport driven by a large bandwidth, bright low-frequency part of the photon spectrum and compute a set of radiation-enhanced transport coefficients. UV, XEUV and hard X-ray signals from flares are reinterpreted, in order to put maximum constraints on the fast electron/return current model. These observations evidence anomalous resistivity, thermal conduction inhibition and high precipitation rates of fast electrons, which are quantified by the model.

Stimulated Bremsstrahlung scattering provides the enhancement of electron collision frequency needed to account for the observed anomalous resistivity in flares. The anomalous resistivity systematically dominates

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over the classical resistivity in the flaring
corona plasma by at least an order of magnitude. The runaway effect due to Coulomb collisions is suppressed.
Thermal conduction is inhibited compared to the Spitzer conduction, in agreement with coronal seismology of slow-mode waves.

Stimulated Bremsstrahlung scattering is found to be the key process in flaring events of the solar corona. It can explain
the above loop-top hard X-ray signal due to the fast electrons, and the measured electrical conductivity due to the thermal ones. As
a perspective, the corresponding transport coefficients can be used in radiation MHD codes. To that aim, a simple model is proposed
to self-consistently describe the transport coefficients and the infrared part of radiation spectrum. The radiation model could also be
applied to stimulate large-angle electron scattering in the kinetic or hybrid models used to study the reconnecting regions of the solar
corona.