Limits on the compression of magnetic islands in strongly radiative magnetic reconnection

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Magnetic reconnection has been suggested to play an important role in the production of gamma-ray flares, which are observed near the magnetospheres around compact objects such as pulsars and magnetars. Reconnection leads to the generation of magnetic islands and acceleration of non-thermal particles. In such scenarios, the field strength can be close to the critical (Schwinger) field, resulting in quantum electrodynamic (QED) effects including discrete gamma-ray emission and pair creation. Therefore, standard plasma models for magnetic reconnection are no longer valid in these scenarios.

The evolution of magnetic islands generated in a reconnecting relativistic pair plasma is investigated using 2D and 3D particle-in-cell simulations in strong magnetic fields. For sufficiently strong fields (and a weak guide field), radiation cooling leads to compression of the magnetic islands, which amplifies fields and plasma density [1]. The QED module [2] of the OSIRIS framework allows us to model the radiation as either classical radiation reaction or the QED emission of discrete photons according to non-linear Compton scattering, as well as single photon decay into pairs (non-linear Breit-Wheeler). We show that the measured increases in density n and magnetic fields B due to compression are limited by power-laws in n-B space. In 3D, the magnetic flux ropes become kink-unstable, which effectively limits the compression of density. However, increasing upstream plasma magnetization leads to stronger magnetic compression, which in turn leads to increased pair production, and gamma-ray emmision.

References

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