Relativistic reconnection in near critical magnetic fields

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Magnetic reconnection is a process that is known to violently release energy from magnetic fields in events such as solar flares, geomagnetic storms, and flares found in various astrophysical objects. In the most extreme magnetic fields found in magnetars, and pulsar magnetospheres, the magnetic fields reach the critical quantum Schwinger field BQ ≃ 4.4×1013 G. The very high field strength in these exotic environments introduces two qualitatively new physical elements: synchrotron radiative cooling and electron-positron pair production [1]. We investigate the effects of radiation and pair-creation in the presence of strong magnetic fields on magnetic reconnection starting with relativistic pair plasma using both 2D and 3D particle-in-cell simulations. The simulations are performed with the QED module [2] of the OSIRIS framework that includes single photon emission by electrons and positrons (non-linear Compton scattering) and single photon decay into pairs (non-linear Breit-Wheeler). We show that even when the magnetic fields initially do not exhibit QED effects, the reconnection leads to both energetic particles, and enhanced magnetic fields, such that radiative cooling and pair production processes begin to play an important role. We show that reconnection in this regime can convert a significant fraction of the magnetic energy to X-ray and gamma ray radiation. We highlight that the radiation spectra that may be observable from such events differs strongly from the classical cases with much steeper spectra. This study is a first concrete step towards better understanding of magnetic reconnection as a possible mechanism powering gamma ray flares in magnetar magnetospheres.

[1] D.A. Uzdensky, Space Science Reviews 160, 45-71 (2011)
[2] T. Grismayer et al., Physics of Plasmas 23, 056706 (2016)