Prompt Emission Of High-Energy Nonthermal Photons From A Radiation-Dominated Relativistic Magnetic Reconnection

B. Qiao*, Y. Xie, Z. H. Zhao, Z. Lei, X. T. He

Center for Applied Physics and Technology & School of Physics, Peking University, Beijing, China

In astrophysics, relativistic magnetic reconnection, where particles can accelerate in a region of high electric field and low magnetic field, is a key physical process for the explanation of high-energy photon synchrotron emission above 160MeV, the limit given by the balance between the accelerating electric force and the radiation reaction force. However, the reconnection, more importantly, the particle acceleration and photon emission dynamics in this radiation-dominated, relativistic regime have not been self-consistently investigated yet so far. In this talk, I shall report our recent self-consistent theoretical and numerical simulation results [1] on the radiation-dominated relativistic magnetic reconnection. Through theoretical derivation of the modified relativistic tearing instability (RTI) and kinetic particle-in-cell simulations, we found that, because of the radiation reaction, the compression of the reconnecting current sheet is significantly enhanced, leading to an increase in the RTI growth rate in the short wavelength range. As a result, during reconnection, the current sheet is fragmented into a chain of much more magnetic null points separated with much smaller plasmoids, which eventually gives rise to significant improvement of particle acceleration efficiency and shortening of photon emission duration. In the simulation, prompt emission at duration $\omega_{pe}\Delta T \simeq 233$ (reduced by a factor of 3) of high-energy non-thermal photons with a hard power law of index 2.11 for photon energies $< 100\,\mathrm{MeV}$ and 1.39 for those $> 100\,\mathrm{MeV}$ is observed. These characters are consistent with the observed emission properties of short gamma-ray bursts (GRBs), in particular GRB 090510, supporting the radiation-dominated reconnection scenario.

*Email: bqiao@pku.edu.cn

References

[1] Y. Xie, Z. H. Zhao, Z. Lei, W. P. Yao, C. T. Zhou, S. P. Zhu, X. T. He, and B. Qiao, Astrophys. J. **921**, 16 (2021).