HEDLA 2022
13th International Conference on High Energy Density Laboratory Astrophysics
hedla@tecnico.ulisboa.pt

Microturbulence in relativistic blast waves

Arno Vanthieghem[1,2,†], Martin Lemoine[3], Laurent Gremillet[4,5], Jens Mahlmann[1], Amir Levinson[6], Ehud Nakar[6], Alexander Philippov[7], Frederico Fiuza[8]

[1] *Department of Astrophysical Sciences, Princeton University, Princeton, USA*
[2] *International Research Collaboration Center, National Institutes of Natural Sciences, Tokyo, Japan*
[3] *Institut d'Astrophysique de Paris, CNRS – Sorbonne Université, Paris, France*
[4] *CEA, DAM, DIF, Arpajon, France*
[5] *Université Paris-Saclay, CEA, Bruyères-le-Châtel, France*
[6] *School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[7] *Center for Computational Astrophysics, Flatiron Institute, New York, USA*
[8] *High Energy Density Science Division, SLAC National Accelerator Laboratory, California, USA*

[†] vanthieghem@princeton.edu

Microturbulence produced by plasma instabilities plays an important role in the dynamics and dissipation mechanisms of relativistic astrophysical blast waves, such as those associated with gamma-ray bursts. Modeling of their afterglow emission bears witness to strong electron heating in the precursor of relativistic Weibel-mediated collisionless shock waves propagating in unmagnetized electron-ion plasmas. We present the tenets of a theoretical model, validated by particle-in-cell simulations, accounting for the electron heating via a Joule-like process through the intricate interplay between pitch-angle scattering in the microturbulence and the coherent electrostatic field induced by the difference in inertia between species [1]. We will then discuss how this model can be extended to relativistic radiation-mediated shocks (RRMS) shaping the prompt gamma-ray burst emission. These shock waves are mediated by Compton scattering and copious electron-positron pair creation. Recently, we demonstrated [2] the development of a microturbulence leading to coupling and heating unaccounted for by current single-fluid models. Our results suggest that the microturbulence could have important consequences for the radiative signatures of RRMS.

References

[1] A. Vanthieghem, M. Lemoine, and L. Gremillet, "Origin of intense electron heating in relativistic blast waves", to be published in ApJ Letters, April 2022

[2] A. Vanthieghem, J. Mahlmann, A. Levinson, A. Philippov, E. Nakar, and F. Fiuza, "The role of plasma instabilities in relativistic radiation mediated shocks: stability analysis and particle-in-cell simulations", MNRAS 511, February 2022