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Plasmas in super-intense laser fiels

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Laboratory Astrophysics

Laboratory Astrophysics is the study of astrophysical phenomena on a laboratory scale. The physics explored in high-power laser experiments address questions that are relevant to understand astrophysical phenomena such as jets and turbulence (e.g. Suzuki-Vidal et al. 2015), shocks (e.g. Fiuza et al. 2020), and particle acceleration (e.g. Rigby et al. 2018). Due to the rapid growth in the overlap between common areas of interest, Laboratory Astrophysics is becoming a very popular field among Laboratory Plasma physicists and High Energy astrophysicists.

Spatial and temporal scales involved in astrophysical processes and those obtained in the laboratory are extremely different, however, magnetohydrodynamic similarity criteria have been identified. The so called scaling laws ensure the equivalence between the astrophysical conditions and those produced in the experiments (e.g. Ryutov 1999, Bouquet 2010, Falize 2012).

In addition to a good scaling of the system under study, it is also very important to diagnose the experiment properly in order to extract the information that we need. For instance, speed, density, and temperature are usually characterized by Thomson scattering measurements, magnetic fields are characterized through proton radiography, and the electron energy spectrum is measured using Bremsstrahlung X-ray emission imaging.

In this lecture we will describe astrophysical sources with shocks, and some of the open questions in Relativistic Astrophysics that can be addressed by performing a well scaled and well diagnosed experiment in a high power laser facility. We will describe the preliminary studies necessary to design the experiment, the numerical simulations needed to confront the data with, and the most common experimental diagnostics. We will illustrate this with the most recent and groundbreaking laser plasma experiments.

References

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