Laboratory-Based Intense Gamma-Ray and Lepton Beams for Strong-Field QED and Laboratory Astrophysics

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Sources of high-energy, dense and collimated photon and lepton beams enable new avenues for research in strong-field QED and relativistic laboratory astrophysics [1-2].

In this talk, we show that a high-current ultrarelativistic electron beam interacting with multiple thin conducting foils can undergo strong self-focusing accompanied by the efficient emission of gamma-ray synchrotron photons. Physically, self-focusing and high-energy photon emission originate from the beam interaction with the near-field transition radiation accompanying the beam-foil collision. This near field radiation is of strength comparable with the beam self-field and can be strong enough that a single emitted photon can carry away a significant fraction of the emitting electron energy. After beam collision with multiple foils, collimated electron and photon beams with a number density exceeding that of a solid are obtained [3].

The relative simplicity, unique properties, and high efficiency of this gamma-ray source open up new opportunities for both applied and fundamental research, including laserless investigations of strong-field QED processes with a single electron beam [3] and the generation of dense electron-positron jets that are essential for laboratory astrophysics investigations of electron-positron plasma [1-2].

Based on these findings, the E-332 experiment on solid-density gamma-ray pulse generation in electron beam-multifoil interaction has been developed and approved with maximal ranking and will be carried out at the FACET-II facility at SLAC.

Finally, we show that high-energy and dense lepton beams enable precision studies of fundamental quantum processes in the supercritical QED regime, where the beam particles experience rest-frame electromagnetic fields, which greatly exceed the QED critical one [4].

References

[1] R Ruffini, G Vereshchagin and S-S Xue, Phys. Rep. **487**, 1 (2010)

[2] A Di Piazza, C Müller, K ZHatsagortsyan and C H Keitel, Rev. Mod. Phys. **84**, 1177 (2012)

[3] A Sampath1, X Davoine, S Corde, *et al.*, Phys. Rev. Lett. **126**, 064801 (2021)

[4] M Tamburini and S Meuren, arXiv:1912.07508 (2019)