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Melamed Lecture Hall

High Intensity Lasers and the Dawn of Ultrafast Nuclear Science

For the past few decades, nuclear research has been exclusive to large accelerator and reactor facilities. The availability of tabletop particle sources based on high intensity lasers opens venues for new research methods in nuclear physics, both at large facilities and at university-scale laboratories.

The first part of my talk will be devoted to intense radiation sources based on tabletop lasers. I will report on our experimental realization of a novel ultra-short pulsed laser-driven neutron generator. Our results show a dramatic onset of high- energy electron generation from petawatt laser-irradiated plastic targets. The copious amounts of multi-MeV electrons are utilized to generate photo-neutrons from a metal converter. The neutrons are generated with a <50 ps pulse duration and an unprecedented flux of 1018 n/cm2/s.

The second part of my talk will focus on the “Extreme Light Infrastructure – Nuclear Physics (ELI-NP)” laser facility coming online soon in Bucharest, Romania. This facility will utilize a high-intensity laser system and a high-flux narrow-bandwidth gamma beam for studies of nuclear structure and nuclear astrophysics.

I will describe our conceptual design for the production of neutron-rich nuclei using high intensity lasers on facilities like ELI-NP. In our approach, large van der Waals bonded clusters of ThO2 undergo coulombic explosion under the high electric field in the focus of the laser. The resulting kinetic energies are sufficient for the oxygen to induce fission in the thorium, and for the fission fragments to fuse into heavy and extremely neutron rich nuclei. I will discuss the prospects of this method in performing r-process nucleosynthesis studies in the lab.