Enhancing Laser-Plasma Acceleration for Nuclear Physics

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Laser plasma acceleration is not only suitable for advanced accelerator, but also possess great potential for plasma nuclear exciter or collider. At present, most of research topics in this field focus on the quality improvement of accelerated particle beams. On the other hand, the laser plasma accelerator also has extremely high density which will produce high brightness gamma ray source and intense neutron source, resulting in powerful tool for nuclear physics research.

Recently, our team has carried out systematic studies on electron acceleration with large charge. For example, we used a solid target to realize relativistic electron acceleration of 100 nC [1] with very small divergence angle; And achieved stable acceleration of $\sim$20 nC with electron energy tens MeV using high-density gas targets, through a novel efficient injection that the atom inner shell electrons are ionized and continuously injected into multiple plasma bubbles [2]. Micro-C level electron beam produced via combination of near critical density plasma and PW lasers [3].

Based on new experimental results of electron acceleration, we have carried out the research about "laser-plasma exciter/reactor". Firstly, a high brightness neutron source [4] is obtained by driving a solid target with an electron beam. And, with optimized high charge electron beam driven (gama,n) reaction, the peak flux of neutron source reaches to 10^{20} n/cm^2/s, which is comparable to Supernova [3]. Then, using the nonlinear resonance of Kr clusters excited by intense laser, the ^{83}Kr isomeric state is achieved experimentally with peak efficiency 2×10^{15} p/s [5]. After carefully measurement of the excitation cross section, the ^{83}Kr excited from the ground state to the 3rd exciting state with cross section as small as 10s pbarn [6], which is usually have to measure them deep into ground to reduce the background; Using the enhanced electron accelerator, MeV-level electron beam has been introduced to excite high energy isomeric states such as In [2]. With the above novel method, a systematic nuclear excitation technique has been constructed covering low energy to high energy range, suitable for the study of BBN, steller and SuperNova nucleosysnesis.

In order to carry out the experimental verification of laser "laser-plasma exciter/reactor" based on extremely strong field QED, we will finalizing the construction of the "laboratory astrophysics research platform" (LAP) [7] in TsungDao Lee Institute, for the nuclear astrophysics research in relativistic.

References

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