Laser-nucleus interaction with keV and MeV photons

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The study of the light-nucleus interaction over a broad photonic energy range is of fundamental importance to better understand nuclear structures and reactions. In my talk two frequency regimes will be covered: keV (x-ray) and MeV (gamma-ray) photons.

In the first part, we treat the resonant interaction between x-rays and low-lying nuclear transitions in solid-state targets. In particular, the recently operational x-ray free electron lasers (XFELs) are expected to enable this kind of interaction, driving nuclear experiments from the excitation regime with at most one excited nucleus per pulse to multiple excitations. However, the highly intense x-ray beam not only amplifies the direct nuclear photoexcitation, but also the interaction with the electrons present in the target. New states of matter like cold, high-density plasmas can arise, where nuclear processes coupled to the atomic shell (e.g. nuclear excitation by electron capture - NEEC) are rendered possible. Taking into account the plasma expansion by a hydrodynamic model, we show that the indirect NEEC channel can even provide the major contribution to the nuclear excitation e.g. in the case of ^{93m}Mo isomer triggering, while it is totally negligible for other nuclear species like ^{57}Fe [1,2].

In the higher frequency regime, new petawatt optical laser facilities such as Extreme Light Infrastructure (ELI) hold promise to deliver in the near future coherent gamma-ray pulses, promoting laser-induced nuclear reactions in a so-far unavailable regime. The coherence strongly amplifies nuclear absorption and if the latter occurs comparably fast to nuclear equilibration, it leads to the formation of a compound nucleus with excitation energy several hundreds MeV above yrast in a so far totally unexplored territory [3]. Within this so-called quasiadiabatic regime we investigate theoretically the competition between photon absorption, photon-induced nucleon emission, neutron evaporation and fission [4].

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