Studying Nuclear Physics in Hot, Dense Plasmas at the National Ignition Facility

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The newly-commissioned National Ignition Facility (NIF) provides a unique laboratory for the study of high energy density plasmas and nuclear processes occurring within. Driven by up to 1.8 MJ of laser power, an imploding NIF capsule can produce average plasma densities of several hundred g/cm^3 at temperatures as high as 100 keV for confinement times of hundreds of picoseconds. With ignition of fusing deuterium and tritium fuel, as many as 10^{19} 14-MeV neutrons will be produced over the ~30 μm implosion, corresponding to fluences of 10^{23} n/cm^2 or fluxes of 10^{34} n/cm^2/s over the rapid burn time. Of more astrophysical relevance, thermal distributions at k_bT around 4 keV of 10^{14} neutrons can be produced in deuterium capsules with correspondingly high fluence and flux. We propose a number of initial experiments to probe nuclear reactions in this stellar-like environment that cannot be performed at accelerators or any other existing laboratory setting. We will aim to study reactions on short-lived excited states, s-process branch point cross sections, nuclei in thermal equilibrium with the plasma environment, and other plasma-nuclear interactions. To perform these experiments, a robust suite of debris collection and capsule performance diagnostics must be developed and implemented. In addition, capsules must be designed to introduce nuclei of interest into the plasma environment. Prepared by LLNL under Contract DE-AC52-07NA27344.