$T(T,^4He)2n$ and $^3He(^3He,^4He)2p$ Reactions and the Energy Dependence of Their Mechanism

A. D. Bacher[1], C.R. Brune[2], D. Sayre[3], G. Hale[4], A.B. Zylstra[4], J.A. Frenje[5], M. Gatu Johnson[5], C. Forest[6], V.Yu. Glebov[6], H.W. Herman[4], R. Janezic[6], Y.H. Kim[5], C.K. Li[5], D. McNabb[3], M. Paris[4], R.D. Petrasso[5], J. Pino[3], T.C. Sangster[6], and C. Stoecki[6]

[1]Indiana University, Bloomington, IN 47405 USA
[2]Ohio University, Athens, OH 45701 USA
[3]Lawrence Livermore National Laboratory, Livermore, CA 94550 USA
[4]Los Alamos National Laboratory, Los Alamos, NM 87544 USA
[5]Massachusetts Institute of Technology, Cambridge, MA 02139 USA
[6]Laboratory for Laser Energetics, University of Rochester, Rochester, NY 14623 USA

We have studied the $T(T, ^4He)2n$ reaction because it is the charge symmetric analog to the $^3He(^3He,^4He)2p$ reaction which completes the most direct mode of the proton-proton chain in stellar interiors. These reactions lead to three-body final states whose energy spectrum shapes are dominated by the strong nucleon-^4He and the weaker nucleon-nucleon interaction. These experiments were done at OMEGA at the University of Rochester LLE and at the NIF at Lawrence Livermore National Laboratory. We will focus on two features: (1) the excitation energy dependence of the reaction mechanism and (2) the center-of-mass energy dependence of the reaction mechanism. For the T+T reaction at stellar energies (OMEGA and the NIF) we find that the shape of the neutron energy spectrum peaks in the middle. The n-^4He $½^-$ state is about two times stronger than the n-^4He $3/2^-$ ground state. For the $^3He+^3He$ reaction (at Cal Tech), the proton energy spectrum peaks at the high energy end of the spectrum. The p-^4He 3/2- state is about two times stronger than the $½^-$ state. This difference in the spectrum shape is explained by new, state-of-the-art theoretical models [1] which include the interference between the two identical fermions in the final state. At Cal Tech we have measured angular distributions of the $^3He+^3He$ reaction between 2 MeV and 12 MeV. We observe that the p-wave strength is increasing. At stellar energies due to the identical nature of the initial state, the reaction is dominated by s-wave.