Near and sub-barrier fusion of neutron-rich light nuclei

K. Brown, M. Rudolph, Z. Gossler, S. Hudan, R.T. de Souza
Department of Chemistry and Center for Exploration of Energy and Matter, Indiana University, Bloomington, IN 47405
M. Famiano: Department of Physics, Western Michigan University, Kalamazoo, MI 49008
F. Liang, D. Shapiro: Oak Ridge National Laboratory, Oak Ridge, TN 37831
A. Chbihi, B. Jacquot: GANIL, Caen, France

**Motivation**

Neutron star crusts present a unique environment for nuclear reactions to occur. The rising electron Fermi energy enhances the rate of electron capture reactions at the density of the outer crust, leading to the production of neutron-rich isotopes. Accreting neutron stars have been identified as the origin of energetic X-ray superbursts. Since the temperature of a neutron star is ~ 1 GK, the fusion of the two nuclei is strongly suppressed by the Coulomb barrier. It has been proposed that enhanced fusion of neutron-rich nuclei in the outer crust provides the necessary heat source to ignite the fusion of two \(^{12}\)C nuclei and fuel the subsequent X-ray superbursts.

Calculations indicate that fusion of two \(^{16}\)O nuclei is a potential heat source. As this reaction is presently experimentally inaccessible, we have chosen to study fusion of neutron-rich oxygen with \(^{12}\)C. The fusion cross-section in previously measured fusion excitation functions for \(^{16,17}\)O + \(^{12}\)C are enhanced due to the increased size of the incident oxygen. The extent to which the fusion cross-section increases with increasing neutron number is presently an open question.

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**Experimental Design**

By looking for light charged particles (LCPs) in the \(^{16}\)O + \(^{12}\)C reaction, the reaction is filtered by the experimental setup was measured at Western Michigan University Tandem Accelerator in March 2011. Comparison of the experimental data with the predictions of evapOR shows good agreement.

**Results**

Fusion followed by charged particle decay in \(^{16}\)O + \(^{12}\)C using the same experimental setup was measured at Western Michigan University Tandem Accelerator in March 2011. Comparison of the experimental data with the predictions of evapOR shows good agreement.

The theoretical predictions from evapOR match the deposited energy in the silicon detectors for residues and the light charged particles.

The cross-section measured for the charged particle channels of \(^{20}\)O + \(^{12}\)C was found to be roughly two times the predicted cross-section from evapOR. This result means either the total fusion cross-section is larger than that predicted by the model, or the model under-predicts charged particle emission relative to neutrons.