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Cluster-induced reactions in astrophysics

Nuclear processes driving the energy production and nucleosynthesis in stars often cannot be studied directly in the laboratory. In many cases the reactions involve short-lived nuclei and are hindered by the Coulomb repulsion of the nuclei, making direct observation of the reactions difficult or even impossible. This is particularly true for reactions related to the breakout from the Hot-CNO cycle in for example X-ray bursts, a nuclear run-away on the surface of neutron stars. These reactions are triggered by the absorption of an alpha-cluster, and are therefore hindered by a large Coulomb barrier. Since the reactions involve the radioactive ¹⁴O, ¹⁵O, and ¹⁸Ne isotopes, direct measurements of the reactions are furthermore impeded by the difficulty in producing sufficiently intense beams of the involved isotopes.

The alpha-induced reactions are therefore best studied through indirect means using a combination of nuclear reactions with beams of both stable and radioactive nuclei. Through such reaction studies the nuclear properties that influence the astrophysical processes are measured, and the impact on stellar explosions determined. The presentation describes a research programme towards the measurement of the key breakout reaction, ¹⁵O(alpha;,gamma;)¹⁹Ne. The planned measurements include: indirect studies of the reaction using alpha-particle transfer; detailed studies of the mirror reaction; as well as a study of the alpha emission from the excited 19Ne states that determine the reaction rate. The programme utilises a combination of radioactive and stable ion beams with measurement of the reactions in high-resolution spectrometers and highly-segmented silicon arrays.

Primary author: Dr DIGET, Christian Aa. (University of York)

Co-authors: Dr LAIRD, Alison M. (University of York); Prof. FULTON, Brian (University of York); Mr ADSLEY, Phillip (University of York)

Presenter: Dr DIGET, Christian Aa. (University of York)