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Advances in Experimental Nuclear Astrophysics

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Explosive stellar events, such as X-ray bursts, novae, and supernovae, play a pivotal role in synthesizing the chemical elements observed in our galaxy and on Earth. The field of nuclear astrophysics seeks to unravel the mysteries behind the origin of the chemical elements and understand the underlying nuclear processes governing the evolution of stars. Particularly, the investigation of radiative capture reactions, involving the fusion of hydrogen or helium and subsequent emission of gamma rays, is crucial for the understanding of nucleosynthesis pathways in stellar environments.

Continuous advancements in accelerated rare isotope beam production offer a unique opportunity to replicate and study reactions occurring inside stars in the laboratory. However, many astrophysically significant reactions involve radioactive isotopes, thus presenting challenges for beam production and background reduction. Furthermore, direct measurements of radiative capture cross sections are extremely challenging due to the vanishingly small cross sections in the astrophysically relevant energy regime.

To address these challenges, dedicated facilities, such as the DRAGON (Detector of Recoils And Gammas Of Nuclear reactions) recoil separator, TUDA, the TRIUMF UK Detector Array for charged particle detection as well as the EMMA (ElectroMagnetic Mass Analyser) recoil mass spectrometer situated at the TRIUMF-ISAC Radioactive Ion Beam Facility have been designed to experimentally determine nuclear reaction rates of interest for nuclear astrophysics with inverse kinematics methods.

In this contribution I will outline the achievements and latest advances of the nuclear astrophysics program at TRIUMF, and present recent highlights from studies utilizing radioactive and high-intensity stable ion beams. Our findings contribute to a deeper understanding of astrophysical processes and pave the way for future breakthroughs in nuclear astrophysics research.

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Keyword-3

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