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Study on explosive nuclear synthesis with low-energy RI beams at CRIB

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Astrophysical reactions involving radioactive isotopes (RI) are of importance for the stellar energy generation and nucleosynthesis especially in explosive stellar environments, such as X-ray bursts, core-collapse supernovae, big-bang and supermassive metal-poor stars. In spite of the essential difficulties in the experimental evaluation of those reaction rates, there are several successful approaches to study them. The experiments at the low-energy RI beam separator CRIB (CNS Radioisotope Beam Separator), operated by Center for Nuclear Study (CNS), the University of Tokyo, are introduced as examples of such studies.
A striking method to study nuclear resonances in unstable nuclei is the proton/alpha resonant scattering with the thick target method in inverse kinematics. Many measurements have been performed at CRIB [1–4], mainly to study properties of resonances which may affect astrophysical reaction rates. With the measurement of 30S+alpha resonant scattering [4], we evaluated the 30S(alpha, p) reaction rate, which produces a considerable effect on the energy generation of X-ray bursts. The latest application of that method is the proton resonant scattering on an isomer-enriched 26Al RI beam, to study the destruction process of 26Al, which may reduce the production rate of cosmic 26Al gamma-rays.
Indirect measurements of relevant astrophysical reactions have also been performed at CRIB. The world's 1st Trojan-horse-method experiment with an RI beam was performed at CRIB by an international collaboration including the INFN-LNS group. Measuring quasi-free 18F(d, n alpha) reaction, the low-temperature 18F(p, alpha) reaction S-factor was experimentally determined for the 1rst time [5]. Another recent Trojan-horse measurement at CRIB was to determine 7Be(n, p) and (n, alpha) reaction rates, which can be relevant for the cosmological 7Li abundance problem. We have performed a measurement of those reactions with the 7Be beam at CRIB, covering the temperature range of the big-bang nucleosynthesis.

References
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