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Resonances of 24O and proton-nucleus interaction potentials via (p,p') scattering at RIBF using the MUST2 array

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Through the studies of the structure and spectroscopy of the neutron-rich nuclei along extended isotopic chain towards the drip-line, we can develop our understanding of the evolution of the nuclear structure with the isospin degree of freedom and of the modeling of the nuclear correlations.
Experimentally the neutron drip-line is known up to the oxygen chain, with 24O being the last bound isotope. Drip-line nuclei combine several aspects which correspond to new phenomena, as compared to the stable isotopes, like low particle threshold energies, very diffuse nuclear surfaces, resonant states, new shell gap effects associated to local magic numbers [1-3]. Today, there exists no unified theoretical framework able to describe consistently the structure properties of these nuclei. They are weakly-bound with few, or no bound excited states, and the coupling to the continuum is playing a significant role since the scattering states are much closer to the continuum states than in stable nuclei. All these aspects are stringent tests for the microscopic structure calculations, and the drip-line nuclei appear as benchmarks for the nuclear models including the effects of the 3-nucleon forces [4-6]. In the region of the neutron-rich nuclei around 24O, the new N=16 shell closure has been discussed [2,3] and theoretically interpreted as due to the enhancement between 2s1/2 and 1d3/2 shells [3]. The properties of the 24O nucleus have been intensively studied. 24O having no bound excited state, its spectroscopy was measured using invariant mass method at MSU [7] and recently at RIKEN [8]. They have both discussed new excited states; the 2+ deformation was studied in Ref. [8], confirming the picture of the N=16 doubly-magic nucleus.
In the same period, we used another technique to investigate the structure and the spectroscopy of 24O via proton elastic and inelastic scattering (p,p') and the missing mass method. The experiment was performed at RIKEN in the BigRIPS line, using a high intensity beam of 24O (mean intensity 1700/s) produced at RIBF at 263 MeV/n, and the state-of-the-art charged particle detector MUST2 [9]. The (p,p') excitation energy spectrum of 24O was deduced but the 2+ state above the Sn (4.19 MeV) could not be observed due to the very low statistics for the inelastic events. However, new states above S2n (6.9 MeV) are indicated, with the possible E1 transition strength located around 9 MeV. In this talk we will discuss the characteristics of these states and compare them to various microscopic calculations, with large scale Shell Model [10] or within QRPA [11]. For the proton elastic scattering of the 21-24O isotopes, we have obtained enough statistics; the angular distributions will be presented. These results constitute a unique benchmark to explore the characteristics of the proton-nucleus interaction potential around 260 MeV/n. We will discuss the validity of the microscopic reaction framework based on the G-matrix density-dependent potentials [12] and of the structure inputs [11].

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