論文内容の要旨

論文題目:　Missing Mass Spectroscopy on Oxygen Isotopes beyond the Proton-Drip Line

(陽子ドリップ線外酸素同位体の欠損質量分光)

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Missing mass spectroscopy was performed on the ^{13}O and ^{12}O isotopes located at and beyond the proton-drip line. The present study aimed at elucidating persistence or disappearance of the magicity at the proton number of Z=8 far from stability.

We pursued to determine the locations and spin-parities of low-lying states, which provide sensitive measures to the magicity. In order to obtain these observables for proton-unbound states, the missing mass method was applied to the (p,t) and (p,d) reactions with secondary ^{14}Obeams at 51 MeV/u. Well-known mechanisms of these direct reactions allow a reliable distorted wave Born approximation (DWBA) analysis, which provides spin-parity determination. The analysis on these direct reactions further provides spectroscopic strengths as a sensitive probe to the associated configurations. By means of the missing mass method, we can access to unbound states and obtain fine sensitivity in determining scattering angle of the reaction. On the other hand, its application to inverse kinematics involves a serious demerit that emission of a very low-energy recoiling particle usually limits the reaction target to be very thin. This causes a fatal loss of the luminosity when using a radioactive isotope beam with a low intensity. However, by using intermediate-energy pickup reactions leading towards a more proton-rich side, a complex effect of the large negative Q value and a high incident energy induces high energy emission of recoiling particles, hence facilitating the use of a thick target.

The present experiment was performed at the accelerator facility, GANIL. The secondary ¥oxy{14} beam was produced by using projectile fragmentation reactions of the ^{16}O beam. As the reaction target, we employed a thick solid hydrogen target of 1-mm thickness. Recoiling particles were detected by an array of the MUST2 telescopes. In order to identify the reaction channel, we performed coincidence measurements with the incident beam and the ejectiles. Incident particles were monitored by two sets of multiwire proportional counter, CATS. The CATS detectors also provided information on the profile and incident angle of the secondary beam. Ejectile detection was conducted by the SPEG spectrometer and a stack of three layers of silicon detectors (RIKEN silicon telescope) with a 2x2-matrices configuration. The angular acceptance of the former corresponded to the forward angular range up to ±2 degree, while the latter complementarily covered the larger angular region up to about ±5 degree.

From the measurement on ^{12}O, we observed a new state at an excitation energy of $1.74(9)_{stat}(30)_{syst}$ MeV as well as the ground state. On the basis of the DWBA analysis, we assigned 0^+ or 2^+ for the ground state and the newly-observed excited state. As to ^{13}O, two unbound excited states were observed at excitation energies of $2.75(4)_{stat}(20)_{syst}$ MeV and $4.18(4)_{stat}(20)_{syst}$ MeV, respectively, together with the ground state. From the DWBA analysis, the spin-parity of the ground state was assigned to be $3/2^-$, while that of the 4.2-MeV state was constrained to be $1/2^-$, $3/2^-$, $3/2^+$ or $5/2^+$. The present analysis suggested that the observed 2.8-MeV state is a new excited state with a spin-parity of $1/2^-$, $3/2^-$, $3/2^+$ or $5/2^+$, which is degenerate to the known $1/2^+$ state at 2.69 MeV. A fairly large spectroscopic factor was deduced for the ground state, while those for the excited states were found to be moderate.

Examining the systematic trend of the neighboring even-even nuclei, it was found that the observed excited state in ^{12}O has an anomalously small excitation energy. The significant decrease of the excitation energy strongly suggests the collapse of the proton shell closure at Z=8. A sizable lowering of the excitation energy was also pointed out in ^{13}O in comparison with the neighboring $^{14\text{-}16}$O isotopes. The excitation energies and the spectroscopic strengths suggest that these low-lying structures have considerable amplitudes of intruding configurations, competing with normal ones. As a consequence of these two reaction studies, we have concluded that the proton shell closure should be rapidly degrading towards ^{12}O.