Search for α-condensed state in ^{20}Ne

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Recently, in a low-density environment, it is theoretically suggested that alpha clusters bacome a main component of the nuclear matter [1] and these alpha clusters are condensed into the lowest orbit. On the other hand, it is possible that a low-density condensed state appears in a certain excited state in atomic nuclei. For example, the 0_2^+ state in ^{12}C is a well-known 3α-condensed state, which is called the Hoyle state. Such nα-condensed states are theoretically predicted to appear in the heavier self-conjugate $A = 4n$ nuclei [2], but have been established only in ^{8}Be, ^{12}C and ^{16}O. Therefore, we search for the α-condensed state in the next $A = 4n$ nucleus, ^{20}Ne.

In order to search for the α-condensed state in ^{20}Ne, we measured the exicitation energy spectrum of the inelastic alpha scattering at 0 degrees using the Grand Raiden spectrometer [3] at Research Center of Nuclear Physics (RCNP), Osaka University. In addition, we measured decaying particles from excited states in ^{20}Ne. Because the α-condensed states are considered to decay by emitting alpha particles, decaying particles from excited states provide useful information of these structures. For the decay particle measurement, we used the 6 segments Si detector array of 3 layer configuration (Fig. 1), which covered about 4% of all the solid angle. Because energies of decay α particles are low, it is difficult to measure these particles using the conventional ^{20}Ne gas target with several-μm-thick organic gas sealing membranes. So, we used 100-nm-thick Silicon Nitride membranes. In Fig. 2, we show the newly-developed ^{20}Ne gas target cell.

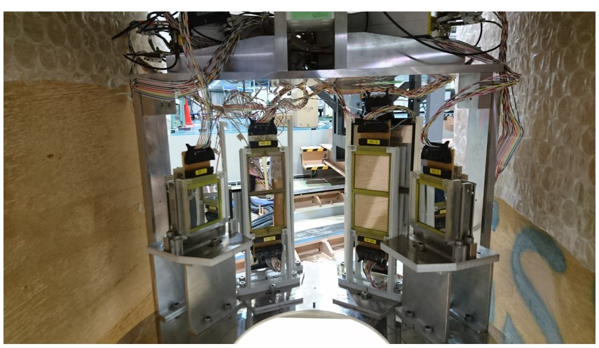

Figure 1: Si detector array

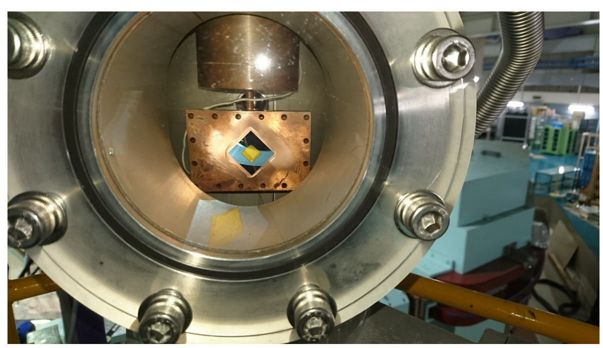

Figure 2: Gas target cell

We used a 389 MeV alpha beam and obtained the excitaion energy spectrum of ^{20}Ne. Moreover, we obtained the excitation energy specta by gating on both the alpha-decay and the proton-decay channels. In the alpha-decay channel spectrum, we found several peaks above the 5α decay threshold at $E_x = 19.17$ MeV. In addition, we selected the decay events to the 0_6^+ state in ^{16}O, which is the candidate for the 4α-condensed state [4–7], and obtained the excitation energy spectrum of ^{20}Ne for selected events. As shown in the bottom of Fig. 3, a prominent peak at $E_x = 23.5$ MeV was found. It suggests that the state at $E_x = 23.5$ MeV in ^{20}Ne strongly couples with the 0_6^+ state in ^{16}O. Since the α-condensed states are expected to decay to the α-condensed states in lighter nuclei, this is a strong candidate for the 5α-condensed state.

However, the statistics were not good enough and we couldn't decide the spin and parity of the new state at $E_x = 23.5$ MeV. Now, we are planning a further measurement to acquire more statistics and to decide the alpha decay channel precisely. We will also measure the anglar distribution of the cross section to determine the spin and parity of the $E_x = 23.5$ MeV state, and establish the α-condensed state in ^{20}Ne.

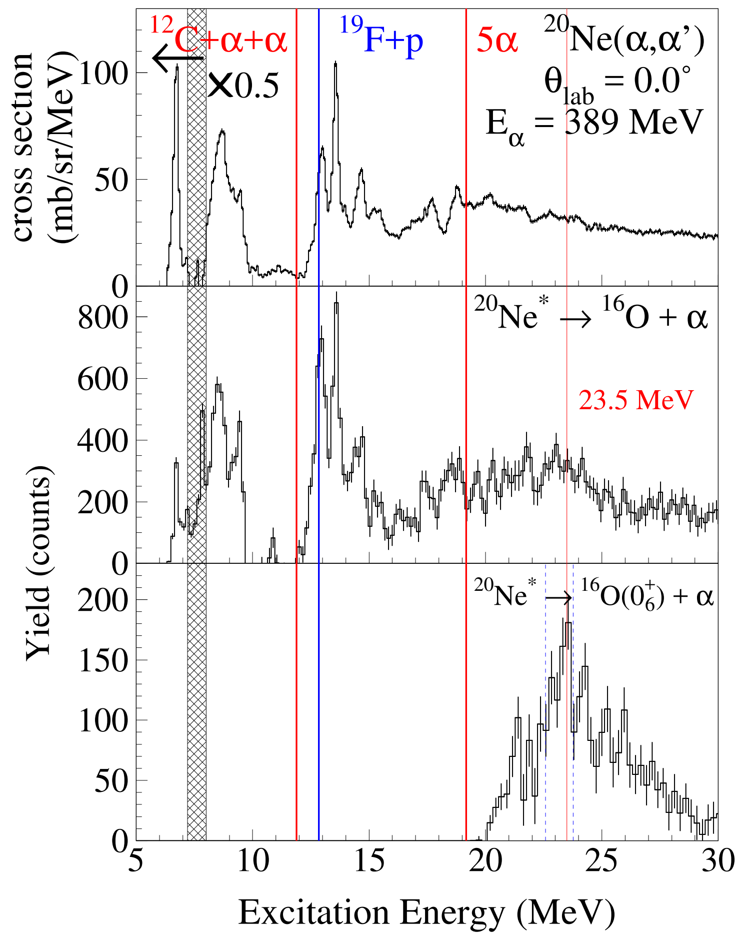

Figure 3: Excitation energy spectra for the ^{20}Ne(α, α') reaction at $E_\alpha = 389$ MeV and $\theta = 0°$. From top, spectra for the all events, the α decay events and the α decay events to the 0_6^+ state in ^{16}O are shown.

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