Direct proton decay from the isosclar giant dipole resonance via the $(\alpha, \alpha' + p)$ coincidence measurement

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The isoscalar giant dipole resonance (ISGDR, $\Delta T = 0,\ \Delta L = 1,\ \Delta S = 0$) has still remained one of the most interesting collective vibration modes, although the giant resonances in nuclei have been studied for about three decades. The exotic feature on incompressive mode of excitation is derived from the fact that the second-order term of isoscalar dipole transition operator leads to intrinsic excitation, after removing the first-order term associated with a spurious center-of-mass motion. Microscopically, the ISGDR is described as coherent $1\hbar\omega$ and $3\hbar\omega$ particle hole excitations with most of the strength concentrated in the $3\hbar\omega$ component [1]. Macroscopically, the ISGDR may be represented as a density oscillation mode ; The compressional wave oscillates back and forth through a nucleus with a constant total volume. It has been often referred to as the “squeezing mode” [2, 3].

The excitation energy of the ISGDR can be directly related to the nuclear incompressibility. Using the value obtained from the experiments, the incompressibility of nuclear matter, an important quantity of the nuclear equation of state, is deduced.

The experiment was performed using the Spectrometer Grand Raiden [4]. The $(\alpha, \alpha' + p)$ reaction was studied at a beam energy of 400 MeV incident on a ^{58}Ni target (4.0 mg/cm^2) and a ^{208}Pb target (10.0 mg/cm^2). In this report, the result of the $^{58}\mathrm{Ni}(\alpha, \alpha' + p)^{57}\mathrm{Co}$ reaction is presented.

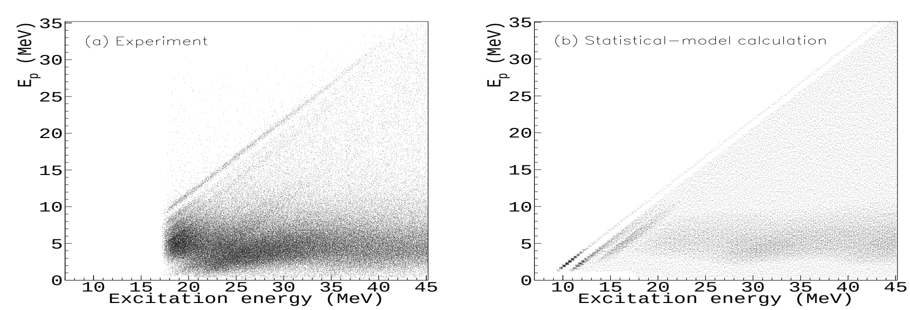

Figure 1: (a) Two-dimensional scatter plot obtained from $^{58}\mathrm{Ni}(\alpha, \alpha' + p)^{57}\mathrm{Co}$ coincidence measurement. The measurement energy region was $18 < E_x(^{58}\mathrm{Ni}) < 45$ MeV. (b) The result of the statistical-model calculation code, “CASCADE” [5].

We used 16 Si(Li) detectors to measure decay particles. The detector thickness was 5 mm, which allowed to measure protons with energies up to 30 MeV. The Si(Li) detector system was mounted at backward angles in the scattering chamber. In contrast to singles measurements, the present measurement requiring the proton-decay in coincidence enables us to suppress the physical continuum background. The decay properties, or knowledge on the microscopic structure and damping mechanism of the giant resonances, which are not understood enough, are expected to be studied via the present coincidence ^{58}Ni$(\alpha,\alpha'+p)^{57}$Co measurement.

Fig. 1(a) shows a two-dimensional scatter plot of decay particle energy versus $E_x(^{58}\mathrm{Ni})$ induced by the ^{58}Ni(α,α') reaction. The feature of decay pattern agreed well with the result of the statistical-model calculation performed for decay protons from ^{58}Ni (Fig. 1(b)). The correlation observed as loci corresponds to the decay events of excited states in ^{58}Ni.

Fig. 2(a) is the final-state spectrum of ^{57}Co gated on the decay events in the energy region of $23 < E_x(^{58}\mathrm{Ni}) < 40$ MeV. The proton-hole states in ^{57}Co were identified, based on the information from the ^{58}Ni(d,^{3}He)^{57}Co reaction shown in Fig. 2(b).

A preliminary spectrum for ^{58}Ni gated on the decay events to the ground state of ^{57}Co is shown in Fig. 3. Improved analyses, including the identification of ISGDR, are in progress.

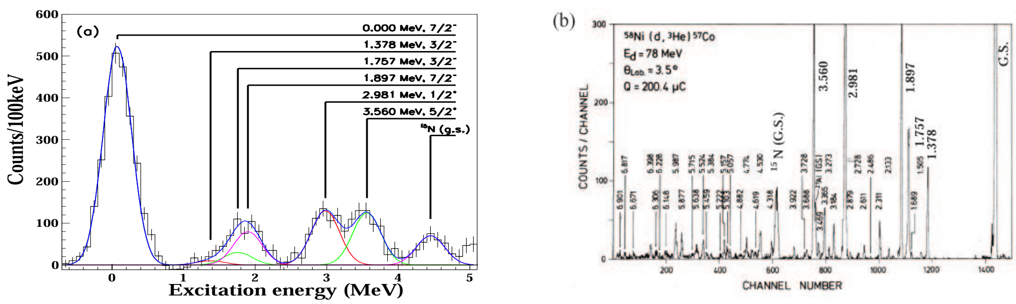

Figure 2: (a) Final-state spectrum for the decay events to the low-lying proton-hole states observed in the ^{58}Ni$(\alpha,\alpha'+p)^{57}$Co reaction. (b) Proton-hole states in ^{57}Co reported from the ^{58}Ni(d,^{3}He)^{57}Co measurement at E$_d$=78 MeV [6].

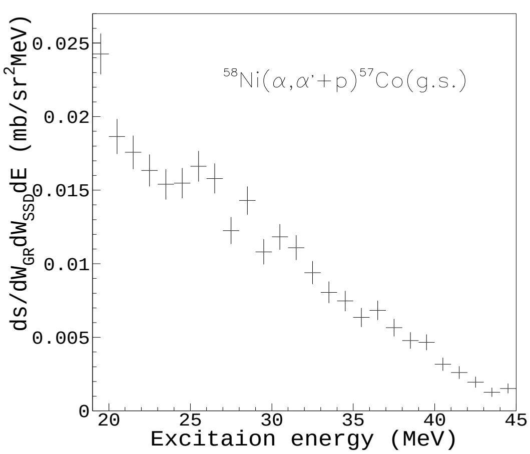

Figure 3: Cross sections of the ^{58}Ni$(\alpha,\alpha'+p)^{57}$Co reaction obtained by gating on the decay events to the ground state ($J^{\pi}=\frac{7}{2}^{-}$) in ^{57}Co.

References

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