

Excitation of dipole resonances in ${}^4\text{He}$ and in the α cluster of ${}^6\text{Li}$ and ${}^7\text{Li}$

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In a series of RCNP experiments we searched for the excitation of the α cluster in ${}^6\text{Li}$ and ${}^7\text{Li}$. As a candidate for the excitation of the α clusters we found dipole resonances (DR's) at $E_x=27.0$ and 29.0 MeV with a width of ~ 12 MeV in the (p,p') reactions on ${}^6\text{Li}$ and ${}^7\text{Li}$ [1]. We also observed similar DR's in ${}^{6,7}\text{He}$ and ${}^{6,7}\text{Be}$ at the reaction Q -values nearly same as the ${}^{6,7}\text{Li}(p,p')$ reactions via the ${}^{6,7}\text{Li}({}^7\text{Li},{}^7\text{Be})$ and ${}^{6,7}\text{Li}({}^3\text{He},t)$ reactions, respectively [1, 2]. The excitation energies for the DR's are much higher than the well known isovector giant dipole resonance (GDR) in ${}^6\text{Li}$ and ${}^7\text{Li}$ reported in the (γ,n) study at $E_x\sim 12$ and 17 MeV, respectively [3]. Based on the comparison of the resonance shapes, excitation energies, and cross sections for the DR's observed in our work with those reported in the photoreactions, we suggested that the DR's are consistent with the DR's consisted of the GDR's and spin dipole resonances (SDR's) in the α cluster of ${}^{6,7}\text{Li}$ and their analogs [1, 2]. It is very interesting to compare the DR's in the α clusters of ${}^6\text{Li}$ and ${}^7\text{Li}$ with the intrinsic DR in ${}^4\text{He}$ excited via the same (p,p') reaction in order to see the medium interaction effect on the α cluster inside the nuclei. Thus, we carried out the ${}^4\text{He}(p,p')$ reaction at RCNP [4]

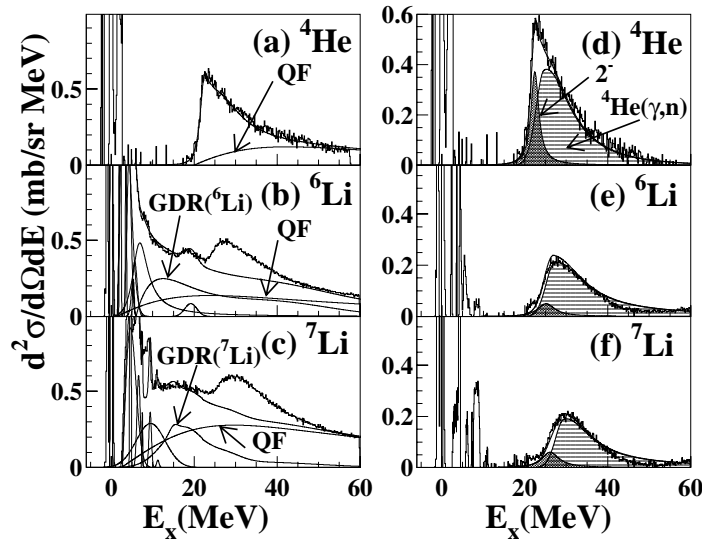


Figure 1: Double-differential cross-sections for the (p,p') reactions on (a) ${}^4\text{He}$, (b) ${}^6\text{Li}$, and (c) ${}^7\text{Li}$. Double-differential cross-sections for the DR peaks in (d) ${}^4\text{He}$, in the α cluster of (e) ${}^6\text{Li}$, and (f) ${}^7\text{Li}$ with underlying continua subtracted.

Figure 1 shows the double differential cross sections for the (p,p') reactions on (a) ${}^4\text{He}$, (b) ${}^6\text{Li}$, and (c) ${}^7\text{Li}$ at $E_p=300$ MeV, and at $\theta_L=10^\circ$. The broad peak observed at $E_x\sim 25$ MeV in Fig. 1(a) is the excitation of the DR in ${}^4\text{He}$. A sharp edge of the 25-MeV peak at the lower excitation side is due to the excitation of the 2^- ($T=1$) SDR at $E_x\sim 22.1$ MeV. The broad resonances observed at $E_x\sim 27$ MeV in ${}^6\text{Li}$ (Fig. 1(b)) and at

~ 30 MeV in ${}^7\text{Li}$ (Fig.1(c)) have been assigned being due to the excitation of the DR's in the α cluster of the respective nuclei [1]. Figs. 1(d)-(f) show the double differential cross sections for the DR peaks in ${}^4\text{He}$, ${}^6\text{Li}$, and ${}^7\text{Li}$ with the underlying continua subtracted. The resonance shape for ${}^4\text{He}$ was fitted with two peaks: The shaded peak shows the 2^- SDR at $E_x=22.1$ MeV, and the hatched peak shows the shape for the GDR taken from photoreactions. Similar fittings were done in (e) and (f) allowing the changes in the excitation energies and widths to fit the resonance shapes.

We observed the DR in ${}^4\text{He}$ at $E_x=25.1\pm 0.5$ MeV with a width of 11.0 ± 2.0 MeV. On the other hand, the DR's in α clusters of ${}^6,7\text{Li}$ were observed at higher excitation energies of $E_x=28.0\pm 0.5$ and 30.5 ± 0.5 MeV with similar widths of 11.7 ± 1.5 and 11.3 ± 2.0 MeV, respectively. The excitation energy for the α cluster slightly increases with increasing A . The differences in the apparent resonance shapes for exciting α clusters are most likely due to the reduction in the relative strength of the corresponding to the 2^- SDR observed in ${}^4\text{He}$ at 22.1 MeV. The resonance shapes for the α cluster in ${}^6,7\text{Li}$ were reproduced well with the DR shape other than the 2^- SDR in ${}^4\text{He}$. The relevant (p,p') cross sections per unit α particle spectroscopic factor for ${}^6\text{Li}$ and ${}^7\text{Li}$ were found to be nearly the same as the corresponding (p,p') cross sections on ${}^4\text{He}$; 1.0 ± 0.3 and 0.83 ± 0.21 times of the ${}^4\text{He}(p,p')$ cross section, respectively. The excitation of the α clusters within ${}^6\text{Li}$ and ${}^7\text{Li}$ are very similar to excitations of a free α particle. The present result is another evidence for the DR's in ${}^6\text{Li}$ and ${}^7\text{Li}$ being the excitation of the α clusters. On the other hand, an explanation for the reduction in the SDR strength and a small shift in the excitation energy is left in the future.

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References

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