

HIGH-EXCITED  $\alpha\alpha^*$  STATES IN  $^8\text{Be}$

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ABSTRACT

Excitation functions and angular distributions for the three-particle reactions  $p+^7\text{Li}+\alpha+\alpha^*+\alpha+t+p$  and  $d+^6\text{Li}+\alpha+\alpha^*+\alpha+t+p$  have been measured in a kinematically complete experiment in the regions of bombarding energies  $E_p=4.5-12$  MeV and  $E_d=1.2-8$  MeV, respectively. The results give evidence for the existence of  $\alpha\alpha^*$  states at high excitation energies in  $^8\text{Be}$ .

The properties of the  $^8\text{Be}$  scattering system have been the subject of continuous interest<sup>1</sup>. The characteristic part of the low-energy spectrum - the ground-state rotational band - can be described to a good approximation as consisting of two unexcited  $\alpha$  clusters. Recent approaches have emphasized the importance of excited  $\alpha$  clusters for the description of states in the high-excitation region. Arickx<sup>2</sup> has shown that the symplectic group  $\text{Sp}(2, R)$  represents a suitable framework for a coherent description of the whole  $^8\text{Be}$  spectrum: In his approach, excited particles appear naturally, corresponding to different values of labels  $F$  of the unitary irreducible representations of this group<sup>3</sup>. Using refined cluster-model calculations, Hackenbroich et al.<sup>4</sup> predicted an additional band in  $^8\text{Be}$  consisting of  $\alpha\alpha^*$  molecules and starting around  $E_x \sim 20$  MeV. ( $\alpha^*$  denotes the first excited state of the  $\alpha$  particle at  $E_{x\alpha^*}=20.1$  MeV,  $J^\pi=0^+$ ; this state is known to be intrinsic spherical like the ground state). As  $\alpha$  and  $\alpha^*$  are not identical bosons, negative-parity states ( $1^-, 3^-$ ) are also members of this band. Its moment of inertia is predicted to be roughly twice as large as the one of the ground-state band in  $^8\text{Be}$ .

States containing  $\alpha^*$  clusters are expected to be coupled to the  $\alpha+\alpha^*$  channel. In order to investigate such states experimentally, we measured excitation functions and angular distributions of the  $^7\text{Li}(p, \alpha)\alpha^*$  and  $^6\text{Li}(d, \alpha)\alpha^*$  reactions (Q-values

being -2.7 and 2.3 MeV, respectively). The measurements were performed at the Heidelberg MPI tandem-accelerator. Since  $\alpha^*$  is particle unstable ( $\alpha^* \rightarrow p+t$ ), measurements of three-particle reactions (exit channel  $\alpha+t+p$ ) are required. In order to identify the reaction products and to obtain clean spectra, time-of-flight measurements ( $T=t_2-t_1$ ) were performed in addition to the measurements of the particle energies  $E_1, E_2$  and the energy loss  $\Delta E_1$ . The data thus obtained are very satisfactory.

The measured excitation functions<sup>5,6</sup> of the  ${}^7\text{Li}(p,\alpha)\alpha^*$  and  ${}^6\text{Li}(d,\alpha)\alpha^*$  exhibit a behaviour that suggests that the primary process can be described as formation of the compound nucleus. The angular distribution<sup>6</sup> is unsymmetrical around  $90^\circ$ , indicating that partial waves of different parity take part in the reaction. Thus far, no resonances of the corresponding width have been observed in the channels  $p+{}^7\text{Li}$ ,  $d+{}^6\text{Li}$ ,  $\alpha+\alpha$ , which are the only open ones. This supports our observation on the existence of the  $\alpha^*$  configurations in  ${}^8\text{Be}$ . The  $\alpha^*$  rotational band with the moment of inertia as predicted by Hackenbroich et al.<sup>4</sup> has not been observed.

#### REFERENCES

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