MOLECULAR STRUCTURE IN HIGHLY-EXCITED STATES OF LIGHT NUCLEI

K. Katō and H. Tanaka
Department of Physics, Hokkaido University, Sapporo 060, Japan

Since the discovery[1] of resonances at the Coulomb barrier of the $^{12}C+^{12}C$ system, many experimental and theoretical studies have been carried out in order to clarify the resonance mechanism and the molecular structure in the highly-excited nuclear states. However, we have not yet fully understood them. The cluster (or molecular) structure in low-lying states of light nuclei are satisfactorily understood by the microscopic and semi-microscopic cluster model.[2] And therefore it has been strongly desired to extend the investigation of the cluster model into the molecular structure in highly-excited states. To do it, we must develop a useful framework of the multi-cluster model to describe various kinds of cluster configurations which are expected to activate with the increase of the excitation energy. For example, as a doorway state for the resonances in the $^{12}C+^{12}C$ system, Michaud and Vogt[3] proposed the picture of α-particle molecules (^{12}C-α-α-α). This picture imposes the calculation of a very complex ^{12}C-3α cluster model on us.

Recently, we developed a very powerful method to construct the Pauli-allowed states of the multi-cluster system. In Table I we show the

Table I SU(3) classification of the ^{16}O-3α Pauli-allowed states.

N	$(\lambda,\mu)^n$							
24	(0,0)	(2,2)	(3,3)	(4,4)	(5,5)	(0,6)	(2,8)	(3,9)
	(6,0)	(5,2)	(6,3)			(3,6)		
	(12,0)		(9,3)			(6,6)		
		(0,12)						
26	$(14,0)^2$	$(15,1)^2$	(16,2)	(14,3)	$(12,4)^3$	(13,5)	(11,6)	$(9,7)^3$
		$(12,1)^2$	$(13,2)^2$	$(11,3)^4$	$(9,4)^4$	$(10,5)^3$	$(8,6)^5$	$(6,7)^4$
	$(8,0)^2$	$(9,1)^2$	$(10,2)^4$	$(8,3)^4$	$(6,4)^6$	$(7,5)^6$	$(5,6)^5$	$(3,7)^4$
		$(6,1)^2$	$(7,2)^2$	$(5,3)^4$	$(3,4)^3$	$(4,5)^4$	$(2,6)^4$	
	$(2,0)^2$	$(3,1)^2$	$(4,2)^4$	$(2,3)^2$	$(0,4)^2$	$(1,5)^2$		
			(1,2)					
	$(6,10)^3$	$(1,11)^2$	(2,12)					
	$(3,10)^3$	$(4,11)^2$						
	$(0,10)^2$							

(8,10) (7,11)

Pauli-allowed states of the ^{16}O-3α system. Using these Pauli-allowed states, we can carry out the calculation of the orthogonality condition model (OCM)[4] which is a semi-microscopic model. Although the OCM calculation for the multi-cluster system is very difficult because of the large number of basis states, the difficulty is greatly reduced by the μ-truncation method.[5] This method has been applied to 3α[6] and ^{16}O-2α [5] systems and showed to be very powerful for the multi-cluster OCM calculation.

The molecular structures in highly-excited states obtained by the ^{16}O-2α OCM for ^{24}Mg are summarized as follows: 1)The ^{20}Ne+α cluster structure is dominant in the excited states with $E_x \gtrsim 10$ MeV. The α-reduced widths of those states show the characteristic distribution which can be interpreted on the basis of the band crossing model.[7] 2)The α-^{16}O-α linear-chain structure is predicted near $E_x \simeq 18$ MeV, which has large α-reduced widths in both channels of positive- and negative-parity states of ^{20}Ne. 3)The ^{8}Be+^{16}O cluster structure is obtained in the energy region higher than about 20 MeV. 4)The cluster structure obtained in the $E_x \simeq 10 \sim 20$ MeV excitation energy region shows the strong correlation with the observed giant E2 resonances.[8](Fig.1)

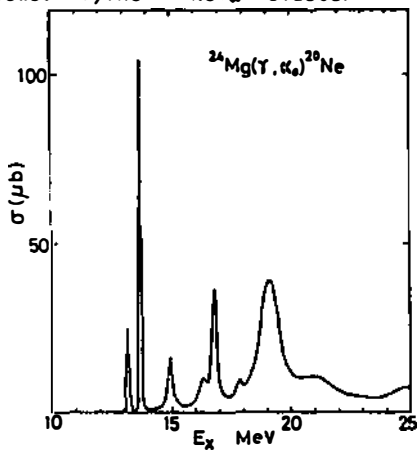

Fig.1 Calculated cross section σ(E2) of $^{24}Mg(\gamma,\alpha_0)^{20}Ne$ reaction.

Our method can be also applied to more complex multi-cluster systems, for example 4α , ^{12}C-2α and ^{16}O-3α systems. The investigations of those systems are now in progress.

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