Resonances of Nuclear Molecule ^{28}Si $-^{28}$ Si

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High-spin resonances well above the Coulomb barrier in ^{24}Mg + ^{24}Mg and ^{28}Si + ^{28}Si systems exhibit many narrow and prominent peaks correlated among the elastic and inelastic channels, which suggest rather long-lived compound systems and offer intriguing subjects in nuclear physics. Angular correlation measurements for ^{28}Si + ^{28}Si recently made with 4π gamma detectors have provided crucially important information on resonances[1]. Characteristic features of the experiments are following three points; 1) the resonance at $E_{cm} = 55.8$MeV decays to the inelastic channels as single and mutual 2^+ even more strongly than the elastic one. 2) angular distributions in those channels indicate a dominance of a single orbital angular momentum $L = J = 38$. 3) the angular correlations of the fragments ^{28}Si and γ-rays emitted from the fragments indicate the intrinsic spins of the constituent nuclei are on the reaction plane. The latter two show a dis-alignment between the orbital angular momentum and the fragments spins.

By the molecular model the authors investigated an equilibrium configuration of interacting two oblate nuclei, and showed it to be the *equator-equator* one. Couplings among various molecular configurations are taken into account by the method of normal mode around the equilibrium, which gives rise to the molecular modes of excitation such as butterfly motion. These excitations exist over the range of spin $J = 34 \sim 42$ in which the equator-equator configuration is stable, and are expected to be the origin of the narrow resonances. Decay properties of the molecular states including spin alignments have been investigated to know which kinds of the molecular modes are consistent with the resonances observed. At the resonance energy $E_{cm} = 55.8$MeV, very strong excitations are seen in the single 2^+ and mutual 2^+ excitations. However the normal-mode excitations exhibit strong yields to the mutual 2^+ channel but weak enhancements to single 2^+ channel, and thus do not fit well. Only the molecular ground state appears to follow those decay characteristics, where rather strong confinements in the vibrational motions are necessary for enough enhancements in inelastic excitations. The fragment angular distributions of the ground-state resonance have been calculated by means of R-matrix theory, and good agreements with the experiments are obtained.

Since the equilibrium configuration is triaxial, rotations of the total system induce a mixing of K-quantum numbers, which is consistent with the measured angular correlations as well as the dis-alignments. At a given angular momentum J, this configuration rotates in a triaxial way approximately about the axis corresponding to the largest moment of inertia in the state with the lowest energy. Therefore the whole system rotates about the normal to the plane defined by the two pancake-like nuclei. The spins of the ^{28}Si fragments are thus in this plane since no rotation can occur about the symmetry axes of ^{28}Si. Thus the angular correlations are very well reproduced with the molecular ground state.

In conclusion, study of the ^{28}Si + ^{28}Si system by means of di-nuclear molecular model gives variety of molecular states. In them the molecular ground state with $J = 38$ is a candidate responsible for the resonance at $E_{cm} = 55.8$MeV. For systematic study for excitations of the molecular modes, the same kind of information on the other nearby resonances of the ^{28}Si +^{28} Si system is strongly called for.

1. R. Nouicer and C. Beck et al., Phys. Rev. **C60**, 041303 (1999)