A Novel Visage of Molecular Resonances in ^{12}C +^{12} C

RCNP-Akita Collaboration.

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Well above the Coulomb barrier of the ^{12}C + ^{12}C system, series of resonances have been found with high spins over 10, which exhibit prominent peaks in the elastic and inelastic 2^+ channels [1]. Band Crossing Model (BCM), based on the double resonance mechanism, has successfully explained the resonance mechanism with the aligned configurations of the orbital angular momentum and the spins of the excited states of ^{12}C [2], which has brought in renaissance of the nuclear molecule.

On the other hand, a resonance observed in ^{28}Si + ^{28}Si, which is the same oblate-oblate system with ^{12}C + ^{12}C, is experimentally known to be spin-disaligned in contrast to the latter system[3]. The disalignment is intuitively explained by a new molecular model based on the compound nucleus with di-nucleus configuration[4]. In high angular momenta, stable configurations of the oblate-oblate system are those of two pancakes sitting side-by-side(interaction between two nuclei is calculated by the folding model with DDM3Y). We call it the equator-equator (E-E) configuration, which corresponds to molecular ground states. Obviously, the spins of the constituent nuclei are on the plane of the two pancakes, because constituent nuclei cannot rotate around their respective symmetry axes, which are perpendicular to the plane. Note also that the orbital angular momentum is perpendicular to the plane.

Furthermore, the E-E configuration is slightly axially asymmetric, and thus it should have rotational states with non-zero K-quantum numbers in low excitation. How can those features be compromised with BCM, which explained a series of the observed gross resonances with the aligned configurations coupling to the elastic channel.

We have applied the new molecular model to ^{12}C + ^{12}C in the same way as to ^{28}Si + ^{28}Si. Furthermore, we have diagonalize the Coriolis coupling among states with different K's. Surprisingly, resultant molecular yrast states are sipn-aligned one. At the same time, several excited bands are obtained naturally.

Using R-matrix theory, we calculate excitation functions of the single 2^+ and the mutual 2^+ inelastic channels as well as the elastic channel. The calculation reproduces the series of gross resonances remarkably well over the wide energy range of the excitation functions[1]. Each gross peak is topped with rather sharp intermediate structure. The predicted spins of those sharp peaks correspond to the experiment[5]. They stem from molecular states of non-zero K and K=0 excited components, with small admixtures of the elastic component. The elastic component is almost exhausted by the yrast and the second yrast states, consistent with BCM. For example, the gross resonance just below E_{cm} = 20 MeV is considered in the present model not as a single broad resonance, but as overlapping resonances of several J = 12 states with dominant non-zero K bands etc. and a J = 14 state with dominant aligned and elastic configurations. The structure of the gross peak and predicted spins of sharp peaks precisely correspond to those of the experiment[5]. Since the present model predicts information on spin orientations of the constituent nuclei in the resonance states, experimental verification is strongly called for, such as particle-particle-gamma angular correlation measurements made for ^{28}Si + ^{28}Si[3].

In brief, the results reveal a new underlying feature of the gross resonance peaks, and give rise to a comprehensive picture compatible with the BCM. The calculations are preliminary, and are still under way[6].

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References

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