

A Model of Resonances in Heavy-Ion Reactions as
Rotating-Cluster Phenomena

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Recent experimental results have shown that for at least ^{24}Mg , ^{28}Si , ^{30}Si , ^{36}Ar , ^{40}Ca and ^{44}Ti heavy-ion reactions leading to the above nuclei as composite systems display a resonant behaviour that can not be explained as statistical fluctuations. This experimental evidence can be summarized as follows:

- (a) all resonance data lie in a narrow zone around a straight median line in the E vs $J(J+1)$ plane,
- (b) for each system the projected $J=0$ resonances lie in the vicinity of $E_B + E_C$, where E_B is the binding in the entrance channel and E_C the Coulomb barrier.

We propose a model describing resonances as due to orbiting of the interacting nuclei forming a molecular type configuration. In particular, the linear dependence of E on $J(J+1)$ yields effective moments of inertia in good agreement with those calculated by assuming the two interacting nuclei as rigid spheres ($r_0=1.3$ fm) rotating around their center of mass.

The presence and the absence of resonances in nuclear systems is related in the model to the damping width $\Gamma^\dagger = 2\pi |\langle \text{cn} | V | \text{el} \rangle|^2 \rho(E, J)$, where $|\text{el}\rangle$ is the entrance and $|\text{cn}\rangle$ the compound nuclear states, and $\rho(E, J)$ is the level density of the compound system. The condition necessary for the observability of resonances is that Γ^\dagger is relatively small. We assume the matrix element to be independent of E and J ; hence, Γ^\dagger is determined by $\rho(E, J)$. On these grounds we predict resonances in systems such as ^{32}S and ^{56}Ni where no clear cut evidence for resonance bands has existed so far.