RESONANT STRUCTURES OF THE ^{56}NI-SYSTEM, SEEN IN ^{28}Si - ^{28}SI ELASTIC AND INELASTIC SCATTERING AND IN THE ^{16}O - ^{40}Ca REACTION

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Resonant structures of the Si - Si elastic and inelastic cross sections as well as the O - Ca reaction cross sections are explained on the basis of a microscopically founded band crossing model: Resonances of the elastic Si - Si and O - Ca channels are calculated in the generator coordinate method[1,2]. While, in the energy range of interest, the O - Ca data show only one band of broad resonances for angular momenta upto $\ell \approx 36$ (see shaded area in Fig. 1), one obtains for the Si - Si system (several) bands of molecular (narrow) resonances in addition to a broad barrier band, ranging upto $\ell \approx 40$. The barrier band agrees well with the spin sequence assigned to the gross structure of the elastic excitation function[3]. Based on this barrier band one obtains the band crossing diagram of Fig. 1, including aligned bands of different spin only. In fair agreement with experiment, the band crossing diagram supports the strong correlations between resonant structure of the elastic and several inelastic channels for energies 45 MeV < E_{cm} = E* - 10.9 MeV < 60 MeV, as seen in experiment[3]. Note that the widths of the barrier band is typically 2-3 MeV. An extended band crossing diagram, which takes into account the microscopically calculated long-lived collective Ni resonances, predicts intermediate structures for the Si-Si cross sections similar to what is observed experimentally[1].

The above interpretation in terms of dinuclear resonances is by no means contradictory to the explanation by shape isomeric Ni states obtained from one center shell model calculations[3], since their mutual overlap is likely to be large due to antisymmetrization. However, the results of the two calculations may be distinguished since the shell model calculation yields strongly deformed Ni states only for angular momenta around $\ell \approx 40$, while the generator coordinate scattering calculation predicts resonances in <u>all</u> partial waves upto $\ell \approx 36$.

The Ca(O,Si)Si reaction at excitation energies E* = 67-72 MeV shows no pronounced gross structure in the reaction cross section, but intermediate structures with widths of 100-200 keV strongly correlated to the ones of the elastic and inelastic reaction cross sections. The experimental analysis[3] reveals that the decay widths of these states into the elastic Si + Si channel is approximately 10 times larger than for decay into the O + Ca channel. These results can be understood in terms of the above band crossing diagram for the O(Ca,Si)Si reaction, noting that[4]

i) coupling of a non-resonant channel to a barrier resonance is generally suppressed, while
ii) the respective coupling to molecular resonances is much stronger and should be observed in the reaction cross section, provided it is not damped by absorption.

Since the microscopically calculated bands in the O + Ca and Si + Si channels do not cross in the energy range E*= 67-72 MeV (see Fig. 1), enhancement of the reaction cross section by the double resonance mechanism is not expected.
Due to i) the coupling of the O - Ca channel to the barrier resonances in the Si + Si channel will not be strong enough to yield resonant gross structures. But according to ii) the coupling to the narrow resonances in Si + Si, which occur at smaller separation and with strongly increased strength due to the geometry of the reaction, should be strong enough to explain the observed intermediate structure.

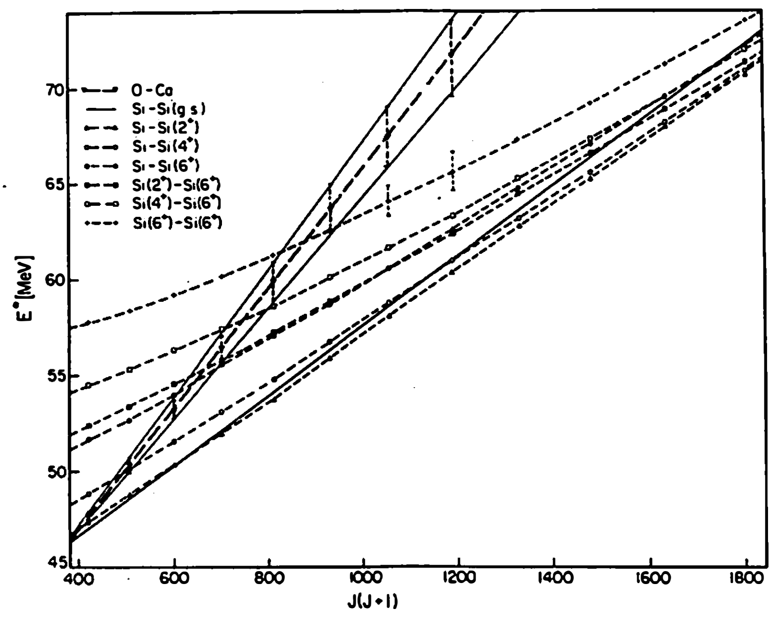

Fig.1. Band crossing diagrams for inelastic Si - Si scattering and the O (Ca,Si)Si reaction, based on the shape resonances calculated in refs.1,2. For each channel spin I, only the aligned band of the channel with highest excitation energy is shown.

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4. K.Langanke et al., Nucl. Phys. A406 (1983) 574.