NEW EVIDENCE FOR A ROTATIONAL BAND IN ^{24}Mg AND ITS FRAGMENTATION

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Several recent experiments[1-3] have provided new information on spins and parities of resonances in ^{24}Mg at high energies of excitation. In the present work, we investigate the $^{12}C(^{12}C,\alpha)^{12}C$ reaction in the range of $10.5 \leq E_{cm} \leq 15$ MeV and report three new resonances at E_{cm} = 11.2, 12.2 and 13.5 MeV; we have assigned definite J^{π} to at least one of them. Combining these results with the data from previously reported measurements and the results of other authors, we attempt a unified picture of the resonances in ^{24}Mg.

The present experiment was performed using the FN tandem accelerator of the CEN Bruyeres-le-Chatel. α particles from the $^{12}C(^{12}C,\alpha)^{20}Ne$ reaction were momentum-analyzed in a split-pole magnetic spectrograph and detected in a position-sensitive Si detector. From the correlated maxima in the forward-angle excitation functions of transitions leading to natural-parity states in ^{20}Ne and the relative smallness of the 2^- excitation function at very forward angles, energies around E_{cm} = 11.2, 12.2 and 13.5 MeV were selected as likely candidates for resonances and ground-state α angular distributions were measured on and off these energies. These angular distributions were compared with pure $P_L^2(\cos\theta)$ shapes; moreover, an analysis in terms of χ^2 vs. ℓ_{max} using the expansion of $\sigma(\theta)$ in Legendre polynomials was performed. Should the distribution correspond to a pure resonance of given angular momentum L, the value of χ^2 (ℓ_{max}) should drop

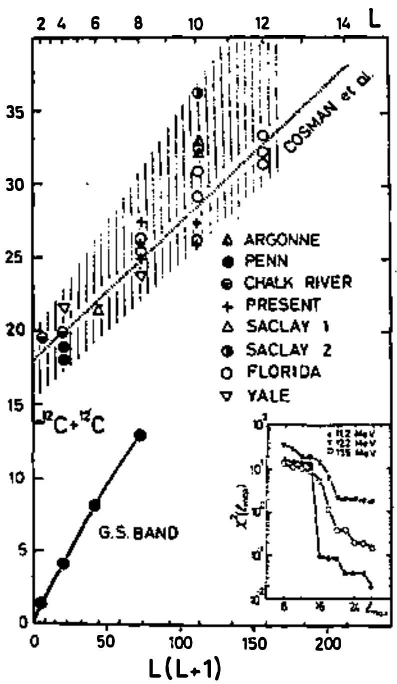

Fig. 1. Resonances in $^{12}C+^{12}C$ plotted in an $E_{exc}(^{24}Mg)$ vs. measured spin diagram.

sharply when $\ell_{max} = 2L$ (see insert in Fig. 1). From the combined analysis we conclude that the resonance at $E_{cm} = 11.2$ MeV (E_{exc} ^{24}Mg = 25.1 MeV) is a pure $J^{\pi} = 8^{+}$ one, while the other two resonances at $E_{cm} = 12.2$ and 13.5 MeV are mixtures of 8^{+} and 10^{+} and only those spins.

Fig. 1 shows the present results together with the results of some earlier measurements plotted vs. L(L+1). Two features of this plot strike the eye: (i) all the measured values lie on a fairly straight line and (ii) resonances of the same J^{π} appear to be grouped within a few MeV.

A conclusion stemming from (i) is the presence of a collective rotational band at high energies of excitation in ^{24}Mg. On the other hand, the grouping of resonances of the same J^{π} into clusters is suggestive of fragmenting of wide shape-resonances (a few MeV) into narrower ones (a few hundred keV). This phenomenon has already been observed in Ref. 4; the present results, however, suggest a considerably larger amount of in-mixing of resonances differing by 2 units of spin. It is also obvious that other resonances of $J^{\pi} = 6^{+}$ should be expected around the one observed at 7.5 MeV.

The existence of narrow resonances at high excitation energies implies a particular intrinsic structure. A vibration coupled to a rotational band, for example, would provide such a structure, exhibiting both the grouping and smaller admixtures of resonances of close J^{π} values.

References

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