Jacobi shape transition from GDR measurements in $^{19}F+^{27}Al$ reaction

G. Mishra[1], D. R. Chakrabarty[1], V. M. Datar[1], Suresh Kumar[1], E. T. Mirgule[1], A. Mitra[1], P. C. Rout[1], S. P. Behera[1], R. Kujur[1], and V. Nanal[2]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085 and*
[2]*Deptartment of Nuclear and Atomic Physics,*
Tata Institute of Fundamental Research, Mumbai - 400005

Introduction

In an earlier work [1], we reported measurements of high energy γ-rays in $^{19}F+^{27}Al$ reaction at E(^{19}F)$\sim$125 MeV for studying the giant dipole resonance (GDR) built on excited states in A$\sim$45 nuclei. The motivation was to address the Jacobi shape transition at high angular momentum (J$\hbar$). Evidence of such a transition through GDR measurements has been reported earlier [2–4]. However, only one work reported measurements in coincidence with the fusion evaporation residue (ER), although, a detailed J-dependence was not studied. In our work, measurements were made in coincidence with ER as well as low energy γ-multiplicity, which is broadly related to J. The preliminary results showed a low-energy component in the GDR strength function evolving with J. This observation was indicative of the occurrence of the Jacobi transition. A measurement in the same reaction at a lower beam energy, populating J below the critical value ($\sim$28) for this transition, is interesting because in this case the shape transition and the associated low energy GDR component should be absent. With this motivation measurements have been made in the afore-mentioned reaction at a beam energy of $\sim$75 MeV. In this paper we report these measurements and make a comparison with the final results obtained at the higher beam energy.

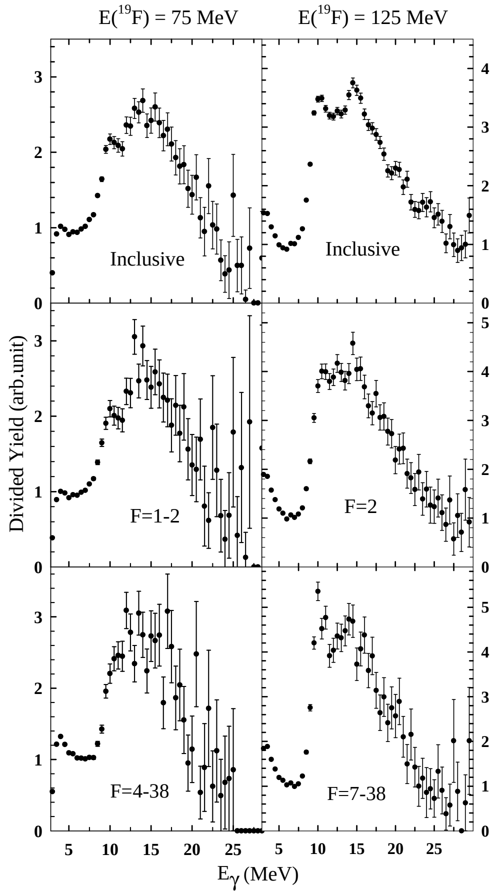

FIG. 1: Linearised plots of inclusive and fold-gated γ-spectra.

Experimental Details

The experiment was performed using a pulsed, collimated 74.7 MeV ^{19}F beam from the Mumbai Pelletron accelerator bombarding a 0.4 mg/cm^2 Al target. The mean excitation energy in the compound nucleus and the critical orbital angular momentum for fusion were $\sim$69 MeV and $\sim$27$\hbar$, respectively. High energy γ-rays in the energy range of $\sim$4 to 30 MeV were detected in an array of seven close packed BaF_2 detectors. The neutron-γ discrimination was done through the time of flight (TOF) measurement with respect to

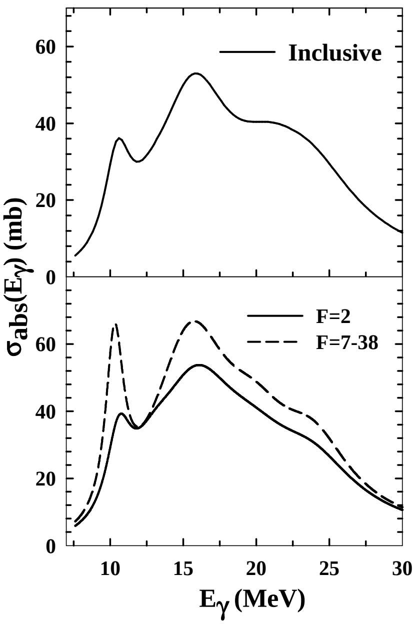

FIG. 2: Inverse photoabsorption cross sections giving the best statistical model fits to the data at 125 MeV beam energy.

the beam pulses. The low energy γ-ray multiplicity (M_γ) was measured with a 38-element BGO detector array. An annular parallel plate avalanche counter, consisting of twelve anode sectors, was placed at ~32 cm from the target for detecting the ERs, through their TOF, over an angular range of ~4−11°.

Results and Discussion

Fig. 1 shows the linearised plots of the inclusive (fold-summed) and fold-gated sepctra, from the present and the earlier measurements, where fold (F) is the number of BGO detectors firing in coincidence and is related to M_γ. The linearised plots were obtained by dividing the measured γ-spectra with a calculated one in which no GDR excitation was assumed. The spectra at the two beam energies show different features. A statistical model analysis was made to extract the inverse photoabsorption cross section best describing the data at 125 MeV. These are shown in Fig. 2. The experimental uncertainties in the derived cross sections, which are mainly decided by the statistical spread in the data, are not shown. The cross sections show a sharp low-energy (at ~10 MeV) and a broad high energy (at ~22 MeV) component superimposed on a broad peak centred at ~16 MeV. The relative intensities of the two extreme components, which are indicative of a large deformation in the decaying nuclei, increase at higher fold. The data thus demonstrates a J-driven deformation which can be related to the occurrence of the Jacobi shape transition at a high J.

At the present beam energy, the linearised plot of the inclusive spectrum (Fig. 1) appears to contain a low energy component, although, with a much reduced intensity. However, there is no evidence of the component becoming more important at the higher fold. This, therefore, should not be related to the J-driven deformation. In fact, a Jacobi transition should not be seen at the lower beam energy because the angular momentum populated in this case is expected to be mostly restricted below the critical value for the transition.

In summary, a comparison of the present results with those at the earlier high energy is supportive of the observation of the Jacobi shape transition at a high angular momentum.

Acknowledgments

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