Gamma-ray Spectroscopy in mirror nuclei ^{19}F - ^{19}Ne

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Introduction

The near equality of the masses of proton and neutron corresponds to Isospin symmetry in mirror nuclei resulting in a identical spectra in mirror nuclei. However, the Coulomb interaction is the primary cause of this symmetry breaking, resulting in energy differences in the analogue states of mirror nuclei. Additionally, there is evidence for the presence of Isospin Symmetry-Breaking (ISB) components of non-Coulomb origin, which further disrupt the symmetry. We can see the effects of symmetry breaking by comparing the level scheme of a mirror nuclei. Previously, ISB effects have been investigated in the mirror pairs ^{47}V - ^{47}Cr, ^{49}Cr - ^{49}Mn, ^{50}Cr - ^{50}Fe and ^{51}Mn - ^{51}Fe [1]. In this work, we aim to explore the ISB phenomena in the lower mass region at A = 19.

Experimental details

The main experiment was done with ^{9}Be as a projectile and ^{76}Ge as target with a thickness of 4.2 mg/cm^2 on a 10.8 mg/cm^2 thick lead as degrader in a heavy ion Fusion - Evaporation reaction. The beam of projectile was accelerated upto an energy E_{lab} = 37 MeV. In this target-projectile combination with an appropriate beam energy the most populated yield was ^{82}Kr together with ^{79}Se. The ^{9}Be beam was delivered by the Pelletron Linac Facility at the Tata Institute of Fundamental Research (TIFR), Mumbai.

The mirror nuclei ^{19}F - ^{19}Ne was produced in a different way. The lead (^{208}Pb) material used as a degrader is highly reactive to oxygen and during target preparation with the backing, the lead underwent oxidation, resulting in the formation of PbO. As the degrader was positioned in front of the beam, ^{19}F and ^{19}Ne were produced through the reaction ^{16}O(^{9}Be, αpn/α2n)^{19}F/^{19}Ne. The PACE4 calculations show a very low production rate of ^{19}Ne in this reaction. Although we could produce the nuclei of interest using a ^{16}O gaseous target, this approach will result in a significantly lower reaction cross-section compared to employing a solid target. We have also explored alternative target-projectile pairings and performed PACE4 calculations, but none yielded superior results compared to what we achieved with the current combination. The INGA ar-

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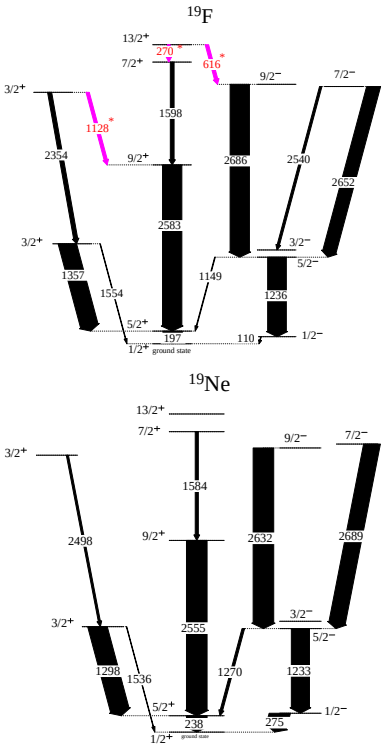

FIG. 1: Partial level scheme of ^{19}F - ^{19}Ne. Newly observed transitions are marked by an asterisk.

ray, consisted of 14 HPGe clover detectors, were deployed at various angles relative to the beam axis for detecting de-exciting gamma rays. Double and tripple coincidence gamma rays were collected and sorted into various symmetric and asymmetric $\gamma-\gamma$ matrices and a $\gamma-\gamma-\gamma$ cube using the MARCOS program. The matrices and the cube were analyzed using the INGASORT and RADWARE software packages [2]. For assigning the multipolarity of gamma rays, angular distribution from oriented nuclei (ADO) ratio (R_θ) were calculated using the following relation,

$$R_\theta = \frac{I_{\gamma_1}\,(\text{At } \theta_1 = 157^\circ\ ;\ \text{gated by all})}{I_{\gamma_1}\,(\text{At } \theta_2 = 90^\circ\ ;\ \text{gated by all})} \quad (1)$$

Results and Discussions

Almost all previously reported low level transitions in positive as well as negative parity **Yrast** and side band have been verified in ^{19}F nucleus. We have observed very few low lying transitions in the ^{19}Ne nucleus which is populated with low cross-section. Three new transitions have been found which are E_γ = **268.7**-, **613.7** and **1130.3**-keV by analysing the experimental data. The level structures of the two nuclei, constructed using a symmetric matrix based on coincidence relationships, are shown in Figure 1.

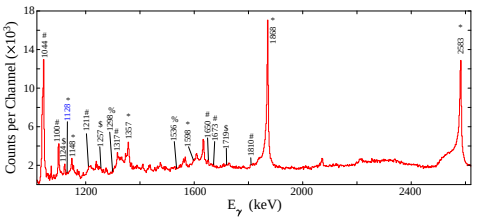

FIG. 2: The 197-KeV gated spectrum. #, $, *, % corresponds to the gamma ray energies of ^{82}Kr, ^{79}Se, ^{19}F and ^{19}Ne respectively.

TABLE I: Energy and Intensity of new gamma rays of ^{19}F. The intensities of gamma rays are normalized to the 197 KeV transition with I_γ = 100.

$J_i^\pi \rightarrow J_f^\pi$	E_γ (keV)	Intensity (I_γ)	R_θ
$13/2^+ \rightarrow 7/2^+$	268.7(5)	14.3(8)	1.35(12)
$13/2^+ \rightarrow 9/2^-$	613.7(6)	17.2(5)	1.29(11)
$3/2^+ \rightarrow 9/2^+$	1130.3(6)	16.5(9)	1.70(13)

The single gated spectra on 197-keV is shown in Figure 2. Further ADO, polarization and lifetime measurement are going on for complete assessment of the states which will be discussed in detail during the presentation.

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