Measurement of Half life of exotic nuclei near proton drip-line

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Introduction

Nuclear decay process is a well-proven probe of nuclear structure as well as of weak interactions. The decay processes of exotic nuclei touches upon many different and highly relevant physics issues. For beta decay close to stability transitions occur between discrete bound levels, γ -rays, X-rays and electrons are the important experimental observables. For exotic nuclei the continuum nuclear structure becomes more and more important. We have initialed research activity on decay properties of exotic nuclei.

In this article, we shall present our recent measurement of half-lives of the nuclei (^{76}Br, ^{79}Sr, ^{79}Rb etc.) near proton drip line (N~ 40) which are obtained from measurement intensity of delayed gamma-ray at different time stamping.

Experimental Details:

Neutron deficient nuclei exotic nuclei near proton drip line with N~40 have been populated through compound nuclear reaction. The experiment was performed using ^{24}Mg beam at energy E_{lab}=95 MeV, from the 14UD BARC-TIFR Pelletron accelerator, Mumbai. The target was enriched ^{58}Ni of thickness ≈ 11.94 mg/cm^2. In this reaction populated compound nucleus ^{82}Zr goes through various particle evaporation channels and populate ^{76}Br, ^{79}Sr, ^{79}Rb etc. nuclei. These nuclei have been de-excited to ground state by emitting gamma-rays and decay to daughter nuclei through β^+, electron capture and in small amount internal . In our experiment we have measured delayed gamma-rays in singles mode using 19 clover detectors [Fig.1] at different time stamps. All the clover detectors have been calibrated for energy and efficiency using ^{60}Co, ^{152}Eu and ^{133}Ba source.

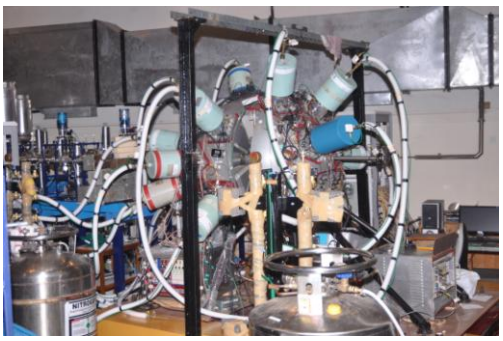

Fig. Setup of this experiment at TIFR

Figure one shows the experimental setup for this experiment, performed at TIFR. Figure.2 and 3 shows singles spectra at different time stamps.

Analysis:

The exponential law of radioactive decay

$$N(t) = N_0 e^{-\lambda t}$$

where, N_0 is the number of nuclei present at t=0. λ is the disintegration or decay constant. Measuring the intensity of delayed gamma of a particular nuclei at different time stamp, decay constant of particular nucleus has been obtained. Now half-life of disintegration is given by $T_{1/2} = \frac{\ln 2}{\lambda}$. Thus we can obtain half-life of the residual nuclei.

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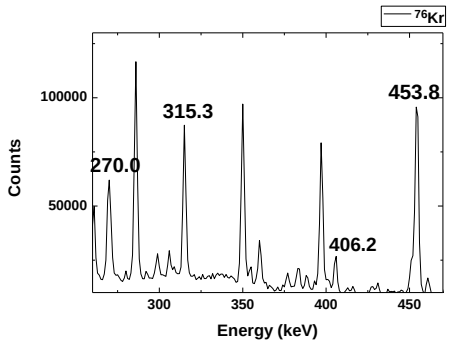

Fig.2. Singles gamma-ray spectra obtained from ^{24}Mg+^{58}Ni reaction at different time interval. Beta delayed gamma rays from ^{76}Kr isotopes are shown in the figure

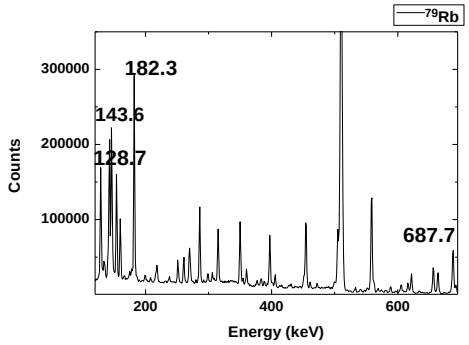

Fig. 3 Singles gamma-ray spectra obtained from ^{24}Mg+^{58}Ni reaction at different time interval. Beta delayed gamma rays from ^{79}Rb isotope are shown in figure.

Table 1. Half life of the nuclei from present measurement and earlier measurement

Residual nuclei (Parent Jπ)	**$T_{1/2}$ From literature[2]**	**$T_{1/2}$ From this Experiment**
^{78}Rb [4(-)]	5.74 min	5.72 min
^{76}Kr [0(+)]	14.8 hrs	1 hr 37 min
^{79}Sr [3/2(-)]	2.25 min	2.27 min
^{79}Rb[5/2(+)]	22.9 min	22.6min

In this way, by analyzing the different energy gamma-ray of that isotope we can get an average of its half-life. The whole analysis has been done using RADWARE [1]. From the above table 1, it can be observed that present experimental values of half lives of ^{78}Rb, ^{79}Rb and ^{79}Sr isotopes are in agreement with the results obtained from previous measurement[2]. But in case of ^{76}Kr, our measured half life is not in agreement with the previous measurement [2].

Results and Discussions:

In case of ^{76}Kr the result is very much away from the actual value. The following gamma-rays with energy 315.7 keV (39%), 270.2 keV (21%) and 406.5 keV(12%) of ^{76}Kr gave almost the same result. P. Sarriguren et.al [4] mentioned that for the spherical shape of this isotope, the theoretical value of half-life is 4.1 hr whereas for prolate shape it is 38.0 hrs.

References:

[1] http://radware.phy.ornl.gov
[2] *http://www.nndc.bnl.gov*
[3] **P. Sarriguren** et.al. *NPA 691,(2001)* 631