Lifetime Measurements in *sdpf* Nuclei with Thick Molecular Target

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Introduction

The Doppler Shift Attenuation Method (DSAM) is a technique widely used in measuring nuclear level lifetimes in the range of tens of fs to a few ps. Conventionally this method is carried out using a thin target on a thick elemental backing (Ta, Au, Pb etc), which ensures reliable estimates for the stopping powers. However, spectroscopic investigations of certain nuclei may require the use of a molecular target. For instance, the neutron rich ^{18}O target in the form of Ta_2O_5 has been used in the spectroscopic studies of *sdpf* nuclei [1]. The Doppler shapes observed for the γ-ray transitions in these measurements cannot be analyzed within the purview of the standard LINESHAPE [2] package, extensively used for analysis of DSAM data. The present paper reports the analysis of the Doppler shapes obtained from thick molecular target setups, using a modified version of the LINESHAPE program with inputs on the target characteristics obtained through XRD and SEM measurements. Lifetime measurements in the $A \sim 30$ nuclei ^{32}P, ^{26}Mg etc have been carried out. The experimental transition probabilities and the branching ratios, following these measurements, have been compared with the predictions from large basis shell model calculations.

Experimental Details

The high spin states of the nuclei of interest, have been populated in a series of experiments at different INGA campaigns [3, 4], using the ^{18}O(^{16}O, $xnypz\alpha$) and ^{18}O(^{13}C, $xnypz\alpha$) reactions with incident beam energies of 30-34 MeV. The details of the experimental setup are outlined in Ref. [1] and references therein. The target was 9.25 mg/cm^2 thick Ta_2O_5 enriched in ^{18}O, acting both as the target and the backing media. SEM and XRD measurements were crucial in probing the structural composition of the target, that has a direct bearing on the stopping mechanism and the resulting estimation of the level lifetimes.

Data Analysis and Calculations

Spectra at different angles have been analyzed using the modified LINESHAPE package [2] that accepts stopping powers calculated by the SRIM software as well as incorporates the cross section dependence of residue production with decreasing beam energy, as the latter traverses the target. The afore-

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TABLE I: Representative comparison of observables from present measurements and shell model calculations.

	E_x (keV)	E_γ (keV)	M	Experimental B(M1) (μ_n^2)	Experimental B(E2) (e^2fm^4)	Experimental BR	Shell Model USDA B(M1) (μ_n^2)	Shell Model USDA B(E2) (e^2fm^4)	Shell Model USDA BR
	1323	1323	M1	$0.027^{+0.002}_{-0.003}$	-	0.53±0.01	0.041	-	0.68
		1245	M1	$0.029^{+0.002}_{-0.003}$	-	0.47±0.01	0.031	-	0.32
^{32}**P**									
	1755	1755	E2+M3	-	$0.796^{+0.076}_{-0.064}$	0.010±0.001		0.782	0.02
		1677	M1+E2	$0.012^{+0.001}_{-2.869}$	$37.611^{+0.020}_{-3.729}$	0.98±0.02	0.001	50.490	0.86
		432	M1+E2	$0.022^{+0.002}_{-0.002}$	$24.980^{+2.033}_{-2.370}$	0.020±0.001	0.027	0.327	0.11
	1809	1809	E2	-	$60.956^{+5.481}_{-3.882}$	1.00	-	68.970	1.00
^{26}**Mg**									
	2938	1130	M1+E2	$0.170^{+0.046}_{-0.013}$	$27.468^{+7.460}_{-2.094}$	0.90±0.05	0.155	37.160	0.78
		2938	E2	-	$1.810^{+0.491}_{-0.138}$	0.10±0.01	-	3.533	0.22

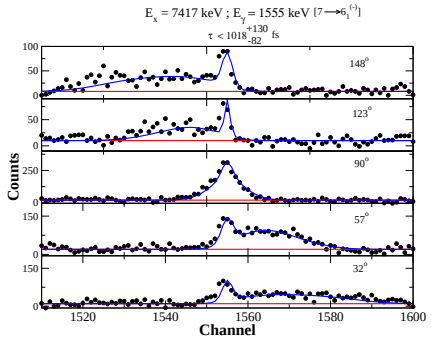

FIG. 1: Lineshape fit of the 1555 keV peak in ^{32}P nucleus.

said modification befits a DSAM setup with thick molecular target, as in the present work. The conventional least square fitting of the calculated shape to the experimental shape has been undertaken. A representative fit has been illustrated in Fig. 1 for the 1555 keV transition in the ^{32}P nucleus. Large basis shell model calculations have been carried out to compare the experimental transition probabilities, extracted from the level lifetimes, and the branching ratios with those from the model predictions. The shell model code NuShellX@MSU [5], along with the *USDA* [6] interaction has been used for the purpose. The results for selected transitions in the ^{32}P, ^{26}Mg nuclei in comparison to the experimental findings are recorded in Table 1 and are seen to be in good agreement, thus validating the present endeavour to extend the DSAM measurements to thick molecular target setups.

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