Lifetime measurements in neutron-rich Xe isotopes

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Abstract. The nuclear properties in the region around the doubly magic nucleus ^{132}Sn are of special interest. This mass region is important in an astrophysical aspect as "waiting points" of the r-process lie in this region and the nuclear structure there has an impact on the modelling of nucleosynthesis. Theory relies on nuclei near closed shells for predicting other, more exotic systems. Our interest lies in particular on the neutron-rich Xe isotopes ($^{138-144}$Xe) which exhibit both quadrupole and octupole collective properties.

The even neutron-rich xenon isotopes show regular behaviour and the $B(E2; 0^+_{gs} \rightarrow 2^+_1)$ values [1] around $N = 82$ are well reproduced by the systematics unlike the $B(E2)$ value in ^{136}Te. The $B(E2)$ values were measured in a Coulomb excitation experiment. The Coulomb excitation cross section depends on both transition ($\propto B(E2)$) and diagonal ($\propto Q_s$) matrix elements. The lifetime of an excited state, on the other side is a direct measure for the strength of the transition and allows for a more precise quadrupole moment determination when combined with the Coulomb excitation data. Also of interest are the negative parity states where the increasing induced electric dipole moment is interpreted as a sign of increasing octupole correlations, maybe peaking at an octupole "magic" number $N = 88$ [2]. Nuclear lifetimes also contribute to the understanding of this phenomenon.

Within the EXILL&FATIMA campaign at ILL [3], Grenoble, in early 2013, the lifetimes of excited states in the neutron-rich xenon isotopes ($^{138-144}$Xe), populated in neutron-induced fission of ^{235}U and ^{241}Pu, were measured. The fast timing array (FATIMA) consists of 16 $LaBr_3$ fast scintillators and allows us to measure lifetimes down to ≈ 10 ps. The high-resolution EXILL array (EXOGAM@ILL), consisting of 32 HPGe detectors, gives us the possibility to identify the nuclides of interest among the big amout of fission fragments produced. This setup is characterized with high efficiency which enables even quadruple $(\mathrm{Ge})^2$-$(\mathrm{LaBr}_3)^2$ γ coincidences. Using the generalized centroid difference method [4], lifetimes as short as several picoseconds can be unambiguously determined.

In this work we present directly measured lifetimes in odd and even mass neutron-rich xenon isotopes. This was the first measurement of this kind for xenon isotopes, except for ^{140}Xe which was studied before by Lindroth et al. [5].

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References

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