Low- and Medium-Spin Level Structure of neutron rich $^{96}$Sr: Competition between Vibrational and Rotational modes of excitations


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Introduction

Nuclei in $A \sim 100$ mass region exhibit large variety of interesting nuclear structure phenomena [1]. It has been observed that the nuclei with $N \leq 58$ display features that characterize a spherical vibrator (see Fig. 1). On the other hand, nuclei with $N \geq 60$ exhibit deformed rotor like behavior. It is obvious from Fig. 1(c) that there is a sudden increase in deformation along the chain of even-even Sr-isotopes as the neutron number increases from $N = 58$ to $N = 60$. Also, it is quite interesting to note that the deformation gets saturated for Sr-isotopes lying in the more neutron-rich side of $^{96}$Sr. The sudden onset of deformation and its immediate saturation at $N \sim 60$ can be explained by the occupation of the valence nucleons at the $g_{9/2}$ proton and $h_{11/2}$ neutron orbitals. Lying in the vicinity of highly deformed and nearly spherical region, $^{96}$Sr occupies a critical position in the nuclide chart where the onset of multifaceted excitation modes can be expected. We are reporting here nuclear structure phenomena associated with $^{96}$Sr in the low- and medium-spin regime following new spectroscopic information, obtained from an experiment employing thermal neutron induced fission.

FIG. 1: Evolution of the low-lying spectroscopic properties along the chain of even-even Sr-isotopes. Variations of (a) $E_{4^+} / E_{2^+}$ values (b) $B(E2; 2^+ \rightarrow 0^+)$ values, and (c) $\beta_2$ values, as a function of mass number, $A$, are shown.

Experimental Details and Data Analysis

The experiment was performed at the PF1B line of the high-flux reactor facility at the Institut Laue-Langevin (ILL), Grenoble, France. The collimated and thermalized neutron flux at the target position was of the order of $10^8$ neutrons per sec. per square centimeter. Neutron-rich $A \sim 100$ nuclei were produced as fission fragments following thermal neutron induced fission of $^{235}$U target. The target was in the form of $\mathrm{UO}_2$ having thickness of $\sim 600 \mu \mathrm{g/cm}^2$ with 99.7% enrichment in $^{235}$U, and was sandwiched between thick backings. De-
exciting γ rays from the fission fragments were
detected by an array consisting of eight EX-
OGAM large clovers, six large coaxial detec-
tors from GASP, and the two clovers from the
ILL. BGO anti-Compton shields were used as
Compton suppressors for the EXOGAM and
GASP detectors in the array. The details of
the experimental set up can be found in Ref.[2].

As the detailed off-line analysis is in
progress, we are reporting here a few prelimi-
nary results. A representative triple-γ coi-
cidence spectrum of neutron rich 96Sr is shown
in Fig. 2. Partial level scheme of 96Sr, as
obtained in the present study, is shown in
Fig. 3(a). Several new γ transitions were
observed and placed in the decay scheme.
The newly observed 183-keV linking transition
firmly establishes the position of the two close-
lying 4+ levels. As can be seen in Fig. 2, the
yrast levels up to the spin of 12ℏ were
populated. The observed levels have been grouped
under two heads: Band-I and Band-II. The
equally spaced sequence of levels at 815-, 1792-
and 2785-keV apparently forms a harmonic
vibrational like band structure (Band-I) cor-
responding to one-phonon, two-phonon, and
three-phonon states. The preferential decay of
the (6+) level at 2785-keV to the lower-lying
4+ level at 1792-keV is the possible indication
that the levels at 815-, 1792- and 2785-keV be-
long to the same band. Band-II is suggestive
of a deformed band with the 0+ \frac{5}{2} band head
at 1229-keV. This feature is quite similar to
what has been observed in the neighboring
98Zr (N = 58 isotope of 96Sr) [2]. However,
it appears that the present reaction mecha-
nism could not populate the 0+ \frac{5}{2} state with
significant strength and hence the expected
2+ \frac{5}{2} \rightarrow 0+ \frac{7}{2} transition could not be
observed in the present data. The possible change in
excitation mode of 96Sr with increasing spin is
highlighted in Fig. 3(b). It is also obvious
from the figure that 96Sr exhibits vibrator like
behavior at low-spin regime (indicative from
the sharp fall in ordinate values), whereas the
higher spin levels exhibit the feature of highly
deformed, stabilized rotational structure (ow-
ing to the saturation of ordinate values).

FIG. 2: A representative triple-γ coincidence spectrum with double-gates on 815- and 978-keV transitions, decaying from the two lowest levels of Band-I (see Fig. 3(a)) in 96Sr. The newly observed transitions have been marked with *.

FIG. 3: (a) Partial level scheme of 96Sr as ob-
tained in the present work. (b) E-GOS curves for the yrast states of N = 58 isotones, 96Sr and 98Zr.

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