BELOW-THE-BARRIER COULOMB EXCITATION OF ^{124,126}Xe

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An experiment to study the Coulomb exciation of stable ^{124}Xe and ^{126}Xe beams at energies below the Coulomb barrier was recently performed at the ATLAS facility at Argonne National Laboratory. These nulcei are interesting because xenon isotopes have been interpreted as a realization of the O(6) symmetry of the IBA model. This corresponds to the geometrical interpretation of a γ-soft rotor. While the yrast and non-yrast level structure and decay-branching ratios have been previously measured in these nuclei [1], high-precision lifetimes for many of the non-yrast low-spin states are not yet determined. The technique of below-the-barrier Coulomb excitation is well suited for this study since this process readily populates non-yrast states (as opposed to heavy-ion fusion-evaporation reactions) and allows the extraction of excitation cross sections that are directly related to the γ-ray transition probability.

Critical to the success of this experiment was to have a high-efficiency Ge-detector array. To achieve this goal, six 32-fold segmented germanium detectors from the Michigan State University germanium array were utilized [2]. The detectors were configured in a compact barrel arrangement where the crystals were located about 6 cm from the center of the excitation target. Fig. 1 shows a photograph of the Ge configuration. In this arrangement, the array had a total photo-peak efficiency of ≈6% for the 1.3 MeV line of ^{60}Co. The effective segment opening angle in this configuration is ≈7°. This experiment represents the first in-beam use of these detectors.

To detect scattered particles, a four-quadrant large-area PPAC was designed at the Argonne National Laboratory. This device was situated 23.9 cm downstream from the target, and it subtended an angle of ≈32°, which was sufficient to cover the entire scattering range of the Xe nuclei (28°). The minimum scattering angle covered by the PPAC was ≈5°, below which the unscattered beam particles passed through a hole located in the middle of the PPAC quadrants to be stopped farther downstream.

The beams of ^{124}Xe and ^{126}Xe were delivered by the ATLAS accelerator at energies of 554-keV each ($\beta \approx 10\%$). These beams were directed at a 1 mg/cm^2 enriched ^{58}Ni target that was located in the center of the germanium array.

The power our segmented Ge array can be seen in Fig. 2(a) where two spectra from the Coulomb excitation of ^{126}Xe are shown. In this figure, the spectrum with the broad peaks is what results if the segmentation of the germanium detectors is ignored. These peaks have an energy resolution of about 6%. If the segmentation of the germanium detectors is taken into account, the position of the first interaction can be localized within

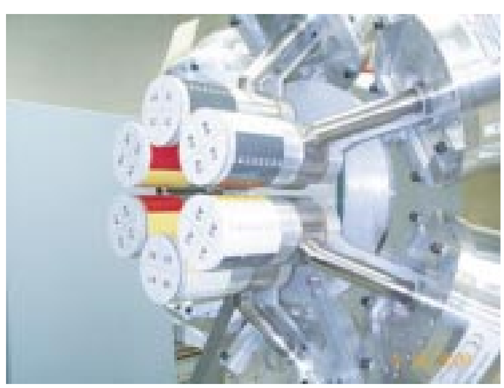

Figure 1: Photograph of the germanium array configuration that was used in the Xe Coulomb excitation experiments.

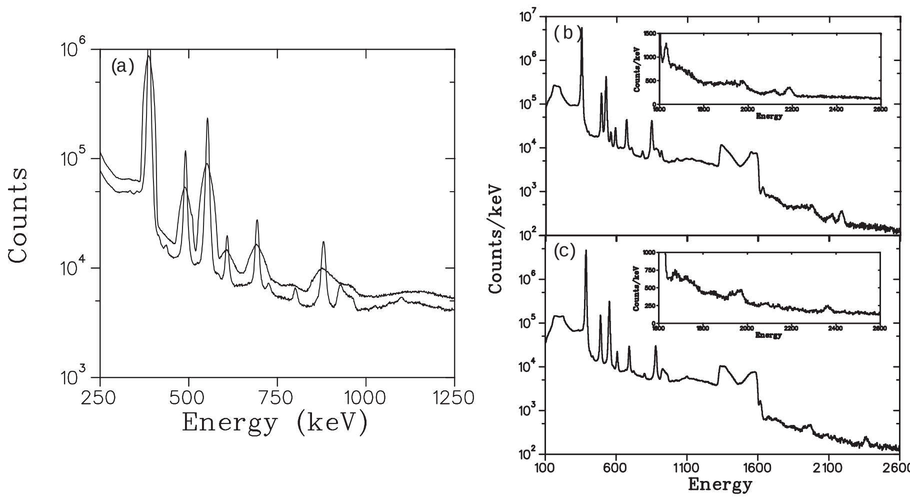

Figure 2: (a) Representative spectra illustrating the success of Ge segmentation for improving the resolution of γ-ray spectroscopic methods. These data are from the Coulomb excitation of ^{126}Xe. (b) ^{124}Xe and (c) ^{126}Xe γ-ray spectra observed after Coulomb excitation on a 1 mg/cm^2 ^{58}Ni target. The inset spectra in both panels are presented to highlight the high-energy γ rays that are observed.

the crystal. One then obtains the spectrum with the narrow peaks in Fig. 2(a). The energy resolution of these narrow peaks is $\approx$1.5%. This is very close to the resolution that is expected if we had perfect identification (1.4%). With perfect identification our limiting factor in the resolution is our physical segment size (1 cm). The power of increased resolution is also readily evident in Fig. 2(a) where peaks that are indestinguishable in the 6% resolution spectra are easily seen in the 1.5% resolution spectrum.

With this setup we were able to observe excited states up to 2.4 MeV in excitation energy. The spectra illustrating the observed γ-ray decays are presented in Figs. 2(b) and (c). In both ^{124}Xe and ^{126}Xe, excitations up to the 8^+ level in the yrast cascade were observed. In addition, numerous off-yrast states were excited. For example, the 1970 and 2359-keV γ-ray transitions from the decay of the 2_6^+ state in ^{126}Xe previously observed by Gade *et al.* [1] are clearly seen in our data. Unlike the previous experiments, we will be able to extract the transition probability of this state. This state in particular is interesting because its configuration is believed to have a significant contribution from mixed-symmetry wave functions. These data will allow us to gain additional insight into the structure of this state and other highly non-yrast states in ^{126}Xe.

Prior to our experiments, excited states with predominantly mixed-symmetry wave functions had not yet been identified in ^{124}Xe. We have observed previously unidentified γ-ray transitions of 1974, 2118, and 2182 keV for the decay of excited states in ^{124}Xe. It is quite possible that these transitions originate from states of mixed-symmetry configuration in ^{124}Xe.

The results from the study of the Coulomb excitation of ^{124}Xe and ^{126}Xe will yield new information about the structure of the highly non-yrast mixed-symmetry configuration for nuclei in this region. The analysis of these data are in progress and will soon yield quantitative results.

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References

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