In-beam γ-ray spectroscopy of ^{50}Ar

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Owing to the advent of intense radioactive isotope beams over recent years, it has become possible to study the structures of nuclei with large neutron-to-proton ratios using techniques including in-beam γ-ray spectroscopy and decay spectroscopy. One of the focal points of such studies has been the evolution of nuclear shell structure in exotic radioisotopes, where the nuclear 'magic' numbers in stable systems have been shown to deviate from their usual values. One such example is the onset of the new neutron magic number $N = 16$ in exotic oxygen. On the contrary, the disappearance of the standard magic number $N = 28$ has been investigated in ^{42}Si. In the neutron-rich fp shell, development of a new subshell closure at $N = 32$ has been reported in Ca[1–3], Ti[4,5], and Cr[6,7] isotones, and more recently, a sizable subshell gap at $N = 34$ was reported in ^{54}Ca[8].

In the present study, the low-lying structure of ^{50}Ar ($Z = 18$) was investigated using multi-nucleon removal reactions from a fast radioactive beam containing ^{54}Ca, ^{55}Sc, and ^{56}Ti, among other constituents, with the technique of in-beam γ-ray spectroscopy, in order to gain further insight on the magnitude of the $N = 32$ subshell closure at $Z < 20$. The secondary beam was created using projectile fragmentation of ^{70}Zn^{30+} ions at 345 MeV/u and products were identified on an event-by-event basis using the BigRIPS separator. A 10-mm-thick ^{9}Be reaction target was placed at the eighth focal plane of BigRIPS to induce nucleon removal reactions and a high efficiency γ-ray detector array[9] (DALI2) was employed to measure transitions from nuclear excited states populated by the reactions. Reaction products were identified by the ZeroDegree spectrometer; the particle identification plot for Ar isotopes is provided in Fig. 1. Data acquisition was triggered by the arrival of an ion at the end of ZeroDegree measured in coincidence with at least one γ ray in DALI2. Data were recorded to disk for offline analysis over a time period of approximately two days.

The Doppler-corrected γ-ray energy spectrum, deduced from the sum of the ^{9}Be(^{54}Ca,^{50}Ar+γ^n)X, ^{9}Be(^{55}Sc,^{50}Ar+γ^n)X, and ^{9}Be(^{56}Ti,^{50}Ar+γ^n)X multi-nucleon removal reactions ($n \geq 1$), is displayed in Fig. 2. Two transitions with energies of ∼1.2 and, tentatively, ∼1.6 MeV are present in the spectrum and are assigned to ^{50}Ar in the present work. Details on the structure of ^{50}Ar and the significance of the $N = 32$ subshell closure at $Z < 20$ will be presented elsewhere.

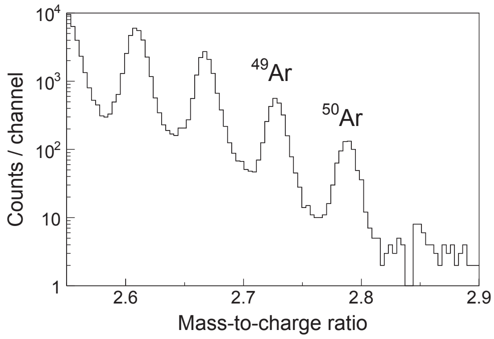

Fig. 1. Particle identification plot (A/q) for Ar isotopes measured using the ZeroDegree spectrometer.

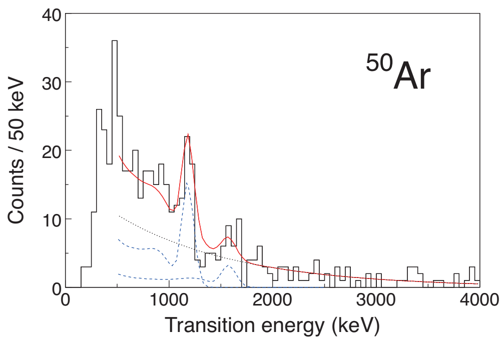

Fig. 2. (colour online) Doppler-corrected γ-ray energy spectrum for ^{50}Ar. The black dotted line and the blue dashed lines are an exponential fit to the background and GEANT4 simulations, respectively; the solid red line is the total (sum) fit.

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