Study of high spin state population by light-ion reaction

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Study of high spin states through in-beam gamma ray spectroscopy provides valuable information about the level structure and properties of nuclei. The fusion-evaporation reactions with beam energies near to above barrier is a conventional tool to populate high spin states. However these reactions limit the beam energy with the choice between higher cross-section or angular momentum pumping in nuclei. Higher beam energies are suitable to populate higher spin states which reduces the cross-section due to competition from other reaction channels. An alternative approach is to use light-ion scattering reactions employing particle-γ coincidence technique, which enables the selection of weak reaction channels by detecting the scattered particles in coincidence with γ rays. In this work, we have performed a particle-γ coincidence experiment to study ^{40}Ca utilizing the CAGRA detector array [1] and high resolution Grand Raiden spectrometer [2]. The ^{40}Ca being doubly-magic and spherical in its ground state, which has multiple deformed bands based on excited state configurations [3, 4, 5, 6].

An experiment was performed at Research Center for Nuclear Physics (RCNP) of the Osaka University to study the yrast and non-yrast states in ^{40}Ca using the inelastic scattering reaction ^{40}Ca(^{6}Li, ^{6}Li$'$)^{40}Ca$'$ with incident beam energies of 130 MeV and 600 MeV. The ^{6}Li beam, with $\approx$ 8 nA current was delivered by the cyclotron facility at RCNP. The target used in this experiment was enriched ^{40}Ca having 1.63 mg/cm^2 thickness. The deexcited γ rays from the reaction products were detected with the CAGRA clover detector array in coincidence with scattered particles. This facility comprised of 12 clover hyperpure germanium (HPGe) detectors and 4 large volume LaBr$_3$:Ce detectors. The HPGe detectors were mounted co-axially in anti-Compton shields subtending angles 90° (eight detectors), 135° (four detectors) and the four LaBr$_3$:Ce detectors were placed at 45° with respect to beam direction. The scattered ^{6}Li particles were detected and analyzed by the high resolution Grand Raiden (GR) spectrometer, which was placed at 11.3° relative beam axis. The GR having two vertical drift chambers (VDCs) and two plastic scintillators at the focal plane.

The particle-γ coincidence data for CAGRA were collected online using high speed digital data acquisition system based on the GRETINA digitizers. The data were collected independently for GR, triggered by the coincidence of the two plastic scintillators. The CAGRA and GR data events were correlated offline based on the time stamps record. The γ-ray energy information of signals were extracted by subtracting the postrise and prerise waveform samples. The prerise sample of the current event and postrise sample of the previous event provide four data points which were used to fit the baseline using baseline fitting procedure [7]. Fig. 1(a) shows the energy correlation (Ex vs E$_\gamma$) 2D histogram for ^{40}Ca(^{6}Li, ^{6}Li$'$)^{40}Ca$'$ at 130 MeV, where Ex is the excitation energy of the ^{40}Ca nucleus obtained from the inelastically scattered ^{6}Li particles in GR and E$_\gamma$ is the energy of the emitted γ rays from target nucleus, measured in CAGRA detectors. The x- and y- projections on this 2D histogram shown in Fig. 1(b) and Fig. 1(c) are the corresponding GR excitation energy and γ-ray energy spectra,respectively. The preliminary results depicts that the GR excitation spectrum of ^{40}Ca showing the prominent energy states up to $\approx$ 8.5 MeV and γ-rays were identified connecting until 6.9 MeV state. The highest intensity was observed for the 3737 keV state with J$^\pi$ = 3^- relative to the 3904 keV state with J$^\pi$ = 2^+, decaying to the ground state 0^+ which indicate the strong population of negative parity states relative to positive parity states. Fig. 1(d) shows the γ ray spectrum obtained from the data collected at beam energy of

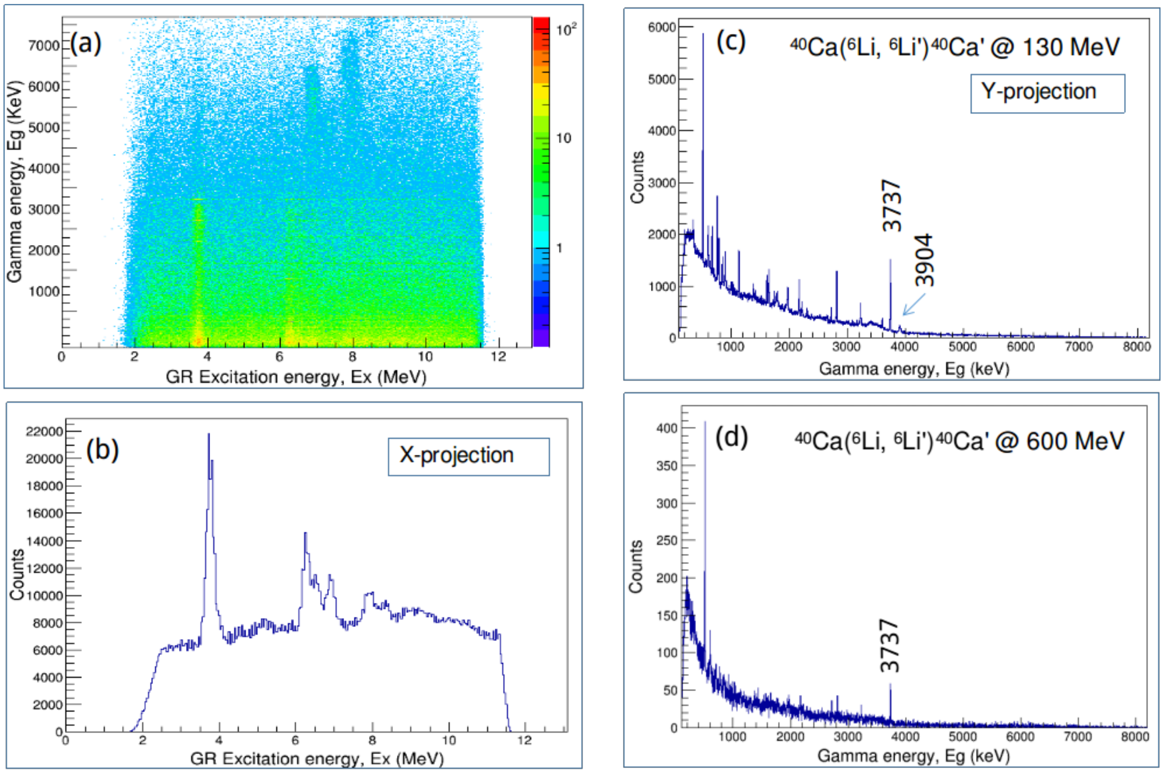

Figure 1: (a) shows the correlation between excitation energy measured in GR as a function of γ ray energy for the data obtained at 130 MeV beam energy, (b) and (c) are the corresponding x-, y- projections, and (d) shows the γ ray energy spectrum obtained from 600 MeV data.

600 MeV. Further analysis is in progress.

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