RCNP EXPERIMENT E

**PROPOSAL FOR EXPERIMENT AT RCNP**

7 Feb 2017

**TITLE:**
**Exploring the shape of doubly-magic $^{40}$Ca through low-energy Coulomb excitation**

**SPOKESPERSON:**


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| and CAGRA Collaboration | | |

**RUNNING TIME:** Installation time without beam 2 days
Test running time for experiment 0.5 days
Data runs 5.5 days

**BEAM LINE:** EN course

**BEAM REQUIREMENTS:** Type of particle $^{40}$Ca, halo-free, small emittance
Beam energy 167 MeV
Beam intensity $\leq$ 5 pnA

**BUDGET:** Experimental expenses: 1) Enriched $^{194}$Pt target: 300,000 yen
2) Minor modifications to the existing scattering chamber and beam port: 300,000 yen
3) Total : 600,000 yen

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**SPOKESPERSON:** M. Kumar Raju, Eiji Ideguchi

## SUMMARY OF THE PROPOSAL

In this proposal, we aim to study the shape of $^{40}$Ca through determining the spectroscopic quadrupole moment, $Q_S$ of first $2^+$ state in $^{40}$Ca through Coulomb-excitation reorientation effect measurement. The doubly magic ($N = Z = 20$) $^{40}$Ca nucleus is one of the best cases in the mass 40 region to observe multiple shape coexistence as it has several excited $0^+$ deformed configurations. The rotational band built on the $0^+_3$ state was reported to have $\beta \approx 0.59$, indicating superdeformed band (SD) structure and the band based on the $0^+_2$ state was known to have $\beta \approx 0.27$, indicating normal deformed (ND) structure. The theoretical calculations based on a cranked relativistic mean-field (CRMF),and a large-scale shell model (LSM) predict that the SD band is associated with $8p$-$8h$ prolate configuration and the ND band is based on $4p$-$4h$ triaxial shape due to mixture of configurations between them, and indicating shape-coexistence in low energy spectrum of $^{40}$Ca. Though these shapes are predicted based on the calculations and their agreement with the experimental transition quadrupole moments, $Q_t$, from lifetime measurements, the direct information about the shapes and the signs of electromagnetic moments are rather scarce. In this proposal, we aim to determine the sign and magnitude of $Q_S$ of the first $2^+$ state at 3.9 MeV in the ND band, which will give a direct information on the shape of ND band and provide insight into the predicted shape coexistence.

The safe Coulomb-excitation reorientation effect is a direct method to extract the matrix elements which would provide the sign and magnitude of $\langle 2^+_1 \,||\, E2 \,||\, 2^+_1 \rangle$, and thereby the $Q_S(2^+)$. The CAGRA detector array at RCNP would be used to detect de-excited $\gamma$ rays in coincidence with the scattered particles which will be detected using a double sided silicon CD type detector and an array of CsI detectors.