

In-Beam γ -Spectroscopy of Low-Spin Mixed-Symmetry States of ^{138}Ce with GAMMASPHERE in Singles-Mode¹

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Mixed-symmetry states (MSSs) were defined [1] in the proton-neutron (pn) version of the interacting boson model (IBM-2). They are quadrupole-collective isovector excitations of the valence shell and their properties are particularly sensitive to the effective pn-interaction. New experimental approaches have recently extended our knowledge about MSSs, *e.g.*, [2]. One-step Coulomb excitation (COULEX) in inverse kinematics has been demonstrated previously [3] as a useful tool for identifying the fundamental one-phonon $2_{1,\text{ms}}^+$ MSS of predominantly vibrational nuclei.

We have performed an inverse-kinematics COULEX measurement with GAMMASPHERE at the ATLAS accelerator using a beam of the rare isotope ^{138}Ce (natural abundance 0.25%) to identify the $2_{1,\text{ms}}^+$ MSS of ^{138}Ce . The ion beam with intensity of about $3 \cdot 10^9$ particles/sec was shot on a carbon target at beam energies of 480 and 400 MeV, well below the Coulomb barrier. We observe, amongst other states, the lowest six $J^\pi = 2^+$ states of ^{138}Ce up to an excitation energy of ≈ 2.7 MeV in a “complete reaction”.

The clean COULEX reaction on a light target in inverse kinematics enables us to detect the γ -radiation with high statistics (and, thus, high precision) in singles-mode. The method is well suited to study MSSs in rare isotopes. Excitation cross sections and angular distributions yield complete γ -spectroscopic information on multipolarities and EM matrix elements in a beam time of less than a day.

The method, experimental results for ^{138}Ce , and their consequences will be discussed.

- [1] F. Iachello, A. Arima, *The interacting boson model* (Cambridge University Press, Cambridge, 1987).
- [2] N. Pietralla, C. Fransen *et al.*, Phys. Rev. Lett. **83**, 1303 (1999); Phys. Rev. Lett. **84**, 3775 (2000).
- [3] N. Pietralla *et al.*, Phys. Rev. C **64**, 031301 (2001).

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