

# Unique Information on Proton-Neutron Structure of Nuclear States from Combined Electromagnetic and Hadronic Scattering Experiments

A consequence of the formulation of the proton-neutron version of the Interacting Boson Model [1] is the occurrence of low-energy mixed-symmetry states with boson couplings that are partially non-symmetric with respect to proton and neutron boson labels. This results in enhanced M1 gamma-ray transitions to lower-lying fully symmetric states that dominate the low-energy M1 strength function in heavy nuclei. The existence of mixed-symmetry states have later-on been verified experimentally. Their properties are uniquely sensitive to the effective proton-neutron interaction in the valence shell. Electromagnetic probes such as photon scattering, electron scattering, or projectile-Coulomb excitation on light targets have proven themselves as powerful methods for the identification and quantitative investigation of the fundamental building block of quadrupole-collective mixed-symmetry structures of heavy nuclei, the one-phonon mixed-symmetry  $2+1_{ms}$  state. A complete set of data on the  $2+1_{ms}$  state has been obtained [2-4] on stable even-even isotopes of the  $A=130$  mass region on the basis of absolute M1 transition rates. For the case of  $^{132}\text{Te}$  the method of projectile-Coulomb excitation has produced first solid evidence for a mixed-symmetry state of a radioactive nuclide [5], too. Information on the dominant single-particle components involved in the formation of quadrupole-collective one-phonon states of vibrational nuclei has recently been obtained [6] from a comparison of inelastic electron-scattering and proton-scattering cross sections. Quantum interferences in charge- or matter-transition densities enable one to determine whether a proton boson or a neutron boson couples antisymmetrically within the mixed-symmetry wave function [6]. New data [7] on that phenomenon will be presented and discussed. The topic represents a strong physics case for a continued collaboration between TU Darmstadt and iThemba Labs.

[1] F. Iachello and A. Arima, *The interacting boson model* (Cambridge Univ. Press, 1987).

[2] L. Coquard et al., *Phys. Rev. C* 82, 024317 (2010).

[3] T. Ahn et al., *Phys. Rev. C* 86, 014303 (2012).

[4] Th. Möller et al., TU Darmstadt, in preparation.

[5] M. Danchev et al., *Phys. Rev. C* 84, 061306(R) (2011).

[6] Ch. Walz et al., *Phys. Rev. Lett.* 106, 062501 (2011).

[7] A. Scheikh-Obeid et al., TU Darmstadt, in preparation.

**Primary author:** Mr PIETRALLA, Norbert (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany)

**Co-authors:** KRUGMANN, A (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); SCHEIKH-OBEID, A (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); BAUER, Ch (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); WALZ, Ch (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); RAINOVSKI, G (Faculty of Physics, St. Kliment Ohridski University of Sofia, BG-1164 Sofia, Bulgaria); WAMBACH, J (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); MOLLER, O (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); VON NEUMANN-COSELL, P (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); MOLLER, Th (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany); PONOMAREV, V Yu (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany)

**Presenter:** Mr PIETRALLA, Norbert (Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany)