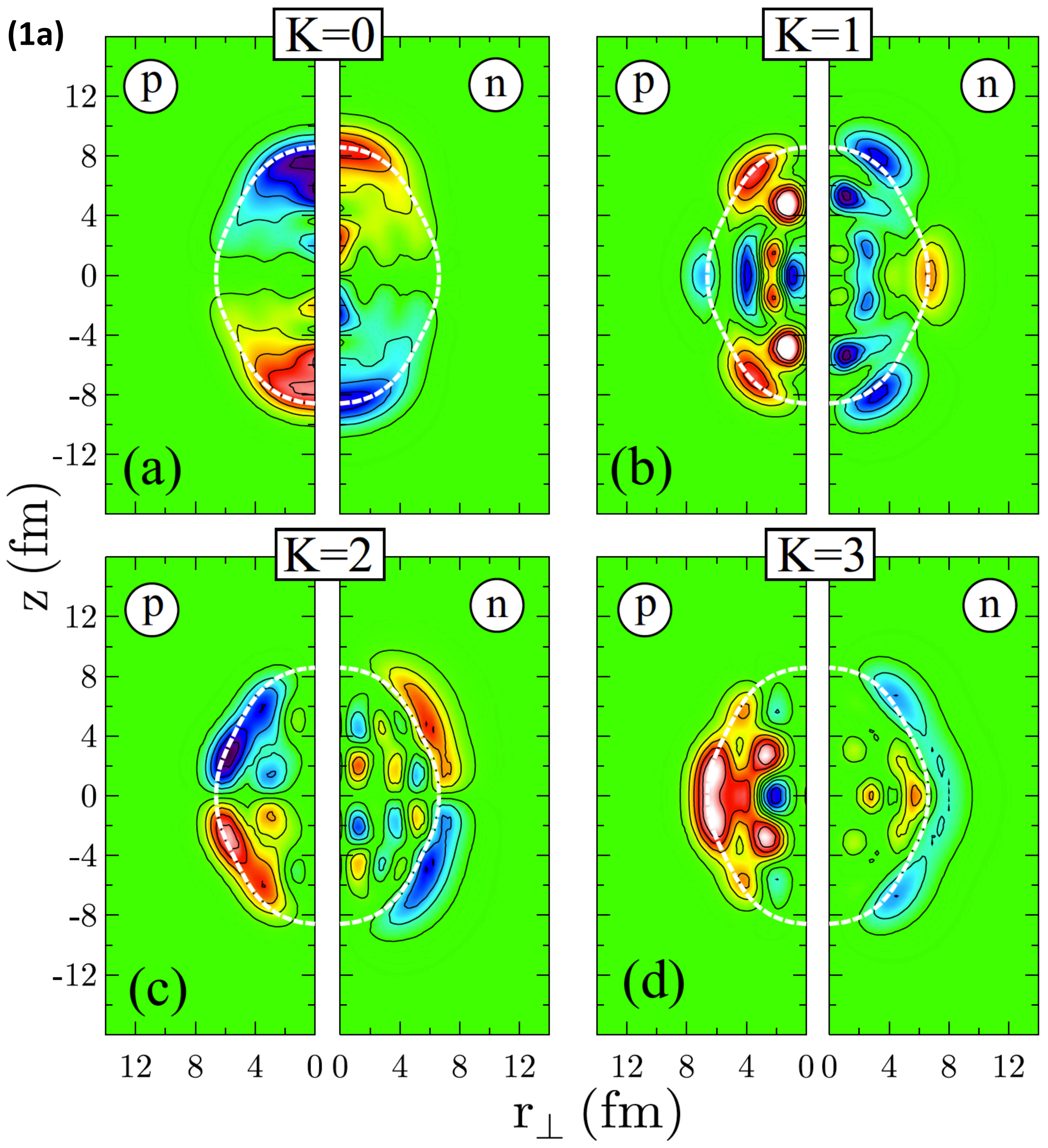
# Computational Nuclear Physics

## Efficient computer code for nuclear response

Nuclei show a variety of collective modes of excitation which influence properties of nuclear reaction. A new computer code (HFBTHO+FAM), based on the finite amplitude method, has been developed under collaboration with researchers in University of Jyvaskyla (Finland) and Michigan State University (USA). This allows us to systematically study both low-energy modes of excitation and high-lying giant resonances in deformed nuclei.



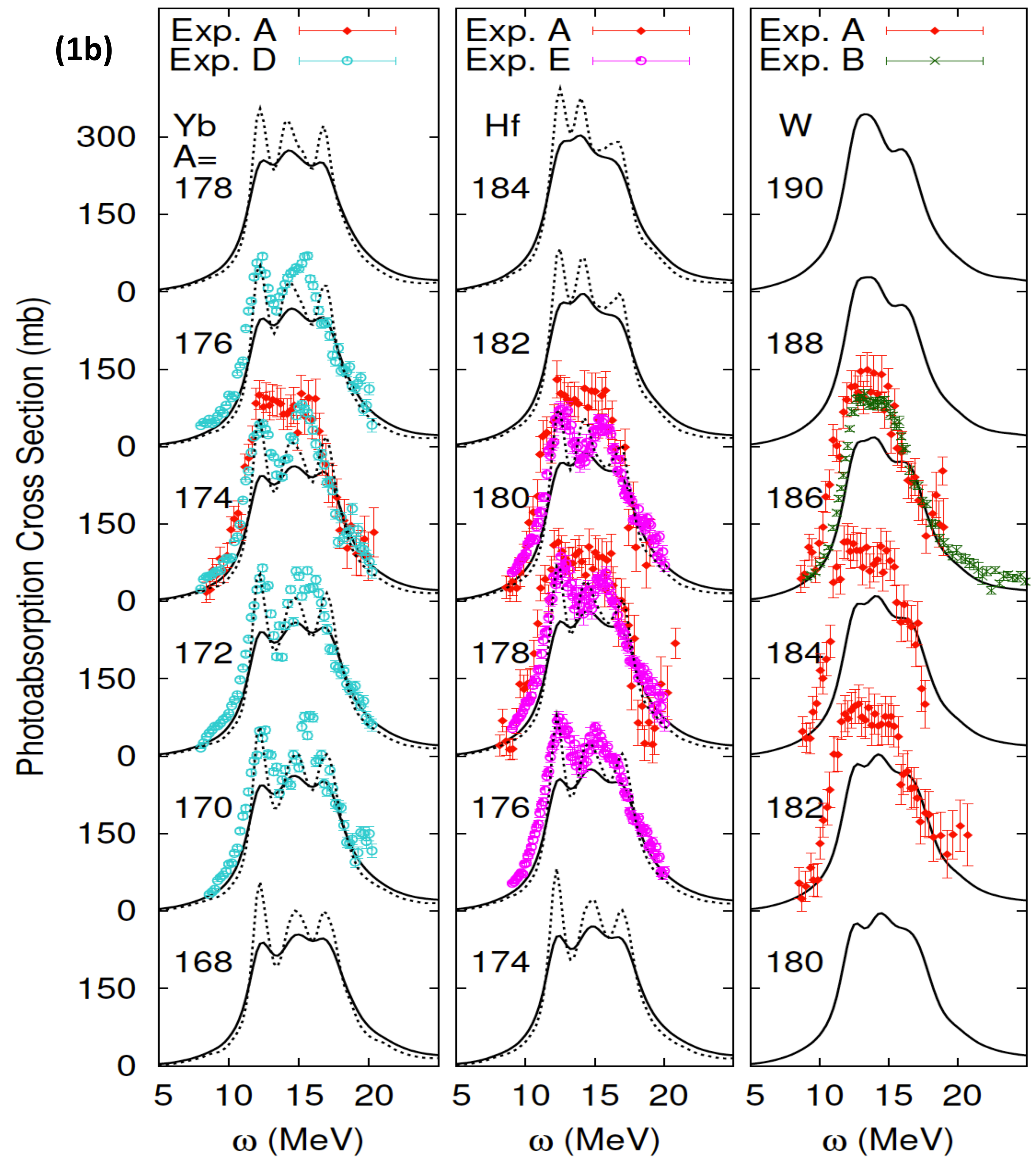




Fig. 1a: Transition densities for octupole modes of excitation in $^{240}Pu$ with different K quantum numbers.
Red indicates the maximum value and the blue indicates the minimum value.
Fig. 1b: Systematic calculation of the photoabsorption cross section in rare-earth nuclei.

[M. Kortelainen, N. Hinohara, W. Nazarewicz, Phys. Rev. C92, 051302(R) (2015), T. Oishi, M. Kortelainen, N. Hinohara, Phys. Rev. C93, 034329 (2016)]

## Spontaneous symmetry breaking in nuclei

Nuclei in several regions in the nuclear chart exhibit many kinds of spontaneous breaking of symmetry: The center of the potential is no longer the energy minimum (Fig.2, inset). Although the quantum fluctuation recovers the symmetry in nuclei, the hidden symmetry breaking becomes manifest in excitation spectra. Figure 2 shows the quantum phase transition of the nuclear shape, from spherical (left) to deformed shape (right). Calculated excitation spectra change from the vibrational to the rotational characters.

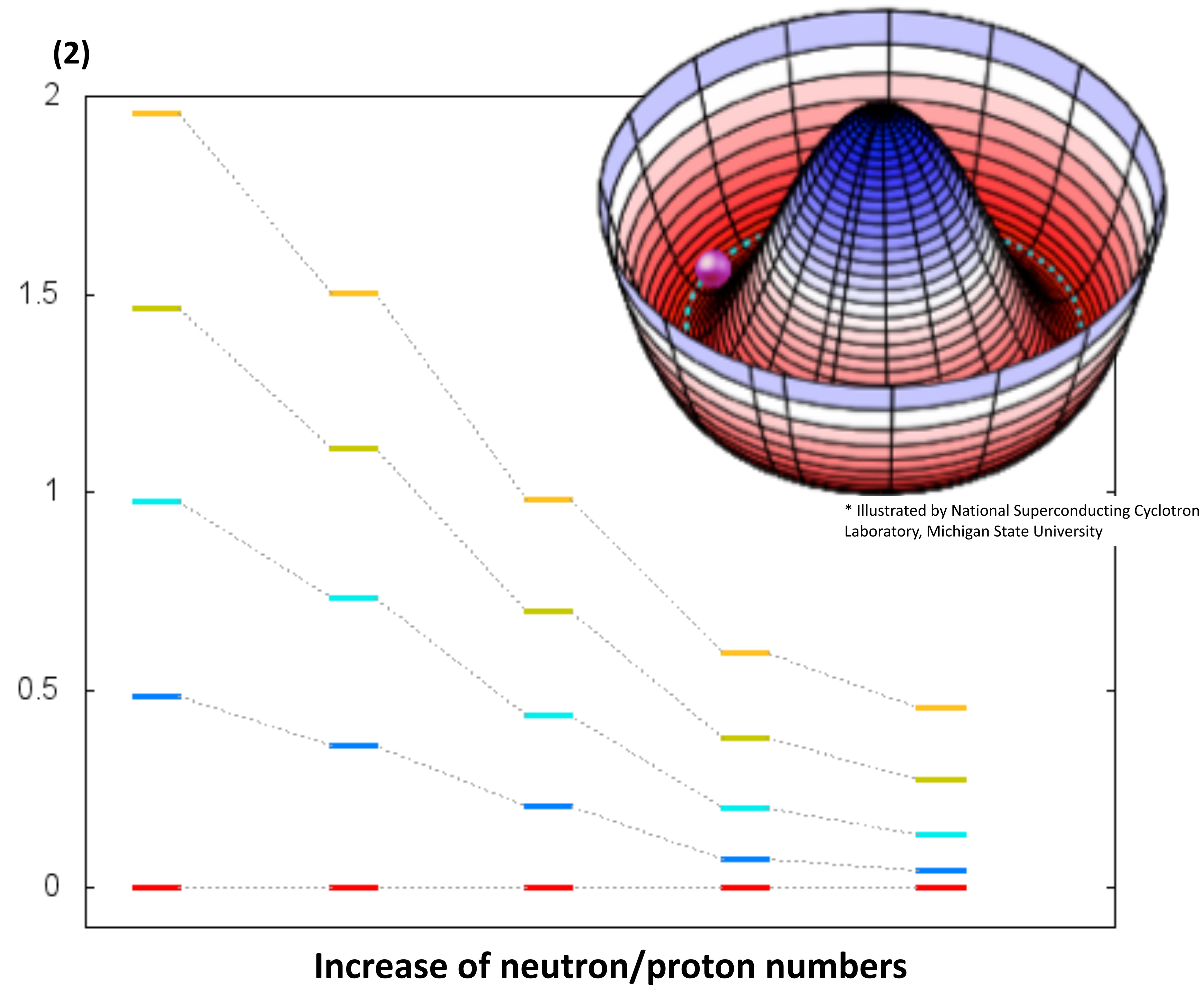



Fig. 2: Calculated excitation spectra for spherical to deformed shape transition in nuclei. The nucleus at the right end has a prolate (lemon-like) shape, while it is spherical at the left.

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