Coexistence of various structures in a narrow excitation energy region in neutron-rich Mg nuclei

Hiroki Nishibata
Dept. of Physics, Kyushu University, Japan

Polarized-decay collaboration

Dept. of Physics, Osaka U, Japan — A. Odahara, T. Shimoda

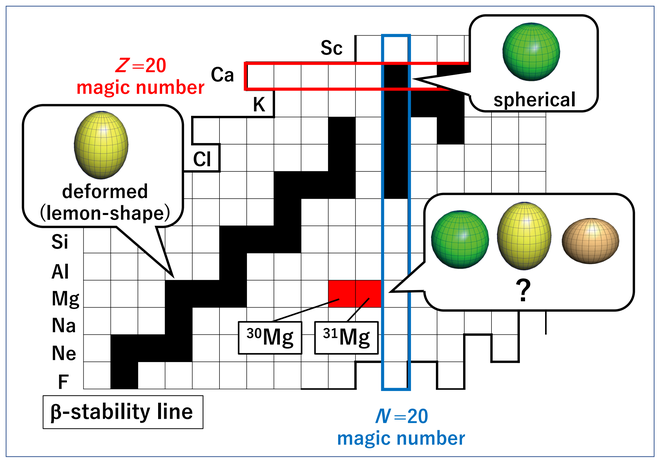
TRIUMF — J. Lassen, C. D. P. Levy, R. Li, M. R. Pearson

International collaboration

Introduction

- Neutron-rich Ne, Na, and Mg isotopes, which are located far from stability line, have attracted attention, because of possible exotic structures.
- Experimental determination of the structure of neuron-rich nuclei is still outstanding for many nuclei due to experimental difficulties.

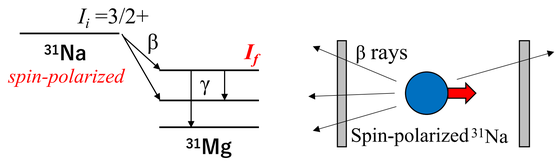
The key quantity to clarify the nuclear structure is the nuclear spin-parity of each state. In the present study, we have investigated the structures of the neutron-rich ^{31}Mg and ^{30}Mg nuclei by a unique method to assign the spin-parity of the states in these nuclei.



Part of the nuclear chart around neutron-rich N=20 region.

Unique method with spin-polarized beam

We take advantage of the parity non-conservation in the β-decay from a spin-polarized Na nucleus; the β-decay shows anisotropic angular distribution.



The β-ray angular distribution in allowed transition is expressed as,

$$W(\theta) \cong 1 + APcos\theta$$

A: asymmetry parameter
P: polarization of parent nucleus
ϑ: emission angle of β-rays with respect to polarization direction

The asymmetry parameter A takes three very discrete values depending on spins of the final daughter states. The parity of the daughter state is the same as that of the parent nucleus.

I_i^π (^{31}Na)	I_f^π (^{31}Mg)	A
3/2+	5/2+	+0.6
	3/2+	-0.4
	1/2+	-1.0

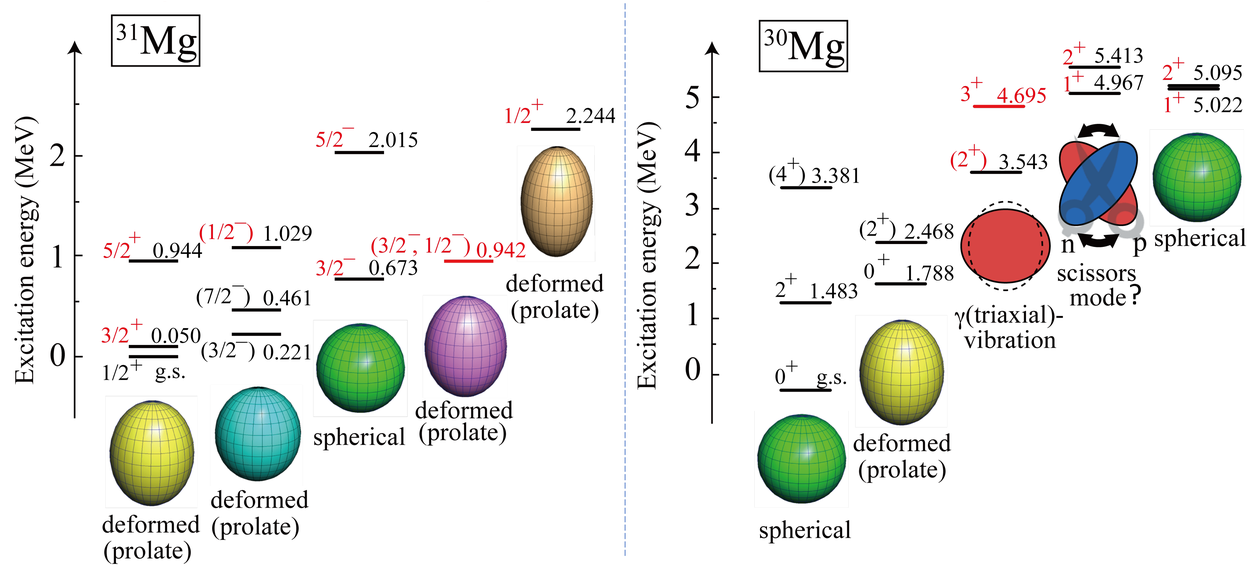
Once the experimental asymmetry parameter for each daughter state is obtained from the β-decay angular distribution, we can precisely assign the spin-parity of the daughter states.

Highly polarized Na beams are essential.
This experiment can be performed ONLY at TRIUMF.

$$\frac{\Delta AP}{AP} \sim \frac{1}{\sqrt{Y}P}$$

Y: yield of β-rays

Shape coexistence; very different from structures in stable nuclei



Partial ^{31}Mg and ^{30}Mg levels displayed according to their structures. The new findings in the present work are shown in red.

Structure of ^{31}Mg and ^{30}Mg

The experiment was performed at TRIUMF's ISAC-1 facility using ~30% polarized ^{31}Na and ^{30}Na beams.

By determining spins and parities of excited states, on a level-by-level basis comparisons with the theoretical predictions were made possible. We revealed the detailed structures as shown in the figures above. Thus, it has been clarified that various types of structures coexist in the neutron-rich ^{31}Mg and ^{30}Mg nuclei.

Summary

- By our unique method with polarized ^{31}Na and ^{30}Na beams, we successfully obtained evidence for the co-existence of various structures in a narrow excitation energy region in ^{31}Mg and ^{30}Mg, respectively.
- We now plan to apply the method to more neutron-rich ^{32}Mg and neutron-rich Al isotopes.

nishibata@phys.kyushu-u.ac.jp

KYUSHU UNIVERSITY
OSAKA UNIVERSITY
TRIUMF

This poster is based on publications of

H. Nishibata et al. Phys. Lett. B 767, 81 (2017).
H. Nishibata et al. Phys. Rev. C 99, 024322 (2019).
H. Nishibata et al. Phys. Rev. C 102, 054327 (2020).

Discovery, accelerated