g-Factor of the ^{99}Zr isomer: monopole evolution in the shape-coexisting region†

F. Boulay,[*1,*2,*3] G. S. Simpson,[*4] Y. Ichikawa,[*2] S. Kisyov,[*5] D. Bucurescu,[*5] A. Takamine,[*2] D. S. Ahn,[*2] K. Asahi,[*2,*6] H. Baba,[*2] D. L. Balabanski,[*2,*7] T. Egami,[*2,*8] T. Fujita,[*2,*9] N. Fukuda,[*2] C. Funayama,[*2,*6] T. Furukawa,[*2,*10] G. Georgiev,[*11] A. Gladkov,[*2,*12] M. Hass,[*13] K. Imamura,[*2,*14] N. Inabe,[*2] Y. Ishibashi,[*2,*15] T. Kawaguchi,[*2,*8] T. Kawamura,[*9] W. Kim,[*12] Y. Kobayashi,[*16] S. Kojima,[*2,*6] A. Kusoglu,[*11,*17] R. Lozeva,[*11] S. Momiyama,[*18] I. Mukul,[*13] M. Niikura,[*18] H. Nishibata,[*2,*9] T. Nishizaka,[*2,*8] A. Odahara,[*9] Y. Ohtomo,[*2,*6] D. Ralet,[*11] T. Sato,[*2,*6] Y. Shimizu,[*2] T. Sumikama,[*2] H. Suzuki,[*2] H. Takeda,[*2] L. C. Tao,[*2,*19] Y. Togano,[*6] D. Tominaga,[*2,*8] H. Ueno,[*2] H. Yamazaki,[*2] X. F. Yang,[*20] and J. M. Daugas[*1,*2]

A rapid change of the ground-state shape has been known to occur in neutron-rich Zr isotopes between the spherical ^{98}Zr and deformed ^{100}Zr.[1)] This change has been described as a quantum phase transition (QPT) with the neutron number as a control parameter. The ^{99}Zr nucleus closest to the critical point of the QPT has an isomer ($^{99\mathrm{m}}$Zr) with a spin parity of $7/2^+$ at 252 keV. The interaction between the $\pi g_{9/2}$ and $\nu g_{7/2}$ orbitals has been thought to be important for this QPT to occur,[2)] and the $7/2^+$ state may be key to this mechanism. In the present study, the nature of $^{99\mathrm{m}}$Zr was investigated through the magnetic moment.

The magnetic-moment measurement was performed at the BigRIPS at RIBF. $^{99\mathrm{m}}$Zr was produced and spin-aligned via the abrasion-fission of a 345-MeV/nucleon ^{238}U beam impinged on a 100-μm-thick ^{9}Be target. The g-factor of $^{99\mathrm{m}}$Zr was measured by the time-differential perturbed angular distribution (TDPAD) method. Figure 1 shows the $R(t)$ ratio evaluated using γ rays of 130 keV and 122 keV by assuming pure $M1$ and $E2$ transitions, respectively, where a degree of spin-alignment of 1.5(4)% was extracted. The g factor of $^{99\mathrm{m}}$Zr determined was determined as $|g| = 0.66(4)$; thus, the magnetic moment is $|\mu| = 2.31(14)\ \mu_\mathrm{N}$.

This value is far from the Schmidt value of $g_{free} = +0.425$ for the $\nu g_{7/2}$ orbital, indicating that $^{99\mathrm{m}}$Zr is not in a pure $(\nu g_{7/2})^1$ state. A comparison of the experimental values with the results of the interacting boson-fermion model (IBFM-1), as shown in Fig. 2, suggests that this state is strongly mixed with the main composition being $\nu d_{5/2}$. Furthermore, we found that monopole single-particle evolution changes significantly with the appearance of collective modes.[4,5)]

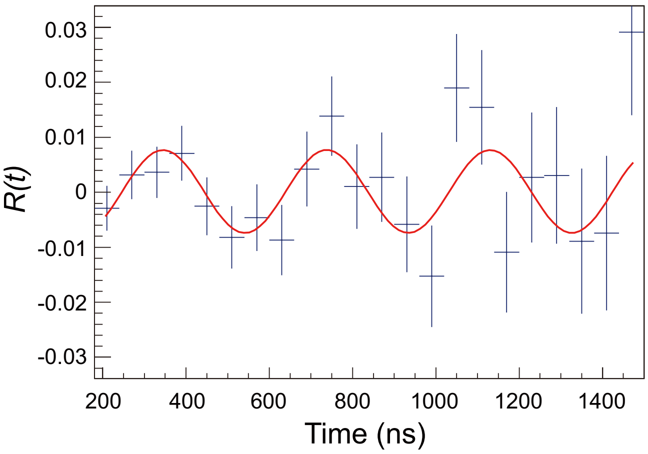

Fig. 1. $R(t)$ ratio associated with two γ rays.

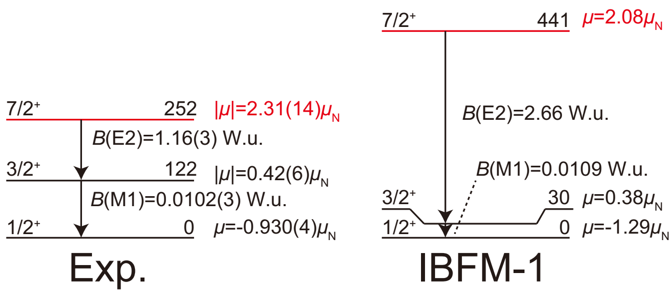

Fig. 2. Comparison between experimental and theoretical values. The IBFM-1 calculation is based on the transition probabilities among the lowest three states and the magnetic moments of the lowest two states.[3)]

† Condensed from the article in Phys. Rev. Lett. **124**, 112501 (2020)

*1 CEA, DAM, DIF
*2 RIKEN Nishina Center
*3 GANIL, CEA/DSM-CNRS/IN2P3
*4 LPSC, CNRS/IN2P3, Université Joseph Fourier Grenoble 1
*5 IFIN-HH
*6 Department of Physics, Tokyo Institute of Technology
*7 ELI-NP, IFIN-HH
*8 Department of Advanced Sciences, Hosei University
*9 Department of Physics, Osaka University
*10 Department of Physics, Tokyo Metropolitan University
*11 IJCLab, CNRS/IN2P3, Université Paris-Saclay
*12 Department of Physics, Kyungpook National University
*13 Department of Particle Physics, Weizmann Institute
*14 Department of Physics, Meiji University
*15 Department of Physics, University of Tsukuba
*16 Department of Informatics and Engineering, University of Electro-Communications
*17 Department of Physics, Istanbul University
*18 Department of Physics, University of Tokyo
*19 School of Physics, Peking University
*20 Intsituut voor Kern-en Stralingsfysica, K. U. Leuven

References

1) P. Campbell *et al.*, Phys. Rev. Lett. **89**, 082501 (2002).
2) P. Federman, S. Pittel, Phys. Lett. B **69**, 385 (1977).
3) P. Spagnoletti *et al.*, Phys. Rev. C **100**, 014311 (2019).
4) Y. Tsunoda *et al.*, Phys. Rev. C **89**, 031301(R) (2014).
5) T. Togashi *et al.*, Phys. Rev. Lett. **117**, 172502 (2016).