Spectrum and Electromagnetic Properties of ^{24}Mg in the Geometric α-Cluster Model: Evidence of $\mathcal{D}_{4h}$ Symmetry

G. Stellin[1,2], **K.-H. Speidel**[†3]

[1]IJCLab, CNRS-In2p3, Universit Paris-Saclay, 91405 Orsay, France
[2]ESNT & IRFU/DPhN, CEA Paris-Saclay, 91191 Gif-sur-Yvette, France
[3]HISKP, Universität Bonn, Nußallee 14-16, 53115 Bonn, Germany

In the framework of a macroscopic approach, the geometric α-cluster model (GαCM), the structural properties and the spectroscopy of the ^{24}Mg nucleus are investigated. Special attention is devoted to the electromagnetic selection rules imposed by the point-symmetry group $\mathcal{D}_{4h}$ that leaves invariant the adopted 6α equilibrium configuration, a square bipyramid. The analysis entails the application of group-theoretical identities and character tables, in a way familiar to quantum chemists.
The results show that the occurrence of interband E0, E2, and M1, M2, M3 transitions is strictly regulated by the transformation properties of the excited vibrational modes to which the states in the process belong. Unlike the ^{12}C nucleus in the $\mathcal{D}_{3h}$-symmetric 3α arrangement, M1 transition channels are active between states corresponding to a single quantum of vibrational excitation. Conversely, the measured E1 strengths in the ^{24}Mg spectrum are attributable to the excitation of single-nucleon degrees of freedom, as E1 transitions are forbidden by the model. The calculated values of some intraband and interband transition probabilities at LO in the GαCM Hamiltonian are presented, together with certian preliminary calculations at NLO, with a perturbative treatment of the coupling between rotational and vibrational motion.

The study of the intrinsic structure of this nucleus is also the target of a new collaboration[1] whose members are active in the realm of nuclear lattice effective field theory (NLEFT). The *ab-initio* NLEFT method is a stochastic approach based on the realistic nuclear forces of chiral effective field theory (χEFT) on a finite and compact configuration space in combination with the auxiliary field Monte-Carlo (AFMC) technique.

The method has been profitably exploited for the prediction of the nuclear density distribution of some excited states of ^{12}C, ^{16}O and ^{20}Ne. Therefore, the relevance of the square bypiramidal α-cluster configuration in the structure of the energy states of ^{24}Mg is going to be assessed and — eventually — corroborated from an ab-initio viewpoint in the near future.

[†]Deceased on June 19, 2023.

[1]Apart from the author, its members are affiliated to the *Beihang University* (Beijing, China), the *Forschungszentrum Jülich* (Jülich, Germany) and the *King Fahd University of Petroleum and Minerals* (Dhahran, Saudi Arabia)