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## Enhanced $\alpha$ -Transfer population of the $2_{ms}^+$ mixed-symmetry state in $^{52}\text{Ti}$

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The residual nucleon-nucleon interaction plays a crucial role in nuclear structure physics. In spherical even-even nuclei the quadrupole interaction leads to characteristic low-lying  $2^+$  states of proton-neutron mixed symmetry character, decaying via M1 transitions to the proton-neutron symmetric states. We have calculated the associated M1 transition strengths in the  $^{52}\text{Ti}$  nucleus within the ab initio valence-space in-medium similarity renormalization group based on NN and 3N forces from chiral effective field theory. In this framework we also construct an effective valence-space M1 operator, which captures nonperturbatively many-body excitations outside the valence space. Our calculations well describe the established mixed-symmetry state in  $^{52}\text{Ti}$  nucleus. Thus, ab-initio calculations are able to describe fundamental low-lying collective excitations in nuclei.

In order to investigate the microscopic structure of the mixed symmetry state in  $^{52}\text{Ti}$  nucleus even further, we run an experiment on the  $^{52}\text{Ti}$  nucleus, populated via the alpha transfer reaction  $^{48}\text{Ca}(^{12}\text{C}, ^8\text{Be})^{52}\text{Ti}$  using a  $^{48}\text{Ca}$  beam from the Maier-Leibnitz-Laboratory in Munich. Gamma rays of populated states were detected with the high-granularity MINIBALL array of HPGe detectors, and charged particles were detected using a highly segmented DSSD silicon detector, allowing to select the channel of interest via a multiplicity coincidence condition. In first order,  $^{52}\text{Ti}$  can be described as the coupling of a  $^4\text{He}$  nucleus to the doubly-magic  $^{48}\text{Ca}$  core. In the framework of the interacting boson model 2 (IBM-2), Alonso *et al.* [1] have shown that the population of the MS  $2_{ms}^+$  state is strictly forbidden. This prediction is also confirmed in our new shell model calculation using the full fp space and effective interactions. Alpha transfer spectroscopic factors were evaluated with a cluster model using the oxbash shell model code. In contrast to the theoretical predictions, we experimentally find an exceptionally strong population of the well-established  $2_{ms}^+$  mixed-symmetry state in  $^{52}\text{Ti}$  relative to the population of the  $2_1^+$  state. We discuss the impact of our findings to our microscopic understanding of the proton-neutron interaction and shell structure in this interesting region of the nuclear chart.

References

[1] C.E. Alonso and J.M. Arias, Phys. Rev. C 78, 017301 (2008).

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