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Magnetic moment in self-conjugate 24Mg. Towards high-precision measurements of picosecond excited states with RIB.

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For many years, the g factors of the first-excited states of self-conjugate nuclei, with equal numbers of protons and neutrons (N = Z), were expected to be very close to g = 0.5. This behavior occurs because protons and neutrons occupy the same orbits and the intrinsic-spin moments of the nucleons largely cancel, leaving the orbital motion of the protons to produce the nuclear magnetism. Recent shell model calculations, however, predict departures from g = 0.5 by up to 10 % for the first-excited 2+ states in the N = Z sd-shell nuclei from 20Ne to 36Ar. These departures stem from three mechanisms, namely, configuration mixing in the shell-model space; the Coulomb interaction between protons leading to isospin mixing; and meson exchange effects.
In an experiment, performed at the ALTO facility in Orsay, we applied a modified version of the Time Dependent Recoil In Vacuum (TDRIV) method using the ORGAM Ge-detectors array and the Orsay Universal Plunger System (OUPS). The use of predominant H-like ions allowed determining the strong hyperfine field (29 kT) created at the nuclear site with very high accuracy, thus obtaining a high precision g-factor value, one of the most precise ever obtained for picosecond nuclear states. In this measurement we used "radioactive-beam configuration", in which the beam was not stopped in the center of the experimental setup but allowed to go through a thin "reset" foil. This modification of the TDRIV technique would allow its further application with radioactive ion beams.
The obtained g factor, g(2+, 24Mg) = 0.538 (13) [1], differs by three standard deviations from the 0.5 value, expected in the simple shell-model picture. In order to reproduce the experimental result it is necessary to take into account all three above-mentioned contributions (wave-function configuration mixing; modification of the free-nucleon magnetic moment operator due to meson-exchange effects; and isospin-mixing effects). This is the first experimental results, obtained with sufficient accuracy to allows testing the nuclear-theory predictions in fine details.

[1] A. Kusoglu et al., Phys. Rev. Lett. 114, 062501 (2015)

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