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Tests of Fundamental Symmetries with Atomic Dysprosium

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While dysprosium (Dy) is arguably among the most complex atoms in terms of spectroscopy, it has proven to be a useful system for testing fundamental physics. In Dy, there is a pair of long-lived excited non-Rydberg opposite-parity states of the same total electronic angular momentum (J=10) that are separated in energy, depending on the isotope and hyperfine component, by anywhere between 3 MHz and a few GHz (with energies expressed in frequency units) in the absence of external fields. The levels may be further manipulated with external fields, for instance, applying 1.4 G brings certain sublevels to a crossing, so that one can work with a particularly "clean" realization of quantum-mechanical two-level system. Moreover, the near degeneracy allows measuring the difference in the energies of the levels directly enabling sensitive measurements and exotic-physics searches with relaxed requirements on atomic clocks in terms of the fractional frequency stability. Over the years, Dy has been used to set stringent limits on physics beyond the standard model [1]: a possible temporal variation of the fine-structure constand α, changes in α induced by the changes of the gravitational potential of the Sun (exploiting the eccentricity of the Earth's orbit), certain types of violations of the Lorentz invariance and the Einstein's Equivalence Principle, etc. Ongoing experiments with Dy aim at measuring atomic parity violation in a chain of isotopes and hyperfine components; Dy may also prove to be a system of interest in searches for various exotic particles and fields permeating our galaxy, for instance, light scalar fields such as axions [1,2].

[1] See detailed bibliography at http://budker.berkeley.edu/
[2] Y. V. Stadnik and V. V. Flambaum arXiv:1312.6667