Transient exotic spin coupling search with noble-gas-alkali-metal co-magnetometer

M. Padniuk[1], Marek Kopciuch[1], Riccardo Cipolletti[2,3], Arne Wickenbrock[2], Dmitry Budker[2], S. Pustelny[1]

[1]Marian Smoluchowski Institute of Physics Jagiellonian University, Łojasiewicza 11, 30-348, Krakow, Poland.
[2]Helmholtz Institute, Johannes Gutenberg-Universitat at Mainz, 55099 Mainz, Germany
[3]Robert Bosch GmbH, Corporate Sector Research and Advance Engineering, Advanced Technologies and Micro Systems, 71272 Renningen, Germany

Existence and composition of dark matter is one of the most puzzling problems in modern physics. One of prominent candidates to solve this problem are axions and axion-like particles. There are many experiments which scrutinize various theoretical predictions for existence of such particles, but none of them succeeded so far.
One of the possible signatures of axion dark matter existence are transient anomalous spin-dependent interactions. The main experimental challenges to detect such couplings is their weakness and transient character. To address this problem the Global Network of Optical Magnetometers for Exotic physics searches (GNOME) was built [1]. Yet, as optical magnetometers are predominantly sensitive to magnetic fields, they suffer from ambient magnetic noise, which results in an increased false-positive rate and hence reduction of sensitivity to anomalous couplings. This problem implies application of a sensor with reduced sensitivity to magnetic fields, which still preserves the sensitivity to anomalous couplings. In the next incarnation of the GNOME, for the purpose, we plan to use a noble-gas-alkali-metal co-magnetometer [2].

During the talk, we will present results of our theoretical investigations on the spin coupled alkali metal-noble gas system used in the co-magnetometer. In particular, we will demonstrate reduced sensitivity of the system to the low-frequency magnetic field, which significantly increases the sensitivity to anomalous interactions. We will also demonstrate the ability of the system to distinguishing between transient couplings of magnetic and nonmagnetic origins, which is not possible with optical magnetometers. In addition, we will show an enhanced sensitivity of the system to nuclear spin couplings. With these results we will demonstrate that the noble-gas-alkali-metal co-magnetometers may improve the GNOME sensitivity no transient spin couplings.

References

[1] S. Afach, et al. Search for topological defect dark matter using the global network of optical magnetometers for exotic physics searches (GNOME), preprint, https://doi.org/10.21203/rs.3.rs-298059/v1
[2] M. Padniuk et al., Self-compensating co-magnetometer vs. spin-exchange relaxation-free magnetometer: sensitivity to nonmagnetic spin couplings, preprint, arXiv:2107.05501