Searching for dark matter with a global network of optical magnetometers

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Astronomical observations provide some of the greatest mystery of modern science. The questions: Why motion of galaxies is different from expected? Why seemly empty space is bending rays of light? Why does the Universe expansion accelerate? are some of the most important puzzles in our understanding of Nature.

A commonly accepted hypothesis, explaining the puzzling astronomical observations, is existence of dark matter and dark energy. Through gravitational interaction, the electrically neutral and electromagnetically “immune” dark matter would modify motion of astrophysical objects. In a similar manner the accelerating expansion of the Universe could be explained by repulsive long-range interactions associated with dark energy.

Despite many sophisticated experiments, hitherto dark-matter searches failed to provide noncontroversial proof of dark-matter existence. This null result of the search not only triggered activities in development of yet more sensitive experiments but also generated activity on theoretical (development of new theoretical theories) and experimental (development of new methodologies) fronts.

A particular reason for dark-matter-search fails is its different from expected nature of dark matter – ordinary matter interaction. In particular, transient or oscillatory character of the interaction would make most of the experiments insensitive. To address this issue, several years ago, we proposed construction of a global network of atomic sensors that would search for dark matter. Our network called the Global Network of Optical Magnetometers for Exotic physics searches (GNOME) [1] aims at the detection of dark matter, manifesting through temporarily modification of a spin state of atoms. To do we proposed to use optical magnetometers, as this is exactly this type of interaction, the sensors are sensitive to. However, in order to perform such measurement unambiguously, we correlate readouts of many geographically separated experiments. This not only allows to reduce the experimental noise, often significantly exceeding signal of interest in a single experiment, but also allows to triangulate the source of the spin perturbation (arising due to a collision with dark-matter planet [2]). Thereby, the GNOME is sensitive to global, exotic spin interactions.

During the talk, basics of the GNOME will be provided. Next, current experimental efforts will be discussed [3]. We will present results of first joint runs of the network identifying requirements for atomic sensors and challenges associated with measurements as well as data analysis. The talk will be concluded with discussion of plans for the future GNOME.

References:

[1] S. Pustelny *et al.*, *The Global Network of Optical Magnetometers for Exotic physics (GNOME): A novel scheme to search for physics beyond the Standard Model,* Ann. Phys. **525**, 659 (2013).

[2] D. F. Jackson Kimball *et al., Searching for axion stars and Q-balls with a terrestrial magnetometer network,* Phys. Rev. D **94**, 043002 (2018).

[3] S. Afach et al., *Characterization of the global network of optical magnetometers to search for exotic physics,* Phys. Dark Universe **22**, 162-180 (2018).