Dark matter searches within the intercontinental optical atomic clock network

P. Wcisło[1], P. Ablewski[1], K. Beloy[2], S. Bilicki[1,3], M. Bober*[1], R. Brown[2], R. Fasano[2], R. Ciuryło[2], H. Hachisu[4], T. Ido[4], J. Lodewyck[3], A. Ludlow[2], W. McGrew[2], P. Morzyński[1,4], D. Nicolodi[2], M. Schioppo[2,5], M. Sekido[4], R. Le Targat[3], P. Wolf[3], X. Zhang[2], B. Zjawin[1], and M. Zawada†[1],

1. Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5, 87-100 Torun, Poland
2. National Institute of Standards and Technology, 325 Broadway, Boulder, CO 80305, USA
3. LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, 61 avenue de l'Observatoire 75014 Paris, France
4. National Institute of Information and Communications Technology 4-2-1 Nukuikitamachi, Koganei, 184-8795 Tokyo, Japan
5. National Physical Laboratory (NPL), Teddington, TW11 0LW, United Kingdom

We report preliminary results of dark mater searches within the worldwide network made of our laboratories. We demonstrate that data routinely collected by our currently operating optical atomic clocks without any further developments of the experimental set-ups may be used to run a global program aimed on searches of dark matter.

Optical atomic clocks are the most precise scientific instruments available to humanity. Their accuracy and stability reach eighteen significant digits. Therefore, optical atomic clocks are one of those experiments that push the boundaries of knowledge and metrology. The cost of their construction and maintenance, however, is many times lower and the needed research team is smaller in comparison to other great experiments that enlarge our knowledge on structure and history of our Universe, and as a consequence, bring new emerging technologies into our lives. The unique properties of these sensors are direct consequences of a typical optical atomic clock set-up. A standard optical atomic clock consists of two state-of-the-art components: an ultra-stable high-Q optical cavity which transfers stability of the length into stability of the frequency, and an atomic sample which transfers accuracy of the energy of the ultra-precise atomic clock transition into accuracy of the frequency. These two components have different susceptibilities to the external perturbations such as electric and magnetic fields, and to the possible changes of fundamental physical constants.

In this paper, we use this property to derive new constraints for oscillating massive scalar fields [1] and topological defects in the scalar fields [2] couplings to standard matter exceeding previously reported limits [3] by several orders of magnitude. These constraints were obtained by tracking the imprint of these effects in the frequency difference between cavities and atoms of several clocks distributed worldwide and running simultaneously. In this network of clocks, the technical noises (thermal noise, drift of cavities) is uncorrelated, while the effects we probe would yield correlations in remote measurements. As a consequence the optical clocks within our network do not have to be linked via phase-noise-compensated optical fibre links but only via a standard internet connection.

References

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*Corresponding author: bober@fizyka.umk.pl
†Corresponding author: zawada@fizyka.umk.pl