CSU PHYSICS COLLOQUIUM

“From the atomic to the nuclear optical clock”

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JILA

Monday, February 10th at 4:00pm

120 Engineering (Hammond Auditorium)

Abstract

A nuclear optical clock based on a single 229Th ion is expected to achieve a higher accuracy than the best atomic clocks operational today [1]. Although already proposed back in 2003 [2], such a nuclear frequency standard has not yet become reality. The main obstacle that has so far hindered the development of a nuclear clock is an imprecise knowledge of the energy value of a nuclear excited state of the 229Th nucleus, generally known as the 229Th isomer. This metastable nuclear excited state is the one of lowest energy in the whole nuclear landscape and - with an energy of less than 10 eV - offers the potential for nuclear laser spectroscopy, which poses a central requirement for the development of a nuclear clock.

In the past few years significant progress toward the development of a nuclear frequency standard has been made: Starting with a first direct detection of the 229Th isomer in 2016 based on its internal conversion decay channel [3], the isomeric lifetime could be determined in 2017 [4], followed by a first laser-spectroscopic characterization in 2018 [5]. Most recently, a first energy determination based on the isomer’s direct detection was successful [6]. This new knowledge provides, in combination with an achieved drastically enhancement of XUV-frequency comb intensity [7], the basis for improved efforts toward the laser-based search for the nuclear transition [8, 9], which can ultimately lead to the development of a nuclear optical clock.

In this presentation I will give an overview over the current status of the nuclear clock development, with a particular focus on the most recent progress. Also the next required steps will be detailed and future perspectives will be given.

References

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[7] G. Porat et al., Nature Photonics 12, 387 (2018).
[8] L. von der Wense, Phys. Rev. Lett. 119, 132503 (2017).
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