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The challenge of a nuclear clock: Recent progress and perspectives

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A nuclear optical clock based on a single ^{229}Th ion is expected to achieve a higher accuracy than the best atomic clocks operational today [1]. Although already proposed back in 2003 [2], this nuclear clock has not yet become reality. The main obstacle that has so far hindered the development of a nuclear clock was an unprecise knowledge of the energy value of a nuclear excited state of the ^{229}Th nucleus, generally known as the ^{229}Th isomer. This metastable nuclear excited state is the one of lowest energy in whole nuclear landscape and with an energy of less than 10 eV in principle allows for direct nuclear laser excitation, 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 clock has been made: Starting with a first direct detection of the 229 Th 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 isomers direct detection was successful, thereby constraining the isomeric energy value to sufficient precision to determine the laser technology required in the nuclear clock concept and paving the way for first nuclear laser spectroscopy experiments [6].

In the 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.

C.J. Campbell et al., Phys. Rev. Lett. 108, 120802 (2012). [2] E. Peik, C. Tamm, Eur. Phys. Lett. 61, 181 (2003). [3] L. von der Wense et al., Nature 533, 47 (2016). [4] B. Seiferle et al., Phys. Rev. Lett. 118, 042501 (2017). [5] J. Thielking et al., Nature 556, 321 (2018). [6] B. Seiferle et al., submitted for publication (2019)

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