世纪物理情·系列讲座

A continuous-wave laser at 148 nm for the Th-229 nuclear clock

【报告人】

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【 地点 】

清华大学高等研究院

科学馆322报告厅

【摘要】

The exceptionally low-energy isomeric transition in Th-229 at around 148 nm offers a unique opportunity for coherent nuclear control and the realization of an ultra-stable nuclear clock. Recent advances, most notably the incorporation of large ensembles of Th-229 nuclei in transparent crystals and the development of pulsed vacuum-ultraviolet (VUV) lasers, have enabled initial laser spectroscopy of this transition. However, the absence of an intense, narrow-linewidth VUV laser has been the critical missing element.

In this talk, I will present our proposal [1,2] and experimental realization [3] of the first continuous-wave laser at 148 nm, generated via four-wave mixing in cadmium vapor. Our source delivers more than 100 nW of power with a linewidth well below 100 Hz and supports broad wavelength tunability. We develop a spatially resolved homodyne technique to place a stringent upper bound on the phase noise induced by the nonlinear process and demonstrate sub-hertz linewidth capability. This development eliminates the final technical hurdle to a Th-229-based nuclear clock and opens new frontiers in quantum metrology, nuclear quantum optics and precision tests of fundamental physics.

[1] Q. Xiao, G. Penyazkov, R. Yu, B. Huang, J. Li, J. Shi, Y. Yu, Y. Mo, S. Ding, “Proposal for the generation of continuous-wave vacuum ultraviolet laser light for Th-229 isomer precision spectroscopy”, Phys. Rev. Appl. 25, 024034 (2026)

[2] G. Penyazkov, Y. Yu, L.V. Skripnikov and S. Ding, “Theoretical study of transition matrix elements in cadmium for vacuum-ultraviolet generation in Th-229 nuclear clock applications”. Physical Review A 112, 022807 (2025).

[3] Q. Xiao, G. Penyazkov, X. Li, B. Huang, W. Bu, J. Shi, H. Shi, T. Liao, G. Yan, H. Tian, Y. Li, J. Li, B. Lu, L. You, Y. Lin, Y. Mo, S. Ding, “A continuous-wave vacuum ultraviolet laser for the nuclear clock”, Nature 650, 852 (2026)

【报告人简介】

丁世谦，清华大学物理系副教授，北京量子信息科学研究院兼聘研究员。2010年至2016年在新加坡国立大学量子技术中心学习，主要从事离子阱量子计算并获博士学位。2016年至2021年在美国科罗拉多大学JILA研究所叶军课题组开展博士后研究，聚焦分子激光冷却。2021年赴德国慕尼黑大学Thirolf课题组访问8个月。同年底加入清华大学物理系。研究方向为量子精密测量，重点开展钍-229原子核光钟及核跃迁的激光操控研究。

主办单位:清华大学高等研究院