量子信息科技学术研讨会 (2018.9.17-21)

报告

利用高精度原子干涉仪检验自由下落普适性

Test of the Universality of the Free Fall with Atom Interferometry Considering the Spin Degree

胡忠坤教授 | 华中科技大学物理学院

讲者介绍 Biography

胡忠坤，男，1972 年 12 月出生，安徽岳西人，中共党员，教授，博士生导师。2001 年获华中科技大学检测技术与自动化装置专业博士学位。2003 年获全国优秀博士学位论文，2004 年入选教育部新世纪优秀人才支持计划，2015 年获湖北高校教师党支部书记“双带头人”，2016 年获国家杰出青年科学基金，2017 年获全国五一劳动奖章。主要从事冷原子干涉精密引力测量研究，作为项目负责人承担国家杰出青年科学基金、国家自然科学基金仪器专项、973 计划课题、国防预研等多项科研任务，发表 SCI 收录论文 50 余篇。围绕引力精密测量取得的主要成果有：采用冷原子干涉技术进行重力测量，系统研究了测量噪声和误差，解决了超低频有源隔振难题，实现了绝对重力测量灵敏度的当前国际最好水平；提出不同自旋取向原子自由下落规律是否相同的科学问题，发展磁敏感原子干涉测量技术检验了这一新型等效原理，并给出了时空挠率梯度的上限；采用扭秤周期法精确测量万有引力常数，测量结果被国际科学数据委员推荐的 CODATA 值收录。

报告摘要 Abstract

With the current state of physics, the question concerning the interaction between quantum theory and gravity is entirely open. Therefore it has excited a huge amount of experiments to test the foundational principles of general relativity (GR) on systems in non-classical states [1-3]. The famous one is testing the validity of universality of free fall (UFF) which is one of the fundamental postulations of GR. Especially, atoms possessing well defined spin properties were employed as test masses in the UFF experiments. We have performed a series of precision atomic interferometry experiments on testing the UFF considering atoms' spin degree of freedom. The test by measuring the acceleration between ^{87}Rb atoms in states of |mF=-1> and |mF=+1> has been achieved [4], in which the corresponding spin orientations projected to the direction of the gravity force are opposite. Raman pulses drives a Mach-Zehnder-type atom interferometer (AI) is exploited to alternately measure the free fall acceleration of the atoms in these two magnetic sublevels. And the resultant Eotvos ratio is$\eta_{\pm1} = (0.2\pm1.2)\times10^{-7}$. This also gives an upper limit of 5.4×10^{-6}m^{-2} for a possible gradient field of the spacetime torsion. Then we employ the Bragg atom interferometer with 87Rb atoms either in hyperfine state $|F = 1;mF = 0\rangle$ or $|F = 2;mF = 0\rangle$, where the spin is projected to the plane perpendicular to the gravity force and considering the different amplitude but not the polarization . We have obtained an Eotvos ratio $\eta_{1-2} = (0.9\pm2.7)\times10^{-10}$, and set a new record on the precision with a nearly 5 times improvement. In the experiments, the atom interferometer acts as the most important role to realize the measurement.

[1] G. Rosi, G. D'Amico, L. Cacciapuoti, F. Sorrentino, M. Prevedelli, M. Zych, C. Brukner, and G. M. Tino, Nature Commun 8, 15529 (2017).

[2] M. G. Tarallo, T. Mazzoni, N. Poli, D. V. Sutyrin, X. Zhang, and G. M. Tino, Phys. Rev. Lett. 113, 023005 (2014).

[3] R. Geiger, and M. Trupke, Phys. Rev. Lett. 120, 043602 (2018).

[4] X. C. Duan, X. B. Deng, M. K. Zhou, K. Zhang, W. J. Xu, F. Xiong, Y. Y. Xu, C. G. Shao, J. Luo, and Z. K. Hu, Phys. Rev. Lett. 117, 023001 (2016).

[5] Y. Cheng, K. Zhang, L. L. Chen, W. J. Xu, Q. Luo, M. K. Zhou, and Z. K. Hu, AIP Advances 7, 095211 (2017).