CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

Dr. Philipp Haslinger

Department of Physics
Technische Universität Wien, Austria
(Guest of Prof. K. Hammerer, Dr. D. Schlippert)

Leibniz Universität Hannover
DQ-mat Colloquium
21 January 2021, 3.30 pm
(via Zoom-Meeting)

"Probing the forces of gravity, blackbody radiation and dark energy with matter waves"

Over the last decades, atom interferometry has proven its surprising versatility to sense with high precision tiniest forces. In this talk I will give an overview of our work using atom interferometric techniques to sense with gravitational strength for fifth forces1,2 and for an on the first place counterintuitive inertial property of blackbody radiation3.
Blackbody (thermal) radiation is emitted by objects at finite temperature with an outward energy-momentum flow, which exerts an outward radiation pressure. At room temperature e. g. a cesium atom scatters on average less than one of these blackbody radiation photons every 108 years. Thus, it is generally assumed that any scattering force exerted on atoms by such radiation is negligible. However, particles also interact coherently with the thermal electromagnetic field4 (ac Stark shift) and this leads to a surprisingly strong force acting in the opposite direction of the radiation pressure3.
If dark energy, which drives the accelerated expansion of the universe, consists of a light scalar field it might be detectable as a “fifth force” between normal-matter objects. In order to be consistent with cosmological observations and laboratory experiments, some leading theories use a screening mechanism to suppress this interaction. However, atom-interferometry presents a tool to reduce this screening5 on so-called chameleon models6. By sensing the gravitational acceleration of a 0.19 kg in vacuum source mass which is 10-8 times weaker than Earth´s gravity, we reach a natural bound for cosmological motivated scalar field theories and were able to place tight constraints1,2

[1] P. Hamilton, M. Jaffe, P. Haslinger, Q. Simmons, H. Müller, J. Khoury, Atom-interferometry constraints on dark energy, Science. 349 (2015) 849–851. doi:10.1126/science.aaa8883.
[2] M. Jaffe, P. Haslinger, V. Xu, P. Hamilton, A. Upadhye, B. Elder, J. Khoury, H. Müller, Testing sub-gravitational forces on atoms from a miniature, in-vacuum source mass, Nat. Phys. 13 (2017) 938–942. doi:10.1038/nphys4189.
[3] P. Haslinger, M. Jaffe, V. Xu, O. Schwartz, M. Sonnleitner, M. Ritsch-Marte, H. Ritsch, H. Müller, Attractive force on atoms due to blackbody radiation, Nat. Phys. 14 (2018) 257–260. doi:10.1038/s41567-017-0004-9.
[[4] M. Sonnleitner, M. Ritsch-Marte, H. Ritsch, Attractive Optical Forces from Blackbody Radiation, Phys. Rev. Lett. 111 (2013) 23601. doi:10.1103/PhysRevLett.111.023601.
[5] C. Burrage, E.J. Copeland, E.A. Hinds, Probing dark energy with atom interferometry, J. Cosmol. Astropart. Phys. 2015 (2015) 042–042. doi:10.1088/1475-7516/2015/03/042.
[6] B. Elder, J. Khoury, P. Haslinger, M. Jaffe, H. Müller, P. Hamilton, Chameleon dark energy and atom interferometry, Phys. Rev. D. 94 (2016) 44051. doi:10.1103/PhysRevD.94.044051.

All DQ-mat members and all interested are cordially invited to attend.