CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

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(Guest of Prof. P. Schmidt)

DQ-mat Colloquium

Physikalisch Technische Bundesanstalt
Bundesallee 100, 38116 Braunschweig,
Goeppert-Mayer-Bau (RZB11), Room 113
March 14, 2023, 1 pm

"Probing Physics Beyond the Standard Model with the JILA eEDM Experiment"

The Standard Model of particle physics is one of the most successful models that we use to describe the universe, yet it is known to be incomplete. Substantial efforts on the theoretical front introduce new physics through extensions of the Standard Model, and these new physics models make predictions on the value of the electric dipole moment of the electron (eEDM). Measurements of (or improved limits on) the eEDM place constraints on these new theories. The eEDM experiments at JILA take advantage of the long trapping time of ions to tap the long coherence times of the eEDM-sensitive states in our molecular ions of choice: HfF$^+$ and ThF$^+$. Our recently completed experiment [1,2] using HfF$^+$ is an upgraded version of our 2017 experiment [3], using a bigger trap for more ions, amongst other improvements for better statistics. Our current data set places our statistical sensitivity at two times better than the previous world record [4]. The upcoming experiment using ThF$^+$ has recently completed spectroscopy of the molecule [5-7], and we are now setting up a prototype experiment to demonstrate much longer coherence times than HfF$^+$, promised to us by the eEDM-sensitive ground state in ThF$^+$ [5,6]. Herein, we present our newest result [1,2], and provide a teaser on the demonstration of long coherence times in ThF$^+$.

[1] L. Caldwell, T. S. Roussy, T. Wright, W. Cairncross, Y. Shagam, K. B. Ng, N. Schlossberger, S. Y. Park, A. Wang, J. Ye, and E. A. Cornell, Systematic and statistical uncertainty evaluation of the HfF$^+$ electron electric dipole moment experiment, Submitted to PRA (2022).
[2] T. S. Roussy, L. Caldwell, T. Wright, W. Cairncross, Y. Shagam, K. B. Ng, N. Schlossberger, S. Y. Park, A. Wang, J. Ye, and E. A. Cornell, A new bound on the electron's electric dipole moment, Submitted to Science (2022).
[3] W. B. Cairncross, D. N. Gresh, M. Grau, K. C. Cossel, T. S. Roussy, Y. Ni, Y. Zhou, J. Ye, and E. A. Cornell, Precision Measurement of the Electron's Electric Dipole Moment Using Trapped Molecular Ions, Phys. Rev. Lett. 119, 153001 (2017).
[4] The ACME Collaboration: V. Andreev, D. G. Ang, D. DeMille, J. M. Doyle, G. Gabrielse, J. Haefner, N. R. Hutzler, Z. Lasner, C. Meisenhelder, B. R. O'Leary, C. D. Panda, A. D. West, E. P. West, and X. Wu, Improved limit on the electric dipole moment of the electron, Nature 562, 355-360 (2018).
[5] D. N. Gresh, K. C. Cossel, Y. Zhou, J. Ye, and E. A. Cornell, Broadband velocity modulation spectroscopy of ThF$^+$ for use in a measurement of the electron electric dipole moment, J. Mol. Spectrosc. 319, 1 (2016).
[6] Y. Zhou, K. B. Ng, L. Cheng, D. N. Gresh, R. W. Field, J. Ye, and E. A. Cornell, Visible and ultraviolet laser spectroscopy of ThF, J. Mol. Spectrosc. 358, 1 (2019).
[7] K. B. Ng, Y. Zhou, L. Cheng, N. Schlossberger, S. Y. Park, T. S. Roussy, L. Caldwell, Y. Shagam, A. J. Vigil, E. A. Cornell, and J. Ye, Spectroscopy on the electron-electric-dipole-moment–sensitive states of ThF$^+$, Phys. Rev. A 105, 022823

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