



Physics Colloquium

Wednesday, 07 October 2026 | 17:00 – 18:00, Seminar Room 3rd Floor

Ultracold Molecules for Quantum Science and Technology

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ABSTRACT

Molecules promise a large variety of applications ranging from precision measurement science to cold chemistry to many-body physics. A major requirement towards realizing these applications is the precise control of molecules and their internal quantum states. To achieve this, important recent advances have been made in the cooling, trapping and manipulation of molecules using laser cooling techniques [1]. I will present two lines of research that exemplify the rapid progress in this field.

First, I will present our recent demonstration of laser cooling of barium monofluoride molecules, which are promising sensors for many different types of precision measurements [2]. I will discuss how to realize novel laser cooling schemes in this complex species, which pave the way for studies of particle and nuclear physics in a tabletop experiment [3].

Second, I will present an experiment aiming at laser cooling calcium monofluoride molecules to quantum degeneracy. In this regime, tunable interactions between the molecules will allow the exploration of dipolar many-body physics and quantum simulations. In particular, I will highlight the unique possibilities that such strongly dipolar molecular systems open up for the study of supersolid states of matter, which show both superfluid and solid properties at the same time [4,5].

[1] T. Langen, G. Valtolina, D. Wang, and J. Ye, *Nature Phys.* 20, 702 (2024).

[2] M. Rockenhäuser, F. Kogel, T. Garg, S. A. Morales-Ramírez, and T. Langen, *Phys. Rev. Res.* 6, 043161 (2024).

[3] T. Garg, J. Weiß, T. Tiemens, C. Beulenkamp, A. Schindewolf and T. Langen, *arXiv:2608.06138* (2026).

[4] T. Langen, *Physics Today* 75, 3, 36 (2022).

[5] M. Ciardi, K. Rønning Pedersen, T. Langen and T. Pohl, *Phys. Rev. Lett.* 135 153401 (2025).