

Seminar Title:

Laser cooling of complex molecules for precision
measurements and many-body physics

Speaker: **Prof. Tim Langen**

Vienna Center for Quantum Science and Technology

日時：2026年5月18日(月) 10:30–12:00

Date and Time: Monday, May 18, 2026, 10:30–12:00

場所：理学研究科5号館5階第4講義室525号室

Place: The 4th Lecture room, Room 525 (5F), Physics Department Building

Abstract:

Ultracold molecules promise a wide variety of applications, ranging from precision measurement science to cold chemistry and many-body physics. A central requirement for realizing these applications is the precise control over molecules and their internal quantum states. Recent work on the cooling, trapping, and manipulation of molecules using laser cooling techniques [1] has brought this within reach, and I will present two lines of research from our group that exemplify the progress in this field.

First, I will discuss our recent demonstration of laser cooling of barium monofluoride, a promising sensor for many different types of precision measurement [2,3]. I will discuss novel cooling strategies we developed for this complex species, which open a route to tabletop tests of particle and nuclear physics and laser-cooled samples of fermionic molecules.

Second, I will present an experiment aiming at laser cooling calcium monofluoride molecules to quantum degeneracy. In this regime, the tunable dipolar interactions between molecules allow the exploration of dipolar many-body physics and the formation of new states of matter. In particular, I will highlight the possibilities that such strongly dipolar molecular systems open up for the study of supersolid states of matter, which exhibit superfluid and crystalline properties simultaneously [4,5,6].

References

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. F. Kogel, T. Garg, M. Rockenhäuser, and T. Langen, *Phys. Rev. Research* 7, L022041 (2025).
4. M. Guo, F. Böttcher, J. Hertkorn, J.-N. Schmidt, M. Wenzel, H.P. Büchler, T. Langen, and T. Pfau, *Nature* 574, 386–389 (2019).
5. T. Langen, J. Boronat, J. Sanchez-Baena, R. Bombin, T. Karman, and F. Mazzanti *Phys. Rev. Lett.* 134, 053001 (2025).
6. A. Schindewolf, J. Hertkorn, I. Stevenson, M. Ciardi, P. Gross, D. Wang, T. Karman, G. Quémener, S. Will, T. Pohl, and T. Langen. [arXiv:2512.14511](https://arxiv.org/abs/2512.14511) (to appear in *Rev. Mod. Phys.*)

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