Creating and Exploring Bose-Einstein Condensates of Dipolar Molecules

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Recently, we have realized the first BEC of dipolar molecules [1]. We evaporatively cool a gas of sodium-cesium molecules to below 10 nanokelvin, deep in the quantum degenerate regime. The BECs live for several seconds. This dramatic improvement over previous molecular cooling efforts is enabled by collisional shielding via microwave dressing, suppressing inelastic losses by four orders of magnitude [2]. Microwave dressing also provides an exceptional level of tunability of dipole-dipole interactions, opening the door to novel phases of matter in molecular quantum liquids. Most recently, we have observed self-bound droplets in a gas of strongly dipolar molecules [3].

In this talk, I will describe our experimental approach, discuss recent results, and give an outlook on novel opportunities enabled by molecular BECs for many-body quantum physics, quantum simulation, and quantum computing. I will also briefly highlight our broader efforts in quantum, including recent advances on single atom trapping in metasurface optical tweezer arrays [4].

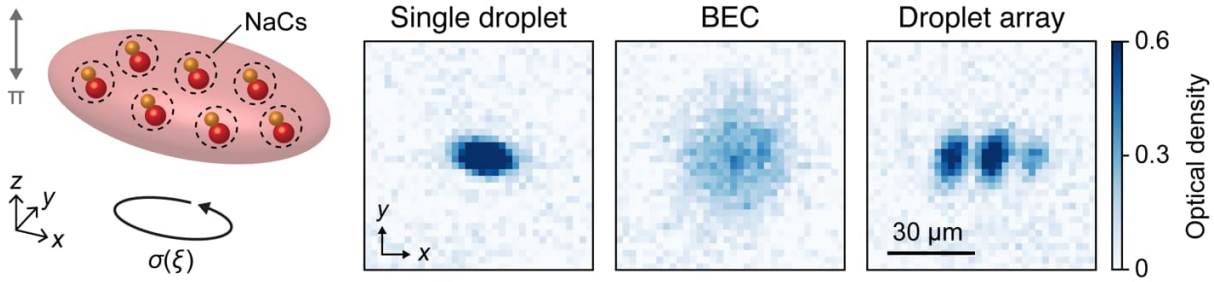

Figure: Formation of self-bound droplets in a BEC of dipolar NaCs molecules

References:

[1] Bigagli, Yuan, Zhang, et al., Observation of Bose-Einstein condensation of dipolar molecules, Nature 631, 289-293 (2024)

[2] Yuan, Zhang, et al., Extreme loss suppression and wide tunability of dipolar interactions in an ultracold molecular gas, arXiv:2505.08773 (2025)

[3] Zhang, Yuan, et al., Observation of self-bound droplets of ultracold dipolar molecules, arXiv:2507.15208 (2025)

[4] Holman, Xu, et al., Trapping of single atoms in metasurface optical tweezer arrays, arXiv:2411.05321 (2024) (in print)

Bio:

Sebastian Will is an Associate Professor of Physics at Columbia University. His research focuses on ultracold atoms and molecules for applications in fundamental

science, quantum simulation, quantum computing, and quantum networking. He is a recipient of the Columbia RISE Award, the NSF Career Award, and a Sloan Fellowship. His research is supported by the NSF, AFOSR, ARO, ONR, DOE, and the Gordon and Betty Moore Foundation.