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RHEINISCHE  
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VERSITÄT BONN

## COLLOQUIUM „OPTICS AND CONDENSED MATTER“

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### Hybrid quantum systems: Rydberg atoms, polar molecules and superconducting circuits

Interfacing distinct quantum systems, through the resonant exchange of excitations, is of interest from a fundamental perspective and in the development of quantum technologies [1]. In this talk, I will discuss two particular hybrid quantum systems. The first, comprises atoms in highly-excited Rydberg states and cold polar ground-state molecules. I will present experiments in which we have studied resonant energy transfer processes that occur at long range [2] - when the molecule is located outside the electron charge distribution of the atom - and at shorter range [3] - when the molecule is located within this charge distribution. The second hybrid system involves atoms in Rydberg states and solid state superconducting microwave circuits. We have realised a coherent interface between these platforms by coupling Rydberg helium atoms to a selected mode of a superconducting coplanar waveguide microwave resonator [4]. In this context, I will describe experiments in which we have probed the interaction of the atoms with the resonator field, and engineered the properties of the Rydberg states at this interface using additional microwave dressing fields [5,6].

- [1] G. Kurizki, P. Bertet, Y. Kubo, K. Mølmer, D. Petrosyan, P. Rabl and J. Schmiedmayer, Proc. Natl. Acad. Sci. 112 3866 (2015)
- [2] K. Gawlas and S. D. Hogan, J. Phys. Chem. Lett. 11, 83 (2020)
- [3] J. Zou, R. R. W. Wang, R. González-Férez, H. R. Sadeghpour and S. D. Hogan, arXiv:2509.21582 (2025)
- [4] A. A. Morgan and S. D. Hogan, Phys. Rev. Lett. 124, 193604 (2020)
- [5] L. L. Brown, J. A. L. Grondin and S. D. Hogan, Phys. Rev. A 110, 022615 (2024)
- [6] L. L. Brown, I. K. Bhangoo, and S. D. Hogan, Phys. Rev. A 113, 013709 (2026)

**January 27th, starting with discussion at 17:00 h, talk at 17:15 h, live IAP lecture hall or via Zoom**

<https://uni-bonn.zoom.us/j/98441612025?pwd=a01SSjlkY1Q3SDFhL09JQk1qc1V6dz09>

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