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“Connecting two-dimensional materials and ultracold atoms“

January 13, 2023 1:30 PM

HYBRID: Great lecture hall in Philosophenweg 12 and Zoom. Meeting ID: 935 6549 3662, Code: 928036
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ABSTRACT

In this presentation I will discuss how universality of quantum systems allows to closely connect the research areas of two-dimensional materials, ultracold atoms, and quantum chemistry. The discussion will be particularly focussed on systems where strong coupling between particles in the few-body regime gives rise to new phenomena in the quantum many-body problem. We will argue that a particular striking example for the synergy of solid state and cold atom research is provided by recently discovered atomically thin two-dimensional semiconductors. In this new class of van-der Waals materials the absence of strong dielectric screening leads to the existence of deeply bound excitons that remain robust bosonic quasiparticles even in the presence of substantial electron doping. Based on a computational quantum chemistry approach we show how exciton-electron mixtures in these materials are remarkably similar to Bose-Fermi mixtures realized in ultracold atoms. Extending this few-body approach we demonstrate how layer-stacking can be employed to realize Feshbach resonances in van-der Waals materials and thus fully tunable interactions. After establishing that Bose-Fermi mixtures both in 2D materials and cold atoms cannot be described using conventional Fröhlich models, we will discuss recent progress in the understanding of Bose polarons and show how their formation can be leveraged to modify and enhance quantum chemical processes. Our findings highlight exciting perspectives for the applied quantum simulation of two-dimensional materials using cold atomic systems, and we will discuss the role 2D materials may play in future applications of physical computation.

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