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Rydberg atoms in optical lattices

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By virtue of their large polarizability, ultracold Rydberg atoms provide a promising route for realizing long-range interacting quantum systems offering a high degree of control via external fields. In this talk, I will outline several scenarios for introducing different types of long-range interactions in optical lattices by exploiting the strong van der Waals level-shifts of highly excited Rydberg states. Particular excitation schemes are shown to yield various spin models, which feature interesting phases determined by the coherent optical drive and/or dissipative processes. Finally, I will consider the utility of virtual Rydberg excitation for realising yet another type of long-range interactions and discuss its prospects for the controlled generation of entangled states and the implementation of extended Bose-Hubbard models with nonlinear tunneling terms.