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Nonlocal light-matter interactions in cold Rydberg gases

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By virtue of their exaggerated properties, cold Rydberg atoms are considered to be promising systems for exploring quantum phenomena on a few- and many-body level. In this talk we discuss different facets of the laser-driven excitation dynamics in ultracold Rydberg gases. The evolution of both the atoms as well as the applied light-field displays profound effects of the strong van der Waals interactions between Rydberg atoms. On the one hand, they gives rise to long-range and collective atomic interactions that induce nonlocal matter-wave dynamics and the formation of exotic quantum phases. On the other hand, this system provides a well-controllable nonlocal optical medium with enormous nonlinearities. We discuss the resulting nonlinear light propagation and possible applications to photonic quantum computation.