Rydberg molecular systems: From antiprotonic Helium to Trilobites in a dense gas

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Highly excited "Rydberg" systems play an important role for progress in theory, experiment, and more recently for potential applications in quantum computing.
Rydberg systems connect ultracold physics, condensed and atomic/molecular physics and also non-linear (semi-)classical dynamics on the theoretical side.
In the talk I will illustrate this progress with exotic Rydberg systems from antiprotonic helium to ultralong-range Rydberg molecules with several thousand atomic units bond length. Immersed in their natural environment of an ultracold gas those molecules thrive through the presence of many randomly located gas atoms - a surprising and counterintuitive result. It is rooted in a novel scarring phenomenon of excited quantum wave functions and the fact that a random gas contains clusters of atoms, a phenomenon more broadly known as "birthday paradoxon".