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Cold Rydberg molecules¹

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Cold atomic systems have opened new frontiers in atomic and molecular physics, including several types of Rydberg molecules. Three types will be reviewed. Long-range Rydberg-ground molecules, first predicted in [1] and observed in [2], are formed via low-energy electron scattering of the Rydberg electron from a ground-state atom within the Rydberg atoms volume. The binding mostly arises from S- and P-wave triplet scattering. We use a Fermi model that includes S-wave and P-wave singlet and triplet scattering, the fine structure coupling of the Rydberg atom and the hyperfine structure coupling of the $5S_{1/2}$ atom (in rubidium [3]). The hyperfine structure gives rise to mixed singlet-triplet potentials for both low-L and high-L Rydberg molecules [3]. A classification into Hund's cases [3,4,5] will be discussed. The talk further includes results on adiabatic potentials and adiabatic states of Rydberg-Rydberg molecules in Rb and Cs. These molecules, which have even larger bonding length than Rydberg-ground molecules, are formed via electrostatic multipole interactions. The leading interaction of neutral Rydberg-Rydberg molecules is dipole-dipole, while for ionic Rydberg molecules it is dipole-monopole. Higher-order terms are discussed. [1] C. H. Greene, A. S. Dickinson, and H. R. Sadeghpour, Phys. Rev. Lett. 85, 2458 (2000). [2] V. Bendkowsky, B. Butscher, J. Nipper, J. P. Shaffer, R. Lw, and T. Pfau, Nature 458, 1005 (2009). [3] D. A. Anderson, S. A. Miller, and G. Raithel, Phys. Rev. A 90, 062518 (2014). [4] D. A. Anderson, S. A. Miller, and G. Raithel, Phys. Rev. Lett. 112, 163201 (2014). [5] A. T. Krupp, A. Gaj, J. B. Balewski, P. Ilzhfer, S. Hofferberth, R. Lw, T. Pfau, M. Kurz, and P. Schmelcher, Phys. Rev. Lett 112, 143008 (2014).

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