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Bound by reflection: Formation of ultralong range Rydberg molecules WEIBIN LI, JOVICA STANOJEVIC, THOMAS POHL, JAN-MICHAEL ROST, MPI for the Physics of Complex Systems — Recent experiments have provided evidence for the existence of an exotic type of molecule arising entirely from low-energy scattering of a Rydberg electron and a nearby ground state atom. The resulting molecular potential reflects the highly oscillatory character of the Rydberg atom's wavefunction and leads to binding at extremely long range of several thousand Bohr radii. Here we demonstrate the existence of a wide spectrum of molecular lines that originate from two different sources: a Rydberg trimer formed in a single photon association and a series of excited dimer states which are bound by a so far unknown mechanism — namely internal quantum reflection. Adapting scattering-theory concepts to long-range bound states, we thoroughly examine this new binding mechanism and explore schemes for coherent control of the molecular stability.

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