Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

An ultracold heavy Rydberg system formed from ultra-long-range molecules bound in a stairwell potential FREDERIC HUMMEL, PETER SCHMELCHER, Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 129, 22671 Hamburg, Germany, HERWIG OTT, Research Center OPTIMAS, Technische Universitt Kaiserslautern, 67663 Kaiserslautern, Germany, HOSSEIN SADEGHPOUR, ITAMP, Harvard-Smithsonian Center for Astrophysics 60 Garden St., Cambridge, Massachusetts 02138, USA — We propose a scheme to realize a *heavy Rydberg system* (HRS), a bound pair of oppositely charged ions, from a gas of ultracold atoms. The intermediate step to achieve large internuclear separations is the creation of a unique class of ultra-long-range Rydberg molecules bound in a stairwell potential energy curve. Here, a ground-state atom is bound to a Rydberg atom in an oscillatory potential emerging due to attractive singlet p-wave electron scattering. The utility of our approach originates in the large electronic dipole transition element between the Rydberg- and the ionic molecule, while the nuclear configuration of the ultracold gas is preserved. The Rabi coupling between the Rydberg molecule and the heavy Rydberg system is typically in the MHz range and the permanent electric dipole moments of the HRS can be as large as one kilo-Debye. We identify specific transitions which place the creation of the heavy Rydberg system within immediate reach of experimental realization.

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Date submitted: 27 Jan 2020 Electronic form version 1.4