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Direct excitation of butterfly states in Rydberg molecules CARSTEN LIPPE, THOMAS NIEDERPRUEM, OLIVER THOMAS, TANITA EICHERT, HERWIG OTT, Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — Since their first theoretical prediction Rydberg molecules have become an increasing field of research. These exotic states originate from the binding of a ground state atom in the electronic wave function of a highly-excited Rydberg atom mediated by a Fermi contact type interaction. A special class of long-range molecular states, the butterfly states, were first proposed by Greene et al.[1]. These states arise from a shape resonance in the p-wave scattering channel of a ground state atom and a Rydberg electron and are characterized by an electron wavefunction whose density distribution resembles the shape of a butterfly. We report on the direct observation of deeply bound butterfly states of Rydberg molecules of ^{87}Rb. The butterfly states are studied by high resolution spectroscopy of UV-excited Rydberg molecules. We find states bound up to -50 GHz from the $25\mathrm{P}_{1/2}, F = 1$ state, corresponding to binding lengths of $50\,a_0$ to $500\,a_0$ and with permanent electric dipole moments of up to 500 Debye. This distinguishes the observed butterfly states from the previously observed long range Rydberg molecules in rubidium.

[1]Chris H. Greene, A. S. Dickinson, H. R. Sadeghpour, **PRL** 85, 2458

Carsten Lippe
Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

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