Rydberg-Exciton Induced Chemical Reactions in Cu_2O

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The quantum-optical properties of Rydberg excitons are strongly influenced by the presence of free carriers and charged impurities in the material. On the one hand the well-known Mott effect leads to a shrinking of the band gap and subsequent vanishing of Rydberg exciton states. Ionization of excitons in the electric fields due to charged impurities on the other hand limits the maximum observable principal quantum number by virtue of reduction of the oscillator strength of exciton transitions and thus the absorption coefficient. Surprisingly, additional application of very weak near-band-gap light results in a strong enhancement of the absorption nearly up to the expected value without charged impurities. This effect is explained by the reduction of the density of the latter; yet, the mechanism of this effect remains unclear.

Here, we propose as such a mechanism the optical excitation of local Rydberg states, modified by the Stark effect due to the electric field of a nearby charged center and subsequent ionization, resulting finally in an uncharged impurity and the opposite free carrier. Already a simple hydrogen model for the Rydberg states yields the strength and spectral dependence of the purification.