Rydberg Excitons in Cuprous Oxide

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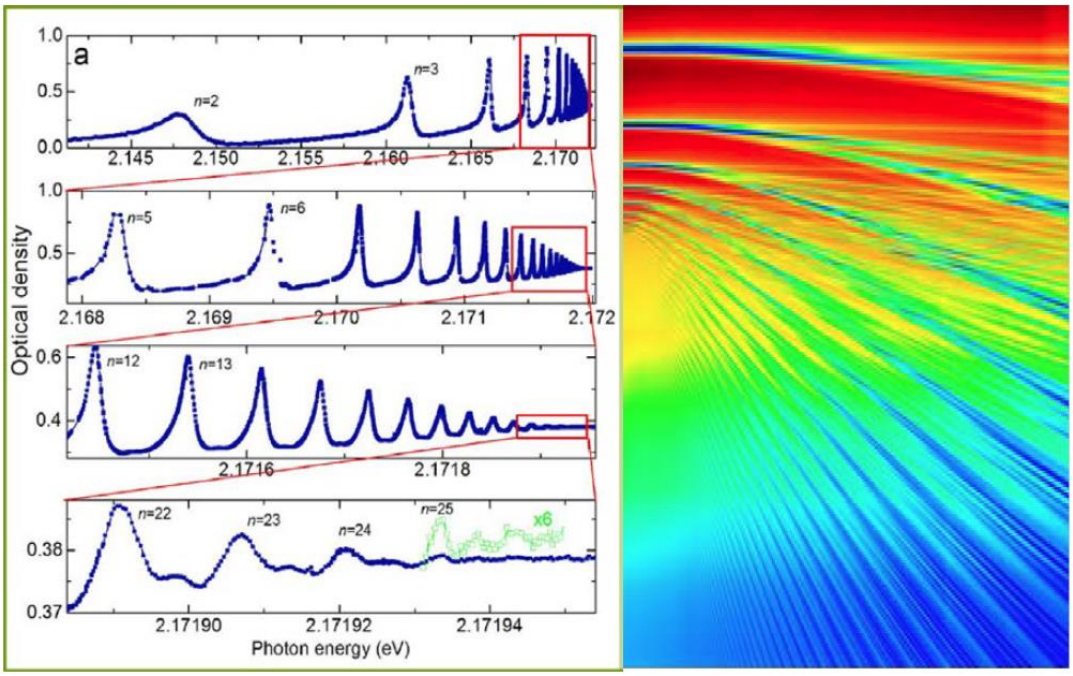
Excitons, bound electron-hole complexes, are decisive for the optical properties of semiconductors. Thereby their description as hydrogen atom-like complexes has turned out to be extremely useful. In Rydberg atoms an electron is promoted into a state with high principal quantum number. The atom becomes a mesoscopic object with dimensions in the micrometer range, which allows one, for example, to study the transition from quantum to classical dynamics. Recently it has been shown that also excitons can be excited into Rydberg states by observing states with principal quantum number up to n=25 in high-quality natural cuprous oxide crystals [1]. This corresponds to an average radius of more than a micrometer, so the exciton wavefunction is extended over more than 10 billion crystal unit cells.

In this contribution, similarities and differences of these Rydberg-excitons with their atomic counterparts will be discussed. In particular, the scaling laws of Rydberg exciton properties such as polarizability and interaction strength with respect to the principal quantum number will be investigated. Due to the strong interactions it becomes possible to create a semiconductor equivalent to Rydberg atom blockade, where the interaction between excitons becomes so strong that the presence of a single exciton within a certain volume is sufficient to shift the energy required to create a second exciton beyond the narrow linewidth of the transition. This results in an effective blockade mechanism. The relation of this effect to the ionization-like plasma blockade will be discussed. Also, results of reduced symmetry, such as the appearance of high-angular momentum excitons in one-photon transmission spectra [2] will be investigated.



References

1. T. Kazimierczuk, D. Fröhlich, S. Scheel, H. Stolz, M. Bayer, Nature 514, 343 (2014).
2. J. Thewes, et al., Phys. Rev. Lett. 115, 027402 (2015).