Recent results on cuprous oxide in the bulk and in quantum wells

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Rydberg excitons in cuprous oxide with high principal quantum numbers up to n=25 have been observed in the seminal work by the experimental group of M. Bayer at the TU Dortmund [1]. These states are within the regime, where the classical correspondence principle is valid. To obtain an interpretation of the exciton spectra in terms of a classical exciton dynamics, we have developed and applied the classical and semiclassical theory of excitons in cuprous oxide [2]. With decreasing energy the semiclassical and quantum mechanical recurrence spectra exhibit stronger deviations from the hydrogen-like behavior. This is related to a growing influence of the spin-orbit coupling and thus a higher velocity of the secular motion of the exciton orbits.

Excitons in external electric and magnetic fields allow for the observation of exceptional points (EPs), where both the eigenenergies and eigenvalues degenerate, at laboratory field strengths. However, their exact localization in the parameter space is challenging due to the numerically expensive computation of the exciton spectra. Here, we have developed an efficient machine learning algorithm, based on Gaussian process regression, to find EPs [3].

Excitons in quantum wells with various widths allow for studying the transition from weak confinement in the bulk to nearly two-dimensional excitons in case of strong confinement [4]. The quenching of states is directly observed in the wave functions [5]. Above threshold, resonances occur, which have been computed with two different methods [6]. We also discuss the effects of image charges in quantum wells with different dielectric constants of the quantum well and the substrate.

References

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