Wave functions and oscillator strengths in a two-band model for Rydberg excitons in cuprous oxide quantum wells

L. Kühner[1,*], J. Main[1]

[1]*Institute for Theoretical Physics I, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany.*
**e-mail: leon-kuehner@web.de*

Since the discovery of Rydberg excitons with a principle quantum number up to n = 25 [1], new interest in the field of Rydberg excitons has been sparked. In latest research the energies of states in cuprous oxide quantum wells have been studied [2]. Now, we utilize B-spline methods to calculate wave functions and oscillator strengths of Rydberg excitons within the framework of a two-band model. By employing ARPACK routines, we efficiently solve the eigenvalue problem by calculating only desired eigenvalues and vectors. We calculate spectra of relative oscillator strengths for different quantum well widths. Furthermore we visualize the wave functions and show the quenching behavior for small quantum well widths. The transition behavior of wave functions in the vicinity of avoided crossings is also investigated.

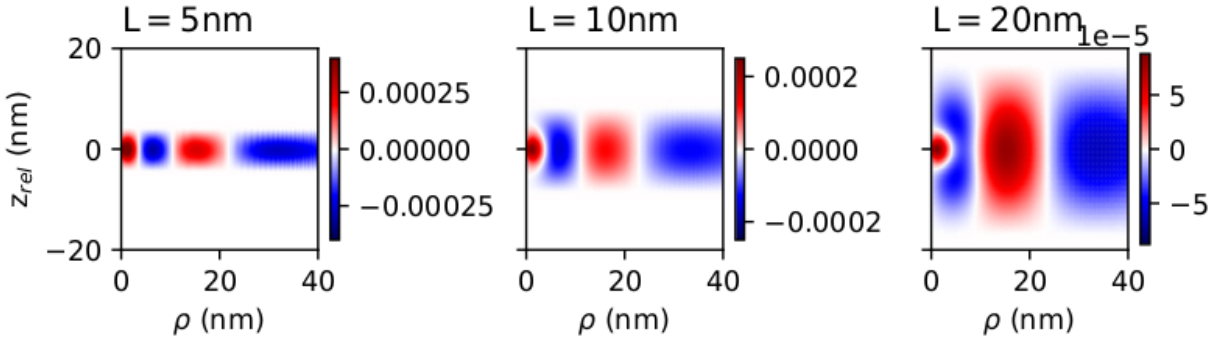

Fig. 1. Rydberg excitons with angular quantum number m = 1 and principle quantum number n = 5. Here, L denotes the quantum well width, while the relative z coordinate is plotted over ρ. The amplitude of the wave function is given by the colormap. The center of mass coordinate is set to the center of the quantum well.

References

[1] T. Kazimierczuk, D. Fröhlich, S. Scheel, H. Stolz, M. Bayer, Giant Rydberg excitons in the copper oxide Cu_2O, Nature. **514**, 343 (2014).

[2] N. Scheuler, P. Rommel, J. Main, P. A. Belov, Resonance energies and linewidths of Rydberg excitons in Cu_2O quantum wells, Phys. Rev. B 109, 165440 (2024).