POLIMA
Center for Polariton-driven Light-Matter Interactions

SDU
Mads Clausen Institute

PROJECT TITLE

# Exciton-polaritons in atomic chains.

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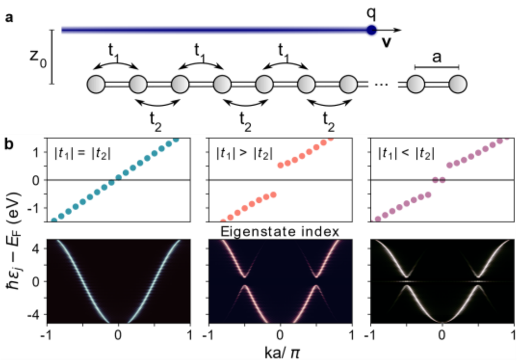
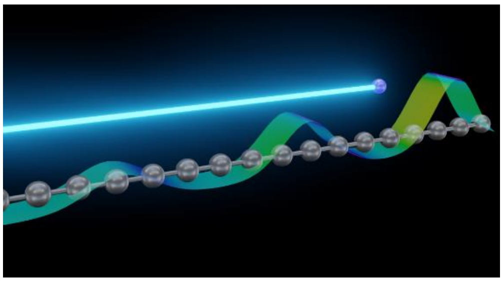
## PROJECT DESCRIPTION

The next generation of computers is predicted to rely on the utilization of light-matter interactions, by combining the speed and energy efficiency of light, the correlation and tunability of quantum states of matter, and the high-precision fabrication techniques available for solid state platforms. Exciton-polaritons—the hybridization between the bound electron-hole pairs (excitons) and the impinging light—formed in low-dimensional semiconductors, incorporates all these advantages. Excitons are created when an electron is promoted to the conduction band and a hole is left behind in the valence band. The electrostatic interaction between these two oppositely charged particles can be described as forming a single neutrally charged quasiparticle behaving as a boson in a bound state - the exciton. In this project, we will use a simple tight-binding model [1], to investigate the exciton-polaritons in a one-dimensional (1D) atomic chain.




The electronic structure of the SSH chain.



Plasmonic excitation of the SSH chain.

The project is purely theoretical and will contain both an analytical part and a numerical part. The starting point of the project will be to familiarize yourself with the Su-Schrieffer-Heeger (SSH) model and how the single-particle density matrix formalism can be used to describe the optical response in SSH chains. The first task will therefore be to reproduce some of the results from [2]. The next part of the project will be to implement the exchange interaction which allow the description of electron-hole pairs and investigate how these changes the optical response. If time permits, interactions between plasmons – which are a collective excitation of electrons in a metal – and the excitons can be investigated by considering a semiconducting and metallic chain in close contact. If the coupling between excitons and plasmons is strong enough plasmon-exciton hybrid states are created which can retain the best properties of both excitations; The high energy density of the plasmon and the long lifetime of the exciton.

[1] W. P. Su, J. R. Schrieffer, and A. J. Heeger, Solitons in Poly- acetylene, Phys.Rev.Lett. 42, 1698 (1979).
[2] S. de Vega, J. D. Cox, F. Sols, and F. J. García de Abajo, Strong-Field-Driven Dynamics and High-Harmonic Generation in Interacting One Dimensional Systems, Phys. Rev. Res. 2, 013313 (2020).

*This is a draft of a Bachelor or Master project. For more options, visit* ***polima.org***.