Surrogate model for exciton-polariton neuromorphic devices

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The surrogate model is an engineering technique approximating a desired result using an equivalent mathematical model. It is useful when the system response cannot be easily measured or calculated. In our work, we use a surrogate model to reproduce the Gross-Pitaevskii equation (GPE) results. The GPE is essential for describing exciton-polariton condensates in the mean-field approximation. However, the numerical integration of the GPE can be time-consuming. Therefore, surrogate models can be used as an alternative to sophisticated numerical calculations, thus reducing the computational resources required.

Consequently, the development of surrogate models becomes essential, especially for the optimisation of novel photonic devices employing exciton-polariton condensates. Therefore, our theoretical work explores surrogate models based on Fourier Neural Operators (FNOs). Neural operators are well-known in deep machine learning architectures and are used to learn the mapping between different function domains. The advantage of neural operators is that the output function can be evaluated at any discretisation, making the method highly useful.

In preliminary research, we have obtained promising results showing that FNO can identify the nonlinearity of exciton-polariton condensation as a function of pump intensity. The application of the FNO surrogate model can accelerate the research on exciton-polariton neuromorphic devices.

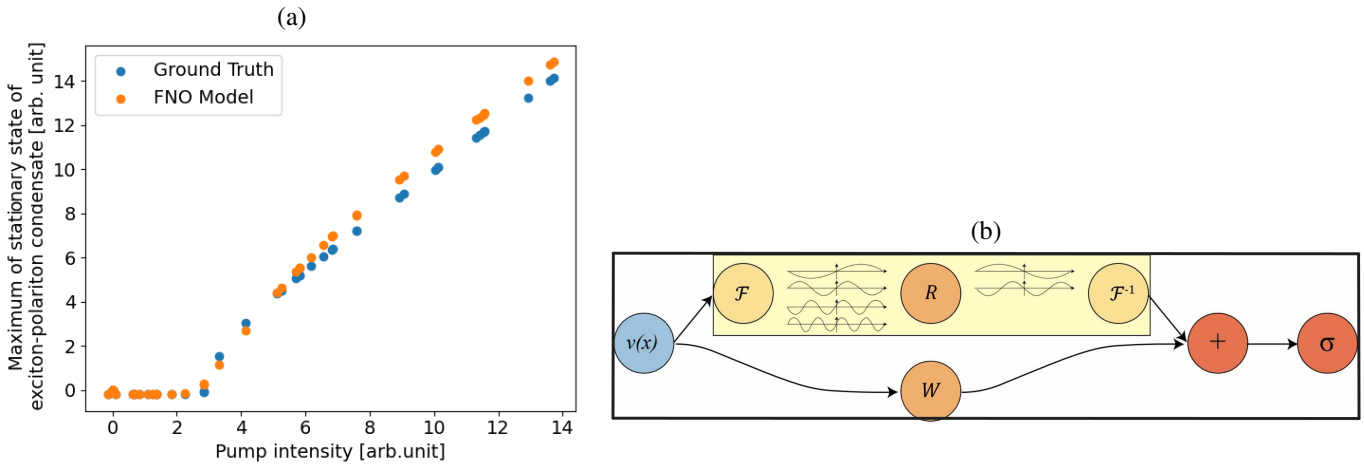

Figure 1: a) Maximum value of stationary state of exciton-polariton condensate as a function of pump intensity. The data for training was generated using coherent spatial gaussian pumping in 2D. b) Graphical representation of Fourier layer [1]

References

[1] Fourier Neural Operator for Parametric Partial Differential Equations, Z. Li, N. Kovachki, K. Azizzadenesheli, B. Liu, K. Bhattacharya, A. Stuart, A. Anandkumar, 2020.