Polaritons as efficient and ultrafast platform for neuromorphic computing

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Exciton-polaritons, mixed states of photons and excitons, have attracted a great deal of interest both from a fundamental point of view, with the observation of quantum macroscopic phenomena, and, given the possibilities they can offer, for the realisation of all-optical devices with limitless advantages in terms of energy consumption, dissipation-less operation and high clock frequencies [1].

After showing some of the most intriguing characteristics of polaritons in semiconductor microcavities, we will focus on the use of polariton systems as semiconductor-based platforms for the realisation of an image recognition system based on a reservoir computing array of polariton nodes [2].

We have studied several schemes to best exploiting the strong polariton nonlinearities in a network of almost degenerate polariton states. We used the MNIST database of handwritten numbers as a benchmark to test the efficiency of the network against the number of training dataset as well as the network dimension.

Using quasi-resonant excitation schemes, we obtained extremely unexpected and startling results. Compared to previous works on hardware implementation of neuronal network schemes we could show a higher success rate in a system that offers the fastest computational speeds. Moreover, despite a smaller set of training data, such an exciton-polariton-based platform demonstrated to outperform even linear classification algorithms working with the full MNIST database.

References

[1]. D. Sanvitto, & S. Kena-Cohen, “The road towards polaritonic devices”. Nat. Mater. 15, 1061–1073 (2016).

[2]. D. Ballarini, A. Gianfrate, R. Panico, A. Opala, S. Ghosh, L. Dominici, V. Ardizzone, M. De Giorgi, G. Lerario, G. Gigli, T.C.H. Liew, M. Matuszewski, D. Sanvitto “Polaritonic neuromorphic computing outperforms linear classifiers”. arXiv:1911.02923 (2019).