Polaritonics: Photonic circuits and optical diodes

T. Espinosa-Ortega[1]*, I. A. Shelykh[1], T. C H Liew[1]
[1]Division of Physics and Applied Physics, Nanyang Technological University 637371, Singapore, teortega@ntu.edu.sg
* Corresponding Author

Keywords: *Strong-light matter coupling, Optical circuits, Neural networks.*

Abstract

The demand for a new generation of computers, more powerful and more compact, have lead the scientist to the task to improve current processors that use electronic devices to perform calculations with boolean algebra. We address the problem by introducing novel devices based in exciton-polaritons: pseudo-particles that arise due to the strong coupling of excitons and photons in microcavities.

First we introduce a fully photonic classic logic gate architecture[1]. We exploit the nonlinearities due to polariton-polariton interactions to produce a signal in the form of a moving domain wall. These signals can be optically controlled and the spin degree of freedom of light can be used as a bit. Using the spin precession of light in 2D channels we demonstrate that the "NOT" and "AND" logic gates can be realized every time the spin flips at the nodes of an interconnected network. Also, we present an optical diode[2] compatible with polaritons propagating in domain walls; it would allow the propagation of the signals in one direction only, avoiding backscattering interference. The dynamics of the systems are modelled using a mean-field approach that allows obtaining the coherent polariton field.

The second approach is inspired in replacing the boolean logic for hardware neural networks. A perceptron is an artificial neural network where a large number of signals experience a linear transformation to produce the desired output. Furthermore, a neuron can be trained such that it preserves its "memory" and applies the same linear transformation for a similar set of inputs. This allows the system to perform tasks such as pattern recognition. We propose a scheme[3] (see Fig.1) where the inputs and outputs can be sent optically. Here the proof of the concept was realized by solving the Schrodinger equation for different scenarios. In particular we will discuss the system's memory associated by the phonon-polaritons interaction.

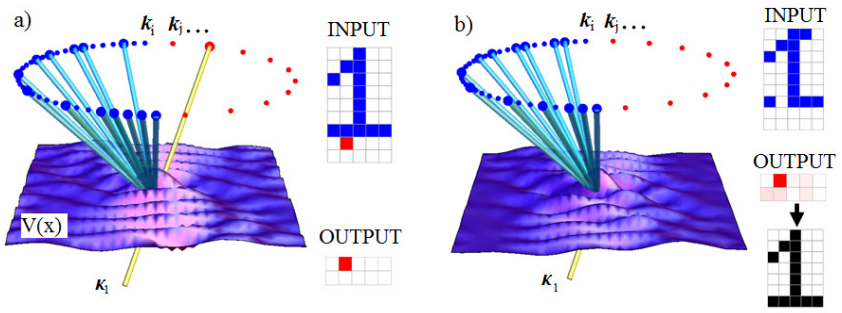

Fig.1. a) Training phase. An input set corresponding to number one, is activated simultaneously with the desired output (red ray). b) Operation phase. The input set represents a digit with defects, here there is no driven field over the output. Scattering with the potential allows the number to be recognized.

References

1. T. Espinosa-Ortega & T. C. H. Liew, Phys. Rev. B, 87, 195305 (2013).
2. T. Espinosa-Ortega, T. C. H. Liew & I. A. Shelykh, Appl. Phys. Lett, 103, 191110 (2013).
3. T. Espinosa-Ortega & T. C. H, Phys. Rev. Lett. 114, 118101 (2015).