# Could light and matter coupling lead to quantum computation?

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(PhysOrg.com) -- In science, one of the issues of great interest is that of quantum computing, and creating a way to make it possible on a scalable level. This could be achieved by taking advantage of the strong interaction between light and matter, the so-called strong-coupling regime that can be found in ultra small optical cavities defined by photonic crystals.

“The first step is to ensure that such strongly coupled cavity is created within or at close proximity to a photonic channel for on-chip computation, which is what we demonstrated here,” Frederic Brossard tells *PhysOrg.com*.

Brossard and colleagues at the Hitachi Cambridge Laboratory, together with fellow scientists at the university of Oxford and University of Sheffield, achieved this with a quantum dot and a cavity directly embedded in a photonic crystal waveguide, the photonic channel. Their work can be found in Applied Physics Letters: “Strongly coupled single quantum dot in a photonic crystal waveguide cavity.”

“From a purely optical point of view, the scalability of such structure, the resonant coupling between multiple cavities has already been demonstrated in silicon, Brossard says. (See M. Notomi, et al., *Nat. Photonics* 2, 741 2008.) “So it is now a matter of including quantum emitters such as quantum dots inside these cavities fabricated in III-V materials.”

Such chain of strongly coupled cavities has been shown to be feasible for quantum operations by various groups, including colleagues of Brossard at the university of Cambridge. (See D. G. Angelakis*, et al., *Phys. Rev. A* 76, 031805R 2007.) However, some challenges must be overcome first: "Basically each dot has to be positioned at or very close to one of the field maxima of the nanoscale cavity," Brossard explains. "The closer you are to a field maximum, the larger the interaction strength between the dot and the cavity mode."

The team is encouraged by the single quantum dot that they were able to strongly couple with their cavity. "Thankfully, the cavity chosen for this study enables a relaxation in the conditions necessary for strong coupling when compared to those required in previous work by other researchers," Brossard says. "This type of cavity makes it easier to align a quantum dot with a field maximum because of the larger volume occupied by the mode."

Another advantage of the team's work is the possibility that losses will be low. "It also has the potential of very low optical losses, which means that the coherence of the system can be maintained on a longer time scale," he continues.

A chain of coupled systems will require some sort of alignment procedure between a chosen dot and the cavity. Brossard says that this is something that the group at the University of Oxford, led by Prof. Robert Taylor, ha developed over the last few years in collaboration with the group at Hitachi. (See K. H. Lee, et al., *Appl. Phys. Lett.* 88, 193106 2006.)

"Right now, the demonstration provides interesting insights into the ability to couple light and matter by nanometer size modifications of the photonic crystal waveguide," Brossard says. In the future, he thinks that optical quantum computation is a very real possibility: "After we scale up the system, we can probe it, and see what is possible. We want to try it with input and output to see an exchange of information that might indicate its fitness for quantum computing."

**More information:** F.S.F. Brossard, X.L. Xu, D.A. Williams, M. Hadjipanayi, M. Hugues, M. Hopkinson, X. Wang, and R.A. Taylor, "Strongly coupled single quantum dot in a photonic crystal waveguide cavity," *Applied Physics Letters* (2010). Available online: link.aip.org/link/APPLAB/v97/i11/p111101/s1

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