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Quantum phase transitions of light CHARLES TAHAN, Cavendish Laboratory, University of Cambridge (UK), ANDREW GREENTREE, JARED COLE, LLOYD HOLLENBERG, University of Melbourne (AU) — Recently, condensed matter and atomic experiments have reached a length-scale and temperature regime where new quantum collective phenomena emerge. Finding such physics in systems of photons, however, is problematic, as photons typically do not interact with each other and can be created or destroyed at will. Here, we introduce a physical system of photons that exhibits strongly correlated dynamics on a mesoscale. By adding photons to a two-dimensional array of coupled optical cavities each containing a single two-level atom in the photon-blockade regime, we form dressed states, or polaritons, that are both long-lived and strongly interacting. Our zero temperature results predict that this photonic system will undergo a characteristic Mott insulator (excitations localised on each site) to superfluid (excitations delocalised across the lattice) quantum phase transition. Each cavity's impressive photon out-coupling potential may lead to actual devices based on these quantum many-body effects, as well as observable, tunable quantum simulators. We explicitly show that such phenomena may be observable in micro-machined diamond containing nitrogen-vacancy colour centres and superconducting microwave strip-line resonators. (Nature Physics, December 2006)

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