QUBITS BASED ON SPLIT-RING CONDENSATES OF EXCITON POLARITONS

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Superconducting flux qubits are based on a superposition of clock-wise and anti-clockwise currents formed by millions of Cooper pairs. In order to excite the system in a superposition state, the half-quantum flux of magnetic field is passed through the superconducting circuit containing one or several Josephson junctions. The system is forced to generate a circular current to either reduce the magnetic flux to zero or to build it up to a full-quantum flux. Circular currents of exciton-polaritons mimic the superconducting flux qubits being composed by a large number of bosonic quasiparticles that compose a single quantum state of a many-body condensate. The essential difference comes from the fact that polaritons are electrically neutral, and the magnetic field would not have a significant effect on a polariton current. We note however, that the phase of a polariton condensate must change by an integer number of 2π, when going around the ring. If one introduces a π-phase delay line in the ring, the system is obliged to propagate a clockwise or anticlockwise circular current to reduce the total phase gained over one round-trip to zero or to build it up to 2π. We show that such a π-delay line can be provided by a dark-soliton embedded into a ring condensate and pinned to a potential well created by the C-shape non-resonant pump-spot. The physics of resulting split-ring polariton condensates is essentially similar to the physics of flux qubits. In particular, they exhibit pronounced Bloch oscillations passing periodically through clockwise and anticlockwise current states as Figure 1 shows. We argue that qubits based on split-ring polariton condensates may be characterized by a high figure of merit that makes them a valuable alternative to superconducting qubits.

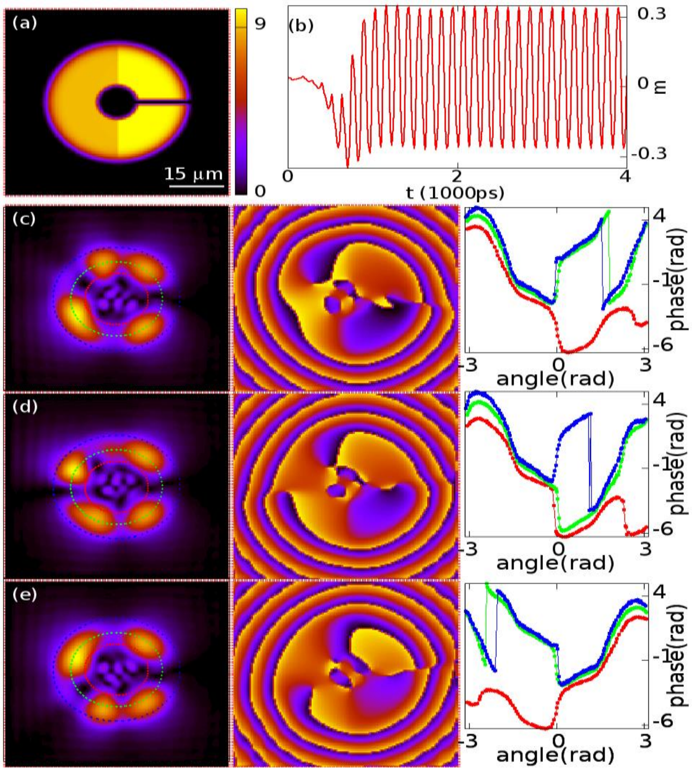

Figure 1. The considered shape of a non-resonant pump spot (a), the oscillations of the topological charge of the resulting split-ring polariton condensate (b), snap-shots of the absolute value of the many-body wave-function of the polariton condensate (left panels), its phase (middle panels) and phase for the fixed radius (right panels) at different stages of the time evolution ((c) m=0.3, (d) m=0, (e) m=-0.3)).