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Persistent Currents in Mesoscopic Loops and Networks

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Abstract: The paper describes persistent (also termed ``permanent'', or ``non-decaying'') currents in mesoscopic metallic and macromolecular rings, cylinders and networks. The current arises as a response of system to Aharonov-Bohm flux threading the conducting loop and does not require external voltage to support the current. Magnitude of the current is periodic function of magnetic flux with a period of normal-metal flux quantum Φ_0 = hc/e. Spontaneous persistent currents arise in regular macromolecular structure without the Aharonov-Bohm flux provided the azimuthal periodicity of the ring is insured by strong coupling to periodic background (a ``substrate''), otherwise the system will undergo the Peierls transition arrested at certain flux value smaller than Φ_0. Extremely small (nanoscopic, macromolecular) loop with three localization sites at flux $\Phi = \Phi_0/2$ develops a Λ-shaped energy configuration suitable to serve as a qubit, as well as at the same time as a ``qugate'' (quantum logic gate) supporting full set of quantum transitions required for universal quantum computation. The difference of the Aharonov-Bohm qubit from another suggested condensed-matter quantum computational tools is in the radiation free couplings in a qubit supporting the scalable, long-lived quantum computation.

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