Mesoscopic rings: multi-states induced by quantum thermal fluctuations

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Mesoscopic multiply connected non-superconducting samples such as rings, cylinders or tori exhibit quantum size effects originated from Aharonov-Bohm like effects. One of the spectacular are persistent currents which are known to flow in such samples at low temperature. At finite temperatures the phase coherence of electrons is lost with finite probability and the samples exhibit Ohmic conductance. There is a cross-over regime where both phase-coherent and dissipative currents coexist.

Such currents produce magnetic flux. Its kinetics can be formulated in terms of a simple semi-phenomenological model based on classical Langevin equation. We strictly limit our consideration to thermal, equilibrium, fluctuations present in any conducting sample. The asymptotic steady state for the probability density of magnetic flux can be bimodal reflecting the possible occurrence of self-sustaining currents. There is an obvious analogy with the Josephson-based flux qubits.

Passing from the moderate into very low temperatures the quantum mechanical effects need to be taken into account. At the low temperature the kinetics of the considered system meets the so-called quantum Smoluchowski limit and the quantum corrections can be incorporated into both diffusion and drift coefficients. The resulting steady state of the system changes qualitatively: from bi- into tri-modal. It opens the door for using non-superconducting rings in qutrit architecture.

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[1] J. Dajka, J. Łuczka, M. Szopa, E. Zipper, Phys. Rev. B **67** (2003) 073305
[2] J. Dajka, J. Łuczka, M.Szopa, P. Hanggi, phys. stat. sol. (b) **242** (2005) 196
[3] J. Łuczka, J. Dajka, M. Mierzejewski, P. Hanggi, Acta Phys. Pol. B **37** (2006) 1605
[4] J. Dajka, L. Machura, S. Rogoziński, J. Łuczka, cond-mat/07095v1 - submitted

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