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Stochastic path integrals and geometric theory of mesoscopic stochastic pumps and reversible ratchets.[1]

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A variety of stochastic systems, from enzyme kinetics to epidemiology, exhibit pump-like behaviors, where adiabatic changes of parameters result in a nonzero directed current through the system. Using the stochastic path integral technique from mesoscopic physics, we have been able to relate these and similar phenomena to geometric effects in mesoscopic stochastic kinetics and construct their unifying theory. In the talk, this methodology will be demonstrated on three examples: (1) an adiabatic pump effect in the evolution of a Michaelis-Menten enzyme, treated as a classical two-state stochastic system; (2) a reversible ratchet; and (3) a related novel phenomenon in a previously unexplored domain, namely the SIS epidemiological model. In all of these examples, pump-like currents follow from very similar geometric phase contributions to the effective action in the stochastic path integral representation of the moment generating functional, and our construction provides the universal technique for identification, prediction, and calculation of these currents in an arbitrary mesoscopic stochastic framework.

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