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Full Counting Statistics for Brownian Sieves and Brownian Molecular Machines

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A Brownian sieve is a spatially periodic microstructured device that combines the effects of thermal noise, local spatial asymmetry, and external forces to separate particles based on their transport properties. By treating the motion of an individual particle as a cyclical process in which the particle fluctuates away from and returns to the origin of some unit cell I derive generalized fluctuation-dissipation and reciprocal relations for the averages (and for all moments) of the number of periodic displacements that are exact and valid for arbitrary values of the external forces. These relations hold not only for Brownian sieves, but for all molecular machines in which a nanoscale system couples two chemical, mechanical, or transport processes by a cycle in which the molecular machine itself fluctuates away from, and then returns to some arbitrary reference state, in the process doing or receiving work on or from the environment.