Entropy Production in Continuous Stochastic Dynamics with Odd-Parity Variables

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The decomposition of the total entropy production is investigated in continuous stochastic dynamics in the presence of odd-parity variables that change their signs under time reversal. The first component of the entropy production, which satisfies the fluctuation theorem, is associated with the usual excess heat that appears during transitions between stationary states. The remaining housekeeping part of the entropy production can be further split into two parts. We show that this decomposition can be achieved in an infinitely many ways characterized by a single parameter $\sigma$. For an arbitrary value of $\sigma$, one of the two parts contributing to the housekeeping entropy production satisfies the fluctuation theorem. For a particular value of $\sigma$, it corresponds to a regularized version of the entropy production responsible for the breakage of the detailed balance, which has been studied for discrete state variables including odd-parity ones. The other part of the housekeeping entropy does not satisfy the fluctuation theorem and is related to the parity asymmetry of the stationary state distribution. For nonzero $\sigma$, this last part is shown to be nontransient. We discuss our results in connection with differences between continuous and discrete variable cases in the conditions for the detailed balance and the parity symmetry of the stationary state distribution.