Dissipation in a 2D classical cluster

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In Ref \cite{1} one showed through a refinement of the work theorem, that the average dissipation $\langle W_{\text{dis}} \rangle$, upon perturbing a Hamiltonian system arbitrarily far out of equilibrium in a transition between two canonical equilibrium states, is exactly given by:

$$
\langle W_{\text{dis}} \rangle = \langle W \rangle - \Delta F = k_B T \int d\lambda \rho(\lambda; t) \ln(\rho(\lambda; t)/\bar{\rho}(\lambda; t)),
$$

where $T$ is the temperature, $k_B$ is the Boltzmann constant, $\lambda$ is an external control parameter, $\Delta F$ is the free energy difference between the two equilibrium states, $\langle W \rangle$ is the delivered work, and $\rho$ and $\bar{\rho}$ are the phase-space density of the system measured at the same intermediate but otherwise arbitrary point in time $t$, for the forward and backward process respectively. The goal of this work is to find an estimate $p$ for the phase-space density $\rho$ by coarse graining. Because $p$ is an estimated quantity the above equality changes to the inequality:

$$
\langle W \rangle - \Delta F \geq k_B T \int d\lambda p(\lambda; t) \ln(p(\lambda; t)/\bar{\rho}(\lambda; t)).
$$

An interesting question is now how this inequality can be verified experimentally. One possibility is through dusty plasma experiments, were the external control parameter can be the strength of the parabolic confinement. In this work we will discuss the best coarse graining strategies which can be applied in an experimental setup. In our simulations we consider overdamped motion which justifies the use of Brownian dynamics simulations. We found that a good choice of the coarse graining strategy can improve the estimate of the average dissipated work significant and that above equation leads to a good estimate of the average dissipated work even for systems far out of equilibrium.