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Diffusive Free Energy and Reversibility in the Continuous Limit[1]

ELIJAH KOLMES, NATHANIEL FISCH, Princeton University — There are multiple ways of defining the free energy associated with a given phase space configuration. The Gardner free energy is the energy that can be extracted by exchanging pairs of elements in phase space. The diffusive free energy is defined similarly, but the elements are averaged rather than being exchanged. Both notions of free energy have been previously studied in discrete systems, in which phase space can be divided into finite blocks, and in continuous systems, in which the phase space elements being exchanged are infinitesimally small. For any discrete system, if the free energies are nonzero, it is well known that the Gardner free energy is always the larger of the two. We demonstrate here that in the continuous limit, they are the same. This is counterintuitive, since Gardner restacking operations are reversible whereas (for any discrete system) diffusive exchanges are irreversible. This result can be understood in terms of the scalings of the entropy production associated with a diffusive exchange.

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