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Unified Theory of Ghost and Quadratic-Flux-Minimizing Surfaces

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A generalized Hamiltonian definition of ghost surfaces (surfaces defined by an action-gradient flow) is given and specialized to the usual Lagrangian definition. Numerical calculations show uncorrected quadratic-flux-minimizing (QFMin) and Lagrangian ghost surfaces give very similar results for a chaotic magnetic field weakly perturbed from an integrable case in action-angle coordinates, described by $L = L_0 + \epsilon L_1$, where $L_0(\dot{\theta})$ (with $\dot{\theta}$ denoting $d\theta/d\zeta$) is an integrable field-line Lagrangian and ϵ is a perturbation parameter. This is explained using a perturbative construction of the auxiliary poloidal angle Θ that corrects QFMin surfaces so they are also ghost surfaces. The difference between the corrected and uncorrected surfaces is $O(\epsilon^2)$, explaining the observed smallness of this difference. An alternative definition of ghost surfaces is also introduced, based on an action-gradient flow in Θ, which appears to have superior properties when unified with QFMin surfaces.

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