Are ghost-surfaces quadratic-flux minimizing?

S.R. Hudson[a] and R.L. Dewar[b]

[a] *Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, NJ, 08543, USA*
[b] *The Australian National University, Canberra ACT 0200, Australia*

shudson@pppl.gov

Two candidates for "almost-invariant" toroidal surfaces passing through magnetic islands, namely quadratic-flux-minimizing (QFMIN) surfaces and ghost surfaces, use families of periodic pseudo-orbits (i.e. paths for which the action is not exactly extremal). QFMIN pseudo-orbits, which are coordinate-dependent, are field lines obtained from a modified magnetic field, and ghost-surface pseudo-orbits are obtained by displacing closed field lines in the direction of steepest descent of magnetic action, $\int A.dl$. A generalized Hamiltonian definition of ghost surfaces is given and specialized to the usual Lagrangian definition. A modified Hamilton's Principle is introduced that allows the use of Lagrangian integration for calculation of the QFMIN pseudo-orbits. Numerical calculations show QFMIN and Lagrangian ghost surfaces give very similar results for a chaotic magnetic field perturbed from an integrable case, and this is explained using a perturbative construction of an auxiliary poloidal angle for which QFMIN and Lagrangian ghost surfaces are the same up to second order. While presented in the context of 3-dimensional magnetic field line systems, the concepts are applicable to defining almost-invariant tori in other $1\frac{1}{2}$ degree-of-freedom nonintegrable Lagrangian/Hamiltonian systems.