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Generalised action-angle coordinates defined on island chains

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Straight-field-line coordinates are very useful for representing magnetic fields in toroidally confined plasmas, but fundamental problems arise regarding their definition in 3-D geometries because of the formation of islands and chaotic field regions, ie non-integrability. In Hamiltonian dynamical systems terms these coordinates are a form of action-angle variables, which are normally defined only for integrable systems. In order to describe 3-D magnetic field systems, a generalisation of this concept was proposed recently by the present authors that unified the concepts of ghost surfaces and quadratic-flux-minimising (QFMin) surfaces. This was based on a simple canonical transformation generated by a change of variable $\theta = \theta (\Theta,\zeta)$, where θ and ζ are poloidal and toroidal angles, respectively, with Θ a new poloidal angle chosen to give pseudo-orbits that are a) straight when plotted in the ζ,Θ plane and b) QFMin pseudo-orbits in the transformed coordinate. These two requirements ensure that the pseudo-orbits are also c) ghost pseudo-orbits. In the present paper, it is demonstrated that these requirements do not \emph{uniquely} specify the transformation owing to a relabelling symmetry. A variational method of solution that removes this lack of uniqueness is proposed.

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