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Description of magnetic field lines without arcana

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This work is based on the variational principle for magnetic field lines introduced in 1983 by Cary and Littlejohn [1]. The action principles for magnetic field lines and for Hamiltonian mechanics are recalled to be analogous. It is shown that the first one can be rigorously proved from first principles without analytical calculations. Not only the action principles are analogous, but also a change of canonical coordinates is recalled to be equivalent to a change of gauge [2]. Furthermore, using the vector potential makes obvious the freedom in the choice of "time" for describing Hamiltonian dynamics. These features may be used for a new pedagogical and intuitive introduction to Hamiltonian mechanics. In the context of confined magnetic fields, the action principle for magnetic field lines makes practical calculations simpler and safer, with an intuitive background. In particular, with a new analytical result: the width of a magnetic island is proportional to the square root of an invariant flux related to this island, the magnetic flux through a ribbon whose edges are the field lines related to the O and X points of the island. This is the first expression of this width avoiding abstract Fourier components and obviously independent of the choice of coordinates. The same analytical calculation provides a simple way to compute numerically the width of a magnetic island. Also to apply Chirikov resonance overlap criterion. Moreover, a new formula provides explicitly the Boozer and Hamada magnetic coordinates from action-angle coordinates.
References:
[1] Cary JR, Littlejohn RG (1983), Annals of Physics 151(1):1-34
[2] Elsasser K (1986) 28(12A):1743

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