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Non-Abelian Courant-Snyder Theory for Coupled Transverse Dynamics of Charged Particles in Electromagnetic Focusing Lattices[1]
HONG QIN, RONALD DAVIDSON, Princeton Plasma Physics Laboratory — The Courant-Snyder theory for charged particle dynamics in electromagnetic focusing lattices is the fundamental theory that underlies the design of modern accelerators and beam transport systems. The basic elements of the Courant-Snyder theory consist of the envelope equation, the phase advance, and the Courant-Snyder invariant. However, the standard Courant- Snyder theory applies only to the 1D transverse dynamics. We have extended the Courant-Snyder theory to 2D coupled transverse dynamics. It is surprising that the concepts of envelope equation, phase advance, and Courant-Snyder invariant can be elegantly generalized to the 2D case, but with the interesting feature of being non-Abelian. The theory is constructed through a time-dependent symplectic transformation that belongs to a non-invariant subset of the symplectic group $Sp(4, R)$. This non-Abelian Courant-Snyder theory provides a non-perturbative theoretical tool for designing focusing lattices with coupled transverse dynamics, which was previously treated primarily by perturbative methods.

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