Theory for high-intensity charged particle beams in strongly coupled focusing lattice

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Objectives

- Develop a comprehensive theoretical description of charged particle beams in strongly coupled focusing lattice.
- Designing advanced focusing lattice that can accommodate higher beam intensity for applications in high energy physics, inertial confinement fusion, and medicine.

Impact

- The generalized theory gives a new parameterization of the 4D symplectic transfer matrix that has the same structure as the parameterization of the 2D symplectic transfer matrix in the original Courant-Snyder theory.
- All of the parameters used in the Courant-Snyder theory correspond to important physical quantities, and this parameterization can provide a valuable framework for accelerator design and particle simulation studies.
- The newly discovered propagation modes in strongly coupled lattice specified by the generalized Kapchinskij-Vladimirskij distribution enable a large increase in flexibility in the amount of beam control and steering capability.
- For example, the new modes allow the beam to tumble (rotate) in the transverse plane perpendicular to the propagation direction, which can be utilized as a beam smoothing technique for accelerator applications where smooth illumination is required, such as in the case of accelerators for heavy ion fusion and medical applications.

Accomplishments

- The Courant-Snyder theory has been generalized to the case of linear coupled lattices with two degree of freedom.
- The generalized theory has a similar formal structure to the original Courant-Snyder theory for one degree of freedom.
- For high-intensity beams, the generalized Courant-Snyder theory has been applied to the discovery of a generalized Kapchinskij-Vladimirskij distribution for high-intensity beams in coupled focusing lattices.

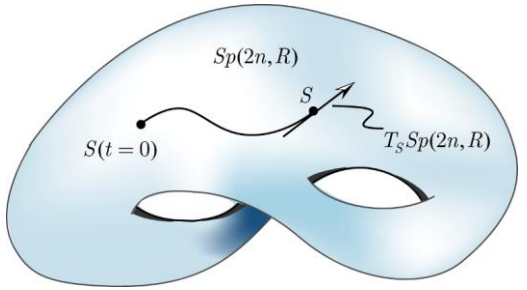

Figure 1. Charged particle dynamics in a strongly coupled lattice is specified by a curve on the symplectic group Sp(2n,R).

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