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Transverse Linear Beam Dynamics I

Tuesday 26 September 2023 15:00 (1 hour)

The subject of this introductory course is transverse dynamics of charged particle beams in linear approximation. Starting with a discussion of the most important types of magnets and defining their multipole strengths, the linearised equations of motion of charged particles in static magnetic fields are derived using an orthogonal reference frame following the design orbit. Analytical solutions are determined for linear elements of a typical beam transfer line (drift, dipole and quadrupole magnets), and stepwise combined by introducing the matrix formalism in which each element's contribution is represented by a single transfer matrix. Applying this formalism allows calculating single particle's trajectories in linear approximation. After introducing the beam emittance as the area occupied by a particle beam in phase space, a linear treatment of transverse beam dynamics based on appropriately defined optical functions is introduced. Formalism is applied to the concepts of both weak and strong focus, in particular, in discussing the properties of the widely used FODO cell. Specific characteristics of transverse beam dynamics in periodic systems like circular accelerators are studied in detail, emphasising the effects of linear field errors on-orbit stability and introducing the phenomena of optical resonances. Finally, the dynamics of off-momentum particles is presented, introducing dispersion functions and explaining effects like chromaticity.

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