Contribution ID: **1258** Contribution code: **WEPM059** Type: **Poster Presentation**

Nonstationary dynamics of vortex electron beam in magnetic lens

Wednesday 4 June 2025 16:00 (2 hours)

The Landau states of electrons with orbital angular momentum in magnetic fields are important in the quantum theories of synchrotron radiation at storage rings and in many other areas. In realistic scenarios, electrons are often born inside the field or injected from a field-free region, requiring nonstationary quantum states to account for boundary or initial conditions. This study presents nonstationary Laguerre–Gaussian (NSLG) states in a longitudinal magnetic field, characterizing vortex electrons after their transfer from vacuum to the field. Comparisons with Landau states show that the r.m.s. radius of the electron packet in the NSLG state oscillates in time around a significantly larger value than that of the Landau state. This quantum effect of oscillations is due to boundary conditions and can potentially be observed in various problems, particularly when using magnetic lenses of linear accelerators and electron microscopes. Analogies are drawn between a quantum wave packet and a classical beam of many particles in phase space, including the calculation of mean emittance of the NSLG state as a measure of its quantum nature.

Footnotes

Paper preparation format

LaTeX

Region represented

Europe

Funding Agency

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Session Classification: Wednesday Poster Session

Track Classification: MC5: Beam Dynamics and EM Fields: MC5.D02 Nonlinear Single Particle Dynamics Resonances, Tracking, Higher Order, Dynamic Aperture, Code Developments