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Non-laminar charged particle beams from quantum to thermal regime

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The standard classical description of non-laminar charge particle beams in paraxial approximation is extended to the context of two wave theories. The first theory is the so-called Thermal Wave Model (TWM) that interprets the paraxial thermal spreading of the beam particles as the analog of the quantum diffraction. The other theory, hereafter called Quantum Wave Model (QWM), takes into account the individual quantum nature of the single beam particle (uncertainty principle and spin) and provides the collective description of the beam transport in the presence of the quantum paraxial diffraction. An envelope equation is derived for both TWM and QWM regimes. In TWM we recover the well known Sacherer equation whilst, in QWM we obtain the evolution equation of the single-particle spot size, i.e., single quantum ray spot in the transverse plane (Compton regime). We show that such a quantum evolution equation contains the same information carried out by an evolution equation for the beam spot size (description of the beam as a whole). This is done by defining the lowest QWM state reachable by a system of overlapping-less Fermions.

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