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Classical patterns in the quantum rainbow channeling of high energy electrons

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We are investigating the quantum dynamics of a well-collimated electron beam transmitting through planar channels of the Si crystal. Electron states were represented by wave packets, while the electron beam was treated as an ensemble of noninteracting wave packets. The evolution of electron states was obtained using the method of Chebyshev global propagation, specifically modified to give complex wave functions at arbitrarily chosen time instances without compromising the accuracy of the time propagation. The evolution of the ensemble in the configuration and the phase space was obtained by numerical simulation. We have analyzed how electron dynamics depend on the initial mean position and angular divergence. We have also investigated the relationship between the classical caustic pattern and the shape of the electron Wigner function. Obtained quantum probability densities have multiple maxima generated by an electron's self-interference. Their sum, which represents an ensemble's probability density, was found to depend strongly on the beam angular divergence. For small divergence, most peaks are aligned, causing the wavelike behavior of the ensemble. For moderate divergence, the maxima of some are aligned with the minima of others, resulting in the emergence of the classical caustic pattern.

Keywords: structural stability, planar channeling, rainbow scattering, classical-quantum correspondence

Summary

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