The ambiguity function in electron quantum optics

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Recently, single electron interferometers have been used as a time resolved sensors of a small amplitude classical electromagnetic field in the GHz frequency range with a 35 pico-second time resolution [1]. This is the proof of principle of the potential of single electron interferometry for on-chip ultra-fast sensing of classical and, potentially quantum [2] electromagnetic fields.

In this presentation, we introduce the electronic ambiguity function as the electron quantum optics analogue of the radar theory concept which characterizes the resolving power of a radar in return time and Doppler shift. In single electron interferometry, the electronic ambiguity function characterizes the resolution in terms of Wigner smith time delay and energy changes of the electron during its interaction with a quantum electromagnetic field.

We will discuss its properties and show how randomization and chirping techniques inspired from classical radar theory can be used to probe specific regions of the time / energy domain. These results open the way to single electron inelastic scattering amplitude tomography by harnessing the full power of single electron sources.

References

1. H. Bartolomei *et al*, Time-resolved sensing of electromagnetic fields with single-electron interferometry, ArXiv:*2408.12903*, to appear in Nature Technology on March 17th, 2025.
2. H. Souquet-Basiège *et al*, *Quantum sensing of time dependent electromagnetic fields with single electron excitations, ArXiv:2405.05796* (submitted to Physics. Rev. X).
3. H. Souquet-Basiège, B. Roussel, G. Rebora, G. Ménard, I. Safi, G. Fève and P. Degiovanni, The electronic ambiguity function in single electron interferometry (in preparation).

Figures

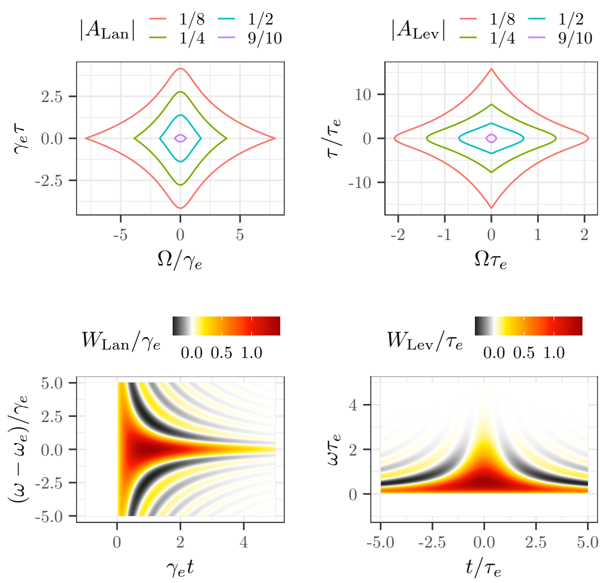

Figure 1: upper row: contour plots of the modulus of the ambiguity function for the Landau (left panel) and Levitov (right panel) excitations. The difference between the directions of algebraic and exponentiel decay is clearly visible. Lower row: Electronic Wigner functions for the corresponding excitations. Here γ_e denotes the inverse of the duration of the wavepacket.