Attosecond shot noise and electron interference

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Abstract. The intensity-intensity (current-current) correlation properties of attosecond light pulses and electron pulses have been studied, and the deviations from the Poisson shot noise level have been estimated.

An attosecond pulse train of light is usually viewed as a special, extreme signal, stemming from a nonlinear dipole moment induced by the strong incoming laser field [1]. By the exclusive usage of classical Fourier synthesis of the very high-order harmonics, the resulting attosecond field is automatically (and tacitly) set to be a many-mode coherent radiation, in the strict sense of quantum optics. According to Glauber’s coherence theory, all the moments characterizing the correlations in such polychromatic signals would factorize, showing the usual shot noise ratio $\langle I_1 I_2 \rangle / \langle I_2 \rangle \langle I_1 \rangle = 1$ in the intensity-intensity correlations. We attempt to show reasons for modeling the attosecond pulses by multi-mode quantum-mechanical phase eigenstates. These should result in a $4/3$ increase relative to the Poisson shot noise level in a delayed coincidence experiment, or in the two multiplied signals of a high resolution split detector.

In a recent study, by analogy with the attosecond light pulses, we have introduced the concept of attosecond electron pulse trains [2], stemming from the interference of above-threshold photoelectron de Broglie wave components. We have found a sort of ‘temporal Talbot effect’, being a consequence of the dispersion relation $E_n = E_0 + n \hbar \omega = [(c^2 n^2) + (mc^2)^2]^{1/2}$ of the free electrons. This effect manifest itself in the appearance of ‘collaps bands’ and ‘revival layers’ in the outgoing current over macroscopic spatial regions. On the basis of preliminary calculations, we attempt to estimate the effect of this spatio-temporal structures on the fermion antibunching in a Hanbury Brown and Twiss type experimental arrangement.

References