CLASSICAL VERSUS QUANTUM-MECHANICAL SHOT NOISE POWER IN A TWO-DIMENSIONAL ARRAY OF ELASTIC SCATTERERS

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Shot Noise is the time-dependent fluctuation of the electrical current due to the discreteness of the charge of the carriers. It has been shown by Büttiker and Beenakker that the average (over impurity configurations) of the noise power $< P >$ in the diffusive regime of metallic conductors with many transverse modes is one-third of the Poisson values, 2e I_{av}, where I_{av} is the time-averaged current [1, 2]. This shot noise suppression is a consequence of the existence of noiseless open quantum channels. De Jong and Beenakker used the random-matrix theory to show that, in the diffusive regime, the shot-noise power has mesoscopic fluctuations of the order of $4\frac{e^3}{h}$ V C_1, where $C_1 = \sqrt{46/2835} \sim 0.127$ and V is the small bias across the sample [3]. This result was found to be independent of the sample size and the degree of disorder.

In this paper, we use the scattering-matrix formalism developed in ref. [4] to study the statistical properties of the shot noise power for electrons propagating in a two-dimensional array of scatterers. We consider wires which are fairly narrow, i.e, with a small number of transverse modes (less than 20 propagating modes). The cascading of probability and amplitude scattering matrices allows a clear illustration of the importance of interference effects on the shot-noise power. A detailed comparison of our numerical results and the predictions of the random-matrix theory for metallic samples within the diffusive regime will be given.

References

[1] M. Büttiker, Phys. Rev. Lett. 65, 2901 (1990).

[2] An extensive review of shot noise on mesoscopic conductors has been written recently by Y.M. Blanter and M. Büttiker in Physics Reports 336, pp.2-166 (2000).

[3] M. J. M. de Jong and C. W. J. Beenakker, Phys. Rev. B 46, 13400 (1992).

[4] M. Cahay, M. McLennan, and S. Datta, Phys. Rev. B 37, 10125 (1988).