Shot noise in the chaotic-to-regular crossover regime

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Classical shot noise

- Emission of electrons at random time intervals [1]
- Hall on a roof: noise < m
- Time-dependent current fluctuations due to granularity of electron charge

Quantum shot noise

- Randomness because of quantum scattering [2]
- Crossover between classical and quantum shot noise in chaotic cavities

Experiment [3]: Quantum cavities with disorder scattering and tunable dwell time

- Fano factor: $F = \frac{S}{S_p}$, noise compared to Poisson value

Shot noise suppression, $F < 1$ (reduction of noise due to correlations)

- Diffusive wires: $F = 1/3$
- Fractional Quantum Hall effect: $F = M/N$ (Laughlin quasiparticles)
- Chaotic quantum dots: $F = 1/4$

Time scales:
- Dwell time $\tau_D$: Time the electron spends inside the cavity
- Ehrenfest time $\tau_E$: (quantum break time)

Quantum-to-classical crossover

- 'quantum chaos' [4]
  \[ F = \frac{1}{4} \exp\left( -\frac{\tau_D}{\tau_E} \right) \]
- 'quantum disorder' [3]
  \[ F = 1/4 \left( 1 + \frac{\tau_Q}{\tau_D} \right)^{-1} \]

Chaotic to regular crossover

- Chaotic (RMT) \rightarrow regular dynamics

Numerical simulation of quantum transport

Disordered quantum dots

- Similar setting as in the experiment [3]
- Correlated random disorder
- Transmission eigenvalues

Modular recursive Green's function method [5]: variable shutters and tunable disorder potential

Quantum diffraction as source of shot noise

- Diffraction at the cavity opening
- Diffraction by disorder scattering

Semiclassical estimate

- Estimate for Fano factor including diffractive scattering (along Ref. [6]):
  \[ F - \frac{1}{4} \int_{0}^{T_D} P(t) dt - \frac{1}{4} \int_{0}^{\infty} P(t) dt \]
  in very good agreement with numerical data

Conclusions

- Dominant sources for shot noise: Diffraction and random scattering
- Diffraction: Regular dots with $F = 1/4$
- RMT-limit of shot noise can be realized without chaotic dynamics
- Semiclassical model including diffraction in agreement with data

Future Projects

- Effects of cavity symmetry on shot noise suppression
- Crossover from long to short range disorder potential

Acknowledgements


Preprint available [7]
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References

[7] F. Aigner et al., cond-mat/0502417