Effect of potential fluctuations on shot noise suppression in mesoscopic cavities

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We perform a numerical investigation of the effect of the disorder associated with randomly located impurities on shot noise in mesoscopic cavities. We show that such a disorder becomes dominant in determining the noise behavior when the amplitude of the potential fluctuations is comparable to the value of the Fermi energy and for a large enough density of impurities. In contrast to existing conjectures, random potential fluctuations are shown not to contribute to achieving the chaotic regime whose signature is a Fano factor of 1/4, but, rather, to the diffusive behavior typical of disordered conductors. In particular, the 1/4 suppression factor expected for a symmetric cavity can be achieved only in high-quality material, with a very low density of impurities. As the disorder strength is increased, a relatively rapid transition of the suppression factor from 1/4 to values typical of diffusive or quasi-diffusive transport is observed. Finally, on the basis of a comparison between a hard-wall and a realistic model of the cavity, we conclude that the specific details of the confinement potential have a minor influence on noise.

I. INTRODUCTION

In the last decades, the rapid development of nanofabrication techniques for sub-micron devices has led to impressive advancements in the field of mesoscopic physics, with a much better understanding of the properties of low-dimensional conductors. Molecular beam epitaxy (MBE) has been perfected to the point of growing extreme high-quality heterostructures, exhibiting low-temperature mobilities, for the case of a 2DEG in the AlGaAs/GaAs material system, up to $3.5 \times 10^7 \text{ cm}^2 \text{V}^{-1}\text{s}^{-1}$ (see Ref.1). These heterostructures represent ideal testbeds for the study of quantum properties of confined electrons.

A field of research that has become very active in recent years is the investigation of the noise properties of mesoscopic devices. In particular, shot noise has been the subject of significant attention, because it can provide useful information about material and device properties.

The fundamental nature of shot noise, resulting from the discreteness of charge, was recognized already at the beginning of last century, when Schottky formulated his well-known theorem, according to which, in the absence of correlation between carriers, the shot noise power spectral density $S_I$ is given by the expression $S_I = 2e\langle I \rangle$, where $e$ is the electron charge and $\langle I \rangle$ the average current in the conductor. This is a result of the Poissonian statistics governing device traversal events. In the presence of correlations among carriers the shot noise power spectral density does differ from Schottky’s result. Especially in mesoscopic devices, strong correlations, mainly due to Pauli exclusion and to Coulomb interaction, lead to considerable deviations from the Poissonian limit.

The so-called Fano factor

$$F = \frac{S_I}{S_{full}} = \frac{S_I}{2e\langle I \rangle},$$

is defined as the ratio of the actual shot noise power spectral density $S_I$ to that which would be expected from Schottky’s formula.

In the Landauer-Büttiker formalism the Fano factor can be expressed as

$$F = \frac{\sum_{i=1}^{N} T_i (1 - T_i)}{\sum_{i=1}^{N} T_i},$$

where the $T_i$’s are the eigenvalues of the $t^t t$ matrix, $t$ being the transmission matrix. Averaging over an interval of energy values is performed separately for the numerator and the denominator, as discussed in Ref.17.

A conductor is said to be in the diffusive regime when its length $L$ is much greater than the elastic mean free path $l_0$ but much smaller than the localization length. Since, in the presence of mode mixing, the localization length is approximately equal to the elastic mean free path times the number $N$ of propagating modes, the diffusive regime is achieved if the following inequality holds:

$$l_0 \ll L \ll N l_0 .$$

It has been theoretically predicted and experimentally observed in metallic wires, that in such a condition shot noise is suppressed by a factor $1/3$. Achieving the diffusive regime in a mesoscopic conductor obtained in the 2DEG of a semiconductor heterostructure can be rather difficult, because of the relatively small (up to a few hundreds) number of propagating modes.

Chaotic cavities, characterized by constrictions that are much narrower than the main part of the cavity, and that connect it to two reservoirs, are another well investigated type of mesoscopic structure and have a potential for practical applications, such as detectors. In the case of a symmetric chaotic cavity, the distribution $p(T_{cav})$ of the transmission eigenvalues has a bimodal shape with peaks at $T = 0$ and $T = 1$. Its expression is given by

$$p(T_{cav}) = \frac{1}{\pi} \frac{1}{\sqrt{T(1-T)}} .$$
This leads to a Fano factor equal to 1/4, a result that has also received experimental confirmation.

This property has been often investigated in relationship with the ratio of the dwell time in the cavity \( \tau_D \) to the characteristic quantum scattering time \( \tau_Q \) or Ehrenfest time\(^{23,26} \): if \( \tau_D \gg \tau_Q \) quantum diffraction will have sufficient time to generate a quantum chaotic, noisy behavior.

In several papers the achievement of quantum chaotic dynamics has been attributed to the classically chaotic shape of the cavity\(^{25} \) (a stadium, for example), to the presence of impurities in the body of the cavity\(^{19} \) or of irregularities in the boundary\(^{10,27,28} \). However, it has been demonstrated by Aigner \textit{et al.}\(^{29} \) and by some of us\(^{17} \), by means of numerical simulations, that a Fano factor of 1/4, corresponding to the RMT result for a symmetric cavity, is achieved also in a cavity with a perfectly regular shape, such as a rectangle, with a completely flat potential inside, as long as the conditions on symmetry and on the width of the constrictions (which must be narrow enough to guarantee the presence of sufficiently strong diffraction and a long enough dwell time for the electrons) are satisfied. In a rectangular cavity diffraction originates from the apertures and from the corners. Since such features have a size comparable to the Fermi wavelength \( \lambda_F \), the uncertainty \( \delta \theta \) in the diffraction angle will be rather large, being given by \( \delta \theta = \lambda_F / a \), where \( a \) is the size of the scatterers\(^{20} \). This implies that a substantial divergence of the trajectories can be achieved without the help of classical chaos.

Some authors are of the opinion that, although not necessary for the achievement of chaotic dynamics, impurities may contribute to approaching the regime with a Fano factor of 1/4 if added to a cavity which, for example, is characterized by a lower value of the Fano factor because of too large openings. This has been discussed by Aigner \textit{et al.}\(^{28} \), Rotter \textit{et al.}\(^{30} \), and Jacquod and Whitney\(^{29} \), who, on the basis of different approaches, argue that, as the strength of the disorder is increased, the Fano factor for a cavity that would otherwise exhibit a stronger suppression of shot noise tends to 1/4. However, in the paper by Aigner \textit{et al.}\(^{29} \) the authors observe a slight increase beyond the value of 1/4 for their largest choice of the disorder strength, but do not explore the effects of a further increase of such a parameter, also because they rely on an analytical expression (their Eq. (5)) according to which the Fano factor would be given by 1/4 times the integral of the dwell time distribution between a modified Ehrenfest time \( \tau_E \) resulting from the contribution of diffusive scattering and infinity. Based on this expression, the noise suppression factor could at most reach 1/4, as \( \tau_E \to 0 \).

Also Jacquod and Whitney do not investigate a further increase in the amplitude of the disorder to see whether the Fano factor actually saturates to the limit of 1/4.

A similar conclusion is reached by Sukhorukov and Bulashenko who argue\(^{34} \), with a rather complex calculation based on full counting statistics, that homogeneous disorder in the cavity leads, as the dwell time is increased, to the Random Matrix Theory (RMT) result and therefore, for a cavity with symmetric constrictions, to a suppression factor of 1/4.

Here we try to gain a better understanding of the action of disorder on the Fano factor for a cavity, using numerical simulations, since analytical techniques based on the ratio of the Ehrenfest time or of a modified Ehrenfest time to the dwell time, although very powerful and suggestive of intuitive explanations, are difficult to apply in a rigorous fashion to practical situations in which cavity confinement and diffusive or quasi-diffusive scattering coexist. For our calculations, we consider the Gallium Arsenide/Aluminum Gallium Arsenide material system, in the effective mass approximation (assuming an effective mass for the electrons equal to 0.067 \( m_0 \), where \( m_0 \) is the free electron mass). For other material systems (such as graphene) the effective mass approximation is not applicable, but for structures like cavities it is still possible to use an envelope function approximation\(^{32} \).

We start out with a simple model, in which the scatterers, mainly corresponding to impurity charges and ionized dopants, are represented with square obstacles with a given height. We study the noise properties of the cavity as a function of the scatterer strength (which in this model corresponds to the height of the square obstacles, and to their concentration).

In particular, we will show that, contrary to what can be found in the existing literature, as disorder is increased the Fano factor does not tend to 1/4, but, rather, crosses such value without any plateau and reaches the diffusive limit 1/3, which is also exceeded as strong localization develops.

Then, the general validity of the results obtained from the simple model is verified considering realistic potential fluctuations that can be found in a mesoscopic cavity based on a GaAs/AlGaAs heterostructure, assuming either a hard-wall model for the cavity or a realistic potential profile, resulting from the electrostatic action of depletion gates at the heterostructure surface.

\section{II. Numerical Method and Results}

Transport and noise properties have been investigated using a recursive Green’s function technique\(^{34,35} \), with a representation in real space in the longitudinal direction and over the transverse eigenmodes in the transverse direction. The device is subdivided into transverse slices: within each slice the potential is assumed to be longitudinally constant, and they are initially considered to be isolated and with Dirichlet boundary conditions at their ends. The Green’s function of each slice can thus be analytically evaluated, in the form of a diagonal matrix. Then, two adjacent sections are connected via a perturbation potential \( \hat{V} \), and the overall Green’s function is obtained using Dyson’s equation. The recursive application of this procedure allows us to compute the Green’s
function of the whole structure, as well as, using a modified version\(^{34-37}\) of the Fisher-Lee relation\(^{36,37}\), the transmission matrix. Finally, from the transmission matrix, the conductance and shot noise power spectral density are obtained, within the Landauer-Büttiker formalism.

We start by considering a rectangular hard-wall cavity with a length of 5 µm and a width of 8 µm, as in the case of the experimental device of Ref.\(^9\), with 400 nm wide openings, containing 50 × 50 nm\(^2\) randomly located scatterers. A sketch of the resulting potential landscape is reported in Fig. 1.

Results have been averaged over a set of 41 uniformly spaced energy values, in a range of 80 µeV (corresponding to about 10\(kT/e\) for a temperature of 100 mK, with \(k\) being the Boltzmann constant and \(T\) the absolute temperature) around a Fermi energy of \(E_F = 9\) meV, typical of electrons in the 2DEG of a GaAs/AlGaAs heterostructure\(^{35}\).

We have initially considered a constant number of 1100 scatterers and we have studied the behavior of the shot noise suppression factor as a function of their height in the 0-20 meV range. Results are reported in Fig. 2 for a height of the scatterers that is much less than the Fermi energy of the electrons, there is substantially no significant effect and the Fano factor equals 1/4, as in an ideal cavity.

As the height of the scatterers is increased, the Fano factor approaches the value 1/3 and seems to saturate around it as the scatterer height grows past 10 meV. From this result one would be tempted to conclude that, as the strength of the scatterers is increased, the noise behavior evolves from that typical of a chaotic cavity to that of a diffusive conductor. However, saturation to 1/3 is observed just because, as the height of the scatterers rises above the Fermi level, their contribution becomes equivalent to that of hard-wall scatterers of infinite height, and therefore any further increase of their actual height has no effect.

In order to vary the strength of the disorder in a way that does not lead to saturation, we have acted upon on the density of the scatterers. We have considered the same square 50 × 50 nm\(^2\) scatterers, but with a height of 15 meV (corresponding to a hard-wall behavior at the considered Fermi energy) and varied their total number. Results are shown in Fig. 3 we notice that, as the scatterer number increases, the Fano factor crosses the value 1/3 and rises well beyond it, due to strong localization. In particular, the interval over which it is close to the 1/3 limit is quite narrow, and it clearly contains the previously considered value of 1100 obstacles. This is in

![Random square scatterers](image1.png)

**Fig. 1.** Sketch of a 5 µm long and 8 µm wide hard-wall mesoscopic cavity with 50 × 50 nm\(^2\) random scatterers and 400 nm or 800 nm wide openings.

![Cavity openings](image2.png)

**Fig. 2.** Fano factor for a 5 µm long and 8 µm wide cavity, as a function of the number of scatterers, for \(E_F = 9\) meV. The cavity has 400 nm wide openings, which, in the absence of randomly located scatterers, lead to a Fano factor of 1/4.

![Fano factor](image3.png)

**Fig. 3.** Fano factor as a function of the number of scatterers, for a 5 µm long and 8 µm wide mesoscopic cavity, with 400 nm wide openings and \(E_F = 9\) meV.
agreement with the results that we have previously reported\cite{12,33} for a disordered conductor without any cavity, for which we have shown that it is quite unlikely that diffusive transport will be reached under the typical conditions that can be found for mesoscopic structures based on semiconductors, mainly because of the limited number of propagating modes.

We have also investigated the probability density function of the transmission eigenvalues, which provides an insight into the transport regime\cite{34}. The interval (0,1) of possible values of the transmission eigenvalues has been subdivided into 200 equal subintervals and (for 81 uniformly spaced energy levels in the considered energy range) the fraction of the \(N\) modes propagating through the overall structure with a transmission value within each subinterval has been evaluated. These data, divided by the width of the subintervals, are reported in Fig. 4 for an empty cavity and for a cavity containing 1100 or 5600 square scatterers. As can be seen, increasing the number of scatterers the fraction of transmission eigenvalues around zero increases, while the peak around one decreases and finally disappears. In particular, we notice that in the absence of scatterers the probability density function is the one analytically expected for an empty cavity (i.e. that of Eq. (4), plotted with a dashed line), while when the Fano factor crosses \(1/3\) (for 1100 scatterers) it approaches the behavior expected\cite{35} for a diffusive conductor (reported with a dotted line).

For a diffusive conductor, the expected probability density function for the transmission eigenvalues is given by:

\[
p(T)_{\text{diff}} = \frac{1}{b} \frac{1}{T\sqrt{1-T}} \Theta(T - T_0),
\]

(5)

where \(\Theta(T)\) is the Heaviside step function and

\[
T_0 = \frac{4e^b}{(1 + e^b)^2}
\]

(6)
is chosen in such a way that the integral between 0 and 1 of \(p(T)_{\text{diff}}\) is equal to 1 (in the absence of the Heaviside step function it would instead diverge). The value of the parameter \(b\) has been chosen to fit the conductance obtained with our transport simulation for 1100 square scatterers. In particular, the conductance in a diffusive structure is given by

\[
G_{\text{diff}} = G_0 N \int_0^1 T p(T)_{\text{diff}} \, dT = G_0 N \frac{2}{b} \tanh \left( \frac{b}{2} \right)
\]

(7)

(where \(G_0 = 2e^2/h\) is the conductance quantum) and, since from our simulations with 1100 scatterers we have obtained \(G = 3.89 G_0\), we have selected the value \(b = 7.2\) for the representation of the analytical curve.

So far we have studied the effect of disorder on a cavity that, when clean, already exhibits a Fano factor of 1/4, due to symmetry and to narrow enough constrictions. Let us now move to a situation analogous to the one investigated in Refs.\cite{31,32}, in which we start from a clean cavity with wider constrictions (800 nm) and, therefore, with a Fano factor below 1/4.

In Fig. 5 the resulting Fano factor is reported as a function of the scatterer height for 1200 scatterers. For very low values of the obstacle height, the Fano factor is below 1/4, while, when the scatterer height is increased, it crosses the value 1/4 and approaches the value 1/3, as in the previously discussed case of Fig. 2.

If the number of scatterers is increased beyond 1200, the Fano factor grows above 1/3, as in the case of the cavity with 400 nm wide constrictions. In Fig. 6 the shot noise suppression factor is plotted as a function of the number of scatterers.

These results confirm a few main points: a) the Fano factor of 1/4 is achieved independent of the chaotic or regular shape of the cavity, as long as the constrictions are
In order to evaluate their contribution to the potential landscape at the 2DEG level, we have resorted to the semi-analytical expression given by Stern and Howard\textsuperscript{20} for the screened potential due to a point charge located at a distance $D$ from the 2DEG.

We have initially computed a potential profile resulting from ionized impurities located $D = 40$ nm away from the 2DEG, which is a realistic distance for actual heterostructures, where a spacer layer separates the dopants from the 2DEG, in order to reduce their effect on transport.

Even without a fully self-consistent approach, the generation of such a potential is a computationally intensive task, due to the relatively large area of the cavity. Therefore, in order to keep the computational complexity under control, the full computation has been performed only for $D = 40$ nm, and the disorder strength has then been varied by simply scaling the result by a factor $M$, instead of repeating the full calculation for different values of $D$.

Since we are considering dopants distributed over a finite region, this leads to a fictitious minimum of the potential in the middle of the structure, due to the reduced number of dopants acting upon points in the region near the boundaries\textsuperscript{22}. In order to avoid this effect and to keep a flat average potential, we have resorted to the approximate approach mentioned in Ref.\textsuperscript{22}, including also positive impurities, in a number equal to the negative ones.

With this approach, the behavior of the Fano factor has been computed for 7 different impurity densities $N_D$, as a function of the disorder strength scale factor $M$.

Results are shown in Fig.\textsuperscript{7} as we can see, for impurity concentrations that are typical of practical heterostructures ($N_D \approx 10^{15}$ m$^{-2}$) the Fano factor, which is close to $1/4$ for very low values of the parameter $M$ as expected, rapidly increases to values well above $1/3$.

As the disorder strength is raised, the curves in Fig.\textsuperscript{7} are characterized by larger fluctuations, because the number of modes with significant transmission decreases, and the energy averaging that we perform is not sufficient to achieve a smooth curve any longer. To make it smoother we should perform an ensemble average over different realizations of the random potential landscape, which however would not be very meaningful, since it would not correspond to what can be measured in an actual experiment (except for the unlikely case in which many cavities were connected together in parallel and measured at the same time).

If we compare these results with those obtained in the absence of the mesoscopic cavity, for a purely disordered conductor\textsuperscript{24}, we see that, although in the present case the behavior is less smooth and the region of diffusive transport is narrower, the Fano factor crosses the value $1/3$ for about the same impurity strength. This indicates that, also in the presence of more realistic disorder inside the cavity, the noise properties of the whole system are dominated by the diffusive (or better, for most values of the disorder strength, quasi-diffusive) regions. Moreover, since the fully diffusive regime is achieved within a

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![FIG. 6. Fano factor as a function of the number of scatterers, for a 5 $\mu$m long and 8 $\mu$m wide mesoscopic cavity, with 800 nm wide openings and $E_F = 9$ meV.](image)

![FIG. 7. Fano factor for a 5 $\mu$m long and 8 $\mu$m wide hard-wall mesoscopic cavity, with 400 nm wide openings, as a function of the scale factor $M$ multiplying the realistic potential fluctuation, for 7 different impurity concentrations $N_D$ and for $E_F = 9$ meV.](image)

symmetric and narrow enough; b) no disorder is needed to achieve the Fano factor of 1/4; c) in the presence of disorder the Fano factor rises: if originally below 1 it crosses the value 1/4 without any appreciable plateau, and reaches, as the disorder strength is increased, the diffusive limit of 1/3, which is crossed, too, for choices of the parameters typical of mesoscopic semiconductor structures, with an increase towards 1, as the strong localization regime is approached.

In order to understand whether the results obtained so far are of general validity, we have studied the effect of a more realistic potential profile on shot noise suppression. We have started by considering the same 5 $\mu$m long and 8 $\mu$m wide hard-wall mesoscopic cavity with 400 nm wide openings, with the addition of potential fluctuations at the level of the 2DEG resulting from randomly located ionized dopants and charged impurities, which, at low temperatures, represent the dominant source of scattering.

![FIG. 7. Fano factor for a 5 $\mu$m long and 8 $\mu$m wide hard-wall mesoscopic cavity, with 400 nm wide openings, as a function of the scale factor $M$ multiplying the realistic potential fluctuation, for 7 different impurity concentrations $N_D$ and for $E_F = 9$ meV.](image)
very narrow interval of the disorder strength scale factor $M$, we observe only a rapid transition of the Fano factor through the value 1/3. This behavior is very similar to what we have previously observed in the presence of hard-wall scatterers.

Something closer to a plateau is observed only for very low impurity concentrations ($N_D = 1.1 \times 10^{13}$ m$^{-2}$) and very large values of the parameter $M$, as shown in Fig. [7]. However, as previously demonstrated (29), with this choice of parameters the resulting potential fluctuations appear definitely unrealistic for a semiconductor-based device. Indeed, there would be few very large, in terms of their extension on the 2DEG plane, scatterers, while in GaAs/AlGaAs heterostructures typical impurities cause very sharp and localized potential fluctuations.

Moreover, in Fig. [7] we can observe that for the lowest considered impurity density ($N_D = 1.1 \times 10^{12}$ m$^{-2}$), the 1/3 value is not reached even for very large values of the scale factor $M$, which indicates that transport becomes almost ballistic.

Then, also for this type of disorder we have considered a cavity with wider constrictions (800 nm wide, as in the case of Fig. [6]), assuming a donor density $N_D = 1.1 \times 10^{14}$ m$^{-2}$. The results for the Fano factor as a function of the disorder strength are reported in Fig. [8]. We observe a behavior analogous to that for the case of hard-wall scatterers, with the shot noise suppression factor increasing from a value below 1/4 (since for a null disorder scale strength factor, i.e. for a clean cavity, the width of the constriction is not small enough to achieve the regime characterized by a Fano factor of 1/4), crossing 1/4, reaching 1/3 and increasing beyond 1/3.

If we again compare the results reported here with those obtained in the absence of the constrictions defining the cavity (see Ref. [29]), we notice that the value of 1/3 is reached for approximately the same parameter values ($N_D$ and disorder scale strength factor), i.e. in the narrow interval within which the conductance satisfies the condition of Eq. [3] for diffusive transport. This confirms that in conductors with strong disorder the noise properties become almost completely independent of the presence of the constrictions that define the cavity.

Finally, we have studied a device that is realistic also from the point of view of the confining potential, obtained by depletion gates deposited on the heterostructure surface. Such a potential is included considering the screening effect of the 2DEG, which provides an essential contribution.

The solution of the complete self-consistent problem for a device with a size of several micrometers would be very demanding from the computational point of view. Therefore, for the evaluation of the potential profile at the 2DEG level, we have used a semi-analytical approach proposed by Davies et al. (40). We can consider the two-dimensional electron gas as an equipotential surface when its kinetic energy is much smaller than the electrostatic potential between the surface and the 2DEG. In this case, we can solve the Poisson equation with Dirichlet boundary conditions: at the surface we consider the potential equal to the gate bias under each electrode and zero elsewhere, and at the 2DEG level the potential is assumed to be constant and equal to zero. Then, combining Coulomb’s theorem and the expression for the two-
dimensional density of states, we obtain that the screened potential, to first order, is given by

$$\phi_{scr} = -\frac{\pi \hbar^2 \varepsilon_0 \varepsilon_r}{m^* e^2} \frac{\partial \phi}{\partial z} \bigg|_{z=d}$$

with $\varepsilon_0$ being the vacuum permittivity, $\varepsilon_r$ the relative permittivity of the semiconductor, $\phi$ the electrostatic potential, $d$ the depth of the 2DEG with respect to the surface, $m^*$ the electron effective mass, and $\hbar$ the reduced Planck constant.

For the potential fluctuations inside the cavity we have used the same approach that has been previously described.

In the upper panel of Fig. 9 the layout of the gates that create the cavity is shown. The split gates defining the constrictions have been designed in such a way as to have the same number of propagating modes as in the hard-wall cavity with 400 nm wide constrictions; this requires a gap of 500 nm, with a bias of $-2.5\, V$. The bias applied to the horizontal gates is instead of $−3.5\, V$. In the lower panel of Fig. 9 we show the resulting potential at the 2DEG level, with the inclusion of disorder.

In Fig. 10 the Fano factor as a function of the disorder scale factor $M$ for 7 different impurity concentrations $N_D$ is shown. The results are comparable to what we have observed in Fig. 4. This indicates that the specific details of the potential profile defining the cavity do not play an essential role in determining the noise properties of the whole system. Also in this case, for typical $N_D$ values of realistic heterostructures, the Fano factor rises rapidly from 1/4 to values well above 1/3, and a behavior close to the diffusive one is observed only in the case of low impurity concentrations and unrealistically large values of $M$. Once again, for $N_D = 1.1 \times 10^{12} \, m^{-2}$ we can argue that transport is almost ballistic.

III. CONCLUSION

We have performed a detailed numerical analysis of the effect of disorder on shot noise suppression in mesoscopic cavities, with the aim of reaching general conclusions and clarifying issues that had been left open in the existing literature.

Our results, while further confirming that the characteristic suppression down to 1/4 of full shot noise in symmetric mesoscopic cavities can be achieved in cavities with a regular shape and as a result of diffraction due just to the constrictions and to the corners, makes clear that the inclusion of disorder leads to an increase of the Fano factor, and, as its strength is raised, a shot noise behavior typical of disordered conductors is reached, independent of the presence of the constrictions.

In particular, for cavities with constrictions that are narrow enough to yield, without disorder, a Fano factor of 1/4, the addition of disorder leads to an increase of shot noise up to 1/3 and beyond, with a plateau around 1/3 only for choices of the parameters that warrant the achievement of the diffusive regime in a range of values of the disorder strength. In the case of cavities with wider constrictions, the Fano factor in the absence of disorder is below 1/4 and, as the disorder strength is increased, raises, crossing 1/4 without any visible plateau and then evolving in a way analogous to that of the cavities with narrower constrictions. This confirms that disorder does not contribute towards the achievement of the chaotic regime associated with the Fano factor of 1/4 in the way predicted by the existing literature.

In the case of strong disorder, the body of the cavity acts as a diffusive or quasi-diffusive conductor that effectively separates the entrance and exit constrictions and dominates the noise behavior.

Furthermore, from our results it is apparent that the overall noise characteristics are not strongly dependent on the details of the confinement potential and on the nature of the specific disorder being considered.
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