An error does not become truth by multiplied propagation. ***Mahatma Gandhi***

Facts and myths about zero-point thermal noise and Information entropy versus thermal entropy

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Abstract.

- The existence of non-zero Johnson noise when approaching zero temperature has been debated many times, yet it is almost generally accepted. We point our that the acceptance of non-zero zero-point noise leads to perpetual motion machines that violates the Second Law of Thermodynamics. The Fluctuation-Dissipation Theorem for voltage/current noise is unacceptable in its present form in the quantum limit and the correct theoretical result must depend on the particular type of noise measurement system.

- Information entropy and thermal entropy are apples and oranges and they do not generally obey Brillouin's principle and never satisfy Landauer's erasure dissipation principle for memories.

L.B. Kish, G.A. Niklasson, C.G Granqvist, "Zero-point term and quantum effects in the Johnson noise of resistors: A critical appraisal", *J. Stat. Mech.* **2016** (2016) 054006. *Online:* http://arxiv.org/abs/1504.08229 .

L.B. Kish, G.A. Niklasson, C.G. Granqvist, "Zero thermal noise in resistors at zero temperature", *Fluct. Noise. Lett.* **15** (2016) 1640001.
Online: http://www.researchgate.net/publication/303959024_Zero_Thermal_Noise_in_Resistors_at_Zero_Temperature

L.B. Kish, D.K. Ferry, "Information entropy and thermal entropy: apples and oranges", submitted for publication (2017)
Online: https://arxiv.org/abs/1706.01459

van Kampen's note at ICNF-1987, when he criticized several different theories:

Theory is good for you

Provided the theory is correct

We can add here:

Experiment is good for you

We can add here:

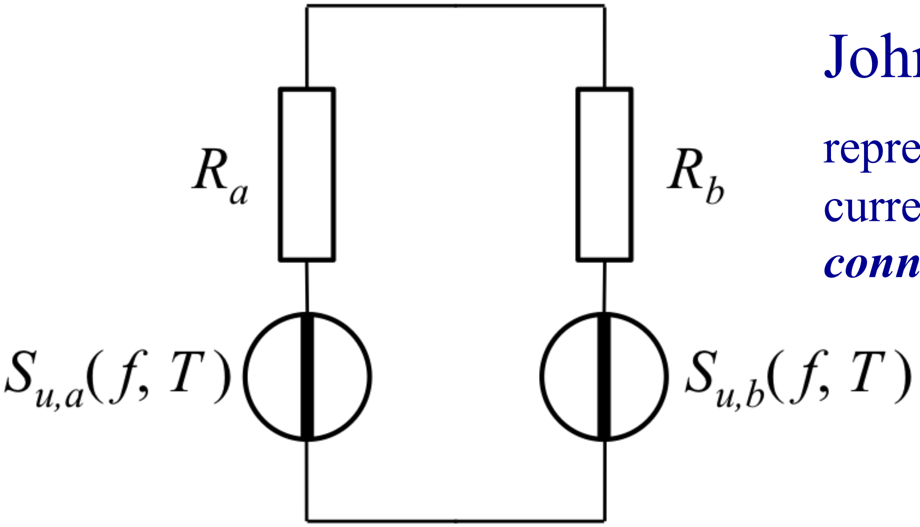
Experiment is good for you

Provided its interpretation is correct

Is the thermal noise at zero temperature?

Note: many colleagues have strong opinions about this issue, which can lead to heated debates ☺

On the picture, Mark Dykman is intensively trying to convince me at UPON-2015 in Barcelona that the FDT is correct and the zero-point term does exist. Now, he agrees with us, see the arguments at the end.



Johnson noise of resistors

represented by a serial voltage generator or parallel current generator ***which are independent from the connected external circuitry or measurement setup***.

$$S_u(f,T) = R(f)Q(f,T) \qquad\qquad S_i(f,T) = G(f)Q(f,T)$$

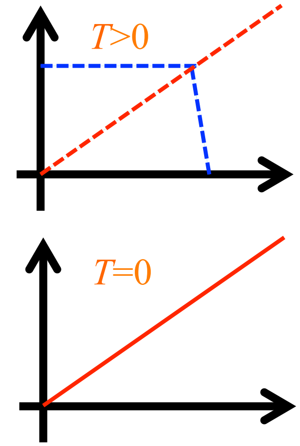
$Q(f,T)$ is a ***universal function*** that is independent from the resistance, the material, the conduction mechanism and the geometry to guarantee the Second Law of Thermodynamics:

$$\text{When} \quad T_A = T_B \ , \quad P_{A\to B}(f,\Delta f) = 0$$

$$P_{A\to B}(f,\mathrm{d}f) = (T_A - T_B)\,Q(f,T)\,\frac{R_A R_B}{(R_A + R_B)^2}\,\mathrm{d}f$$

The topic of debate: Does $Q(f,T)$ converge to zero when the temperature approaches zero?

Callen-Welton (quantum FDT), 1951:



$$S_{u,q}(f,T) = \underbrace{R\,4hf\left[N(f,T)\right.}_{\textbf{Nyquist 1927.}} \left.+\,0.5\right]$$

Planck quantum number $$N(f,T) = \left[\exp(hf/kT) - 1\right]^{-1}$$

For $f << kT/h$, or $hf/k << T$, *classical* Johnson noise formula: $S_u \cong 4kTR$

For $\boldsymbol{kT/h << f}$, or $\boldsymbol{T << hf/k}$, zero-point noise formula: $S_{u,ZP} = 2hfR$

similar for current noise: $S_{i,ZP} = 2hfG$

The meaning of the power-density spectrum of voltage in measurements is well-established and most of today's quantum schools believe *in the explicit visibility* of the zero-point term in Johnson noise. (Otherwise the fluctuation-dissipation theorem for resistor noise is not more but just Nyquist.)

Alternative quantum FDT theories later on, including ones based on quantum electrodynamics, yielding the same result as that of Callen-Welton.

The experiment: Josephson-junction heterodyne detection (spectral analysis by frequency mixing to DC)

Note: this Josephson-junction effect has been confirmed even at many independent occasions.

$$S_{u,q}(f,T) = 4Rhf\left[N(f,T) + \mathbf{0.5}\right]$$

VOLUME 47, NUMBER 17 PHYSICAL REVIEW LETTERS 26 OCTOBER 1981

Observation of Zero-Point Fluctuations in a Resistively Shunted Josephson Tunnel Junction

Roger H. Koch, D. J. Van Harlingen,[a] and John Clarke

Department of Physics, University of California, Berkeley, California 94720, and Materials and Molecular Research Division, Lawrence Berkeley Laboratory, Berkeley, California 94720

(Received 27 July 1981)

The spectral density of the voltage noise has been measured in current-biased resistively shunted Josephson junctions in which quantum corrections to the noise are expected to be important. The experimental data are in excellent agreement with theoretical predictions, demonstrating clearly the contribution of zero-point fluctuations that are generated in the shunt at frequencies near the Josephson frequency and mixed down to the measurement frequency.

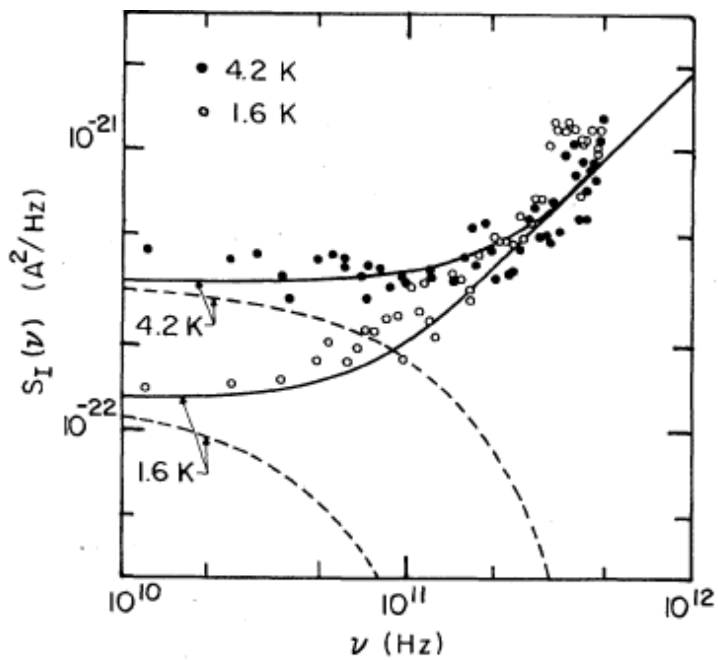


FIG. 3. Measured spectral density of current noise in shunt resistor vs the Josephson frequency $\nu = 2eV/h$ at 4.2 K (solid circles) and 1.6 K (open circles). Solid lines are predictions of Eq. (2), while dashed lines are $(4h\nu/R)[\exp(h\nu/k_BT)-1]^{-1}$.

John Clarke,

ICNF, Montreal, May 27, 1987

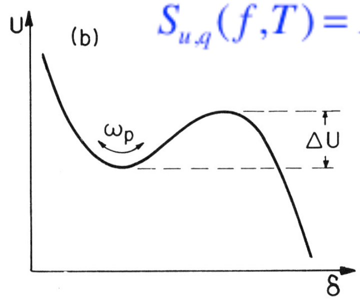
Negative experiments

1981, the same Richard Voss, who went around with the 1/f noise in music show later.

PHYSICAL REVIEW B VOLUME 24, NUMBER 12 15 DECEMBER 1981

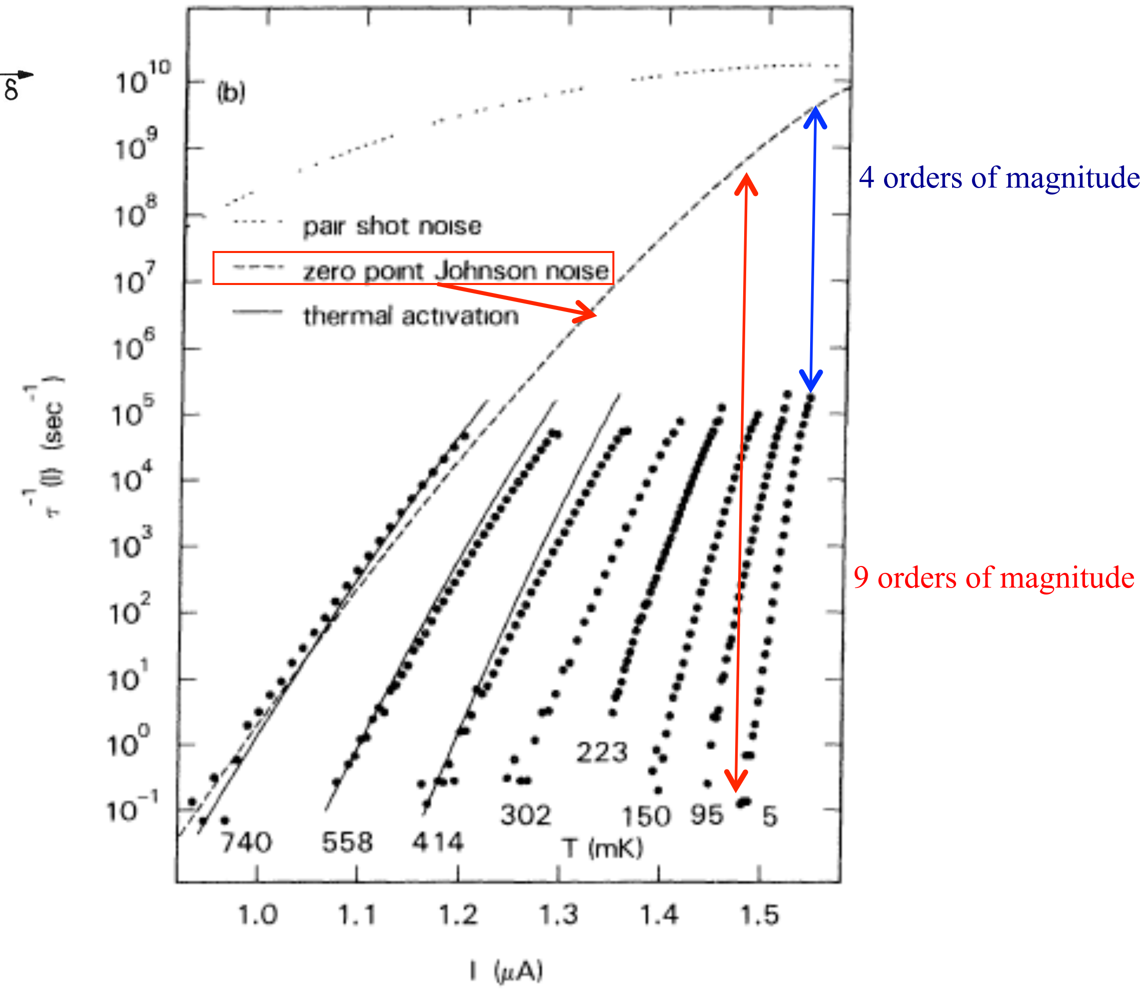
Pair shot noise and zero-point Johnson noise in Josephson junctions

Richard F. Voss and Richard A. Webb
IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598



$$S_{u,q}(f,T)=R\,4hf\left[N(f,T)+\cancel{0.5}\right]$$

Transition rates $\tau^{-1}(I)$ with theoretical predictions.



Their conclusion was the potential well models of Josephson junctions with Langevin type formulation were inappropriate. *The possibility that the zero-point noise was not present was not mentioned.*

A. van der Ziel's negative experimental outcome for non-heterodyne microwave measurements.

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$

They did not see the zero-point term via direct (non-heterodyne) measurements of *Hanbury Brown-Twiss (HBT)* type microwave circuitry at 1 Kelvin temperature and up to 95 GHz frequency, even though this frequency limit at this temperature is about 5 times beyond the *kT/h* classical/quantum boundary and their accuracy to measure noise-temperature was 0.1 Kelvin.

C.M. Van Vliet, Equilibrium and non-equilibrium statistical mechanics, (World Scientific 2008).

A. van der Ziel, Proc. ICNF, Washington DC, 1981.

(The *HBT* principle of the instrument is based upon the correlation between the rectified outputs of two independent receivers.)

I guess they saw only the black body radiation and gave it up due to the KVC experiments in PRL ...

Aldert van der Ziel

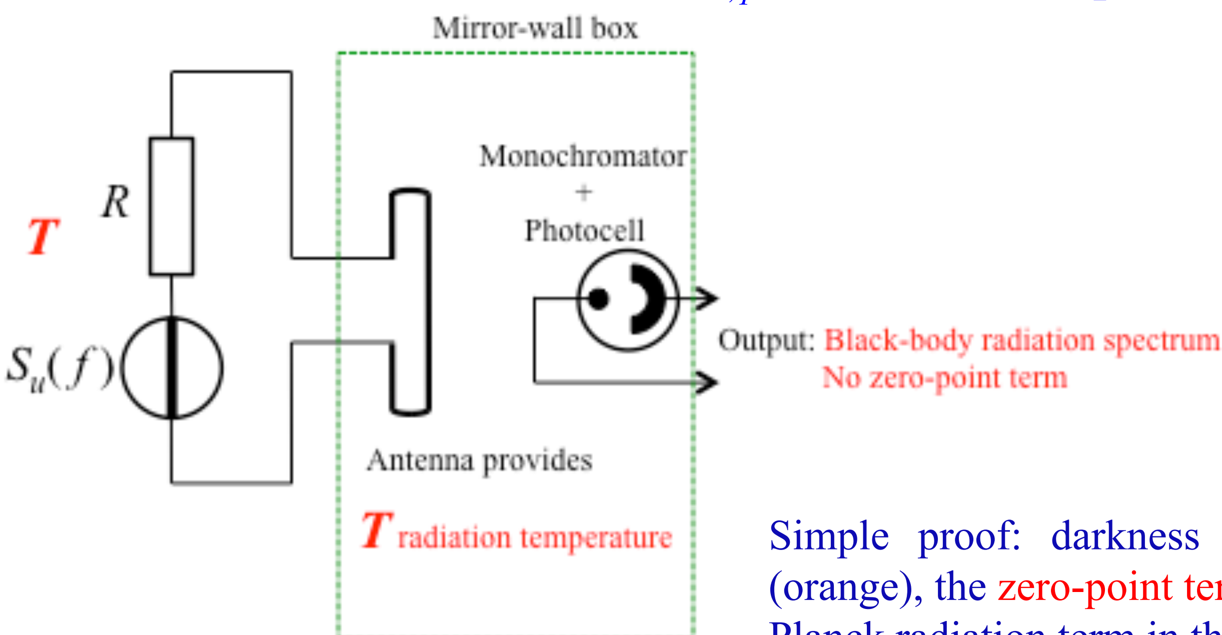
Montreal, ICNF, May 27, 1987

Negative experiments Wilhelm Wien 1896:

Black-body radiation (see Planck formula) in the high-frequency limit

Photocell vs antenna, G. Grau and W. Kleen, Solid-State Electron. 25, 749 (**1982**)

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$



Werner Kleen 1967

(In 1988, I was guest at his house, in Munich, for a few days, but he was not interested in the zero-point problem, anymore.)

Simple proof: darkness in a dark room. At 600 nm (orange), the zero-point term is 30 times greater (!) than the Planck radiation term in the sunshine.

(This scheme is a more rigorous derivation of the Nyquist formula than Nyquist's own derivation, which contains some ad-hoc, unjustified steps.)

Correct claim and it has not been answered by quantum the FDT theory from the very beginning!

Conceptual objections

D. K. C. Macdonald, Physica 28, 409 (**1962**)

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$

The zero-point noise cannot exist because, in that frequency range, kT/h << f , processes are reversible and noise would require irreversibility.

Incorrect statement, it is not valid in general. For example optical absorption is irreversible while ***kT/h << f*** *.*

=====================

I.A. Harris, Electron. Lett. 7, 148 (**1971**)   (at National Buro of Standards)

The <u>available (observable) noise power</u> should include only the Nyquist term and any other quantum term associated with the detector or receiver.

$$S_{u,q}(f,T) = 4Rhf\left[N(f,T) + \cancel{0.5}\right]$$

(based on J. Weber, "Quantum theory of a damped electrical oscillator and noise", Phys. Rev. 90, 977 (**1953**) and H. Heffner, "The Fundamental Noise Limit of Linear Amplifiers", Proc. IRE 50, 1604 (**1962**))

Can the observed zero-point term be the fluctuation of the zero-point energy ?

W. Kleen, ICNF Proc. (**1985**) : *In a stable system, the zero-point energy does not fluctuate thus in cannot emit any energy thus it cannot generate a noise.*

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$

FDT derivations are incorrect?

Recently, L. Reggiani, et al. criticized the FDT derivations.

L. Reggiani, P. Shiktorov, E. Starikov and V. Gružinskis, "Quantum fluctuation dissipation theorem revisited: remarks and contradictions", *Fluct. Noise Lett.* **11** (2012) 1242002 .

Excerpt from their conclusions:

"... the FDT holds at the resonant frequencies of the physical system under test ***only***. Outside the resonant frequencies, the formalism of δ-functions does not allow to determine the frequency interrelation between the spectrum of fluctuations, $S_{xx}(\omega)$, and the imaginary part of the susceptibility, $\mathrm{Im}[\alpha(x)]$.

As a consequence, the commonly adopted interpretation of the QFDT as a universal spectral relation between $S_{xx}(\omega)$ and $\mathrm{Im}[\alpha(x)]$, which is continuous in the whole frequency range $[0,\infty]$ and holds for an arbitrary physical system, is invalid/incorrect."

Lino Reggiani

Pavel Shiktorov

Evgeni Starikov

So, when the measurement frequency is a "resonance frequency" of the system, the old FDT results are still accepted to be correct. For general cases, they show a new formula, which is not easy to evaluate. *Their results support a non-zero zero-point noise, at least at the resonance frequencies of the system.*

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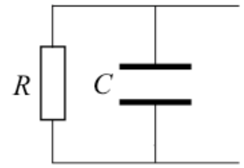
Note: Lino Reggiani and Eleonora Alfinito have a new manuscript claiming that the *zero-point term is invisible because of Casimir force in the material*. At this stage we cannot comment on that work because of issues that are unclear for us and some other points where we disagree.

Renormalization needed ?

L.B. Kiss, Solid State Comm. 67, 749 (**1988**): *zero-point noise would cause divergent energy in a shunt capacitor due to the zero-point noise term, so it should be renormalized*



$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$

However, renormalization, that is neglecting certain infinite terms from results, is not the organic part of quantum theory, so they should be avoided, if possible.

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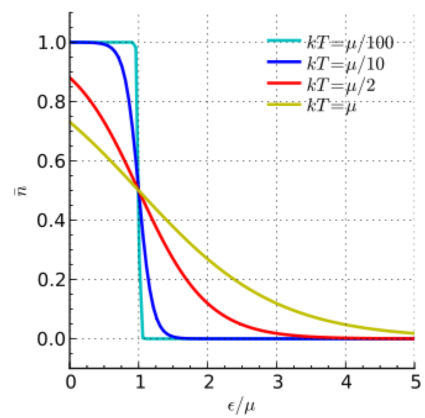
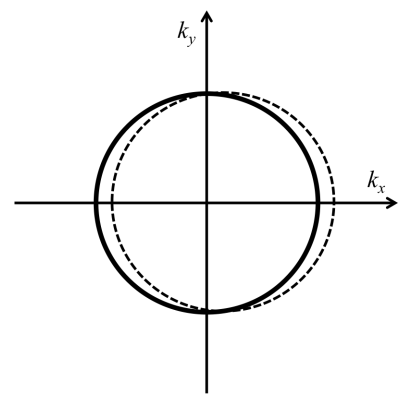
Violation of the Fermi-Dirac statistics?

Kish, et al, *Fluct. Noise. Lett.* **15** (2016) 1640001.

The claim of zero-point current noise contradicts to the Fermi-Dirac statistics in metallic conductors when the temperature is approaching zero. Then all states are occupied up to the Fermi surface and no states can be occupied above. That prohibits any current, including noise current, in this situation.

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$





Uncertainty principle

$$S_{u,q}(f,T) = 4Rhf\left[N(f,T) + \mathbf{0.5}\right]$$

W. Kleen, Solid-State Electron. 30, 1303 (**1987**). :

The observed zero-point noise in the KVC experiments is not coming from the resistor but it is the amplifier noise due the phase-particle number (energy-time) uncertainty noise of quantum amplifiers (masers, Heffner, 1963)

The effect is indeed there and it disqualifies the Josephson junction experiments as proofs of zero-point noise. However, it cannot not prove that the zero-point noise itself does not exist in the resistor.

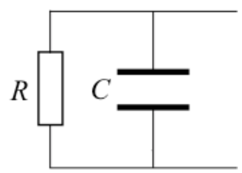
Perpetual motion machines ?

- In fact, already the **antenna-blackbody-radiation system** (Kleen 1982, see above) offers a perpetual motion machine if the FDT is correct.

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T)+\cancel{0.5}\right]$$

- Resistance-dependent energy in a capacitor if the FDT is correct:

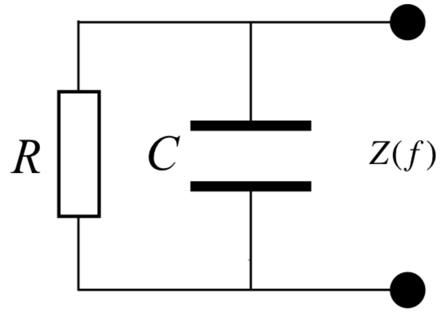
L.B. Kish, Solid State Comm. 67, 749 (**1988**): *If the zero-point noise exists, perpetual motion machines could be constructed by moving capacitor plates. Realization of such was not shown that time.*



$$S_{u,q}(f,T) = R\,4hf\left[N(f,T)+\cancel{0.5}\right]$$

UPoN-2015: We showed two perpetual motion machines. If the zero-point noise is objectively present, we can create at least 2 different types of perpetual motion machines, that is *the Second Law is violated*. One is with a *fixed* capacitor, and another one with a *moving capacitor plate*.

Consider the mean energy due to the zero-point noise term in a capacitor shunting a resistor:

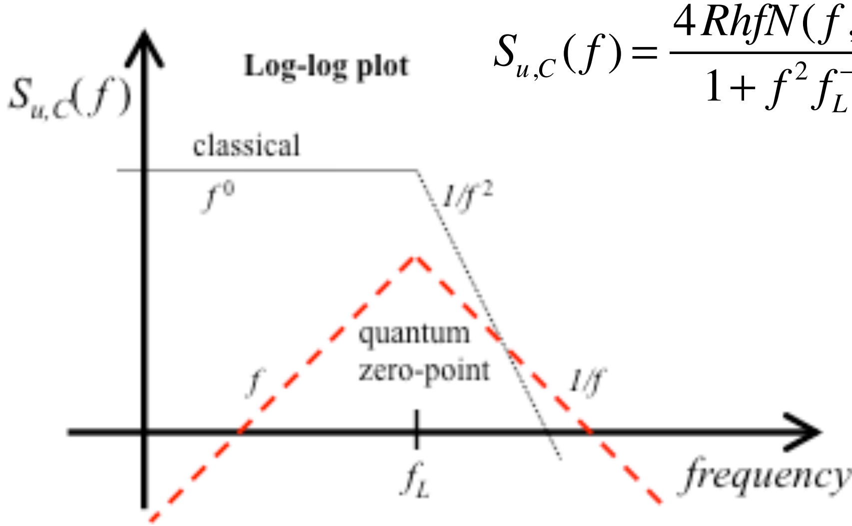


$$Z(f) = \frac{R}{1 + \mathbf{j}\dfrac{f}{f_L}}$$

$$\mathrm{Re}[Z(f)] = R\left(1 + f^2 f_L^{-2}\right)^{-1} \qquad f_L = (2\pi RC)^{-1}$$

$$S_{u,q}(f,T) = 4\,\mathrm{Re}[Z(f)]hf\left[N(f,T) + \mathbf{0.5}\right]$$

$$N(f,T) = \left[\exp(hf/kT) - 1\right]^{-1}$$



$$S_{u,C}(f) = \frac{4RhfN(f,T)}{1 + f^2 f_L^{-2}} + \frac{2Rhf}{1 + f^2 f_L^{-2}}$$

$$\langle E_C \rangle = 0.5C\langle U_C^2(t)\rangle = 0.5C\int_0^{f_c} S_{u,C}(f)\,df$$

For $T \longrightarrow 0$, the classical term exponentially vanishes because of N(T)

thus:
$$\left\langle U_{C,q}^2(t)\right\rangle = \int_0^{f_c} \frac{2hfR}{1+f^2 f_L^{-2}}\,df = hRf_L^2 \ln\left(1+\frac{f_c^2}{f_L^2}\right)$$

and the mean energy is:
$$\boxed{\left\langle E_C\right\rangle = \frac{h}{8\pi^2 RC}\ln\left(1+4\pi^2R^2C^2f_c^2\right)}$$

Because it depends on the resistance, perpetual motion machines can be constructed. How?

Heat generator from zero-point noise (if the zero-point noise in the FDT is correct)

It is an ensemble of ***M*** Units, each one containing two different resistors and one capacitor controlled by the same flywheel in asynchronous way. The capacitors in the Units are periodically alternated between the two resistors by centrally controlled switches, in a synchronized fashion, that makes the relative control energy negligible.
See, LBK, "Johnson noise engines", Chaos, Solitons & Fractals 44, 114 (**2011**)

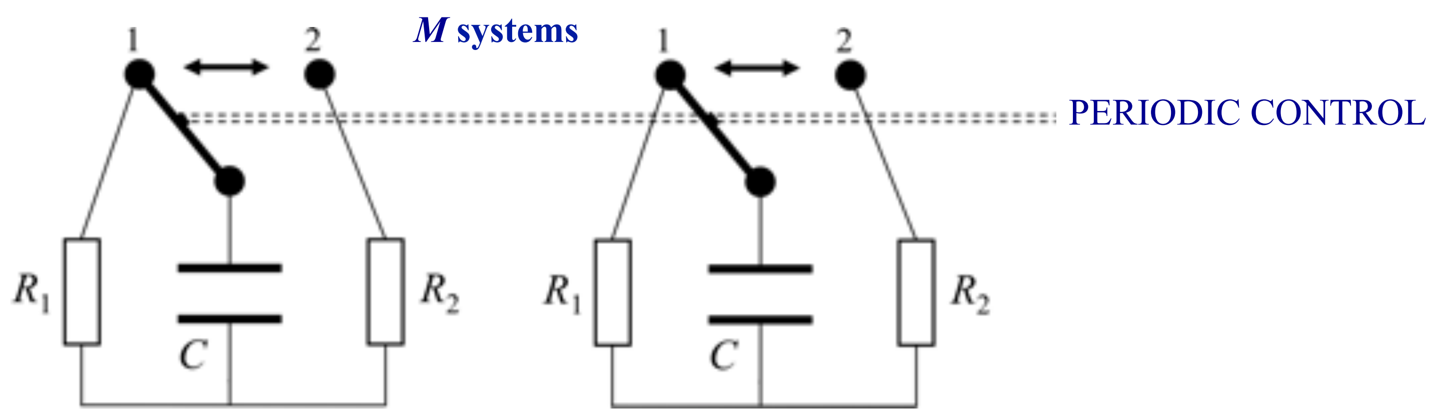
The duration of the period is much longer than any of the RC time constants thus the capacitors are "thermalized" by the zero-point noise in each state. Suppose, $R_1 < R_2$.

Then at each 1 ➔ 2 transition

$$\boxed{0 < E_h = M\frac{h}{8\pi^2 C}\left[\frac{\ln\left(1+4\pi^2 R_1^2 C^2 f_c^2\right)}{R_1} - \frac{\ln\left(1+4\pi^2 R_2^2 C^2 f_c^2\right)}{R_2}\right]}$$

energy is dissipated in R_2 .

This energy is coming from the zero-point noise of R_1. It can be used to drive the flywheel that controls the system.



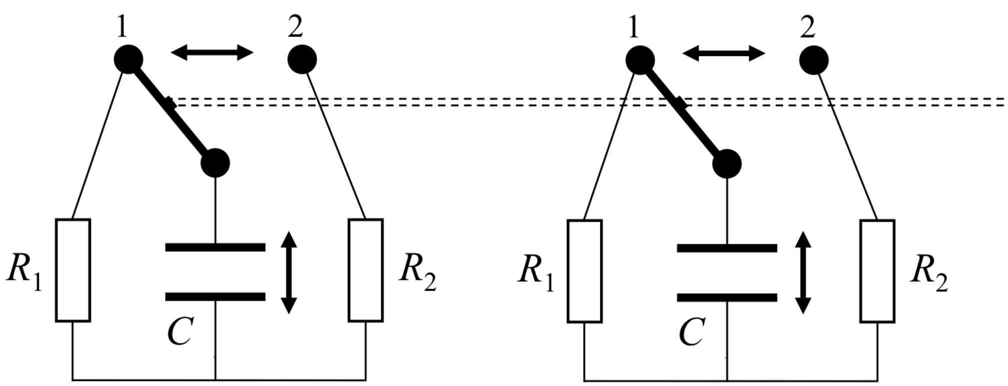
Thus, the zero-point term cannot exist: $\boxed{S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]}$

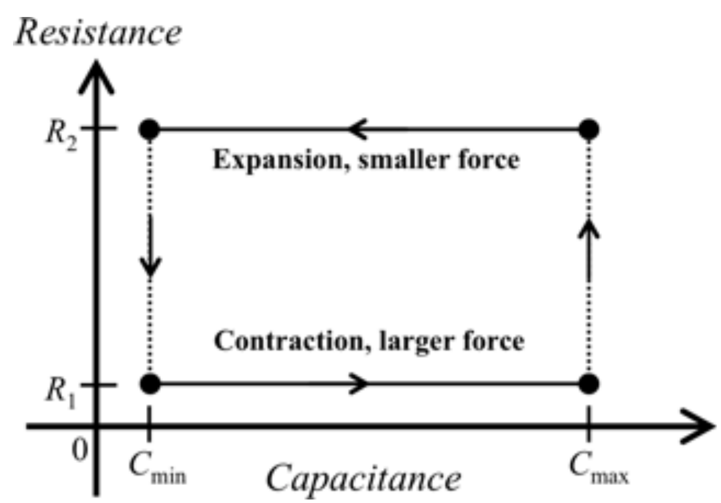
Two-stroke engine (and heat generator) from zero-point noise (if the FDT is correct)

The engine has M parallel cylinders with identical elements and parameters as in the heat generator. The plate-capacitors have a moving plate, which acts as a piston. The moving plates are coupled to a flywheel, which moves them in a periodic, synchronized fashion. When the plate distance reaches its nearest and farthest distance limits respectively, the switch alternates the driving resistor. *During contraction and expansion, we have R_1 and R_2, respectively.*

The mean force in the plate-capacitors is: $$\langle F(x)\rangle = \frac{\langle E_C\rangle}{x} = \frac{1}{x}\frac{h}{8\pi^2 RC(x)}\ln\left[1+4\pi^2R^2C^2(x)f_c^2\right]$$

With $R_1 < R_2$, at any given plate distance x (and corresponding capacitance value), the force is stronger during contraction than during expansion.





The heat-generation effect also kicks in, that is, heat is generated in R_2, similarly to the first perpetual motion machine.

Thus, the zero-point term cannot exist: $\boxed{S_{u,q}(f,T) = R\,4hf\left[N(f,T)+\cancel{0.5}\right]}$

NOTE: Casimir effect in the capacitor is irrelevant!

In the perpetual motion machines introduced above the Casimir effect can always be made negligible by the proper choice of the range of distance x between the capacitor plates during operation.

The Casimir-pressure in a plain capacitor decays with x^{-4}, which implies that

the Casimir force at fixed capacitance value decays with x^{-3}

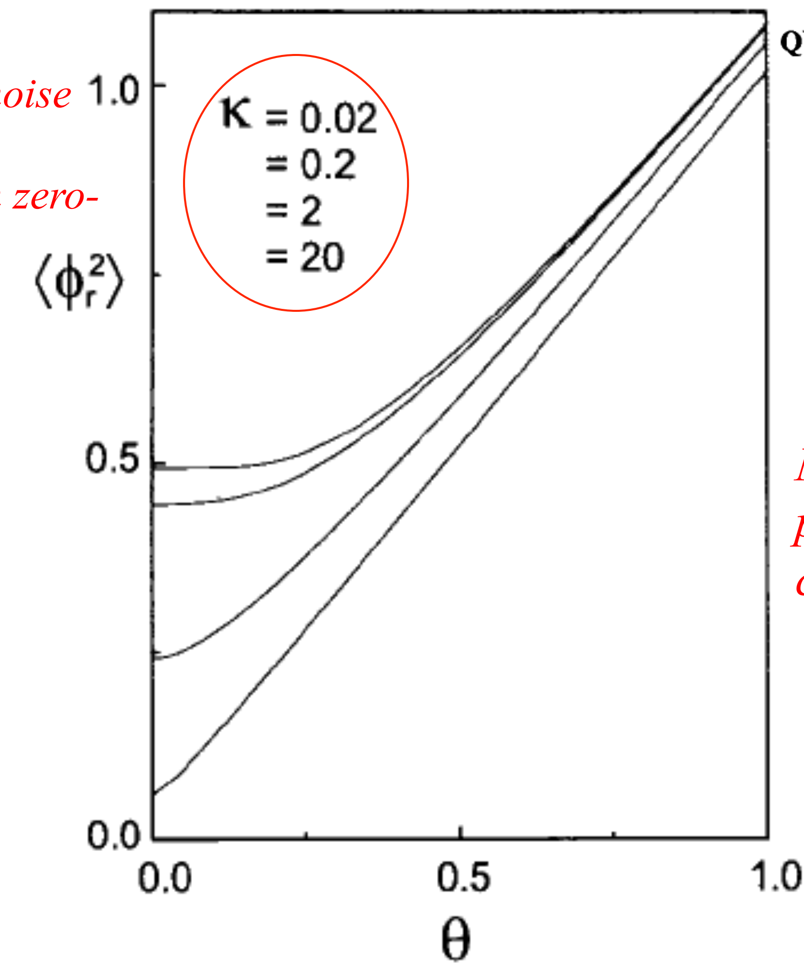
see G. Bressi, et al, Phys. Rev. Lett. 88, 041804 (2002).

At the same time, the force due to the zero-point noise decays as x^{-1}.

Already former theories contain hidden perpetual motion machines! $S_{u,q}(f,T) = 4Rhf[N(f,T) + \mathbf{0.5}]$

Quantum Fluctuations in Electrical Circuits 377

Different magnetic noise energy at different resistances! All from zero-point noise!



QUANTUM FLUCTUATIONS IN ELECTRICAL CIRCUITS

Michel H. Devoret

Service de Physique de l'Etat Condensé
CEA-Saclay, F91191 Gif-sur-Yvette, France

(1997)

Magnetic versions of the above perpetual motion machines can be constructed if the FDT is correct!!!

Fig. 10. Variations of the dimensionless variance $\langle \phi_r^2 \rangle = \langle \Phi^2 \rangle / (\hbar Z_0)$ of flux fluctuations of the LCR circuit as a function of the dimensionless temperature $\theta = k_B T / \hbar\omega_0$ for different values of the dimensionless damping coefficient $\kappa = (2RC\omega_0)^{-1}$.

Possible explanation of positive experiments? (Prof. Pertti Hakonen may judge it)

In the quantum electrodynamical treatment of black body radiation, negative frequencies are carrying the related zero-point terms and those components represent absorption, not emission (Mark Dykman, Kyle Sundqvist).

If the measurement supplies energy that resistor absorbs and the measurement sensitive for these components then the observed effects could somehow be explained. (Mark Dykman)

Kyle Sundqvist

$$S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$$

energy-injection artifact:

$$S_{u,q}(f,T) = 4Rhf\left[N(f,T) + \mathbf{0.5}\right]$$

Questions about this explanation

- How about the uncertainty principle argument of Kleen about the seeming existence of the zero-point term? It looks OK. Niels Bohr's and Heisenberg's thought experiments about the uncertainty principle all include an energy injection by the measurement.

- Is it possible to design a quantum measurement where this negative frequency band is not excited by the measurement setup?

- Or, if not: In classical heterodyne techniques it is possible to construct a setup that discards a given side band. So, even if the negative band is being excited, it may be possible to design a quantum experiment that discards the negative frequency band and to see if the zero-point noise is absent. Or not?

Returning to our perpetual motion machine issue, is this the correct answer? :

In the case of measuring the mean-square thermal noise by the average force in a capacitor in an RC configuration:

- The zero-point term of the FDT is nonexistent; $S_{u,q}(f,T) = R\,4hf\left[N(f,T) + \cancel{0.5}\right]$

- and Nyquist's formula is the correct theory. $S_{u,q}(f,T) = 4Rhf\,N(f,T)$

Returning to our perpetual motion machine issue, is this the correct answer? :

In the case of measuring the mean-square thermal noise by the average force in a capacitor in an RC configuration:

- The zero-point term of the FDT is nonexistent; $S_{u,q}(f,T) = R\,4hf\left[N(f,T)+\cancel{0.5}\right]$ YES!

~~- and Nyquist's formula is the correct theory.~~ $\cancel{S_{u,q}(f,T) = 4Rhf\,N(f,T)}$ NO!

A simple scaling analysis shows that Nyquist's formula has similar problem with a weaker effect of opposite sign. Thus that also allows a perpetual motion machine. At a single frequency the zero-point and Nyquist effects cancel.

Massimo Macucci, as the Reviewer of our paper has even calculated the exact result of the integral for the Nyquist case.

Massimo Macucci

Conclusions for the quantum thermal noise issue:

a) In the quantum limit, the *Johnson noise source spectrum depends on the measurement system* thus the *existing Fluctuation-Dissipation Theories are incorrect for general considerations*.

b) Particularly, each of the discussed measurement systems: the *antenna-based*, the *Josephson junction based* and the *force-in-capacitor based* systems, require different voltage Johnson noise generators in the resistor.

c) *Therefore, in the quantum range, the Johnson noise cannot be represented by a serial voltage noise generator (or parallel current generator) that is independent from the rest of the circuit, like it is in the classical physical limit at low frequencies / high temperatures.*

Information entropy and thermal entropy are apples and orange

Online: https://arxiv.org/abs/1706.01459

The frequent misunderstanding of information entropy is pointed out. It is shown that the two major efforts to find general physical principles that interrelate changes in the information entropy and the thermal entropy in physical systems are invalid. Particularly:

i) In general, the information entropy and its changes contain a component that is subjective to the measurement instrument, while the changes of thermal entropy can be stated objectively.

ii) Brillouin's negentropy principle of information (the expanded formulation of the Second Law including the sum of thermal and information entropies), is invalid as a general rule because principle violations can occur in a physical system provided the temperature of the measurement system is less than that of the measured physical system.

iii) In the case of homogeneous temperatures, it can be seemingly valid if the measurement system is integrated with the measured physical system, or if not, it can be valid within the measurement system alone. However, in classical physical situations, the measurement system and the measured physical system, as well as the change of information entropy and the related change of thermal entropy can be separated in space and time leading to the break of Brillouin's negentropy principle.

iv) There is no case where Landauer's principle of erasure-by-resetting dissipation is even seemingly valid. *Erasure-by-resetting* of the memory does not yield change in the (zero) information entropy when we know the memory content. However, it yields information entropy reduction if we do not know the data. The dissipation is the same in both cases. On the other hand, when erasure happens by *spontaneous thermal randomization* in the same memory, the erasure dissipation is zero.

v) The information entropy can violate the Third Law of Thermodynamics, see zero-point thermal noise. experiments.

Classical physical measurement example to determine a single bit value

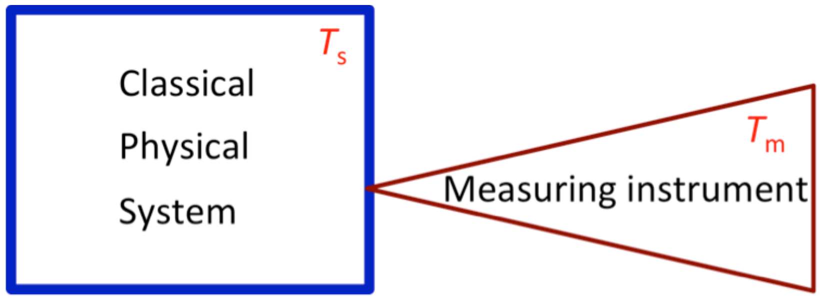


Fig. 3. Classical physical measurement. The measurement instrument can have so weak coupling to the physical system that the energy communication between them is approaching zero (see Figure 4 as example.)

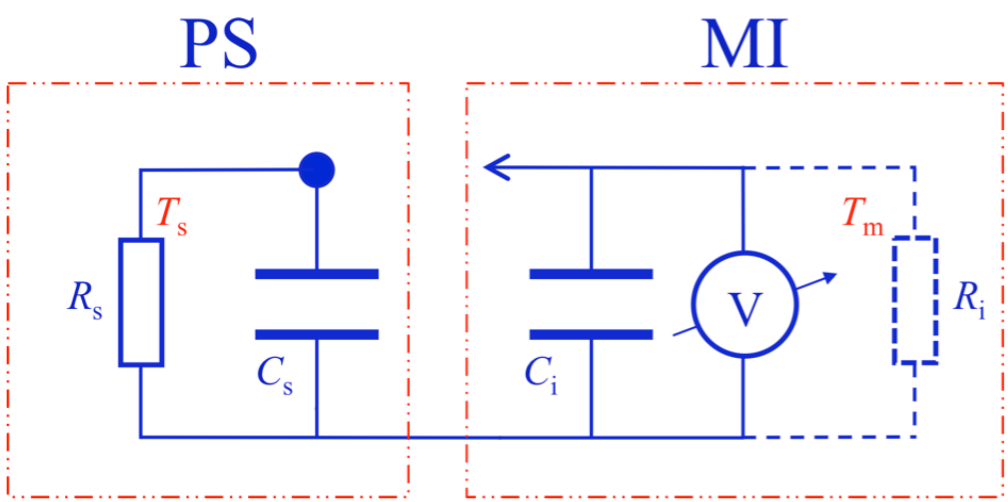


Fig. 4. Determination of the sign of the Johnson noise voltage (thermal noise) on a parallel RC circuit. The MI is briefly connected to the PS to take a sample of the thermal noise voltage on the capacitor C_s. The sample is held by the C_i input capacitor. The voltmeter then measures and displays the result. Note, the measurement of the sampled voltage on C_i can be done later thus the energy dissipation in the physical system and the information entropy change can be separated in time indicating their unconnected nature: the energy dissipation in the PS takes place even when the voltage measurement of the sample is skipped and the information entropy does not change, see Section 4.4.

4.3 A practical example

Here we show a practical example proving that the assumptions in Section 4.2 about the PS and MI are valid. Suppose that the physical system and the measurement instrument are at room temperature, that is, $T_s = T_m = 300\text{K}$. The PS consists of standard commercially available components, $R_s = 4*10^5\,\Omega$ and $C_s = 10^{-9}\,\text{F}$. The MS is also commercially available: the SR 560 preamplifier and an arbitrary AC digital voltmeter connected to its output. The SR 560 has $C_i = 10^{-11}\,\text{F}$ and $R_i = 10^8\,\Omega$ with equivalent input noise data given below.

the energy dissipation in the system is (see Equation 18):

$$\Delta S_{st} T_s = Q_s \le k_B T_s C_i / C_s = 0.01\, k_B T \ , \qquad (31)$$

corresponding to

$$\Delta S_{st} \le 0.01\, k_B \ , \qquad (32)$$

The detailed circuit and error analysis shows that:

$$\boxed{\Delta S_{st} + k_B \Delta S_I = 0.01 k_B - 0.32 k_B = -0.31 k_B \ .} \qquad (33)$$

In conclusion, Brillouin's negentropy principle is violated for the measured physical system when we can separate the measurement instrument, such as in this case.

Reminder: *An error does not become truth by multiplied propagation.* ***Mahatma Gandhi***[i]

End of talk

Quantum Nyquist formula and the applicability ranges of the Callen-Welton formula

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We discuss Yu. L. Klimontovich's objections to the generally accepted derivations of the fluctuation-dissipation theorem and his proposed additional restrictions on the applicability of this theorem. We demonstrate that Yu. L. Klimontovich's arguments contradict the basic principles of statistical physics and hence cannot be correct.

1. Let us recall the problem at hand.

In an electrical circuit described by the equations

$$L\frac{dI}{dt} + RI + \frac{q}{C} = \mathcal{E}, \qquad \frac{dq}{dt} = I, \qquad (1)$$

the varying frequency ω, whereas in the $\hbar\omega \gg kT$ expression (2) falls off exponentially as the frequen creases.*) Obviously, reaching the quantum regime r lowering the temperature T and (or) going to hig quencies ω. We believe that the quantum regime

They use the same kind of calculations for a serial RLC circuit as we do for the perpetual motion machine calculations. They show that, with the Callen-Welton zero-point noise spectrum result, the energy in the weakly-damped LC resonator is equal to the energy of the of the quantum linear harmonic oscillator. At zero temperature, and small resistance, this energy converges to the zero-point energy of the oscillator, $hf_0/2$.

However, there is a problem. If their derived result is correct, then in the large resistance and small inductance limit, *they will get our results and a perpetual motion machine with it!* Thus the assumption that the zero-point noise is in the resistor in this passive situation must be dropped.

Conclusion: it is not possible to derive the zero-point energy of the oscillator with this unphysical assumption that the zero-point voltage noise in the resistor is objectively present there. The agreement in the small resistance limit is only a coincidence.