On the Fluctuations of Dissipation:

An annotated bibliography on the Fluctuation Theorems, Stochastic Thermodynamics and related subjects*

Tech. Note 005 (2025-04-09)
http://threeplusone.com/ftbib

Gavin E. Crooks

2010–2025

Origins: Fluctuation theorem: Evans et al. (1993) [50]. Evans-Searles transient fluctuation theorem: Evans and Searles (1994) [52]. Gallavotti-Cohen fluctuation theorem: Gallavotti and Cohen (1995) [54]. Fluctuation theorem, first use of terminology: Gallavotti (1996) [56]. Jarzynski equality: Jarzynski (1997) [58]. Crooks fluctuation theorem: Crooks (1999) [74]. Hatano-Sasa fluctuation theorem: Hatano and Sasa (2001) [87]. Feedback Jarzynski equality: Sagawa and Ueda (2010) [195].

Reviews and expositions: For a gentle, modern introduction see Spinney and Ford (2013) [223], and then try reading some of the other reviews in the same volume: Sagawa and Ueda (2013) [225], Reid et al. (2013) [226], Gaspard (2013) [224]. See also Evans and Searles (2002) [98], Harris and Schütz (2007) [159], Seifert (2012) [219], Van den Broeck and Esposito (2015) [228]. For reviews and expositions of non-equilibrium single-molecule experiments see Hummer and Szabo (2005) [132], Bustamante et al. (2005) [131], Ritort (2006) [149], Ritort (2008) [181]. Other reviews and expositions: Crooks (1999) [77], Maes (2003) [107], Seifert (2008) [176], Kurchan (2009) [186], Martins et al. (2025) [240]. Textbooks: Gallavotti (1999) [79], Peliti and Pigolotti (2021) [234], Strasberg (2022) [235], Gaspard (2023) [237], Limmer (2024) [239]

Foundations – Thermodynamics and statistical mechanics Efficiency of heat engines and the foundation of thermodynamics: Carnot (1824) [2]; First law of thermodynamics: von Helmholtz (1847) [4]; Second law of thermodynamics Thomson (Lord Kelvin) [5], Clausius (1865) [8]; Entropy: Clausius (1865) [8]; Statistical definition of entropy: Boltzmann (1872) [11], Boltzmann (1898) [15], Planck (1901) [16], Gibbs (1902) [17], Shannon (1948) [30], Jaynes (1957) [33], Jaynes (1957) [32]; Maxwell-Boltzmann distribution: Maxwell (1860) [7], Maxwell (1860) [6], Maxwell (1871) [10], Boltzmann (1872) [11], Boltzmann (1877) [12]; Foundations of statistical mechanics: Boltzmann (1877) [12], Gibbs (1902) [17].

Foundations – Microscopic reversibility and detailed balance: Origins: Tolman (1924) [19], Dirac (1924) [20], Tolman (1925) [22], Lewis (1925) [21], Fowler and Milne (1925) [23]. Discussion: Onsager (1931) [26], Onsager (1931) [27], Tolman (1938) [28], Crooks (1998) [62], Crooks (2011) [211].

Experiments:

- Single molecule Jarzynski: Liphardt et al. (2002) [94];
- single molecule fluctuation theorems: Collin et al. (2005) [135], Ritort (2006) [149];
- dragged optically trapped colloid particle: Wang et al. (2002) [95], Wang et al. (2005) [125], Wang et al. (2005) [139];
- Hatano and Sasa with optically trapped colloid particle: Trepagnier et al. (2004) [117];
- optically trapped colloid particle, time varying spring constant: Carberry et al. (2004) [110], Carberry et al. (2004) [120];
- colloidal particle in periodic potential: Speck et al. (2007) [162];
- colloidal particle in viscoelastic media: Carberry et al. (2007) [160];
- colloidal particle in time dependent non-harmonic potential: Blickle et al. (2006) [144], Speck et al. (2007) [162];
- two level system: Schuler et al. (2005) [126];
- turbulent flow: Ciliberto et al. (2004) [116];
- electric circuit: Garnier and Ciliberto (2005) [128], Andrieux et al. (2008) [169];

*Massively incomplete, hopelessly out-of-date, and only occasionally updated.

- mechanical oscillator: Douarche et al. (2005) [129], Douarche et al. (2005) [137];
- bit erasure, colloidal particle: Bérut et al. (2012) [214];
- theory and discussion: Hummer and Szabo (2001) [84].

Analytic model systems: (Model systems for which the work distributions can be computed analytically)
- Harmonic potentials: Mazonka and Jarzynski (1999) [78];
- two level systems: Ritort et al. (2002) [97], Ritort (2004) [118];
- ideal gas compression: Lua and Grosberg (2005) [124], Lua (2005) [142], Bena et al. (2005) [136], Pressé and Silbey (2006) [152] and effusion: Cleuren et al. (2006) [150];
- Gaussian polymer chains: Speck and Seifert (2005) [123], Dhar (2005) [122], Imparato and Peliti (2005) [121], Pressé and Silbey (2006) [152];
- Joule experiments: Cleuren et al. (2006) [143], adiabatically stretched rotors: Bier (2005) [140];
- charged particles in magnetic fields: Jayannavar and Sahoo (2006) [145];
- adiabatic compression of a dilute gas: Crooks and Jarzynski (2007) [154];

Simulations of work distributions:
- double well: Sun (2003) [102]
- two-dimensional Ising model: Chatelain and Karevski (2006) [147]
- fluctuating lattice Boltzmann model: Chari et al. (2012) [217]

Bochkov-Kuzovlev generalized fluctuation-dissipation theorem: Origins: Bochkov and Kuzovlev (1977) [42], Bochkov and Kuzovlev (1979) [43], Bochkov and Kuzovlev (1981) [44], Bochkov and Kuzovlev (1981) [45]. Summary: Stratonovich (1994) [53]. Relation to Jarzynski equality and fluctuation theorems: Jarzynski (2007) [157], Horowitz and Jarzynski (2008) [174], Pitaevskii (2011) [207]. See also: Schurr and Fujimoto (2003) [105]

Jarzynski equality:
- Origins: Jarzynski (1997) [58], Jarzynski (1997) [61], Crooks (1998) [62].
- Connection to fluctuation theorems: Crooks (1999) [74], Crooks (2000) [80], Kurchan (2007) [161].
- Strong coupling: Jarzynski (2004) [115].
- Microcanonical: Adib (2005) [127]
- Annealed Importance Sampling: Neal (2001) [88]

Gallavotti-Cohen Fluctuation theorem Origins: Gallavotti and Cohen (1995) [54], Gallavotti and Cohen (1995) [55], Gallavotti (1999) [68] Discussion: Gallavotti (1999) [71], Cohen and Gallavotti (1999) [75], Gallavotti (2007) [166], Kurchan (2007) [163], Gallavotti (2019) [230] Simulations: Bonetto et al. (1998) [67]

Stochastic fluctuation theorems Kurchan (1998) [63], Crooks (1998) [62], Lebowitz and Spohn (1999) [69], Crooks (1999) [74], Searles and Evans (1999) [73] ragraphMultivariant fluctuation theorems: García-García et al. (2010) [196], García-García et al. (2012) [213], Sivak et al. (2013) [221]

Fluctuation theorems:
- Escorted fluctuation theorems: Vaikuntanathan and Jarzynski (2011) [205]
- Multivariant fluctuation theorems: García-García et al. (2010) [196], García-García et al. (2012) [213], Sivak et al. (2013) [221]
- Quantum fluctuation theorems: Kurchan (2000) [82], Mukamel (2003) [103], Jarzynski and Wójcik (2004) [112], Monnai (2005) [133], Allahverdyan and Nieuwenhuizen (2005) [130], De Roeck and Maes (2006) [148], Talkner and Hänggi (2007) [158], Crooks (2008) [170], Crooks (2008) [178], Andrieux et al. (2009) [194], Campisi et al. (2009) [189], Campisi et al. (2011) [209], Campisi et al. (2011) [212], Hänggi and Talkner (2015) [227]

Excess free energy: The connection between the excess free energy of nonequilibrium ensembles and relative entropy seems to have been independently rediscovered multiple times[1]. Bernstein and Levine (1972) [39] (Eqs. 44 and 54) defined an "entropy deficiency" as the relative entropy of a nonequilibrium to canonical equilibrium. Shaw (1984) [47] p37 states that available free energy is the relative entropy, but without detailed discussion. Gaveau and Schulman (1997) [60] p348 notes that the relative entropy to equilibrium state is a generalized free energy, but again without much discussion. (See also Gaveau et al. (2002) [100] and Gaveau et al. (2008) [184].) Qian (2001) [86] provides a detailed discussion of the definition of free energy away from equilibrium and its expression as a relative entropy. Hatano and Sasa (2001) [87] discuss the generalization of free energy out of equilibrium and a generalized minimum work principle for steady states. Honerkamp (2002) [101] (p298–301) also makes the connection between relative energy and generalized free energy, apparently independently. The connection between excess free energy and reversible work is shown in Vaikuntanathan and Jarzynski (2009) [193] using a Jarzynski equality like argument. The instantaneous stabilization procedure for (in principle) extracting the reversible (maximum) work is detailed in Hasegawa et al. (2010) [198], Takara et al. (2010) [199] and further discussed in Esposito and

[1] Kudos to David Sivak for tracking down many of the early citations to relative entropy and free energy.

Van den Broeck (2011) [210]. Further discussion and consequences of this interrelation can be found in Sivak and Crooks (2012) [216] and Deffner and Lutz (2012) [220].

Dissipation and the relative entropy between conjugate trajectory ensembles: A good discussion of this relation is found in: Kawai et al. (2007) [155]. See also: Gaspard (2004) [111], Gaspard (2004) [119], Jarzynski (2006) [146], Kawai et al. (2007) [155], Gomez-Marin et al. (2008) [171], Andrieux et al. (2008) [169], Feng and Crooks (2008) [173], Horowitz and Jarzynski (2009) [187], Parrondo et al. (2009) [192], Jarzynski (2011) [204]

Feedback control: Origins: Sagawa and Ueda (2010) [195]; Generalized Jarzynski (Single loop feedback): Sagawa and Ueda (2010) [195]; Experiments: Toyabe et al. (2010) [200]; Multi-loop feedback: Horowitz (2010) [202], Fujitani and Suzuki (2010) [197].

Time's Arrow: Origin of term: Eddington (1928) [24]; Useful philosophical discussions: Price (1996) [57], Albert (2000) [83]. Past hypothesis: Albert (2000) [83]. Length of: Feng and Crooks (2008) [173].

Work and heat The microscopic definition of work was discussed by Gibbs (1902) [17] (Pages 42–35) and Schrödinger (1946) [29] (See the paragraphs found between Eqs. 2.13 and 2.14). However, the importance of this viewpoint was not appreciated until advances in simulation and experimentation made it necessary to carefully contemplate performing controlled perturbations of single, microscopic systems. The microscopic definition of work was also discussed by: Uhlenbeck and Ford (1963) [36], Hunter et al. (1993) [51], Jarzynski (1997) [58], Crooks (1998) [62], Sekimoto (1997) [59], Sekimoto (1998) [64] and further developed in Jarzynski (1997) [61], Jarzynski (1998) [65], Crooks (1999) [74], Hendrix and Jarzynski (2001) [89], Jarzynski (2007) [157], Sekimoto (2010) [201]. Another clear exposition with a discussion of thermodynamic consistency is found in: Peliti (2008) [175]. See also Narayan and Dhar (2004) [108], Imparato et al. (2007) [165].

Maxwell's demon
- Origin: Maxwell (1871) [10]
- Szilárd engine: Szilard (1929) [25]
- Reviews: Leff and Rex (2003) [106]

Stochastic thermodynamics Origin of term: Van den Broeck (1986) [49]

Free energy calculations
- Thermodynamic integration:
- Free energy perturbation: [31]
- Jarzynski: [58, 61, 65, 62, 89, 102]; Convergence [151, 104, 146]; Experiments [94]
- Crooks: [62, 74, 77, 241]; Experiments [ ]
- Bennett acceptance ratio method (BAR): Origin [41];
- Escorted free energy simulations: [172, 205]
- Thermodynamic geometry and: [ ]
- Reviews: [99, 167, 203, 233, 238]

Stochastic Thermodynamics and Machine Learning
- Diffusion Models: [**?** 236]

Chronological Bibliography

★ Great papers that have been, will be, or should be influential.

[1] Thomas Young. *A Course of Lectures on Natural Philosophy and the Mechanical Arts*, volume 2. Johnson (1807).
- First use of the term "energy" in its modern sense. [Young1807a]

[2] Sadi Carnot. *Réflexions sur la puissance motrice du feu et sur les machines propres a développer cette puissance*. Chez Bachelier, Libraire, Paris (1824). Reflections on the motive power of fire and machines fitted to develop that power.
- Foundation of thermodynamcs. Heat engines and Carnot efficiency. "The driving power of heat is independent of the agents used to realize it; its value is uniquely fixed by the temperatures of the bodies between which the transfer of caloric is made" [Carnot1824a]

[3] Émile Clapeyron. Mémoire sur la puissance motrice de la chaleur (memoir on the motive power of heat). *Journal de l'École polytechnique*, 23::153–190 (1834).
- Clausius-Clapeyron equation. Origin of usage of Q for heat. [Clapeyron1834a]

[4] Hermann von Helmholtz. *Über die Erhaltung der Kraft* (*On the Conservation of Force*). Druck und Verlag, Berlin (1847). On the Conservation of Force.
- Definitive statement of the conservation of energy, and thereby the first law of thermodynamics. (Terminology was not yet settled: Helmholtz's uses the word *force* for what we now call *energy*.) [Helmholtz1847a]

[5] William Thomson (Lord Kelvin). On the dynamical theory of heat, with numerical results deduced from Mr. Joule's equivalent of a thermal unit, and M. Regnault's observations on steam. *Trans. Roy. Soc. Edin.*, XX (part II):261–268; 289–298 (1851).
- First statement of (essentially) the second law of thermodynamics. "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects." [Thomson1851a]

[6] James C. Maxwell. Illustrations of the dynamical theory of gases. Part II. On the process of diffusion of two or more kinds of moving particles among one another. *Phil. Mag.*, 20:19–32 (1860).

[7] James C. Maxwell. Illustrations of the dynamical theory of gases. Part 1. On the motion and collision of perfectly elastic spheres. *Phil. Mag.*, 19:19–32 (1860).

[8] Rudolf Clausius. Ueber verschiedene für die anwendung bequeme formen der hauptgleichungen der mechanischen wärmetheorie. *Annalen der Physik und Chemie*, 201(7):353–400 (1865). doi:10.1002/andp.18652010702.
- Introduction of the term entropy, and statement of Clausius's form of the second law of thermodynamics. Quote: "We now seek an appropriate name for S . . . . We would call S the transformation content of the body. However I have felt it more suitable to take names of important scientific quantities from the ancient languages in order that they may appear unchanged in all contemporary languages. Hence I propose that we call S the entropy of the body after Greek word . . . meaning "transformation". I have intentionally formed the word entropy to be as similar as possible to the word energy, since the two quantities that are given these names are so closely related in their physical significance that a certain likeness in their names has seemed appropriate." The paper concludes with concise statements of the First and Second Laws of thermodynamics: "1. The energy of the universe is a constant. 2) The entropy of the universe tends to a maximum." [Clausius1865a]

[9] Rudolf Clausius. On the second fundamental theorem of the mechanical theory of heat; a lecture delivered before the forty-first meeting of the German Scientific Association, at Frankfort on the Maine. *Philos. Mag. Ser. 4*, 35(239):405–419 (1868).

[10] James C. Maxwell. *Theory of heat*. Appleton, London (1871).
- Invocation of Maxwell's demon. [Maxwell1871a]

[11] Ludwig Boltzmann. Weitere studien über das Wärmegleichgewicht unter Gasmolekülen (Further studies on the thermal equilibrium of gas molecules). *Sitzungsberichte Akad. Wiss., Vienna, part II*, 66:275–370 (1872).
- The Boltzmann equation and Boltzmann's H-theorem. Statistical definition of entropy, Eq 7. Boltzmann's derivation of the Mazwell-Boltzmann velocity distribution. First paper on non-equilibrium thermodynamics. [Boltzmann1872a]

[12] Ludwig Boltzmann. Über die beziehung swischen dem zweiten hauptsatz der mechanischen wärmetheorie und der wahrscheinlichkeitsrechnung respektive den sätzen über des wärmegleichgewicht (on the relation between the second law of thermodynamics and probability theory with respect to the laws of thermal equilibrium). *Wien. Ber.*, 76:373–435(1877); W. A. Band II, p.164–223 (1877).
- Entropy argued to be statistical and defiend via probabilities (33). Argue that at equilibrium all possible microscopic states of an isolated system are equally probable (which leads to the $S = k \ln W$ formula for entropy engraved on his tombstone). [Boltzmann1877a]

[13] Hermann von Helmholtz. *Physical memoirs, selected and translated from foreign sources*, volume 1, chapter On the Thermodynamics of Chemical Processes (1882), pages 43–97. Taylor & Francis (1888).
- Definiton and explication of free energy, "Given the unlimited validity of Clausius' law, it would then be the value of the free energy, not that of the total energy resulting from heat production, which determines in which sense the chemical affinity can be active." [Helmholtz1882a]

[14] Ludwig Boltzmann. *Vorlesungen über Gastheorie* (*Lectures on gas theory*), volume I. J. A. Barth (1896). Translated in [37].

[15] Ludwig Boltzmann. *Vorlesungen über Gastheorie* (*Lectures on gas theory*), volume II. J. A. Barth (1898). Translated in [37].

[16] Max Planck. Ueber das gesetz der energieverteilung im normalspektrum (on the law of distribution of energy in the normal spectrum). *Annalen der Physik*, 309(3):553–563 (1901). doi:10.1002/andp.19013090310.

[17] J. Willard Gibbs. *Elementary principles in statistical mechanics*. Charles Scribner's Sons, New York (1902).
- Genesis and foundation of modern statistical mechanics. Nonstandard notations: energy: ϵ; temperature: θ; free energy: ψ; index of probability: $\nu \equiv \ln p_x$; entropy: $-\bar{\nu}$. Canonical ensemble (91). Statistical definition of entropy (111) p44. Second law expressed as an average work inequality (481). [Gibbs1902a]

[18] Max Planck. *Treatise on Thermodynamics*. Longmans, Green, and Co., 3rd edition (1910).

[19] Richard C. Tolman. Duration of molecules in upper quantum states. *Phys. Rev.*, 23:693–709 (1924). doi:10.1103/PhysRev.23.69.
- Genesis of "The principle of microscopic reversibility" (p699). Quote: "This assumption should be recognized as a distinct postulate and might be called the principle of microscopic reversibility.- In the case of a system in thermodynamic equilibrium, the principle would require not only that the total number of molecules leaving a given quantum state in unit time shall equal-the number arriving in that state in unit time, but also the the number leaving by any one particular path shall be equal to the number arriving by the reverse of that particular path." [Tolman1924a]

[20] Paul A. M. Dirac. The conditions for statistical equilibrium between atoms, electrons and radiation. *Proc. R. Soc. Lond. A*, 106:581–596 (1924).
- Definition and discussion of the "Principle of Detailed Balance". [Dirac1924a]

[21] Gilbert N. Lewis. A new principle of equilibrium. *Proc. Natl. Acad. Sci. U.S.A.*, 11(3):179–183 (1925).
- Quote: "Corresponding to every individual process there is a reverse process, and in a state of equilibrium the average rate of every process is equal to the average rate of its reverse process." [Lewis1925a]

[22] Richard C. Tolman. The principle of microscopic reversibility. *Proc. Natl. Acad. Sci. U.S.A.*, 11(7):436–439 (1925).
- Historical commentary on The Principle of Microscopic Reversibility. [Tolman1925a]

[23] Ralph H. Fowler and E. A. Milne. A note on the principle of detailed balancing. *Proc. Natl. Acad. Sci. U.S.A.*, 11:400–402 (1925).

[24] Arthur S. Eddington. *The nature of the physical world*. Cambridge University Press, Cambridge (1928).
- Origin of the phrase "Time's Arrow". [Eddington1928a]

[25] L. Szilard. Über die entropieverminderung in einem thermodynamischen system bei eingriffen intelligenter wesen (on the reduction of entropy in a thermodynamic system by the intervention of intelligent beings). *Z. Phys.*, 53:840–856 (1929). doi:10.1007/BF01341281.

[26] Lars Onsager. Reciprocal relations in irreversible processes. I. *Phys. Rev.*, 37(4):405–426 (1931). doi:10.1103/PhysRev.37.405.
- ⋆ Origin of Onsager's reciprocal relations. Detailed discussion of microscopic reversibility. For experimental verification, see [34]. [Onsager1931a]

[27] Lars Onsager. Reciprocal relations in irreversible processes. II. *Phys. Rev.*, 38(12):2265–2279 (1931). doi:10.1103/PhysRev.38.2265.
- ⋆ Onsager regression hypothesis: "...the average regression of fluctuations will obey the same laws as the corresponding macroscopic irreversible process". [Onsager1931b]

[28] Richard C. Tolman. *The principles of statistical mechanics*. Oxford University Press, London (1938).
- Comparison of the principles of detailed balance and microscopic reversibility (pp. 163 and 165). [Tolman1938a]

[29] Erwin Schrödinger. *Statistical Thermodynamics*. Cambridge University Press, Cambridge (1946).

[30] Claude E. Shannon. A mathematical theory of communication. *Bell Syst. Tech. J.*, 27:379–423, 623–656 (1948). doi:10.1002/j.1538-7305.1948.tb01338.x.
- ⋆ Foundation of information theory. Latter reprinted in book form with the subtle change in title "The Mathematical Theory of Communication". Entropy; mutual information; channel coding theorem; first use of word 'bit' in print. [Shannon1948a]

[31] Robert W. Zwanzig. High-temperature equation of state by a perturbation method: I. Nonpolar gases. *J. Chem. Phys.*, 22:1420–1426 (1954). doi:10.1063/1.1740409.
- This is the standard citation for free energy perturbation, although the method predates this paper. This may be becasue it was the oldest paper on thermodynamic perturbation referenced in [41]. [Zwanzig1954a]

[32] Edwin T. Jaynes. Information theory and statistical mechanics II. *Phys. Rev.*, 108:171–190 (1957). doi:10.1103/PhysRev.108.171.

[33] Edwin T. Jaynes. Information theory and statistical mechanics. *Phys. Rev.*, 106:620–630 (1957). doi:10.1103/PhysRev.106.620.

[34] Donald G. Miller. Thermodynamics of irreversible processes. The experimental verification of the Onsager reciprocal relations. *Chem. Rev.*, 60:15–37 (1960). doi:10.1021/cr60203a003.

[35] Rolf Landauer. Irreversibility and heat generation in the computing process. *IBM J. Res. Develop.*, 5(3):183–191 (1961). doi:10.1147/rd.53.0183.
- ⋆ Genesis of Landauer's principle: It requires at least $k_B T \ln 2$ (About 3×10^{-21} Joules at 300K) to erase 1 bit of information. [Landauer1961a]

[36] George E. Uhlenbeck and George W. Ford. *Lectures in Statistical Mechanics*. American Mathematical Society (1963).

[37] Ludwig Boltzmann. *Lectures on gas theory*. Univ. of Calif. Press (1964). Translation of [14] and [15].

[38] Tomoji Yamada and Kyozi Kawasaki. Nonlinear effects in shear viscosity of critical mixtures. *Prog. Theor. Phys.*, 38(5):1031–1051 (1967). doi:10.1143/PTP.38.1031.
- Original reference for the Kawasaki response function. [Yamada1967a]

[39] R. B. Bernstein and R. D. Levine. Entropy and chemical change. I. Characterization of product (and reactant) energy distributions in reactive molecular collisions: Information and entropy deficiency. *J. Chem. Phys.*, 57(1):434–449 (1972). doi:10.1063/1.1677983.

[40] J. Schnakenberg. Network theory of microscopic and macroscopic behavior of master equation systems. *Rev. Mod. Phys.*, 48(4):571–585 (1976). doi:10.1103/RevModPhys.48.571.
- ⋆ Microscopic expression for average entropy production rate (7.6), for continuous time Markov processes. [Schnakenberg1976a]

[41] Charles H. Bennett. Efficient estimation of free energy differences from Monte Carlo data. *J. Comput. Phys.*, 22(1):245–268 (1976). doi:10.1016/

0021-9991(76)90078-4.

★ ∘ Origin of Bennett Acceptance Ratio method (BAR). [Bennett1976a]

[42] G. N. Bochkov and Yu. E. Kuzovlev. Contribution to general theory of thermal fluctuations in nonlinear-systems. *Zh. Eksp. Teor. Fiz.*, 72(1):238–247 (1977). [JETP 45, 125 (1977)].

[43] G. N. Bochkov and Yu. E. Kuzovlev. Fluctuation-dissipation relations for nonequilibrium processes in open systems. *Zh. Eksp. Teor. Fiz.*, 76:1071 (1979). [*Sov. Phys. JETP*, 49:543, 1979].

[44] G. N. Bochkov and Yu. E. Kuzovlev. Nonlinear fluctuation-dissipation relations and stochastic models in nonequilibrium thermodynamics: I. Generalized fluctuation-dissipation theorem. *Physica*, 106(3):443–479 (1981). doi:10.1016/0378-4371(81)90122-9.

∘ Bochkov-Kuzovlev generalized fluctuation-dissipation theorem (2.11). [Bochkov1981a]

[45] G. N. Bochkov and Yu. E. Kuzovlev. Nonlinear fluctuation-dissipation relations and stochastic models in nonequilibrium thermodynamics: II. Kinetic potential and variational principles for nonlinear irreversible processes. *Physica*, 106(3):480–520 (1981). doi:10.1016/0378-4371(81)90123-0.

[46] Charles H. Bennett. The thermodynamics of computation - a review. *Int. J. Theor. Phys.*, 21(12):905–940 (1981).

[47] Robert Shaw. *The Dripping Faucet as a Model Chaotic System*. Aerial Press, Santa Cruz (1984).

[48] Ryogo Kubo, Morikazu Toda, and Natsuki Hashitsume. *Statistical physics II: Nonequilibrium statistical mechanics*. Springer-Verlag, Berlin (1985).

[49] C. Van den Broeck. Stochastic thermodynamics. In Werner Ebeling and Heinz Ulbricht, editors, *Selforganization by Nonlinear Irreversible Processes*, pages 57–61. Springer Berlin Heidelberg, Berlin, Heidelberg (1986).

∘ Origin of the term "Stochastic Thermodynamics". [Van-den-Broeck1986a]

[50] Denis J. Evans, E. G. D. Cohen, and Gary P. Morriss. Probability of second law violations in shearing steady-states. *Phys. Rev. Lett.*, 71(21):3616–3616 (1993). doi:10.1103/PhysRevLett.71.2401. Errata 71(21):2401.

★ ∘ Original exposition of the steady-state fluctuation theorem (8), founded on plausible reasoning and computer simulation. Sheared system with isoenergetic molecular dynamics. Modern era begins. Signs and portents. [Evans1993a]

[51] John E. Hunter, III, William P. Reinhardt, and Thomas F. Davis. A finite-time variational method for determining optimal paths and obtaining bounds on free energy changes from computer simulations. *J. Chem. Phys.*, 99(9):6856–6864 (1993). doi:10.1063/1.465830.

∘ Explicit microscopic definition of work (7). [Hunter1993a]

[52] Denis J. Evans and Debra J. Searles. Equilibrium microstates which generate second law violating steady-states. *Phys. Rev. E*, 50(2):1645–1648 (1994). doi:10.1103/PhysRevE.50.1645.

★ ∘ Genesis of the Evan-Searles version of the fluctuation theorem for the transient steady state trajectory probabilities in isothermal deterministic molecular dynamics (2). Backed by computer simulation of sheared fluid. [Evans1994a]

[53] Ruslan L. Stratonovich. *Nonlinear nonequilibrium thermodynamics II: Advanced theory*. Springer-Verlag, Berlin (1994).

∘ Section 1.2 contains a concise summary of some of the relevant results of Bochkov and Kuzovlev [44, 45]. [Stratonovich1994a]

[54] Giovanni Gallavotti and E. G. D. Cohen. Dynamical ensembles in nonequilibrium statistical-mechanics. *Phys. Rev. Lett.*, 74(14):2694–2697 (1995). doi:10.1103/PhysRevLett.74.2694.

★ ∘ Genesis of the Gallavotti-Cohen fluctuation theorem for asymptotic steady state fluctuations of the phase space contraction rate in isoenergetic molecular dynamics. Derived from the time reversal symmetry and the chaotic hypothesis. [Gallavotti1995a]

[55] Giovanni Gallavotti and E. G. D. Cohen. Dynamical ensembles in stationary states. *J. Stat. Phys.*, 80(5-6):931–970 (1995). doi:10.1007/BF02179860.

[56] Giovanni Gallavotti. Chaotic hypothesis: Onsager reciprocity and fluctuation-dissipation theorem. *J. Stat. Phys.*, 84(5-6):899–925 (1996). doi:10.1007/BF02174123.

★ ∘ First use of the term "Fluctuation theorem". [Gallavotti1996a]

[57] Huw Price. *Time's arrow and Archimedes' point*. Oxford University Press, New York (1996).

[58] Christopher Jarzynski. Nonequilibrium equality for free energy differences. *Phys. Rev. Lett.*, 78(14):2690–2693 (1997). doi:10.1103/PhysRevLett.78.2690.

★ ∘ Revelation of the Jarzynski identity (2a). Hamiltonian dynamics. Insights into the nature of work. Cumulant expansion of the Jarzynski identity, Clausius inequality, fluctuation-dissipation ratio, inequalities given a finite number of observations. [Received April 1996, published Jun 1997] [Jarzynski1997a]

[59] Ken Sekimoto. Kinetic characterization of heat bath and energetics of thermal ratchet models. *J. Phys. Soc. Jpn*, 66(5):1234–1237 (1997).

∘ Insights into thermodynamic work (3) and heat (4) for microscopic systems with stochastic dynamics. [Sekimoto1997a]

[60] Bernard Gaveau and Lawrence S. Schulman. A general framework for non-equilibrium phenomena: the master equation and its formal consequences. *Phys. Lett. A*, 229(6):347–353 (1997). doi:10.1016/S0375-9601(97)00185-0.
- Interrelation between relative entropy and free energy out-of-equilibrium (Sec.2). [Gaveau1997a]

[61] Christopher Jarzynski. Equilibrium free-energy differences from nonequilibrium measurements: A master-equation approach. *Phys. Rev. E*, 56(5):5018–5035 (1997). doi:10.1103/PhysRevE.56.5018.
★ ◦ Further exposition of the Jarzynski identity. Hamiltonian, Langevin, isothermal molecular, and Monte Carlo dynamics. Relation to thermodynamic integration and perturbation. Free energy-work inequality chain. [Jarzynski1997b]

[62] Gavin E. Crooks. Nonequilibrium measurements of free energy differences for microscopically reversible Markovian systems. *J. Stat. Phys.*, 90(5–6):1481–1487 (1998). doi:10.1023/A:1023208217925.
★ ◦ [Crooks1998a]

[63] Jorge Kurchan. Fluctuation theorem for stochastic dynamics. *J. Phys. A*, 31(16):3719–3729 (1998). doi:10.1088/0305-4470/31/16/003.
★ ◦ Transient fluctuation theorem for Langevin dynamics driven by non-conservative forces (3.7). First fluctuation theorem for a stochastic dynamics. [Kurchan1998a]

[64] Ken Sekimoto. Langevin equation and thermodynamics. *Prog. Theor. Phys. Suppl.*, 130:17–27 (1998). doi:10.1143/PTPS.130.17.
★ ◦ Expressions for heat and work along trajectories of Langevin dynamics. [Sekimoto1998a]

[65] Christopher Jarzynski. Equilibrium free energies from nonequilibrium processes. *Acta. Phys. Pol. B*, 29(6):1609–1622 (1998).
- Insights into the nature of work and the driving of a system by an externally controllable parameter. [Jarzynski1998a]

[66] Janka Petravic and Denis J. Evans. The Kawasaki distribution function for nonautonomous systems. *Phys. Rev. E*, 58(2):2624–2627 (1998). doi:10.1103/PhysRevE.58.2624.

[67] F. Bonetto, N. I. Chernov, and Joel L. Lebowitz. (Global and local) fluctuations of phase space contraction in deterministic stationary nonequilibrium. *Chaos*, 8(4):823–833 (1998). doi:10.1063/1.166369.
- Numerical evidence in a simulation of 2D sheared particle flow for the Gallavotti-Cohen style phase space contraction rate fluctuation theorem [54]. [Bonetto1998a]

[68] Giovanni Gallavotti. A local fluctuation theorem. *Physica A*, 263(1-4):39–50 (1999). doi:10.1016/S0378-4371(98)00502-0.

[69] Joel L. Lebowitz and Herbert Spohn. A Gallavotti-Cohen-type symmetry in the large deviation functional for stochastic dynamics. *J. Stat. Phys.*, 95(1-2):333–365 (1999). doi:10.1023/A:1004589714161.
★ ◦ [Lebowitz1999a]

[70] Christian Maes. The fluctuation theorem as a Gibbs property. *J. Stat. Phys.*, 95(1-2):367–392 (1999). doi:10.1023/A:1004541830999.

[71] Giovanni Gallavotti. Fluctuation patterns and conditional reversibility in nonequilibrium systems. *Ann. Inst. H. Poincare-Phys.*, 70(4):429–443 (1999).

[72] Christopher Jarzynski. Microscopic analysis of Clausius-Duhem processes. *J. Stat. Phys.*, 96(1-2):415–427 (1999). doi:10.1023/A:1004541004050.

[73] Debra J. Searles and Denis J. Evans. Fluctuation theorem for stochastic systems. *Phys. Rev. E*, 60(1):159–164 (1999). doi:10.1103/PhysRevE.60.159.

[74] Gavin E. Crooks. Entropy production fluctuation theorem and the nonequilibrium work relation for free energy differences. *Phys. Rev. E*, 60(3):2721–2726 (1999). doi:10.1103/PhysRevE.60.2721.
★ ◦ [Crooks1999a]

[75] E. G. D. Cohen and Giovanni Gallavotti. Note on two theorems in nonequilibrium statistical mechanics. *J. Stat. Phys.*, 96(5-6):1343–1349 (1999). doi:10.1023/A:1004604804070.
- Discussion of difference between Evans-Searles [52] and Gallavotti-Cohen [54] fluctuation theorems. [Cohen1999a]

[76] Takahiro Hatano. Jarzynski equality for the transitions between nonequilibrium steady states. *Phys. Rev. E*, 60(5):R5017–R5020 (1999). doi:10.1103/PhysRevE.60.R5017.

[77] Gavin E. Crooks. *Excursions in statistical dynamics*. Ph.D. thesis, University of California, Berkeley (1999).

[78] O. Mazonka and Christopher Jarzynski. Exactly solvable model illustrating far-from-equilibrium predictions. Cond-mat/991212.
- Analytic study of a colloidal particle dragged through a viscose medium by a harmonic spring. Gaussian work distributions. [Mazonka1999a]

[79] Giovanni Gallavotti. *Statistical Mechanics* (1999).

[80] Gavin E. Crooks. Path-ensemble averages in systems driven far from equilibrium. *Phys. Rev. E*, 61(3):2361–2366 (2000). doi:10.1103/PhysRevE.61.2361.
★ ◦ [Crooks2000a]

[81] Christian Maes, Frank Redig, and A. V. Moffaert. On the definition of entropy production, via examples. *J. Math. Phys.*, 41(3):1528–1554 (2000). doi:10.1063/1.533195.

[82] Jorge Kurchan. A quantum fluctuation theorem. arXiv:cond-mat/0007360.

[83] David Z. Albert. *Time and chance*. Harvard Univ. Press, Cambridge, MA (2000).

[84] Gerhard Hummer and Attila Szabo. Free energy reconstruction from nonequilibrium single-molecule pulling experiments. *Proc. Natl. Acad. Sci. U.S.A.*, 98(7):3658–3661 (2001). doi:10.1073/pnas.071034098.
★ ◦ Proposed application of the Jarzynski equality to real world, single molecule experiments. Experiments consequently performed by [94]. Derived Jarzynski using Feynman-Kac theorem. Weighting of driven trajectories to recover equilibrium distributions (4). Hummer-Szabo correction for removing the influence of a harmonic trap potential (12). See also [85, 132]. [Hummer2001a]

[85] Christopher Jarzynski. How does a system respond when driven away from thermal equilibrium? *Proc. Natl. Acad. Sci. U.S.A.*, 98(7):3636–3638 (2001). doi:10.1073pnas.081074598.
◦ Commentary on [84]. [Jarzynski2001a]

[86] Hong Qian. Relative entropy: free energy associated with equilibrium fluctuations and nonequilibrium deviations. *Phys. Rev. E*, 63:042103 (2001). doi:10.1103/PhysRevE.63.042103.
◦ Extensive discussion of the connection between free energies of non-equilibrium ensembles and relative entropy. [Qian2001a]

[87] Takahiro Hatano and Shin-ichi Sasa. Steady-state thermodynamics of Langevin systems. *Phys. Rev. Lett.*, 86(16):3463–3466 (2001). doi:10.1103/PhysRevLett.86.3463.
★ ◦ Genesis of Hatano-Sasa fluctuation theorem. [Hatano2001a]

[88] Radford M. Neal. Annealed importance sampling. *Stat. Comput.*, 11(2):125–139 (2001). doi:10.1023/A:1008923215028.
★ ◦ [Neal2001a]

[89] D. A. Hendrix and Christopher Jarzynski. A "fast growth" method of computing free energy differences. *J. Chem. Phys.*, 114(14):5974–5981 (2001). doi:10.1063/1.1353552.
◦ Estimate of bias when using the Jarzynski identity to calculate free energies from finite samples. [Hendrix2001a]

[90] Gerhard Hummer. Fast-growth thermodynamic integration: Error and efficiency analysis. *J. Chem. Phys.*, 114(17):7330–7337 (2001). doi:10.1063/1.1363668.

[91] Gerhard Hummer. Fast-growth thermodynamic integration: Results for sodium ion hydration. *Mol. Simul.*, 28(1-2):81–90 (2002). doi:10.1080/08927020211972.

[92] Christian Maes, Frank Redig, and Michel Verschuere. No current without heat. *J. Stat. Phys.*, 106(3):569–587 (2002). doi:10.1023/A:1013706321846.
◦ Equivalence of thermodynamic and microscopic reversibility. See also [211]. [Maes2002a]

[93] David A. Egolf. Statistical mechanics: Far from equilibiurm. *Science*, 296(5574):1813–1815 (2002). doi:10.1126/science.1073595.
◦ Commentary on [94]. [Egolf2002a]

[94] Jan Liphardt, Sophie Dumont, Steven B. Smith, Ignacio Tinoco, Jr., and Carlos Bustamante. Equilibrium information from nonequilibrium measurements in an experimental test of Jarzynski's equality. *Science*, 296(5574):1832–1835 (2002). doi:10.1126/science.1071152.
★ ◦ First experimental demonstration of the Jarzynski equality. [Liphardt2002a]

[95] G. M. Wang, E. M. Sevick, E. Mittag, Debra J. Searles, and Denis J. Evans. Experimental demonstration of violations of the second law of thermodynamics for small systems and short time scales. *Phys. Rev. Lett.*, 89(5):050601 (2002). doi:10.1103/PhysRevLett.89.050601.
◦ Experimental evidence for the fluctuation theorem from dragged colloidal particles. [Wang2002a]

[96] Steven K. Blau. The unusual thermodynamics of microscopic systems. *Phys. Today*, 55(9):19–21 (2002). doi:10.1063/1.1522201.
◦ [Blau2002a]

[97] Felix Ritort, Carlos Bustamante, and Ignacio Tinoco, Jr. A two-state kinetic model for the unfolding of single molecules by mechanical force. *Proc. Natl. Acad. Sci. U.S.A.*, 99(21):13544–13548 (2002). doi:10.1073/pnas.172525099.

[98] Denis J. Evans and Debra J. Searles. The fluctuation theorem. *Adv. Phys.*, 51(7):1529–1585 (2002). doi:10.1080/00018730210155133.

[99] D. Frenkel and B. Smit. *Understanding Molecular Simulation*. Academic Press, 2nd edition (2002).
◦ First textbook exposition of the Jarzynski equality. [Frenkel2002a]

[100] B. Gaveau, K. Martinas, Michel Moreau, and J. Toth. Entropy, extropy and information potential in stochastic systems far from equilibrium. *Physica A*, 305:445 (2002). doi:10.1016/S0378-4371(01)00502-7.

[101] Josef Honerkamp. *Statistical Physics*. Springer Berlin, 2nd edition (2002).

[102] Sean X. Sun. Equilibrium free energies from path sampling of nonequilibrium trajectories. *J. Chem. Phys.*, 118(13):5769–5775 (2003). doi:10.1063/1.1555845.

[103] Shaul Mukamel. Quantum extension of the Jarzynski relation: Analogy with stochastic dephasing. *Phys. Rev. Lett.*, 90(17):170604 (2003). doi:10.1103/PhysRevLett.90.170604.

[104] J. Gore, Felix Ritort, and Carlos Bustamante. Bias and error in estimates of equilibrium free-energy differences from nonequilibrium measurements. *Proc. Natl. Acad. Sci. U.S.A.*, 100(22):12564–12569 (2003). doi:10.1073pnas.1635159100.

[105] J. M. Schurr and B. S. Fujimoto. Equalities for the nonequilibrium work transferred from an external potential to a molecular system. analysis of single-molecule extension experiment. *J. Phys. Chem. B*, 107(50):14007–14019 (2003). doi:10.1021/jp0306803.
- Rediscovery of Bochkov-Kuzovlev identity (18) and generalization to stochastic dynamics. Detailed discussion of Liphardt experiment [94] . [Schurr2003a]

[106] Harvey S. Leff and Andrew F. Rex, editors. *Maxwell's Demon 2: Entropy, Classical and Quantum Information, Computing*. IOP Publishing, Bristol and Philadelphia (2003).

[107] Christian Maes. On the origin and use of the fluctuation relations for the entropy. *Seminaire Poincare*, 2:29–62 (2003).

[108] Onuttom Narayan and Abhishek Dhar. Reexamination of experimental tests of the fluctuation theorem. *J. Phys. A*, 37(1):63–76 (2004). doi:10.1088/0305-4470/37/1/004.

[109] T. Monnai. Fluctuation theorem in rachet system. *J. Phys. A*, 37(6):L75–L79 (2004). doi:10.1088/0305-4470/37/6/L02.

[110] D. M. Carberry, James C. Reid, G. M. Wang, E. M. Sevick, Debra J. Searles, and Denis J. Evans. Fluctuations and irreversibility: An experimental demonstration of a second-law-like theorem using a colloidal particle held in an optical trap. *Phys. Rev. Lett.*, 92(14):140601 (2004). doi:10.1103/PhysRevLett.92.140601.
- Experimental transient fluctuation theorem for a particle in an optical trap with a varying spring constant. [Carberry2004a]

[111] Pierre Gaspard. Fluctuation theorem for nonequilibrium reactions. *J. Chem. Phys.*, 120(19):8898–8905 (2004). doi:10.1063/1.1688758.

[112] Christopher Jarzynski and D. K. Wójcik. Classical and quantum fluctuation theorems for heat exchange. *Phys. Rev. Lett.*, 92(23):230602 (2004). doi:10.1103/PhysRevLett.92.230602.

[113] E. G. D. Cohen and D. Mauzerall. A note on the Jarzynski equality. *J. Stat. Mech.: Theor. Exp.*, page P07006 (2004). doi:10.1088/1742-5468/2004/07/P07006.
- Specious objections to the Jarzynski and Crooks relations. See [115]. Quote "If true, it [the Jarzynski relation] would incorporate a hitherto unknown symmetry for irreversible processes for any switching rate, i.e. a new extension of the second law". This at least we can agree on. See [62]. [Cohen2004a]

[114] James C. Reid, D. M. Carberry, G. M. Wang, E. M. Sevick, Denis J. Evans, and Debra J. Searles. Reversibility in nonequilibrium trajectories of an optically trapped particle. *Phys. Rev. E*, 70(1):016111 (2004). doi:10.1103/PhysRevE.70.016111.

[115] Christopher Jarzynski. Nonequilibrium work theorem for a system strongly coupled to a thermal environment. *J. Stat. Mech.: Theor. Exp.*, page P09005 (2004). doi:10.1088/1742-5468/2004/09/P09005.
- Comment on [113]. Succinct derivation of Jarzynski identity for Hamiltonian dynamics and non-negligible system-environment coupling. [Jarzynski2004b]

[116] Sergio Ciliberto, N. Garnier, S. Hernandez, C. Lacpatia, J.-F. Pinton, and G. Ruiz Chavarria. Experimental test of the Gallavotti-Cohen fluctuation theorem in turbulent flows. *Physica A*, 340(1-3):240–250 (2004). doi:10.1016/j.physa.2004.04.013.

[117] E. H. Trepagnier, Christopher Jarzynski, Felix Ritort, Gavin E. Crooks, Carlos Bustamante, and Jan Liphardt. Experimental test of Hatano and Sasa's nonequilibrium steady-state equality. *Proc. Natl. Acad. Sci. U.S.A.*, 101(42):15038–15041 (2004). doi:10.1073/pnas.0406405101.
- First experimental test of Hatano and Sasa's nonequilibrium steady-state equality [87], using an optically trapped colloid particle. [Trepagnier2004a]

[118] Felix Ritort. Work and heat fluctuations in two-state systems: a trajectory thermodynamics formalism. *J. Stat. Mech.: Theor. Exp.*, page P10016 (2004). doi:10.1088/1742-5468/2004/10/P10016.
- [Ritort2004b]

[119] Pierre Gaspard. Time-reversed dynamical entropy and irreversibility in Markovian random processes. *J. Stat. Phys.*, 117(3):599–615 (2004). doi:10.1007/s10955-004-3455-1. Erratum: 126, 1109 (2006).
- Time-reversed entropy per unit time, (5). [Gaspard2004a]

[120] D. M. Carberry, Stephen R. Williams, G. M. Wang, E. M. Sevick, and Denis J. Evans. The Kawasaki identity and the fluctuation theorem. *J. Chem. Phys.*, 121(17):8179–8182 (2004). doi:10.1063/1.1802211.

[121] Alberto Imparato and Luca Peliti. Work probability distribution in single-molecule experiments. *Europhys. Lett.*, 69(4):643–649 (2005). doi:10.1209/epl/i2004-10390-3.

[122] Abhishek Dhar. Work distribution functions in polymer stretching experiments. *Phys. Rev. E*, 71(3):036126 (2005). doi:10.1103/PhysRevE.71.036126.
- Gaussian work distributions for a stretched harmonic chain. [Dhar2005a]

[123] Thomas Speck and Udo Seifert. Dissipated work in driven harmonic diffusive systems: General solution and application to stretching Rouse polymers.

Eur. Phys. J. B, 43(4):521–527 (2005). doi:10.1140/epjb/e2005-00086-6.

[124] R. C. Lua and A. Y. Grosberg. Practical applicability of the Jarzynski relation in statistical mechanics: A pedagogical example. *J. Phys. Chem. B*, 109(14):6805–6811 (2005). doi:10.1021/jp0455428.
- Analytic work distribution for a driven, ideal gas in a piston with Hamiltonian dynamics. [Lua2005a]

[125] G. M. Wang, James C. Reid, D. M. Carberry, D. R. M. Williams, E. M. Sevick, and Denis J. Evans. Experimental study of the fluctuation theorem in a nonequilibrium steady state. *Phys. Rev. E*, 71(4):046142 (2005). doi:10.1103/PhysRevE.71.046142.

[126] S. Schuler, Thomas Speck, C. Tietz, J. Wrachtrup, and Udo Seifert. Experimental test of the fluctuation theorem for a driven two-level system with time-dependent rates. *Phys. Rev. Lett.*, 94(18):180602 (2005). doi:10.1103/PhysRevLett.94.180602.

[127] Artur B. Adib. Entropy and density of states from isoenergetic nonequilibrium processes. *Phys. Rev. E*, 71(5):056128 (2005). doi:10.1103/PhysRevE.71.056128.

[128] N. Garnier and Sergio Ciliberto. Nonequilibrium fluctuations in a resistor. *Phys. Rev. E*, 71(6):060101 (2005). doi:10.1103/PhysRevE.71.060101.

[129] F. Douarche, Sergio Ciliberto, A. Petrosyan, and I. Rabbiosi. An experimental test of the Jarzynski equality in a mechanical experiment. *Europhys. Lett.*, 70(5):593–599 (2005). doi:10.1209/epl/i2005-10024-4.

[130] Armen E. Allahverdyan and Th. M. Nieuwenhuizen. Fluctuations of work from quantum subensembles: The case against quantum work-fluctuation theorem. *Phys. Rev. E*, 71:066102 (2005). doi:10.1103/PhysRevE.71.066102. Critique [156].

[131] Carlos Bustamante, Jan Liphardt, and Felix Ritort. The nonequilibrium thermodynamics of small systems. *Phys. Today*, 58(7):43– 48 (2005).
- [Bustamante2005a]

[132] Gerhard Hummer and Attila Szabo. Free energy surfaces from single-molecule force spectroscopy. *Acc. Chem. Res.*, 38(7):504–513 (2005). doi:10.1021/ar040148d.
- A gentle introduction to the deep results expounded in [84]. [Hummer2005a]

[133] T. Monnai. Unified treatment of the quantum fluctuation theorem and the Jarzynski equality in terms of microscopic reversibility. *Phys. Rev. E*, 72(2):027102 (2005). doi:10.1103/PhysRevE.72.027102.

[134] W. P. Wong and E. Evans. Biological physics - rare returns on lost effort. *Nature*, 437(7056):198–199 (2005). doi:10.1038/437198a.
- Commentary on [135]. [Wong2005a]

[135] D. Collin, Felix Ritort, Christopher Jarzynski, Steven B. Smith, Ignacio Tinoco, Jr., and Carlos Bustamante. Verification of the Crooks fluctuation theorem and recovery of RNA folding free energies. *Nature*, 437(7056):231–234 (2005). doi:10.1038/nature04061.
- ⋆ First experimental verification of Crooks fluctuation theorem [74], using RNA hairpins. [xkcd/54] Commentary [134] [Collin2005a]

[136] I. Bena, Christian Van den Broeck, and R. Kawai. Jarzynski equality for the Jepsen gas. *Europhys. Lett.*, 71(6):879–885 (2005). doi:10.1209/epl/i2005-10177-0.
- [Bena2005a]

[137] F. Douarche, Sergio Ciliberto, and A. Petrosyan. Estimate of the free energy difference in mechanical systems from work fluctuations: experiments and models. *J. Stat. Mech.: Theor. Exp.*, page P09011 (2005). doi:10.1088/1742-5468/2005/09/P09011.

[138] F. Zamponi, F. Bonetto, Leticia F. Cugliandolo, and Jorge Kurchan. A fluctuation theorem for non-equilibrium relaxational systems driven by external forces. *J. Stat. Mech.: Theor. Exp.*, page P09013 (2005). doi:10.1088/1742-5468/2005/09/P09013.

[139] G. M. Wang, D. M. Carberry, James C. Reid, E. M. Sevick, and Denis J. Evans. Demonstration of the steady-state fluctuation theorem from a single trajectory. *J. Phys.: Condens. Matter*, 17(45):S3239–S3244 (2005). doi:10.1088/0953-8984/17/45/007.

[140] M. Bier. Note on cond-mat/0510119: Jarzynski equation for adiabatically stretched rotor. Cond-mat/0510270.
- Anaytic work distribution of an adiabatically stretched rotor. [Bier2005a]

[141] Alberto Imparato and Luca Peliti. Work-probability distribution in systems driven out of equilibrium. *Phys. Rev. E*, 72(4):046114 (2005). doi:10.1103/PhysRevE.72.046114.

[142] R. C. Lua. Illustration of the Jarzynski nonequilibrium work relation for an ideal gas. arXiv:cond-mat/0511302.
- [Lua2005b]

[143] B. Cleuren, Christian Van den Broeck, and R. Kawai. Fluctuation and dissipation of work in a Joule experiment. *Phys. Rev. Lett.*, 96(5):050601 (2006). doi:10.1103/PhysRevLett.96.050601.

[144] V. Blickle, Thomas Speck, L. Helden, Udo Seifert, and C. Bechinger. Thermodynamics of a colloidal particle in a time-dependent nonharmonic potential. *Phys. Rev. Lett.*, 96(7):070603 (2006). doi:10.1103/PhysRevLett.96.070603.

[145] A.M. Jayannavar and Mamata Sahoo. A charged particle in a magnetic field - Jarzynski equality. *Phys. Rev. E*, 75(3):032102 (2006). doi:10.1103/PhysRevE.75.032102. arXiv:cond-mat/0611516.

[146] Christopher Jarzynski. Rare events and the convergence of exponentially averaged work values. *Phys. Rev. E*, 73(4):046105 (2006). doi:10.1103/PhysRevE.73.046105.

[147] C. Chatelain and D. Karevski. Probability distributions of the work in the two-dimensional Ising model. *J. Stat. Mech.: Theor. Exp.*, page P06005 (2006). doi:10.1088/1742-5468/2006/06/P06005.
- Simulation study of the driven 2D Ising model. [Chatelain2006a]

[148] Wojciech De Roeck and Christian Maes. Steady state fluctuations of the dissipated heat for a quantum stochastic model. *Rev. Math. Phys.*, 18:619–653 (2006). doi:10.1142/S0129055X06002747.

[149] Felix Ritort. Single-molecule experiments in biological physics: methods and applications. *J. Phys.: Condens. Matter*, 18:R531–R583 (2006). doi:10.1088/0953-8984/18/32/R01.
- [Ritort2006a]

[150] B. Cleuren, Christian Van den Broeck, and R. Kawai. Fluctuation theorem for the effusion of an ideal gas. *Phys. Rev. E*, 74:021117 (2006). doi:10.1103/PhysRevE.74.021117.

[151] David A. Kofke. On the sampling requirements for exponential-work free-energy calculations. *Mol. Phys.*, 104:3701–3708 (2006).

[152] S. Pressé and R. Silbey. Memory effects on the convergence properties of the Jarzynski equality. *Phys. Rev. E*, 74(6):061105 (2006). doi:10.1103/PhysRevE.74.061105.

[153] Thomas M. Cover and Joy A. Thomas. *Elements of information theory*. Wiley, New York, 2nd edition (2006).
- Standard go-to reference for information theory. [Cover2006a]

[154] Gavin E. Crooks and Christopher Jarzynski. Work distribution for the adiabatic compression of a dilute and interacting classical gas. *Phys. Rev. E*, 75:021116 (2007). doi:10.1103/PhysRevE.75.021116.

[155] R. Kawai, Juan M. R. Parrondo, and Christian Van den Broeck. Dissipation: The phase-space perspective. *Phys. Rev. Lett.*, 98:080602 (2007). doi:10.1103/PhysRevLett.98.080602.

[156] Peter Talkner, Eric Lutz, and Peter Hänggi. Fluctuation theorems: Work is not an observable. *Phys. Rev. E*, 75:050102 (2007). doi:10.1103/PhysRevE.75.050102.

[157] Christopher Jarzynski. Comparison of far-from-equilibrium work relations. *C. R. Physique*, 8:495–506 (2007). doi:10.1016/j.crhy.2007.04.010.
- An elucidation of Bochkov and Kuzovlev. [Jarzynski2007b]

[158] Peter Talkner and Peter Hänggi. The Tasaki-Crooks quantum fluctuation theorem. *J. Phys. A*, 40:F569–F571 (2007). doi:10.1088/1751-8113/40/26/F08.

[159] R. J. Harris and G. M. Schütz. Fluctuation theorems for stochastic dynamics. *J. Stat. Mech.: Theor. Exp.*, page P07020 (2007). doi:10.1088/1742-5468/2007/07/P07020. Cond-mat/0702553v1.
- A good review that ties together a larage number of results in a single framework.w [Harris2007a]

[160] D. M. Carberry, M. A. B. Baker, G. M. Wang, E. M. Sevick, and Denis J. Evans. An optical trap experiment to demonstrate fluctuation theorems in viscoelastic media. *J. Opt. A: Pure Appl. Opt.*, 9(8):S204–S214 (2007). doi:10.1088/1464-4258/9/8/S13.

[161] Jorge Kurchan. Non-equilibrium work relations. *J. Stat. Mech.: Theor. Exp.*, page P07005 (2007). doi:10.1088/1742-5468/2007/07/P07005. arXiv:cond-mat/0511073.

[162] Thomas Speck, V. Blickle, C. Bechinger, and Udo Seifert. Distribution of entropy production for a colloidal particle in a nonequilibrium steady state. *Europhys. Lett.*, 79:30002 (2007). doi:10.1209/0295-5075/79/30002.

[163] Jorge Kurchan. Gallavotti-Cohen theorem, chaotic hypothesis and the zero-noise limit. *J. Stat. Phys.*, 128(6):1307–1320 (2007). doi:10.1007/s10955-007-9368-z.

[164] Gavin E. Crooks. Measuring thermodynamic length. *Phys. Rev. Lett.*, 99:100602 (2007). doi:10.1103/PhysRevLett.99.100602. arXiv:0706.0559.

[165] Alberto Imparato, Luca Peliti, G. Pesce, G. Rusciano, and A. Sasso. Work and heat probability distribution of an optically driven Brownian particle: theory and experiments. *Phys. Rev. E*, 76(5):050101 (2007).

[166] Giovanni Gallavotti. Fluctuation relation, fluctuation theorem, thermostats and entropy creation in nonequilibrium statistical physics. *Comptes Rendus Physique*, 8:486 – 494 (2007).

[167] Christophe Chipot and Andrew Pohorille, editors. *Free Energy Calculations: Theory and Applications in Chemistry and Biology*. Springer (2007).

[168] Jose M. G. Vilar and J. Miguel Rubi. Failure of the work-Hamiltonian connection for free-energy calculations. *Phys. Rev. Lett.*, 100:020601 (2008). doi:10.1103/PhysRevLett.100.020601.
- The authors use inconsistent definitions of “work” and “free energy” and not surprisingly get inconsistent results. Comments: [174, 175, 190]. [Vilar2008a]

[169] David Andrieux, Pierre Gaspard, Sergio Ciliberto, N. Garnier, S. Joubaud, and A. Petrosyan. Thermodynamic time asymmetry in non-equilibrium fluctuations. *J. Stat. Mech.: Theor. Exp.*, page P01002 (2008).

[170] Gavin E. Crooks. Quantum operation time reversal. *Phys. Rev. A*, 77(3):034101(4) (2008). doi:10.1103/PhysRevA.77.034101.

[171] A. Gomez-Marin, Juan M. R. Parrondo, and Christian Van den Broeck. The footprints of irreversibility. *Europhys. Lett.*, 82:50002 (2008). doi:10.1209/0295-5075/82/50002.

[172] Suriyanarayanan Vaikuntanathan and Christopher Jarzynski. Escorted free energy simulations: Improving convergence by reducing dissipation. *Phys. Rev. Lett.*, 100(19):190601 (2008). doi:10.1103/PhysRevLett.100.190601.
★ ∘ [Vaikuntanathan2008a]

[173] Edward H. Feng and Gavin E. Crooks. Length of time's arrow. *Phys. Rev. Lett.*, 101(9):090602 (2008). doi:10.1103/PhysRevLett.101.090602.

[174] Jordan M. Horowitz and Christopher Jarzynski. Comment on "Failure of the work-Hamiltonian connection for free-energy calculations". *Phys. Rev. Lett.*, 101(9):098901 (2008). doi:10.1103/PhysRevLett.101.098901.
∘ Comment on [168]. [Horowitz2008a]

[175] Luca Peliti. Comment on "Failure of the work-Hamiltonian connection for free-energy calculations". *Phys. Rev. Lett.*, 101:098903 (2008). doi:10.1103/PhysRevLett.101.098903.
∘ Comment on [168]. [Peliti2008b]

[176] Udo Seifert. Stochastic thermodynamics: principles and perspectives. *Eur. Phys. J. B*, 64(3-4):423–431 (2008). doi:10.1140/epjb/e2008-00001-9.

[177] L. Y. Chen. On the Crooks fluctuation theorem and the Jarzynski equality. *J. Chem. Phys.*, 129(9):091101 (2008). doi:10.1063/1.2978949.
∘ Wrong. See [191] and [188]. The incongruous "unexpected inapplicability of the Crook's fluctuation theorem" is due to an inexplicable, inappropriate use of inconsistent expressions. [Chen2008a]

[178] Gavin E. Crooks. On the Jarzynski relation for dissipative quantum dynamics. *J. Stat. Mech.: Theor. Exp.*, page P10023 (2008). doi:10.1088/1742-5468/2008/10/P10023.

[179] L. Y. Chen. Nonequilibrium fluctuation-dissipation theorem of Brownian dynamics. *J. Chem. Phys.*, 129(14):144113 (2008). doi:10.1063/1.2992153.
∘ Also wrong. See See [191] and [188]. [Chen2008b]

[180] Pierre Gaspard. Thermodynamic time asymmetry and nonequilbrium statistical mechanics. In S. Ishiwata and Y. Matsunaga, editors, *Physics of Self-Organization Systems*, pages 67–87. World Scientific (2008).

[181] Felix Ritort. Nonequilibrium fluctuations in small systems: from physics to biology. In S. A. Rice, editor, *Advances in Chemical Physics*, volume 137, pages 31–123. Wiley (2008).

[182] Gavin E. Crooks. Whither time's arrow. Technical report, (2008). FQXi essay contest, The Nature of Time, award winner.

[183] Michael R. Shirts and John D. Chodera. Statistically optimal analysis of samples from multiple equilibrium states. *J. Chem. Phys.*, 129(12):124105 (2008). doi:10.1063/1.2978177. arXiv:0801.1426.

[184] Bernard Gaveau, Michel Moreau, and Lawrence S. Schulman. Work and power production in non-equilibrium systems. *Phys. Lett. A*, 372(19):3415–3422 (2008). doi:10.1016/j.physleta.2008.01.081.

[185] Edward H. Feng and Gavin E. Crooks. Far-from-equilibrium measurements of thermodynamic length. *Phys. Rev. E*, 79:012104 (2009). doi:10.1103/PhysRevE.79.012104.

[186] Jorge Kurchan. Six out of equilibrium lectures. arXiv:0901.1271.

[187] Jordan M. Horowitz and Christopher Jarzynski. Illustrative example of the relationship between dissipation and relative entropy. *Phys. Rev. E*, 79(2):021106 (2009). doi:10.1103/PhysRevE.79.021106.

[188] Gavin E. Crooks. Comment regarding "On the Crooks fluctuation theorem and the Jarzynski equality" [J. Chem. Phys. 129, 091101 (2008)] and "Nonequilibrium fluctuation-dissipation theorem of Brownian dynamics" [J. Chem. Phys. 129, 144113 (2008)]. *J. Chem. Phys.*, 130(10):107101 (2009). doi:10.1063/1.3080751.
∘ Comment on [177] and [179]. I resent the necessity. [Crooks2009a]

[189] Michele Campisi, Peter Talkner, and Peter Hänggi. Fluctuation theorem for arbitrary open quantum systems. *Phys. Rev. Lett.*, 102:210401 (2009). doi:10.1103/PhysRevLett.102.210401.

[190] E. N. Zimanyi and R. Silbey. The work-Hamiltonian connection and the usefulness of the Jarzynski equality for free energy calculations. *J. Chem. Phys.*, 130(17):171102 (2009). doi:10.1063/1.3132747.
∘ Comment on [168]. [Zimanyi2009a]

[191] A. B. Adib. Comment on "On the Crooks fluctuation theorem and the Jarzynski equality" [J. Chem. Phys. 129, 091101 (2008)]. *J. Chem. Phys.*, 130(24):247101 (2009). doi:10.1063/1.3158474.
∘ Comment on [177] and [179]. [Adib2009a]

[192] Juan M. R. Parrondo, Christian Van den Broeck, and R. Kawai. Entropy production and the arrow of time. *New J. Phys.*, 11:073008 (2009). doi:10.1088/1367-2630/11/7/073008.

[193] S. Vaikuntanathan and Christopher Jarzynski. Dissipation and lag in irreversible processes. *Europhys. Lett.*, 87:60005 (2009). doi:10.1209/0295-5075/87/60005.

[194] David Andrieux, Pierre Gaspard, Takaaki Monnai, and Shuichi Tasaki. Fluctuation theorem for currents in open quantum systems. *New J. Phys.*, 11:043014 (2009).

[195] Takahiro Sagawa and Masahito Ueda. Generalized Jarzynski equality under nonequilibrium feedback control. *Phys. Rev. Lett.*, 104(9):090602 (2010). doi:10.1103/PhysRevLett.104.090602.
- ★ ◦ Feedback fluctuation dissipation-theorem (5). Proposed experimental test (6). Jarzynski equality and the Szilard engines. Information ratchet. [Sagawa2010a]

[196] Reinaldo García-García, Daniel Domínguez, Vivien Lecomte, and Alejandro B. Kolton. Unifying approach for fluctuation theorems from joint probability distributions. *Phys. Rev. E*, 82:030104 (2010). doi:10.1103/PhysRevE.82.030104.
- ◦ Genesis of multivaraint fluctuation theorems. [GarciaGarcia2010a]

[197] Y. Fujitani and Hirofumi Suzuki. Jarzynski equality modified in the linear feedback system. *J. Phys. Soc. Jpn*, 79(10):104003 (2010). doi:10.1143/JPSJ.79.104003.

[198] H.-H. Hasegawa, J. Ishikawa, K. Takara, and D.J. Driebe. Generalization of the second law for a nonequilibrium initial state. *Phys. Lett. A*, 374(8):1001–1004 (2010). doi:10.1016/j.physleta.2009.12.042.
- ◦ Instantaneous stabilization argument justifying the definition of nonequilibium free energy. [Hasegawa2010a]

[199] K. Takara, H.-H. Hasegawa, and D.J. Driebe. Generalization of the second law for a transition between nonequilibrium states. *Phys. Lett. A*, 375(2):88–92 (2010). doi:10.1016/j.physleta.2010.11.002.

[200] Shoichi Toyabe, Takahiro Sagawa, Masahito Ueda, Eiro Muneyuki, and Masaki Sano. Experimental demonstration of information-to-energy conversion and validation of the generalized Jarzynski equality. *Nat. Phys.*, 6(12):988–992 (2010). doi:10.1038/nphys1821.

[201] Ken Sekimoto. *Stochastic Energetics*. Springer-Verlag, Berlin (2010). doi:10.1007/978-3-642-05411-2.

[202] Jordan M. Horowitz. *Controlling molecular-scale motion: Exact predictions for driven stochastic systems*. Ph.D. thesis, University of Maryland, College Park (2010).

[203] T. Lelièvre, M. Rousset, and Gabriel Stoltz. *Free energy computations: A mathematical perspective*. Imperial College Press (2010).

[204] Christopher Jarzynski. Equalities and inequalities: Irreversibility and the second law of thermodynamics at the nanoscale. *Ann. Rev. Cond. Mat. Phys.*, 2:329–351 (2011). doi:10.1146/annurev-conmatphys-062910-140506.

[205] Suriyanarayanan Vaikuntanathan and Christopher Jarzynski. Escorted free energy simulations. *J. Chem. Phys.*, 134(5):054107 (2011). doi:10.1063/1.3544679.

[206] Gavin E. Crooks and David A. Sivak. Measures of trajectory ensemble disparity in nonequilibrium statistical dynamics. *J. Stat. Mech.: Theor. Exp.*, page P06003 (2011). doi:10.1088/1742-5468/2011/06/P06003.

[207] L. P. Pitaevskii. Rigorous results of nonequilibrium statistical physics and their experimental verification. *Physics - Uspekhi*, 54(6):625–632 (2011). doi:10.3367/UFNr.0181.201106d.0647.

[208] S. Vaikuntanathan and Christopher Jarzynski. Modeling Maxwell's demon with a microcanonical Szilard engine. *Phys. Rev. E*, 83(6):061120 (2011). doi:10.1103/PhysRevE.83.061120.

[209] Michele Campisi, Peter Hänggi, and Peter Talkner. Colloquium: Quantum fluctuation relations: Foundations and applications. *Rev. Mod. Phys.*, 83 (2011). doi:10.1103/RevModPhys.83.771.

[210] Massimiliano Esposito and Christian Van den Broeck. Second law and Landauer principle far from equilibrium. *Europhys. Lett.*, 95(4):40004 (2011). doi:10.1209/0295-5075/95/40004.

[211] Gavin E. Crooks. On thermodynamic and microscopic reversibility. *J. Stat. Mech.: Theor. Exp.*, page P07008 (2011). doi:10.1088/1742-5468/2011/07/P07008.
- ◦ Equivelence of thermodynamic and microscopic reversibility. See also [92]. [Crooks2011b]

[212] Michele Campisi, Peter Talkner, and Peter Hänggi. Quantum bochkov–kuzovlev work fluctuation theorems. *Phil. Trans. R. Soc. A*, 369:291–306 (2011). doi:10.1098/rsta.2010.0252.

[213] Reinaldo García-García, Vivien Lecomte, Alejandro B. Kolton, and Daniel Domínguez. Joint probability distributions and fluctuation theorems. *J. Stat. Mech.: Theor. Exp.*, page P02009 (2012). doi:10.1088/1742-5468/2012/02/P02009.

[214] A. Bérut, A. Arakelyan, A. Petrosyan, Sergio Ciliberto, R. Dillenschneider, and Eric Lutz. Experimental verification of Landauer's principle linking information and thermodynamics. *Nature*, 483(7388):187–189 (2012). doi:10.1038/nature10872.
- ★ ◦ Experimental verification of Landauer's principle. [Berut2012a]

[215] Carlos Pérez-Espigares, Alejandro B. Kolton, and Jorge Kurchan. Infinite family of second-law-like inequalities. *Phys. Rev. E*, 85(3):031135 (2012). doi:10.1103/PhysRevE.85.031135.

[216] David A. Sivak and Gavin E. Crooks. Near-equilibrium measurements of nonequilibrium free energy. *Phys. Rev. Lett.*, 108(15):150601 (2012). doi:10.1103/PhysRevLett.108.150601.

[217] S. S. N. Chari, K. P. N. Murthy, and R. Inguva. Study of nonequilibrium work distributions from a fluctuating lattice Boltzmann model. *Phys. Rev. E*, 85:041117 (2012). doi:10.1103/PhysRevE.85.041117.

[218] Susanne Still, David A. Sivak, Anthony J. Bell, and Gavin E. Crooks. Thermodynamics of prediction. *Phys. Rev. Lett.*, 109(12):120604 (2012). doi:10.1103/PhysRevLett.109.120604.
★ ○ [Still2012a]

[219] Udo Seifert. Stochastic thermodynamics, fluctuation theorems, and molecular machines. *Rep. Prog. Phys.*, 75(12):126001 (2012). doi:10.1088/0034-4885/75/12/126001. arXiv:1205.4176.
★ ○ [Seifert2012a]

[220] Sebastian Deffner and Eric Lutz. Information free energy for nonequilibrium states. arXiv:1201.3888.

[221] David A. Sivak, John D. Chodera, and Gavin E. Crooks. Using nonequilibrium fluctuation theorems to understand and correct errors in equilibrium and nonequilibrium discrete Langevin dynamics. *Phys. Rev. X*, 3:011007 (2013). doi:10.1103/PhysRevX.3.011007.

[222] Sosuke Ito and Takahiro Sagawa. Information thermodynamics on causal networks. *Phys. Rev. Lett.*, 111:180603 (2013). doi:10.1103/PhysRevLett.111.180603.

[223] Richard Spinney and Ian Ford. Fluctuation relations: A pedagogical overview. In Rainer Klages, Wolfram Just, and Christopher Jarzynski, editors, *Nonequilibrium Statistical Physics of Small Systems: Fluctuation Relations and Beyond*, chapter 1, pages 3–56. Wiley-VCH, Weinheim (2013). doi:10.1002/9783527658701.ch1.

[224] Pierre Gaspard. Time-reversal symmetry relations for currents in quantum and stochastic nonequilibrium systems. In R. Klages, W. Just, and C. Jarzynski, editors, *Nonequilibrium Statistical Physics of Small Systems: Fluctuation Relations and Beyond*, chapter 7, pages 213–257. Wiley-VCH, Weinheim (2013). doi:10.1002/9783527658701.ch7.

[225] Takahiro Sagawa and Masahito Ueda. Information thermodynamics: Maxwell's demon in nonequilibrium dynamics. In Rainer Klages, Wolfram Just, and Christopher Jarzynski, editors, *Nonequilibrium Statistical Physics of Small Systems: Fluctuation Relations and Beyond*, chapter 6, pages 181–211. Wiley-VCH, Weinheim (2013). doi:10.1002/9783527658701.ch6.

[226] James C. Reid, Stephen R. Williams, Debra J. Searles, Lamberto Rondoni, and Denis J. Evans. Fluctuation relations and the foundations of statistical thermodynamics: A deterministic approach and numerical demonstration. In Rainer Klages, Wolfram Just, and Christopher Jarzynski, editors, *Nonequilibrium Statistical Physics of Small Systems: Fluctuation Relations and Beyond*, chapter 2, pages 57–82. Wiley-VCH, Weinheim (2013). doi:10.1002/9783527658701.ch2.

[227] Peter Hänggi and Peter Talkner. The other QFT. *Nat. Phys.*, 11(2):108–110 (2015). doi:10.1038/nphys3167.

[228] Christian Van den Broeck and Massimiliano Esposito. Ensemble and trajectory thermodynamics: A brief introduction. *Physica A*, 418:6–16 (2015). doi:10.1016/j.physa.2014.04.035.

[229] T. Goldfriend and Jorge Kurchan. Fluctuation theorem for quasi-integrable systems. *Europhysics Letters*, 124(1):10002 (2018). doi:10.1209/0295-5075/124/10002.

[230] Giovanni Gallavotti. Nonequilibrium and fluctuation relation. *J. Stat. Phys.*, 180(1–6):172–226 (2019). doi:10.1007/s10955-019-02376-3.

[231] Gavin E. Crooks and Susanne Still. Marginal and conditional second laws of thermodynamics. *Europhys. Lett.*, 125(4):40005 (2019). doi:10.1209/0295-5075/125/40005. arXiv:1611.04628.

[232] Carsten Hartmann, Christof Schütte, and Wei Zhang. Jarzynski's equality, fluctuation theorems, and variance reduction: Mathematical analysis and numerical algorithms. *Journal of Statistical Physics*, 175(6):1214–1261 (2019). doi:10.1007/s10955-019-02286-4.

[233] Antonia S. J. S. Mey, Bryce K. Allen, Hannah E. Bruce McDonald, John D. Chodera, David F. Hahn, Maxmillian Kuhn, Julien Michel, David L. Mobley, Levi N. Naden, Samarjeet Prasad, Andrea Rizzi, Jenke Scheen, Michael R. Shirts, Gary Tresadern, and Huafeng Xu. Best practices for alchemical free energy calculations [article v1.0]. *Living Journal of Computational Molecular Science*, 2:18378 (2020). doi:10.33011/livecoms.2.1.18378.

[234] Luca Peliti and Simone Pigolotti. *Stochastic Thermodynamics: An Introduction*. Princeton University Press (2021).

[235] Philipp Strasberg. *Quantum Stochastic Thermodynamics: Foundations and Selected Applications*. Oxford University Press (2022).

[236] Francisco Vargas, Shreyas Padhy, Denis Blessing, and Nikolas Nüsken. Transport meets variational inference: Controlled Monte Carlo diffusions (2023). doi:10.48550/arXiv.2307.01050.

[237] Pierre Gaspard. *The Statistical Mechanics of Irreversible Phenomena* (2023).

[238] Daan Frenkel and Berend Smit. *Understanding Molecular Simulation: From Algorithms to Applications*. Academic Press, 3rd edition (2023).

[239] David T. Limmer. *Statistical Mechanics and Stochastic Thermodynamics*. Oxford University Press (2024).

[240] Thalyta T. Martins, André H. A. Malavazi, Lucas P. Kamizaki, Artyom Petrosyan, Benjamin Besga, Sergio Ciliberto, and Sérgio R. Muniz. A brief introduction to fluctuation theorems: from theory to experiments (2025). doi:https://doi.org/10.48550/arXiv.2503.20894.

[241] [citation needed].

[242] ( ). Boundary of bibliographic coherance.

[243] Denis J. Evans and Debra J. Searles. Steady states, invariant measures, and response theory. *Phys. Rev. E*, 52(6):5839–5848 (1995). doi:10.1103/PhysRevE.52.5839.

[244] Denis J. Evans and Debra J. Searles. Causality, response theory, and the second law of thermodynamics. *Phys. Rev. E*, 53(6):5808–5815 (1996). doi:10.1103/PhysRevE.53.5808.

[245] E. G. D. Cohen. Dynamical ensembles in statistical mechanics. *Physica A*, 240(1-2):43–53 (1997). doi:10.1016/S0378-4371(97)00129-5.

[246] Pierre Gaspard. Entropy production in open volume-preserving systems. *J. Stat. Phys.*, 88(5-6):1215–1240 (1997). doi:10.1007/BF02732432.

[247] Ken Sekimoto and Shin-ichi Sasa. Complementarity relation for irreversible process derived from stochastic energetics. *J. Phys. Soc. Jpn*, 66(11):3326–3328 (1997). doi:10.1143/JPSJ.66.3326.

[248] Sergio Ciliberto and C. Laroche. An experimental test of the Gallavotti-Cohen fluctuation theorem. *J. Phys. IV*, 8(P6):215–219 (1998). doi:10.1051/jp4:1998629.

[249] Y. Oono and M. Paniconi. Steady state thermodynamics. *Prog. Theor. Phys. Suppl.*, 130:29–44 (1998). doi:10.1143/PTPS.130.29.

[250] D. Daems and G. Nicolis. Entropy production and phase space volume contraction. *Phys. Rev. E*, 59(4):4000–4006 (1999). doi:10.1103/PhysRevE.59.4000.

[251] T. Gilbert and J. R. Dorfman. Entropy production: From open volume-preserving to dissipative systems. *J. Stat. Phys.*, 96(1-2):225–269 (1999). doi:10.1023/A:1004576517254.
  ◦ Entropy production in systems described by Anosov maps. [Gilbert1999a]

[252] R. van Zon. Kinetic approach to the Gaussian thermostat in a dilute sheared gas in the thermodynamic limit. *Phys. Rev. E*, 60(4):4158–4163 (1999). doi:10.1103/PhysRevE.60.4158.

[253] G. Ayton and Denis J. Evans. On the asymptotic convergence of the transient and steady-state fluctuation theorems. *J. Stat. Phys.*, 97(3-4):811–815 (1999). doi:10.1023/A:1004679628622.

[254] Lamberto Rondoni and E. Segre. Fluctuations in two-dimensional reversibly damped turbulence. *Nonlinearity*, 12(6):1471–1487 (1999). doi:10.1088/0951-7715/12/6/302.

[255] Christopher Jarzynski. Hamiltonian derivation of a detailed fluctuation theorem. *J. Stat. Phys.*, 98(1-2):77–102 (2000). doi:10.1023/A:1018670721277.
  ◦ Apparent origin of term ”detailed fluctuation theorem”. [Jarzynski2000a]

[256] H. Sakaguchi. Fluctuation theorem for a Langevin model of the Feynman ratchet. *J. Phys. Soc. Jpn*, 69(1):104–108 (2000). doi:10.1143/JPSJ.69.104.

[257] S. Lepri, Lamberto Rondoni, and G. Benettin. The Gallavotti-Cohen fluctuation theorem for a non-chaotic model. *J. Stat. Phys.*, 99(3-4):857–872 (2000). arXiv:chao-dyn/9909004.

[258] Lamberto Rondoni, T. Tél, and J. Vollmer. Fluctuation theorems for entropy production in open systems. *Phys. Rev. E*, 61(5):R4679–R4682 (2000). doi:10.1103/PhysRevE.61.R4679.

[259] Debra J. Searles and Denis J. Evans. The fluctuation theorem and Green-Kubo relations. *J. Chem. Phys.*, 112(22):9727–9735 (2000). doi:10.1063/1.481610.

[260] S. Yukawa. A quantum analogue of the Jarzynski equality. *J. Phys. Soc. Jpn*, 69(8):2367–2370 (2000). doi:10.1143/JPSJ.69.2367. Critique [**?**].

[261] Debra J. Searles and Denis J. Evans. Ensemble dependence of the transient fluctuation theorem. *J. Chem. Phys.*, 113(9):3503–3509 (2000). doi:10.1063/1.1287424.

[262] Hal Tasaki. Jarzynski relations for quantum systems and some applications. Cond-mat/0009244.

[263] Debra J. Searles and Denis J. Evans. Fluctuation theorem for heat flow. *Int. J. Thermophys.*, 22(1):123–134 (2001). doi:10.1023/A:1006759703505.

[264] S. Aumaître, S. Fauve, S. McNamara, and P. Poggi. Power injected in dissipative systems and the fluctuation theorem. *Eur. Phys. J. B*, 19(3):449–460 (2001).

[265] Denis J. Evans, Debra J. Searles, and E. Mittag. Fluctuation theorem for Hamiltonian systems: Le Chatelier's principle. *Phys. Rev. E*, 63(5):051105 (2001). doi:10.1103/PhysRevE.63.051105.

[266] G. Ayton, Denis J. Evans, and Debra J. Searles. A local fluctuation theorem. *J. Chem. Phys.*, 115(5):2033–2037 (2001). doi:10.1063/1.1385158.

[267] F. Bonetto and Joel L. Lebowitz. Thermodynamic entropy production fluctuation in a two-dimensional shear flow model. *Phys. Rev. E*, 64(5):056129 (2001). doi:10.1103/PhysRevE.64.056129.

[268] H. Hu, R. H. Yun, and J. Hermans. Reversibility of free energy simulations: Slow growth may have a unique advantage. (With a note on use of Ewald summation). *Mol. Simul.*, 28(1-2):67–80 (2002). doi:10.1080/08927020211971.

[269] D. M. Zuckerman and T. B. Woolf. Overcoming finite-sampling errors in fast-switching free-energy estimates: extrapolative analysis of a molecular system. *Chem. Phys. Lett.*, 351(5-6):445–453 (2002). doi:10.1016/S0009-2614(01)01397-5.

[270] E. Mittag, Debra J. Searles, and Denis J. Evans. Isobaric-isothermal fluctuation theorem. *J. Chem. Phys.*, 116(16):6875–6879 (2002). doi:10.1063/1.1462043.
- Transient fluctuation theorem for isothermal-isobaric molecular dynamics. [Mittag2002a]

[271] M. Athènes. Computation of a chemical potential using a residence weight algorithm. *Phys. Rev. E*, 66:046705 (2002). doi:10.1103/PhysRevE.66.046705.

[272] W. I. Goldburg, Y. Y. Goldschmidt, and H. Kellay. Fluctuation and dissipation in liquid crystal electroconvection. *Physica A*, 314(1):391–395 (2002). doi:10.1016/S0378-4371(02)01155-X.

[273] M. Dolowschiák and Z. Kovács. Fluctuation formula for nonreversible dynamics in the thermostated Lorentz gas. *Phys. Rev. E*, 66(6):066217 (2002). doi:10.1103/PhysRevE.66.066217.

[274] Christian Maes and Karel Netočný. Time-reversal and entropy. *J. Stat. Phys.*, 110(1-2):269–310 (2003). doi:10.1023/A:1021026930129.

[275] E. Mittag and Denis J. Evans. Time-dependent fluctuation theorem. *Phys. Rev. E*, 67(2):026113 (2003). doi:10.1103/PhysRevE.67.026113.

[276] R. van Zon and E. G. D. Cohen. Extension of the fluctuation theorem. *Phys. Rev. Lett.*, 91(11):110601 (2003). doi:10.1103/PhysRevLett.91.110601.

[277] Denis J. Evans. A non-equilibrium free energy theorem for deterministic systems. *Mol. Phys.*, 101(10):1551–1554 (2003). doi:10.1080/0026897031000085173.
- Interrelations between various fluctuation theorems. Derivation of work fluctuation theorem for deterministically thermostated molecular dynamics (e.g. Gaussian isokinetic, or Nośe-Hoover thermostat). [Evans2003a]

[278] Andras Baranyai. The kinetics of mixing and the fluctuation theorem in ideal mixtures of two-component model fluids. *J. Chem. Phys.*, 119(4):2144–2146 (2003). doi:10.1063/1.1585015.

[279] S. Park, F. Khalili-Araghi, E. Tajkhorshid, and K. Schulten. Free energy calculation from steered molecular dynamics simulations using Jarzynski's equality. *J. Chem. Phys.*, 119(6):3559–3566 (2003). doi:10.1063/1.1590311.

[280] D.-Q. Jiang, M. Qian, and F.-X. Zhang. Entropy production fluctuations of finite markov chains. *J. Math. Phys.*, 44(9):4176–4188 (2003). doi:10.1063/1.1581971.

[281] R. van Zon and E. G. D. Cohen. Stationary and transient work-fluctuation theorems for a dragged brownian particle. *Phys. Rev. E*, 67(4):046102 (2003). doi:10.1103/PhysRevE.67.046102.

[282] Ronald F. Fox. Using nonequilibrium measurements to determine macromolecule free-energy differences. *Proc. Natl. Acad. Sci. U.S.A.*, 100(22):12537–12538 (2003). doi:10.1073/pnas.2336065100.
- Commentary on [**?**]. [Fox2003a]

[283] Michael R. Shirts, Eric Bair, Giles Hooker, and Vijay S. Pande. Equilibrium free energies from nonequilibrium measurements using maximum-likelihood methods. *Phys. Rev. Lett.*, 91(14):140601 (2003). doi:10.1103/PhysRevLett.91.140601.

[284] O. Jepps, Denis J. Evans, and Debra J. Searles. The fluctuation theorem and lyapunov weights. *Physica D*, 187(1-4):326–337 (2004). doi:10.1016/j.physd.2003.09.019.

[285] D. Rodriguez-Gomez, E. Darve, and A. Pohorille. Assessing the efficiency of free energy calculation methods. *J. Chem. Phys.*, 120(8):3563–3578 (2004). doi:10.1063/1.1642607.

[286] M. Athènes. A path-sampling scheme for computing thermodynamic properties of a many-body system in a generalized ensemble. *Eur. Phys. J. B*, 38(4):651–663 (2004). doi:10.1140/epjb/e2004-00159-0.

[287] S. Park and K. Schulten. Calculating potentials of mean force from steered molecular dynamics simulations. *J. Chem. Phys.*, 120(13):5946–5961 (2004). doi:10.1063/1.1651473.

[288] R. van Zon and E. G. D. Cohen. Extended heat-fluctuation theorems for a system with deterministic and stochastic forces. *Phys. Rev. E*, 69(5):056121 (2004). doi:10.1103/PhysRevE.69.056121.

[289] B. Derrida, B. Douçot, and P.-E. Roche. Current fluctuations in the one-dimensional symmetric exclusion process with open boundaries. *J. Stat. Phys.*, 115(3-4):717–748 (2004). doi:10.1023/B:JOSS.0000022379.95508.b2.

[290] Phillip L. Geissler and Christoph Dellago. Equilibrium time correlation functions from irreversible transformations in trajectory space. *J. Phys. Chem. B*, 108(21):6667–6672 (2004).

[291] R. van Zon and E. G. D. Cohen. Non-equilibrium thermodynamics and fluctuations. *Physica A*, 340(1-3):66–75 (2004). doi:10.1016/j.physa.2004.03.078.

[292] F. Zamponi, G. Ruocco, and L. Angelani. Fluctuations of entropy production in the isokinetic ensemble. *J. Stat. Phys.*, 115(5-6):1655–1668 (2004). doi:10.1023/B:JOSS.0000028072.34588.32.

[293] Vladimir Chernyak and Shaul Mukamel. Effect of quantum collapse on the distribution of work in driven single molecules. *Phys. Rev. Lett.*, 93(4):048302 (2004). doi:10.1103/PhysRevLett.93.048302.

[294] T. Gilbert. Entropy fluctuations in shell models of turbulence. *Europhys. Lett.*, 67(2):172–178 (2004). doi:10.1209/epl/i2004-10066-0.

[295] Christian Maes. Fluctuation relations and positivity of the entropy production in irreversible dynamical systems. *Nonlinearity*, 17(4):1305–1316 (2004). doi:10.1088/0951-7715/17/4/008.

[296] Giovanni Gallavotti. Entropy production and thermodynamics of nonequilibrium stationary states: A point of view. *Chaos*, 14(3):680–690 (2004). doi:10.1063/1.1781911.

[297] R. van Zon, Sergio Ciliberto, and E. G. D. Cohen. Power and heat fluctuation theorems for electric circuits. *Phys. Rev. Lett.*, 92(13):130601 (2004). doi:10.1103/PhysRevLett.92.130601.

[298] David Andrieux and Pierre Gaspard. Fluctuation theorem and Onsager reciprocity relations. *J. Chem. Phys.*, 121(13):6167–6174 (2004). doi:10.1063/1.1782391.

[299] O. Braun, A. Hanke, and Udo Seifert. Probing molecular free energy landscapes by periodic loading. *Phys. Rev. Lett.*, 93(15):158105 (2004). doi:10.1103/PhysRevLett.93.158105.

[300] Udo Seifert. Fluctuation theorem for birth-death or chemical master equations with time-dependent rates. *J. Phys. A*, 37(42):L517–L521 (2004). doi:10.1088/0305-4470/37/42/L04.

[301] D. Wu and David A. Kofke. Model for small-sample bias of free-energy calculations applied to Gaussian-distributed nonequilibrium work measurements. *J. Chem. Phys.*, 121(18):8742–8747 (2004). doi:10.1063/1.1806413.

[302] F. M. Ytreberg and D. M. Zuckerman. Single-ensemble nonequilibrium path-sampling estimates of free energy differences. *J. Chem. Phys.*, 120(23):10876–10879 (2004). doi:10.1063/1.1760511. [Erratum: J. Chem. Phys. 120, 10876 (2004)].

[303] E. Atılgan and Sean X. Sun. Equilibrium free energy estimates based on nonequilibrium work relations and extended dynamics. *J. Chem. Phys.*, 121(21):10392–10400 (2004). doi:10.1063/1.1813434.

[304] C. Beck and E. G. D. Cohen. Superstatistical generalization of the work fluctuation theorem. *Physica A*, 344(3-4):393–402 (2004). doi:10.1016/j.physa.2004.06.001.

[305] O. Braun and Udo Seifert. Periodically driven stochastic un- and refolding transitions of biopolymers. *Europhys. Lett.*, 68(5):746–752 (2004). doi:10.1209/epl/i2004-10279-1.

[306] M. Schmick and M. Markus. Fluctuation theorem for a deterministic one-particle system. *Phys. Rev. E*, 70(6):065101 (2004). doi:10.1103/PhysRevE.70.065101.

[307] Debra J. Searles and Denis J. Evans. Fluctuations relations for nonequilibrium systems. *Aust. J. Chem.*, 57(12):1119–1123 (2004). doi:10.1071/CH04115.

[308] Thomas Speck and Udo Seifert. Distribution of work in isothermal nonequilibrium processes. *Phys. Rev. E*, 70(6):066112 (2004). doi:10.1103/PhysRevE.70.066112.

[309] Stephen R. Williams, Debra J. Searles, and Denis J. Evans. Independence of the transient fluctuation theorem to thermostatting details. *Phys. Rev. E*, 70(6):066113 (2004). doi:10.1103/PhysRevE.70.066113.

[310] Vladimir Chernyak, Michael Chertkov, and Christopher Jarzynski. Dynamical generalization of nonequilibrium work relation. *Phys. Rev. E*, 71(2):025102R (2005). doi:10.1103/PhysRevE.71.025102.

[311] M. Dolowschiák and Z. Kovács. Fluctuation formula in the Nosé-Hoover thermostated Lorentz gas. *Phys. Rev. E*, 71(2):025202 (2005). doi:10.1103/PhysRevE.71.025202.

[312] F. Zamponi, G. Ruocco, and L. Angelani. Generalized fluctuation relation and effective temperatures in a driven fluid. *Phys. Rev. E*, 71(2):020101 (2005). doi:10.1103/PhysRevE.71.020101.

[313] H. Nanda, N. Lu, and T. B. Woolf. Using non-Gaussian density functional fits to improve relative free energy calculations. *J. Chem. Phys.*, 122:134110 (2005). doi:10.1063/1.1877252.

[314] H. Oberhofer, Christoph Dellago, and Phillip L. Geissler. Biased sampling of nonequilibrium trajectories: Can fast switching simulations outperform conventional free energy calculation methods? *J. Phys. Chem. B*, 109(14):6902–6915 (2005). doi:10.1021/jp044556a.

[315] Udo Seifert. Fluctuation theorem for a single enzym or molecular motor. *Europhys. Lett.*, 70(1):36–41 (2005). doi:10.1209/epl/i2005-10003-9. (sic).

[316] Michael R. Shirts and V. S. Pande. Comparison of efficiency and bias of free energies computed by exponential averaging, the Bennett acceptance ratio, and thermodynamic integration. *J. Chem. Phys.*, 122(14):144107 (2005). doi:10.1063/1.1873592.

[317] Denis J. Evans, Debra J. Searles, and Lamberto Rondoni. Application of the gallavotti-cohen fluctuation relation to thermostated steady states near equilibrium. *Phys. Rev. E*, 71(5):056120 (2005). doi:10.1103/PhysRevE.71.056120.

[318] Denis J. Evans. Relation between two proposed fluctuation theorems. *Mol. Simul.*, 31(6-7):389–391 (2005). doi:10.1080/08927020412331332721.

[319] A. Giuliani, F. Zamponi, and Giovanni Gallavotti. Fluctuation relation beyond linear response theory. *J. Stat. Phys.*, 119(3-4):909–944 (2005). doi:10.1007/s10955-005-3021-5.

[320] D. Wu and David A. Kofke. Rosenbluth-sampled nonequilibrium work method for calculation of free energies in molecular simulation. *J. Chem. Phys.*, 122(20):204104 (2005). doi:10.1063/1.1906209.

[321] Alberto Imparato and Luca Peliti. Work distribution and path integrals in general mean-field systems. *Europhys. Lett.*, 70(6):740–746 (2005). doi:10.1209/epl/i2005-10067-5.

[322] Felix Ritort. Single-molecule experiments in biophysics: Exploring the thermal behavior of nonequilibrium small systems. *Pramana-J. Phys.*, 64(6):1135–1147 (2005).

[323] Udo Seifert. Entropy production along a stochastic trajectory and an integral fluctuation theorem. *Phys. Rev. Lett.*, 95(4):040602 (2005). doi:10.1103/PhysRevLett.95.040602.
- ⋆ ◦ Definition of entropy production for single trajectory (16). Seifert integral fluctuation theorem (18) (And origin of the general term "integral fluctuation theorem"). Experimental realizations see [**?**] [Seifert2005b]

[324] X.-D. Shang, P. Tong, and K.-Q. Xia. Test of steady-state fluctuation theorem in turbulent rayleigh-benard convection. *Phys. Rev. E*, 72(1):015301 (2005). doi:10.1103/PhysRevE.72.015301.

[325] Thomas Speck and Udo Seifert. Integral fluctuation theorem for the housekeeping heat. *J. Phys. A*, 38(34):L581–L588 (2005). doi:10.1088/0305-4470/38/34/L03.

[326] G. Adjanor and M. Athènes. Gibbs free-energy estimates from direct path-sampling computations. *J. Chem. Phys.*, 123:234104 (2005). doi:10.1063/1.2137698.

[327] E. G. D. Cohen and D. Mauzerall. The Jarzynski equality and the Boltzmann factor. *Mol. Phys.*, 103(21-23):2923–2926 (2005). doi:10.1080/00268970500151536.
- ◦ The attempt fails. [Cohen2005a]

[328] R. Marathe and Abhishek Dhar. Work distribution functions for hysteresis loops in a single-spin system. *Phys. Rev. E*, 72(6):066112 (2005). doi:10.1103/PhysRevE.72.066112.
- ◦ Simulation study of single driven Ising spin, which exibits very non-Gaussian work distributions, but non-the-less satisfies the expected Jarzynski and fluctuation theorems. The claim that the steady state fluctuation theorem doesn't hold (Sec. 3c) is erroneous, since the steady state relation is only expected to hold asymptotically, and not over a single cycle. [Marathe2005a]

[329] Wei Min, Liang Jiang, Ji Yu, S. C. Kou, Hong Qian, and X. Sunney Xie. Nonequilibrium steady state of a nanometric biochemical system: Determining the thermodynamic driving force from single enzyme turnover time traces. *Nano. Lett.*, 5(12):2373–2378 (2005). doi:10.1021/nl0521773.

[330] James C. Reid, E. M. Sevick, and Denis J. Evans. A unified description of two theorems in non-equilibrium statistical mechanics: The fluctuation theorem and the work relation. *Europhys. Lett.*, 72(5):726–732 (2005). doi:10.1209/epl/i2005-10300-3.

[331] Hiroshi Teramoto and Shin-ichi Sasa. Microscopic description of the equality between violation of fluctuation-dissipation relation and energy dissipation. *Phys. Rev. E*, 72:060102 (2005). doi:10.1103/PhysRevE.72.060102.

[332] Pierre Gaspard. Brownian motion, dynamical randomness, and irreversibility. *New J. Phys.*, 7:77 (2005).

[333] A. B. Adib. Symmetry relations in chemical kinetics arising from microscopic reversibility. *Phys. Rev. Lett.*, 96(2):028307 (2006). doi:10.1103/PhysRevLett.96.028307.

[334] David Andrieux and Pierre Gaspard. Fluctuation theorems and the nonequilibrium thermodynamics of molecular motors. *Phys. Rev. E*, 74(1):011906 (2006). doi:10.1103/PhysRevE.74.011906.

[335] D. Ben-Amotz and J. M. Honig. Average entropy dissipation in irreversible mesoscopic processes. *Phys. Rev. Lett.*, 96(2):020602 (2006). doi:10.1103/PhysRevLett.96.020602.

[336] Wolfgang Lechner, H. Oberhofer, Christoph Dellago, and Phillip L. Geissler. Equilibrium free energies from fast-switching trajectories with large time steps. *J. Chem. Phys.*, 124(4):044113 (2006). doi:10.1063/1.2162874.

[337] Y. Mu and X. Song. Calculations of crystal-melt interfacial free energies by nonequilibrium work measurements. *J. Chem. Phys.*, 124(3):034712 (2006). doi:10.1063/1.2159474.

[338] T. Gilbert and J. R. Dorfman. Fluctuation theorem for constrained equilibrium systems. *Phys. Rev. E*, 73(2):026121 (2006). doi:10.1103/PhysRevE.73.026121.

[339] Takahiro Harada and Shin-ichi Sasa. Energy dissipation and violation of the fluctuation-response relation in nonequilibrium langevin systems. *Phys. Rev. E*, 73(2):026131 (2006). doi:10.1103/PhysRevE.73.026131.

[340] I. Kosztin, B. Barz, and L. Janosi. Calculating potentials of mean force and diffusion coefficients from nonequilibrium processes without Jarzynski's equality. *J. Chem. Phys.*, 124(6):064106 (2006). doi:10.1063/1.2166379.

[341] Vladimir Chernyak, František Šanda, and Shaul Mukamel. Coherence and correlations in multitime quantum measurements of stochastic quantum trajectories. *Phys. Rev. E*, 73(3):036119 (2006). doi:10.1103/PhysRevE.73.036119.

[342] Michel A. Cuendet. Statistical mechanical derivation of Jarzynski's identity for thermostated non-Hamiltonian dynamics. *Phys. Rev. Lett.*, 96(12):120602 (2006). doi:10.1103/PhysRevLett.96.120602.

[343] Alberto Imparato and Luca Peliti. Evaluation of free energy landscapes from manipulation experiments. *J. Stat. Mech.: Theor. Exp.*, page P03005 (2006). doi:10.1088/1742-5468/2006/03/P03005.

[344] P. Maragakis, M. Spichty, and M. Karplus. Optimal estimates of free energies from multistate nonequilibrium work data. *Phys. Rev. Lett.*, 96(10):100602 (2006). doi:10.1103/PhysRevLett.96.100602.

[345] C. Oostenbrink and W. F. van Gunsteren. Calculating zeros: Non-equilibrium free energy calculations. *Chem. Phys.*, 323(1):102–108 (2006). doi:10.1016/j.chemphys.2005.08.054.

[346] Massimiliano Esposito and Shaul Mukamel. Fluctuation theorems for quantum master equations. *Phys. Rev. E*, 73(4):046129 (2006). doi:10.1103/PhysRevE.73.046129.

[347] Thomas Speck and Udo Seifert. Restoring a fluctuation-dissipation theorem in a nonequilibrium steady state. *Europhys. Lett.*, 74(3):391–396 (2006). doi:10.1209/epl/i2005-10549-4.

[348] Christian Maes and Maarten H. van Wieren. Time-symmetric fluctuations in nonequilibrium systems. *Phys. Rev. Lett.*, 96(24):240601 (2006). doi:10.1103/PhysRevLett.96.240601.

[349] Vladimir Y. Chernyak, Michael Chertkov, and Christopher Jarzynski. Path-integral analysis of fluctuation theorems for general Langevin processes. *J. Stat. Mech.: Theor. Exp.*, page P08001 (2006). doi:10.1088/1742-5468/2006/08/P08001.

[350] E. Schöll-Paschinger and Christoph Dellago. A proof of Jarzynski's nonequilibrium work theorem for dynamical systems that conserve the canonical distribution. *J. Chem. Phys.*, 125(5):054105 (2006). doi:10.1063/1.2227025.

[351] C. Tietz, S. Schuler, Thomas Speck, Udo Seifert, and J. Wrachtrup. Measurement of stochastic entropy production. *Phys. Rev. Lett.*, 97(5):050602 (2006). doi:10.1103/PhysRevLett.97.050602.

[352] G. Adjanor, M. Athènes, and F. Calco. Free energy landscape from path-sampling: application to the structural transition in LJ_38. *Eur. Phys. J. B*, 53:47–60 (2006). doi:10.1140/epjb/e2006-00353-0.

[353] F. Douarche, S. Joubaud, N. B. Garnier, A. Petrosyan, and Sergio Ciliberto. Work fluctuation theorems for harmonic oscillators. *Phys. Rev. Lett.*, 97(14):140603 (2006). doi:10.1103/PhysRevLett.97.140603.

[354] Piero Procacci, Simone Marsili, Alessandro Barducci, G. F. Signorini, and Riccardo Chelli. Crooks equation for steered molecular dynamics using a Nosé-Hoover thermostat. *J. Chem. Phys.*, 125:164101 (2006). doi:10.1063/1.2360273.

[355] Daniel K. West, P. D. Olmsted, and Emanuele Paci. Free energy for protein folding from nonequilibrium simulations using the Jarzynski equality. *J. Chem. Phys.*, 125:204910 (2006). doi:10.1063/1.2393232.

[356] A. Baule, R. M. L. Evans, and P. D. Olmsted. Validation of the Jarzynski relation for a system with strong thermal coupling: an isothermal ideal gas model. *Phys. Rev. E*, 74(061117) (2006). doi:10.1103/PhysRevE.74.061117. arXiv:cond-mat/0607575.

[357] David D. L. Minh. Free-energy reconstruction from experiments performed under different biasing programs. *Phys. Rev. E*, 74:061120 (2006). doi:10.1103/PhysRevE.74.061120.

[358] Pierre Gaspard. Hamiltonian dynamics, nanosystems, and nonequilibrium statistical mechanics. *Physica A*, pages 201–246 (2006).

[359] D. Karevski. Steps toward the foundations of statistical mechanics: in and out of equilibrium. *Cond. Mat. Phys.*, 9(2):219–236 (2006).

[360] Trieu Mai and Abhishek Dhar. Non-equilibrium work fluctuations for oscillators in non-Markovian baths. Cond-mat/0612021.

[361] Daniel A. Beard and Hong Qian. Relationship between thermodynamic driving force and one-way fluxes in reversible processes. *PLoS ONE*, 2(1):e144 (2007). doi:10.1371/journal.pone.0000144.

[362] Riccardo Chelli, Simone Marsili, Alessandro Barducci, and Piero Procacci. Recovering the Crooks equation for dynamical systems in the isothermal-isobaric ensemble: A strategy based on the equations of motion. *J. Chem. Phys.*, 126:044502 (2007). doi:10.1063/1.2424940.

[363] Shaul Mukamel. Comment on "Failure of the Jarzynski identity for a simple quantum system". arXiv:cond-mat/0701003.
◦ Critique of [?]. [Mukamel2007a]

[364] B. Palmieri and D. Ronis. Jarzynski equality: Connections to thermodynamics and the second law. *Phys. Rev. E*, 75:011133 (2007). doi:10.1103/PhysRevE.75.011133.

[365] Tim Schmiedl and Udo Seifert. Stochastic thermodynamics of chemical reaction networks. *J. Chem. Phys.*, 126:044101 (2007). doi:10.1063/1.2428297.

[366] Kyung H. Kim and Hong Qian. Fluctuation theorems for a molecular refrigerator. *Phys. Rev. E*, 75(2):022102 (2007). doi:10.1103/PhysRevE.75.022102.

[367] T. Lelièvre, M. Rousset, and Gabriel Stoltz. Computation of free energy differences through nonequilibrium stochastic dynamics: The reaction coordinate case. *J. Comput. Phys.*, 222(2):624–643 (2007). doi:10.1016/j.jcp.2006.08.003.
◦ Extends Hummer-Szabo's Feynman-Fac approach to Jarzynski relation to perturbations imposed by hard constraints. [Lelievre2007a]

[368] Tim Schmiedl and Udo Seifert. Optimal finite-time processes in stochastic thermodynamics. *Phys. Rev. Lett.*, 98(10):108301 (2007). doi:10.1103/PhysRevLett.98.108301.

[369] David Andrieux, Pierre Gaspard, Sergio Ciliberto, N. Garnier, S. Joubaud, and A. Petrosyan. Entropy production and time asymmetry in nonequilibrium fluctuations. *Phys. Rev. Lett.*, 98(15):150601 (2007). doi:10.1103/PhysRevLett.98.150601.

[370] C. Chatelain. A temperature-extended Jarzynski relation: application to the numerical calculation of surface tension. *J. Stat. Mech.: Theor. Exp.*, page P04011 (2007). doi:10.1088/1742-5468/2007/04/P04011. arXiv:cond-mat/0702044.

[371] Petr Chvosta, Peter Reineker, and Michael Schulz. Probability distribution of work done on a two-level system during a nonequilibrium isothermal process. *Phys. Rev. E*, 75(4):041124 (2007). doi:10.1103/PhysRevE.75.041124.

[372] Massimiliano Esposito, Upendra Harbola, and Shaul Mukamel. Fluctuation theorem for counting-statistics in electron transport through quantum junctions. *Phys. Rev. B*, 75:155316 (2007). doi:10.1103/PhysRevB.75.155316.

[373] V. Blickle, Thomas Speck, C. Lutz, Udo Seifert, and C. Bechinger. Einstein relation generalized to nonequilibrium. *Phys. Rev. Lett.*, 98(21):210601 (2007). doi:10.1103/PhysRevLett.98.210601.

[374] V. Blickle, Thomas Speck, Udo Seifert, and C. Bechinger. Characterizing potentials by a generalized Boltzmann factor. *Phys. Rev. E*, 75(6):060101 (2007). doi:10.1103/PhysRevE.75.060101.

[375] B. Cleuren, Christian Van den Broeck, and R. Kawai. Fluctuation and dissipation. *C. R. Physique*, 8(5):567–578 (2007). doi:10.1016/j.crhy.2007.04.015.

[376] Andreas Engel and R. Nolte. Jarzynski equation for a simple quantum system: Comparing two definitions of work. *Europhys. Lett.*, 79:10003 (2007). doi:10.1209/0295-5075/79/10003.
◦ See [?]. [Engel2007a]

[377] Tim Schmiedl, Thomas Speck, and Udo Seifert. Entropy production for mechanically or chemically driven biomolecules. *J. Stat. Phys.*, 128(1):77–93 (2007). doi:10.1007/s10955-006-9148-1.

[378] Thomas Speck and Udo Seifert. The Jarzynski relation, fluctuation theorems, and stochastic thermodynamics for non-Markovian processes. *J. Stat. Mech.: Theor. Exp.*, page L09002 (2007). doi:10.1088/1742-5468/2007/09/L09002.

[379] Jordan M. Horowitz and Christopher Jarzynski. Comparison of work fluctuation relations. *J. Stat. Mech.: Theor. Exp.*, page P11002 (2007). doi:10.1088/1742-5468/2007/11/P11002.

[380] Jens Teifel and Günter Mahler. Model studies on the quantum Jarzynski relation. *Phys. Rev. E*, 76(051126):6 (2007). doi:10.1103/PhysRevE.76.051126.

[381] David Andrieux and Pierre Gaspard. Network and thermodynamic conditions for a single macroscopic current fluctuation theorem. *Comptes Rendus Physique*, pages 579–590 (2007).

[382] Pierre Gaspard. Temporal ordering of nonequilibrium fluctuations as a corollary of the second law of thermodynamics. *Comptes Rendus Physique*, 8:598–608 (2007).

[383] Christopher Jarzynski. Nonequilibrium fluctuations of a single biomolecule. In *Controlled Nanoscale Motion*, volume 711 of *Lect. Notes Phys.*, page 201. Springer-Verlag, Berlin (2007).

[384] S. Joubaud, N. B. Garnier, and Sergio Ciliberto. Fluctuation theorems for harmonic oscillators. *J. Stat. Mech.: Theor. Exp.*, page P09018 (2007).

[385] H. Schrödera, Jens Teifel, and Günter Mahler. Work and work fluctuations in quantum systems. *Eur. Phys. J. Special Topics*, 151:181–188 (2007).

[386] R. A. Blythe. Reversibility, heat dissipation, and the importance of the thermal environment in stochastic models of nonequilibrium steady states. *Phys. Rev. Lett.*, 100(010601):4 (2008). doi:10.1103/PhysRevLett.100.010601.

[387] Teruhisa S. Komatsu and N. Nakagawa. Expression for the stationary distribution in nonequilibrium steady states. *Phys. Rev. Lett.*, 100(3):030601 (2008). doi:10.1103/PhysRevLett.100.030601.

[388] Tim Schmiedl and Udo Seifert. Efficiency at maximum power: An analytically solvable model for stochastic heat engines. *Europhys. Lett.*, 81(2):20003 (2008). doi:10.1209/0295-5075/81/20003.

[389] Takahiro Sagawa and Masahito Ueda. Second law of thermodynamics with discrete quantum feedback control. *Phys. Rev. Lett.*, 100(8):080403 (2008). doi:10.1103/PhysRevLett.100.080403.

[390] Riccardo Chelli, Simone Marsili, and Piero Procacci. Calculation of the potential of mean force from nonequilibrium measurements via maximum likelihood estimators. *Phys. Rev. E*, 77(3):031104 (2008). doi:10.1103/PhysRevE.77.031104.

[391] P. Maragakis, M. Spichty, and M. Karplus. A differential fluctuation theorem. *J. Phys. Chem. B*, 112:6168–6174 (2008). doi:10.1021/jp077037r.

[392] Punyabrata Pradhan, Yariv Kafri, and Dov Levine. Nonequilibrium fluctuation theorems in the presence of local heating. *Phys. Rev. E*, 77:041129 (2008). doi:10.1103/PhysRevE.77.041129.

[393] J. Berg. Out-of-equilibrium dynamics of gene expression and the Jarzynski equality. *Phys. Rev. Lett.*, 100:188101 (2008). doi:10.1103/PhysRevLett.100.188101.

[394] David D. L. Minh and A. B. Adib. Optimized free energies from bidirectional single-molecule force spectroscopy. *Phys. Rev. Lett.*, 100:180602 (2008). doi:10.1103/PhysRevLett.100.180602.

[395] Luca Peliti. On the work–Hamiltonian connection in manipulated systems. *J. Stat. Mech.: Theor. Exp.*, page P05002 (2008). doi:10.1088/1742-5468/2008/05/P05002.

[396] Teruhisa S. Komatsu, N. Nakagawa, Shin-ichi Sasa, and Hal Tasaki. Steady-state thermodynamics for heat conduction: Microscopic derivation. *Phys. Rev. Lett.*, 100(23):230602 (2008). doi:10.1103/PhysRevLett.100.230602.

[397] M. Athènes and G. Adjanor. Measurement of nonequilibrium entropy from space-time thermodynamic integration. *J. Chem. Phys.*, 129(2):024116 (2008). doi:10.1063/1.2953328.

[398] A. Gomez-Marin, Tim Schmiedl, and Udo Seifert. Optimal protocols for minimal work processes in underdamped stochastic thermodynamics. *J. Chem. Phys.*, 129(2):024114 (2008). doi:10.1063/1.2948948.

[399] P. Maragakis, Felix Ritort, M. Karplus, Carlos Bustamante, and Gavin E. Crooks. Bayesian estimates of free energies from nonequilibrium work data in the presence of instrument noise. *J. Chem. Phys.*, 129:024102 (2008). doi:10.1063/1.2937892.

[400] J. Mehl, Thomas Speck, and Udo Seifert. Large deviation function for entropy production in driven one-dimensional systems. *Phys. Rev. E*, 78(1):011123 (2008). doi:10.1103/PhysRevE.78.011123.

[401] Tim Schmiedl and Udo Seifert. Efficiency of molecular motors at maximum power. *Europhys. Lett.*, 83(3):30005 (2008). doi:10.1209/0295-5075/83/30005.

[402] Stephen R. Williams and Denis J. Evans. Time-dependent response theory and nonequilibrium free-energy relations. *Phys. Rev. E*, 78(2):021119 (2008). doi:10.1103/PhysRevE.78.021119.

[403] David Andrieux and Pierre Gaspard. Temporal disorder and fluctuation theorem in chemical reactions. *Phys. Rev. E*, 77:031137 (2008).

[404] David Andrieux and Pierre Gaspard. Quantum work relations and response theory. *Phys. Rev. Lett.*, 100:230404 (2008).

[405] David Andrieux and Pierre Gaspard. Fluctuation theorem for currents in semi-Markov processes. *J. Stat. Mech.: Theor. Exp.*, page P11007 (2008).

[406] David Andrieux and Pierre Gaspard. Dynamical randomness, information, and Landauer's principle. *Europhys. Lett.*, 81:28004 (2008).

[407] David Andrieux and Pierre Gaspard. Fluctuation theorem and mesoscopic chemical clocks. *J. Chem. Phys.*, 128:154506 (2008).

[408] S. Joubaud, N. B. Garnier, and Sergio Ciliberto. Fluctuations of the total entropy production in stochastic systems. *Europhys. Lett.*, 82:30007 (2008).

[409] Teruhisa Komatsu, N. Nakagawa, Shin-Ichi Sasa, and Hal Tasaki. Representation of nonequilibrium steady states in large mechanical systems. *J. Stat. Phys.*, 134(2):401–423 (2009). doi:10.1007/s10955-009-9678-4.

[410] Thomas Speck and Udo Seifert. Extended fluctuation-dissipation theorem for soft matter in stationary flow. *Phys. Rev. E*, 79(4):040102 (2009). doi:10.1103/PhysRevE.79.040102.

[411] A. J. Ballard and Christopher Jarzynski. Replica exchange with nonequilibrium switches. *Proc. Natl. Acad. Sci. U.S.A.*, 106(30):12224–12229 (2009). doi:10.1073/pnas.0900406106.

[412] Arnab Saha, Sourabh Lahiri, and A. M. Jayannavar. Entropy production theorems and some consequences. *Phys. Rev. E*, 80(1):011117 (2009). doi:10.1103/PhysRevE.80.011117.

[413] Tim Schmiedl, E. Dieterich, P.-S. Dieterich, and Udo Seifert. Optimal protocols for Hamiltonian and Schrödinger dynamics. *J. Stat. Mech.: Theor. Exp.*, page P07013 (2009). doi:10.1088/1742-5468/2009/07/P07013.

[414] Jordan M. Horowitz and Christopher Jarzynski. Exact formula for currents in strongly pumped diffusive systems. *J. Stat. Phys.*, 136(5):917–925 (2009). doi:10.1007/s10955-009-9818-x.

[415] David D. L. Minh and John D. Chodera. Optimal estimators and asymptotic variances for nonequilibrium path-ensemble averages. *J. Chem. Phys.*, 131:134110 (2009). doi:10.1063/1.324228.

[416] David Andrieux and Pierre Gaspard. Stochastic approach and fluctuation theorem for ion transport. *J. Stat. Mech.: Theor. Exp.*, page P02057 (2009).

[417] Massimiliano Esposito, Katja Lindenberg, and Christian Van den Broeck. Universality of efficiency at maximum power. *Phys. Rev. Lett.*, 102(13):130602 (2009). doi:10.1103/PhysRevLett.102.130602.

[418] Christian Maes, Karel Netočný, and B. Shergelashvili. A selection of nonequilibrium issues. In R. Kotecký, editor, *Methods of Contemporary Mathematical Statistical Physics*, volume 1970 of *Lecture Notes in Mathematics*, pages 1–60. Springer-Verlag, Berlin (2009). doi:10.1007/978-3-540-92796-9_6.

[419] David Andrieux and Pierre Gaspard. Molecular information processing in nonequilibrium copolymerizations. *J. Chem. Phys.*, 130:014901 (2009).

[420] C. P. Amann, Tim Schmiedl, and Udo Seifert. Communications: Can one identify nonequilibrium in a three-state system by analyzing two-state trajectories? *J. Chem. Phys.*, 132(4):041102 (2010). doi:10.1063/1.3294567.

[421] Massimiliano Esposito and Christian Van den Broeck. Three detailed fluctuation theorems. *Phys. Rev. Lett.*, 104(9):090601 (2010). doi:10.1103/PhysRevLett.104.090601.
★ ∘ [Esposito2010a]

[422] Christian Maes. Fluctuations and response out-of-equilibrium. *Prog. Theor. Phys. Suppl.*, 184:318–328 (2010). doi:10.1143/PTPS.184.318.

[423] Udo Seifert and Thomas Speck. Fluctuation-dissipation theorem in nonequilibrium steady states. *Europhys. Lett.*, 89(1):10007 (2010). doi:10.1209/0295-5075/89/10007.

[424] James C. Reid, Stephen R. Williams, and Debra J. Searles. Applying bi-directional Jarzynski methods to quasi-equilibrium states. *Aust. J. Chem.*, 63:357–362 (2010). doi:10.1071/CH09458.

[425] J. R. Gomez-Solano, L. Bellon, A. Petrosyan, and Sergio Ciliberto. Steady-state fluctuation relations for systems driven by an external random force. *EPL*, 89(6):60003 (2010). doi:10.1209/0295-5075/89/60003.

[426] Udo Seifert. Generalized Einstein or Green-Kubo relations for active biomolecular transport. *Phys. Rev. Lett.*, 104(13):138101 (2010). doi:10.1103/PhysRevLett.104.138101.

[427] Tony Lelièvre, Mathias Rousset, and Gabriel Stoltz. Langevin dynamics with constraints and computation of free energy differences. arXiv:1006.4914v1.

[428] Christian Van den Broeck. The many faces of the second law. *J. Stat. Mech.: Theor. Exp.*, page P10009 (2010). doi:10.1088/1742-5468/2010/10/P10009.

[429] J. Mehl, V. Blickle, Udo Seifert, and C. Bechinger. Experimental accessibility of generalized fluctuation-dissipation relations for nonequilibrium steady states. *Phys. Rev. E*, 82(3):032401 (2010). doi:10.1103/PhysRevE.82.032401.

[430] M. Ponmurugan. Generalized detailed fluctuation theorem under nonequilibrium feedback control. *Phys. Rev. E*, 82:031129 (2010). doi:10.1103/PhysRevE.82.031129.

[431] Stephen R. Williams and Denis J. Evans. Nonequilibrium dynamics and umbrella sampling. *Phys. Rev. Lett.*, 105(11):110601 (2010). doi:10.1103/PhysRevLett.105.110601.

[432] Eliran Boksenbojm, Bram Wynants, and Christopher Jarzynski. Nonequilibrium thermodynamics at the microscale: Work relations and the second law. *Physica A*, 389(20):4406–4417 (2010). doi:10.1016/j.physa.2010.01.001. Proceedings of the 12th International Summer School on Fundamental Problems in Statistical Physics.

[433] Sergio Ciliberto, S. Joubaud, and A. Petrosyan. Fluctuations in out-of-equilibrium systems: from theory to experiment. *J. Stat. Mech.: Theor. Exp.*, page P12003 (2010). doi:10.1088/1742-5468/2010/12/P12003.

[434] Pierre Gaspard. Nonequilibrium nanosystems. In G. Radons, B. Rumpf, and H. G. Schuster, editors, *Nonlinear Dynamics of Nanosystems*. Wiley-VCH, Weinheim (2010).

[435] E. Gerritsma and Pierre Gaspard. Chemomechanical coupling and stochastic thermodynamics of the f1-atpase molecular motor with an applied external torque. *Biophys. Rev. Lett.*, pages 163–208 (2010).

[436] Thomas Speck. Driven soft matter: Entropy production and the fluctuation-dissipation theorem. *Prog. Theor. Phys. Suppl.*, 184:248–261 (2010). doi:10.1143/PTPS.184.248.

[437] Massimiliano Esposito, Katja Lindenberg, and Christian Van den Broeck. Entropy production as correlation between system and reservoir. *New J. Phys.*, 12:013013 (2010). doi:10.1088/1367-2630/12/1/013013.

[438] David D. L. Minh and John D. Chodera. Estimating equilibrium ensemble averages using multiple time slices from driven nonequilibrium processes: Theory and application to free energies, moments, and thermodynamic length in single-molecule pulling experiments. *J. Chem. Phys.*, 134:024111 (2011). doi:10.1063/1.3516517.

[439] Rosa Maria Velasco, Leopoldo Scherer García-Colín, and Francisco Javier Uribe. Entropy production: Its role in non-equilibrium thermodynamics. *Entropy*, 13(1):82–116 (2011). doi:10.3390/e13010082.

[440] Matteo Colangeli, Christian Maes, and Bram Wynants. A meaningful expansion around detailed balance. *J. Phys. A*, 44(9):095001 (2011). doi:10.1088/1751-8113/44/9/095001.

[441] Udo Seifert. Stochastic thermodynamics of single enzymes and molecular motors. *Eur. Phys. J. A*, 34(3):26 (2011). doi:10.1140/epje/i2011-11026-7.

[442] D. Abreu and Udo Seifert. Extracting work from a single heat bath through feedback. *Europhys. Lett.*, 94(1):10001 (2011). doi:10.1209/0295-5075/94/10001.

[443] Jordan M. Horowitz and Juan M. R. Parrondo. Designing optimal discrete-feedback thermodynamic engines. *New J. Phys.*, 13:123019 (2011).

[444] Thomas Speck. Work distribution for the driven harmonic oscillator with time-dependent strength: exact solution and slow driving. *J. Phys. A*, 44(30):305001 (2011). doi:10.1088/1751-8113/44/30/305001.

[445] Eliran Boksenbojm, Christian Maes, Karel Netočný, and J. Pesek. Heat capacity in nonequilibrium steady states. *Europhys. Lett.*, 96(4):40001 (2011). doi:10.1209/0295-5075/96/40001. arXiv:1109.3054.

[446] Niraj Kumar, Christian Van den Broeck, Massimiliano Esposito, and Katja Lindenberg. Thermodynamics of a stochastic twin elevator. *Phys. Rev. E*, 84:051134 (2011). doi:10.1103/PhysRevE.84.051134.

[447] Jerome P. Nilmeier, Gavin E. Crooks, David D. L. Minh, and John D. Chodera. Nonequilibrium candidate Monte Carlo is an efficient tool for equilibrium simulation. *Proc. Natl. Acad. Sci. U.S.A.*, 108(45):E1009–E1018 (2011). doi:10.1073/pnas.1106094108. Erratum: *Proc. Natl. Acad. Sci. U.S.A.* 109:9665 (2012).

[448] Takahiro Sagawa and Hisao Hayakawa. Geometrical expression of excess entropy production. *Phys. Rev. E*, 84(5):051110 (2011). doi:10.1103/PhysRevE.84.051110.

[449] Stephen Williams, Denis Evans, and Debra Searles. Nonequilibrium umbrella sampling and the functional Crooks fluctuation theorem. *J. Stat. Phys.*, 145:831–840 (2011). doi:10.1007/s10955-011-0281-0.

[450] G. B. Cuetara, Massimiliano Esposito, and Pierre Gaspard. Fluctuation theorems for capacitively coupled electronic currents. *Phys. Rev. B*, 84:165114 (2011).

[451] Pierre Gaspard. Fluctuation theorem, nonequilibrium work, and molecular machines. In J.-P. Sauvage and P. Gaspard, editors, *Proceedings of the 21st Solvay Conference on Chemistry, Brussels, 2007, From Non-Covalent Assemblies to Molecular Machines*, pages 307–312 (2011).

[452] Pierre Gaspard. Self-organization at the nanoscale scale in far-from-equilibrium surface reactions and copolymerizations. In A. S. Mikhailov and G. Ertl, editors, *Proceedings of the International Conference "Engineering of Chemical Complexity" Berlin Center for Studies of Complex Chemical Systems* (2011).

[453] Yu. E. Kuzovlev. Short remarks on the so-called fluctuation theorems and related statements. arXiv:1106.0589v1.
  ◦ "It is demonstrated that the [Bochkov-Kuzovlev] generalized fluctuation-dissipation theorem covers [everything, ever done, ever.]". See [157] for a more nuanced perspective. [Kuzovlev2011a]

[454] Alberto Suarez, R. Silbey, and Irwin Oppenheim. Phase transition in the Jarzynski estimator of free energy differences. arXiv:1108.5783.

[455] D. Abreu and Udo Seifert. Thermodynamics of genuine nonequilibrium states under feedback control. *Phys. Rev. Lett.*, 108(3):030601 (2012). doi:10.1103/PhysRevLett.108.030601.

[456] Takahiro Sagawa and Masahito Ueda. Nonequilibrium thermodynamics of feedback control. *Phys. Rev. E*, 85(2):021104 (2012). doi:10.1103/PhysRevE.85.021104.

[457] Van A. Ngo. Parallel-pulling protocol for free-energy evaluation. *Phys. Rev. E*, 85(3):036702 (2012). doi:10.1103/PhysRevE.85.036702.

[458] Haitao T. Quan and Christopher Jarzynski. Validity of nonequilibrium work relations for the rapidly expanding quantum piston. *Phys. Rev. E*, 85:031102 (2012). doi:10.1103/PhysRevE.85.031102. arXiv:1112.5798.

[459] Édgar Roldán and Juan M. R. Parrondo. Entropy production and Kullback-Leibler divergence between stationary trajectories of discrete systems. *Phys. Rev. E*, 85(3):031129 (2012). doi:10.1103/PhysRevE.85.031129.

[460] M. Bauer, D. Abreu, and Udo Seifert. Efficiency of a Brownian information machine. *J. Phys. A*, 45(16):162001 (2012). doi:10.1088/1751-8113/45/16/162001.

[461] Massimiliano Esposito. Stochastic thermodynamics under coarse graining. *Phys. Rev. E*, 85:041125 (2012). doi:10.1103/PhysRevE.85.041125. Erratum Phys. Rev. E 86, 049904 (2012).

[462] A. J. Ballard and Christopher Jarzynski. Replica exchange with nonequilibrium switches: Enhancing equilibrium sampling by increasing replica overlap. *J. Chem. Phys.*, 136(19):194101 (2012). doi:10.1063/1.4712028.

[463] S. J. Davie, James C. Reid, and Debra J. Searles. The free energy of expansion and contraction: Treatment of arbitrary systems using the Jarzynski equality. *J. Chem. Phys.*, 136:174111 (2012). doi:10.1063/1.4707348.

[464] Jae Dong Noh and Jong-Min Park. Fluctuation relation for heat. *Phys. Rev. Lett.*, 108(24):240603 (2012). doi:10.1103/PhysRevLett.108.240603.

[465] Dibyendu Mandal and Christopher Jarzynski. Work and information processing in a solvable model of Maxwell's demon. *Proc. Natl. Acad. Sci. U.S.A.*, 109(29):11641–11645 (2012). doi:10.1073/pnas.1204263109.

[466] R. Chetrite and K. Mallick. Quantum fluctuation relations for the Lindblad master equation. *J. Stat. Phys.*, 148(3):480–501 (2012). doi:10.1007/s10955-012-0557-z.

[467] Anupam Kundu. Nonequilibrium fluctuation theorem for systems under discrete and continuous feedback control. *Phys. Rev. E*, 86:021107 (2012). doi:10.1103/PhysRevE.86.021107.

[468] Takahiro Sagawa and Masahito Ueda. Fluctuation theorem with information exchange: Role of correlations in stochastic thermodynamics. *Phys. Rev. Lett.*, 109(18):180602 (2012). doi:10.1103/PhysRevLett.109.180602.

[469] Pierre Gaspard. Fluctuation relations for equilibrium states with broken discrete symmetries. *J. Stat. Mech.: Theor. Exp.*, (P08021) (2012). doi:10.1088/1742-5468/2012/08/P08021. arXiv:1207.4409.

[470] Jordan M. Horowitz. Quantum trajectory approach to the stochastic thermodynamics of a forced harmonic oscillator. arXiv:1111.7199.

[471] Valerio Lucarini and Matteo Colangeli. Beyond the linear fluctuation-dissipation theorem: the role of causality. arXiv:1202.1073.

[472] Takahiro Sagawa. Thermodynamics of information processing in small systems. *Prog. Theor. Phys.*, 127(1):1–56 (2012). doi:10.1143/PTP.127.1.

[473] Andre C. Barato, D. Hartich, and Udo Seifert. Information-theoretic versus thermodynamic entropy production in autonomous sensory networks. *Phys. Rev. E*, 87:042104 (2013). doi:10.1103/PhysRevE.87.042104.

[474] Guillaume Michel and Debra J. Searles. Local fluctuation theorem for large systems. *Phys. Rev. Lett.*, 110:260602 (2013). doi:10.1103/PhysRevLett.110.260602.

[475] Sebastian Deffner and Christopher Jarzynski. Information processing and the Second Law of thermodynamics: An inclusive, Hamiltonian approach. *Phys. Rev. X*, 3:041003 (2013). doi:10.1103/PhysRevX.3.041003.

[476] Dibyendu Mandal. Nonequilibrium heat capacity. *Phys. Rev. E*, 88:062135 (2013). doi:10.1103/PhysRevE.88.062135.

[477] Takahiro Sagawa and Masahito Ueda. Role of mutual information in entropy production under information exchanges. *New J. Phys.*, 15(12):125012 (23) (2013). doi:10.1088/1367-2630/15/12/125012.

[478] G. N. Bochkov and Yu. E. Kuzovlev. Fluctuation–dissipation relations. Achievements and misunderstandings. *Phys.-Usp.*, 56(6):590–602 (2013). doi:10.3367/UFNe.0183.201306d.0617. arXiv:1208.1202.
  ◦ "If dear reader have recognized some other probably significant aspects of the subject, this does not mean that they are unknown to us." Claims that Jarzynski (and Crooks) relations only apply to cyclic processes, which is just wrong. [Bochkov2013a]

[479] Folarin Latinwo and Charles M. Schroeder. Nonequilibrium work relations for polymer dynamics in dilute solutions. *Macromolecules*, 46(20):8345–8355 (2013). doi:10.1021/ma400961s.

[480] Mikhail Prokopenko, Joseph T. Lizier, and Don C. Price. On thermodynamic interpretation of transfer entropy. *Entropy*, 15(2):524–543 (2013). doi:10.3390/e15020524.

[481] D. Hartich, Andre C. Barato, and Udo Seifert. Stochastic thermodynamics of bipartite systems: transfer entropy inequalities and a Maxwell's demon interpretation. *J. Stat. Mech.: Theor. Exp.*, (2):P02016 (2014). doi:10.1088/1742-5468/2014/02/P02016.

[482] Giovanni Diana and Massimiliano Esposito. Mutual entropy production in bipartite systems. *J. Stat. Mech.: Theor. Exp.*, (4):P04010 (2014). doi:10.1088/1742-5468/2014/04/P04010.

[483] Jordan M. Horowitz and Henrik Sandberg. Second-law-like inequalities with information and their interpretations. *New J. Phys.*, 16(12):125007 (2014). doi:10.1088/1367-2630/16/12/125007.

[484] J. V. Koski, V. F. Maisi, Takahiro Sagawa, and J. P. Pekola. Experimental observation of the role of mutual information in the nonequilibrium dynamics of a Maxwell demon. *Phys. Rev. Lett.*, 113:030601 (2014). doi:10.1103/PhysRevLett.113.030601.

[485] Folarin Latinwo, Kai-Wen Hsiao, and Charles M. Schroeder. Nonequilibrium thermodynamics of dilute polymer solutions in flow. *J. Chem. Phys.*, 141(17) (2014). doi:10.1063/1.4900880.

[486] Juan M. R. Parrondo, Jordan M. Horowitz, and Takahiro Sagawa. Thermodynamics of information. *Nat. Phys.*, 11(2):131–139 (2015). doi:10.1038/nphys3230.

[487] Jordan M. Horowitz. Multipartite information flow for multiple Maxwell demons. *J. Stat. Mech.: Theor. Exp.*, (3):P03006 (2015). doi:10.1088/1742-5468/2015/03/P03006.

[488] A. Alemany, M. Ribezzi-Crivellari, and Felix Ritort. From free energy measurements to thermodynamic inference in nonequilibrium small systems. *New J. Phys.*, 17(7):075009 (2015). doi:10.1088/1367-2630/17/7/075009.

[489] Bernard Gaveau and Michel Moreau. Time reversal invariance, entropy production and work dissipation in stochastic thermodynamics. *Eur. Phys. J. Special Topics*, 224(5):905–925 (2015). doi:10.1140/epjst/e2015-02435-6.

[490] Sosuke Ito and Takahiro Sagawa. Information flow and entropy production on Bayesian networks. In *Mathematical Foundations and Applications of Graph Entropy*. Whiley (2015). arXiv:1506.08519.

[491] Anthony Bartolotta, Sean M. Carroll, Stefan Leichenauer, and Jason Pollack. The Bayesian second law of thermodynamics. *Phys. Rev. E*, 94:022102 (2016). doi:10.1103/PhysRevE.94.022102.

I got another quarter hundred weight of books on the subject last night. I have not read them all through.

William Thomson (Lord Kelvin) Lecture IX, p87