Kuantum Kaynak Teorilerine Giriş

KUANTUM TERMODİNAMİK

⟨ QSB | KU ⟩

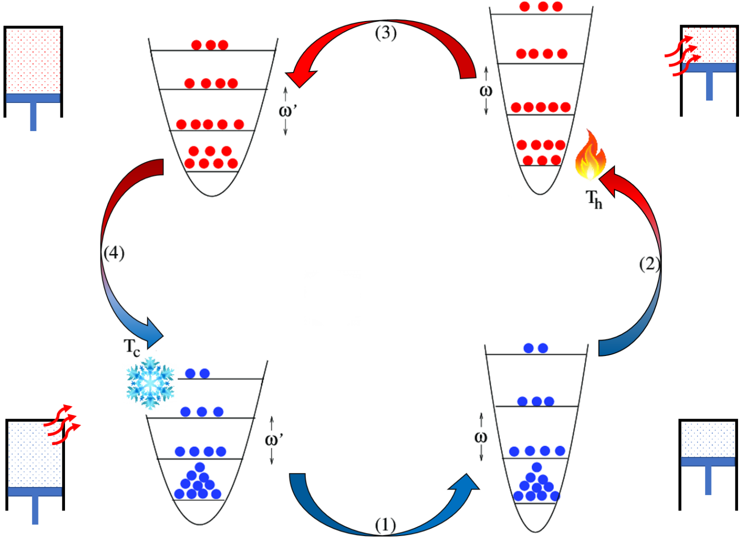
Dr. Onur Pusuluk

Koç Üniversitesi

11 Nisan 2021

Gündem

Otto Çevrimi

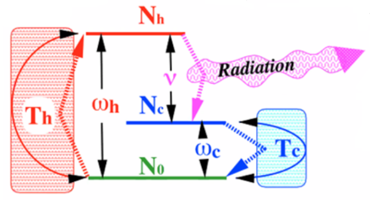


Carnot Çevrimi

VOLUME 2, NUMBER 6 PHYSICAL REVIEW LETTERS MARCH 15, 1959

THREE-LEVEL MASERS AS HEAT ENGINES

H. E. D. Scovil and E. O. Schulz-DuBois



İleri Okuma

REPORT

A single-atom heat engine

Johannes Roßnagel[1,*], Samuel T. Dawkins[1], Karl N. Tolazzi[2], Obinna Abah[3], Eric Lutz[3], Ferdinand Sc...
+ See all authors and affiliations

Science 15 Apr 2016:
Vol. 352, Issue 6283, pp. 325-329
DOI: 10.1126/science.aad6320

A single-atom heat engine

Eric Lutz

Physics Today **73**, 5, 66 (2020)
https://doi.org/10.1063/PT.3.4482

PHYSICAL REVIEW LETTERS

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Featured in Physics | Editors' Suggestion

Experimental Demonstration of Quantum Effects in the Operation of Microscopic Heat Engines

James Klatzow, Jonas N. Becker, Patrick M. Ledingham, Christian Weinzetl, Krzysztof T. Kaczmarek, Dylan J. Saunders, Joshua Nunn, Ian A. Walmsley, Raam Uzdin, and Eilon Poem

Phys. Rev. Lett. **122**, 110601 – Published 20 March 2019

Physics See Viewpoint: Powering an Engine with Quantum Coherence

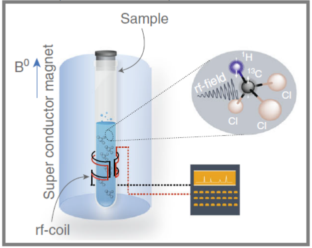
Gündem

NATURE COMMUNICATIONS | https://doi.org/10.1038/s41467-019-10333-7

Reversing the direction of heat flow using quantum correlations

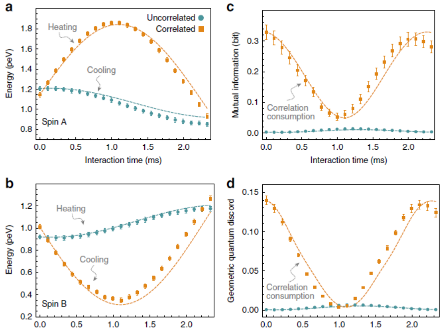
Kaonan Micadei[1,2,8], John P.S. Peterson[3,8], Alexandre M. Souza[3], Roberto S. Sarthour[3], Ivan S. Oliveira[3], Gabriel T. Landi[4], Tiago B. Batalhão[5,6], Roberto M. Serra[1,7] & Eric Lutz[2]

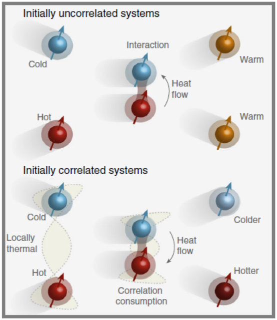
Heat spontaneously flows from hot to cold in standard thermodynamics. However, the latter theory presupposes the absence of initial correlations between interacting systems. We here experimentally demonstrate the reversal of heat flow for two quantum correlated spins-1/2, initially prepared in local thermal states at different effective temperatures, employing a Nuclear Magnetic Resonance setup. We observe a spontaneous energy flow from the cold to the hot system. This process is enabled by a trade off between correlations and entropy that we quantify with information-theoretical quantities. These results highlight the subtle interplay of quantum mechanics, thermodynamics and information theory. They further provide a mechanism to control heat on the microscale.



Anormal Isı Akışları

NATURE COMMUNICATIONS | https://doi.org/10.1038/s41467-019-10333-7



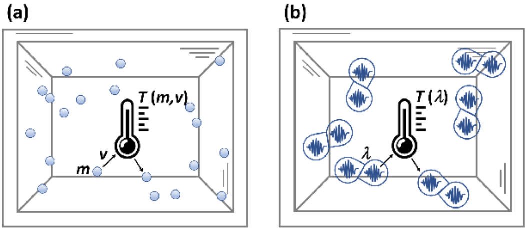


Quantum Rayleigh Problem and Thermocoherent Onsager Relations

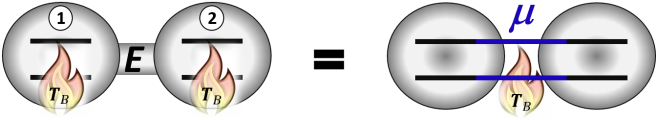
Onur Pusuluk[1] and Özgür E. Müstecaplıoğlu[1]
[1] Department of Physics, Koç University, Sarıyer, İstanbul, 34450 Turkey

arXiv:2006.03186

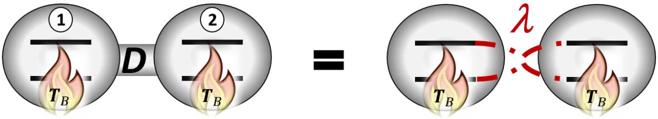
$$\mathcal{J}_h = L_{hh}\,\Delta(1/T) + L_{hc}\,\Delta(C/T) \qquad (1)$$
$$\mathcal{J}_c = L_{ch}\,\Delta(1/T) + L_{cc}\,\Delta(C/T) \qquad (2)$$



Karşılıklılık İlişkileri

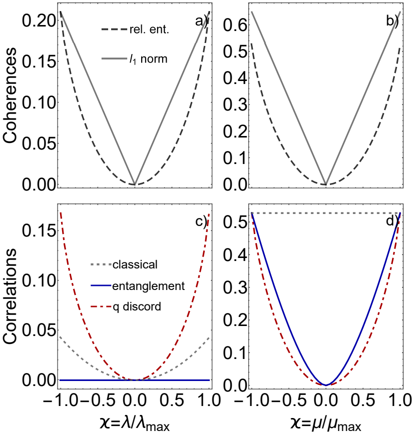


$$\rho_E = p_g|gg\rangle\langle gg| + p_e|ee\rangle\langle ee| + (\mu|gg\rangle\langle ee| + \text{h.c.}) = \begin{pmatrix} p_g & 0 & 0 & \mu \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ \mu & 0 & 0 & p_e \end{pmatrix}$$



$$\rho_D = (p_g|g\rangle\langle g| + p_e|e\rangle\langle e|)^{\otimes 2} + (\lambda|ge\rangle\langle eg| + \text{h.c.}) = \begin{pmatrix} p_g^2 & 0 & 0 & 0 \\ 0 & p_g p_e & \lambda & 0 \\ 0 & \lambda & p_g p_e & 0 \\ 0 & 0 & 0 & p_e^2 \end{pmatrix}$$

Karşılıklılık İlişkileri



$$E_g = 1,\, E_e = 2,\, \beta_B = 2.$$

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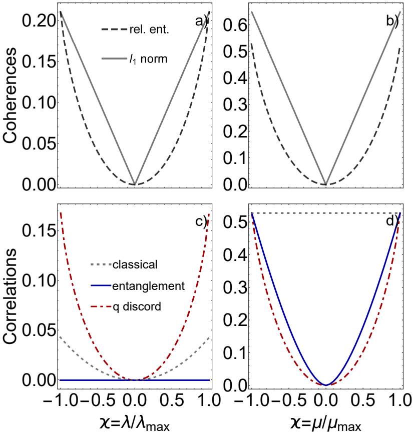

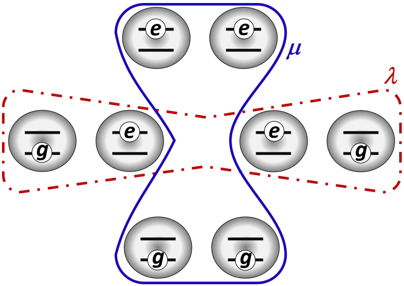

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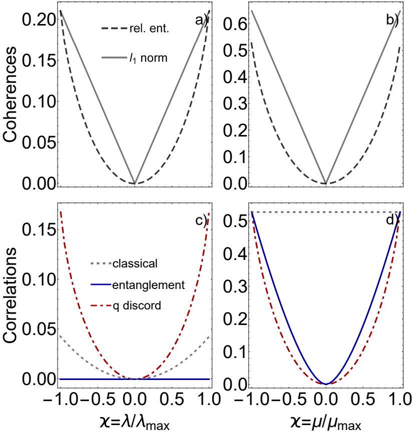

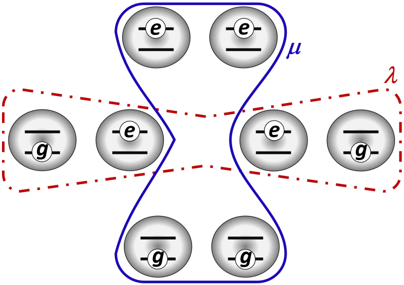

Entropy 18, 244 (2016); PRE 99, 042145 (2019)

Sci. Rep. 9, 3191; PRR 1, 033097 (2019); PRA 102, 042220 (2020)

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Gündem

Termodinamik Vs Kuantum

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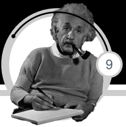

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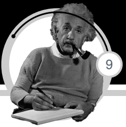

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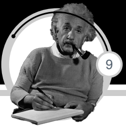

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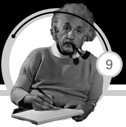

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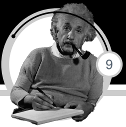

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$$\boxed{\rho_{12} \neq \rho_1 \otimes \rho_2}$$

Gündem

0: Sistem-Banyo Bölüşümü

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- İndirgenmiş Tanımlama

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- Dengeye Yaklaşma

$$\boxed{\rho_S(t) = \Lambda_t(\rho_S(0)) \to \rho_S^\infty = \exp(-\beta_B \hat{H}_S)/\mathcal{Z}}$$

1: Enerji Değişimi

- Enerjinin Korunumu

$$\boxed{[\hat{H}_S, \hat{H}_{SB}] = 0} \Rightarrow \boxed{\mathrm{d}E_S = -\mathrm{d}E_B}$$

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$$\boxed{\frac{\mathrm{d}}{\mathrm{d}t} E_S(t) = \langle \frac{\partial}{\partial t} \hat{H}_S \rangle + \langle \mathcal{L}_t \big[\rho_S(t) \big] \rangle}$$

J. Phys. A: Math. Gen. 12, L103 (1979); EPL 83, 30008 (2008); arXiv:1801.08314 [quant-ph] (2018)

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$$\boxed{\mathcal{P} \equiv \mathrm{tr}[\rho_S \frac{\partial}{\partial t} \hat{H}_S]}$$

$$\boxed{\mathcal{J} \equiv \mathrm{tr}[\rho_S \mathcal{D}(\rho_S)]}$$

J. Phys. A: Math. Gen. 12, L103 (1979); EPL 83, 30008 (2008); arXiv:1801.08314 [quant-ph] (2018)

- Entropinin Artması

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$$\boxed{S[\Lambda_t(\rho_S)||\Lambda_t(\rho_S^\infty)] \leq S[\rho_S||\rho_S^\infty]}$$

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$$\boxed{\Pi(t) \equiv -\frac{\mathrm{d}}{\mathrm{d}t} S[\rho_S(t)||\rho_S^\infty] \qquad \geq 0}$$

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PRL 122, 150603 (2019); PRL 123, 200603 (2019); npj Quantum Inf. 5, 23 (2019); arXiv:2009.07668 [quant-ph] (2020)

Gündem

Atermalliğin Kaynak Teorisi

Phys. Rep. 583, 1 (2015); J. Phys. A 49, 143001 (2016); Contemp. Phys. 57:4, 545-579 (2016)

Atermalliğin Kaynak Teorisi

- Kaynak değeri olan durumlar:

$$\boxed{(\rho, \hat{H})}$$

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$$\left[U(\rho \otimes \rho_\beta)U^\dagger\right]$$

$$[\hat{H}_{tot}, U] = 0$$

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- İzinli (Termal) Dönüşümler:

$$(\rho, \hat{H}) \rightarrow (\sigma, \hat{H}')$$

Phys. Rep. 583, 1 (2015); J. Phys. A 49, 143001 (2016); Contemp. Phys. 57:4, 545-579 (2016)

Article | Published: 26 June 2013

Fundamental limitations for quantum and nanoscale thermodynamics

Michał Horodecki & Jonathan Oppenheim

Nature Communications **4**, Article number: 2059 (2013) | Download Citation

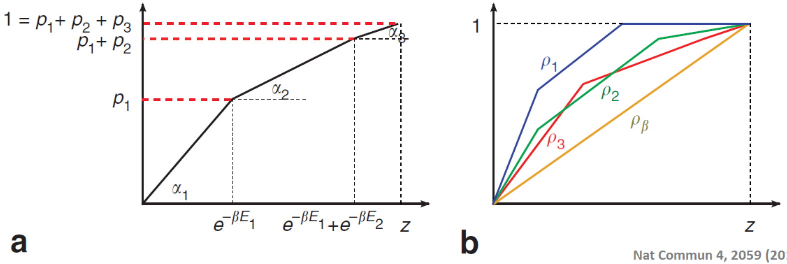
The second laws of quantum thermodynamics

Fernando Brandão, Michał Horodecki, Nelly Ng, Jonathan Oppenheim, and Stephanie Wehner

PNAS March 17, 2015 112 (11) 3275-3279; first published February 9, 2015 https://doi.org/10.1073/pnas.1411728112

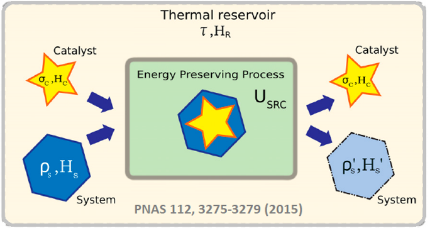
Edited by Peter W. Shor, Massachusetts Institute of Technology, Cambridge, MA, and approved January 12, 2015 (received for review June 26, 2014)

Termo-majorizasyon Ön-sıralaması



Nat Commun 4, 2059 (2013)

2. Yasa Ailesi ve Katalitik Dönüşümler



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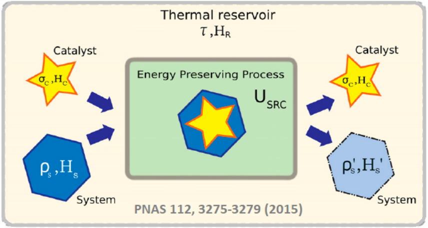

$$F_\alpha(\rho,\rho_\beta) := kTD_\alpha(\rho\|\rho_\beta) - kT\log Z$$

$$D_\alpha(\rho\|\rho_\beta) = \frac{\mathrm{sgn}(\alpha)}{\alpha-1}\log\sum_i p_i^\alpha q_i^{1-\alpha}$$

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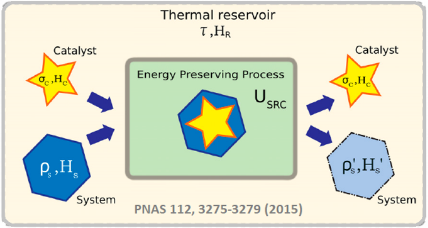

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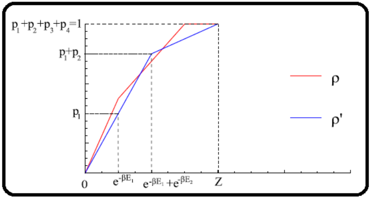

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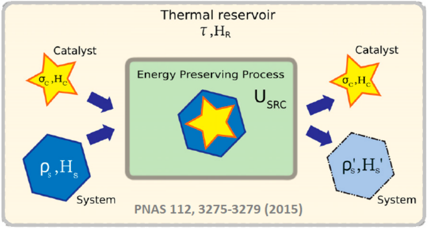

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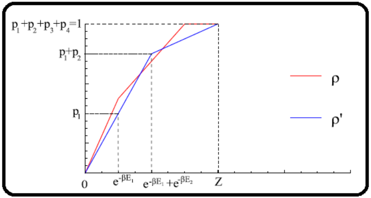
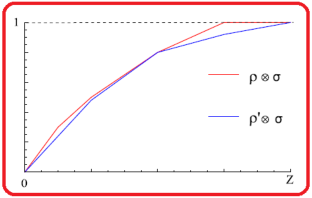
$$D_\alpha(\rho\|\rho_\beta) = \frac{\mathrm{sgn}(\alpha)}{\alpha-1}\log\sum_i p_i^\alpha q_i^{1-\alpha}$$





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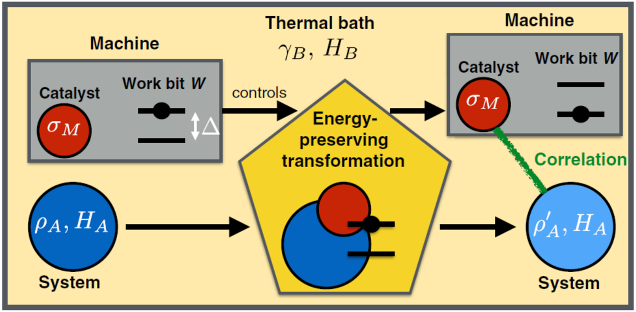
Correlating Thermal Machines and the Second Law at the Nanoscale

Markus P. Müller



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