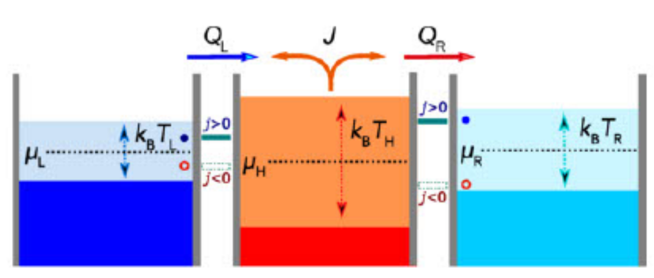

# Autonomous quantum absorption refrigerators: towards thermal control across a chain of electronic nanocavities

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Etienne, Bibek, and Andrew Jordan

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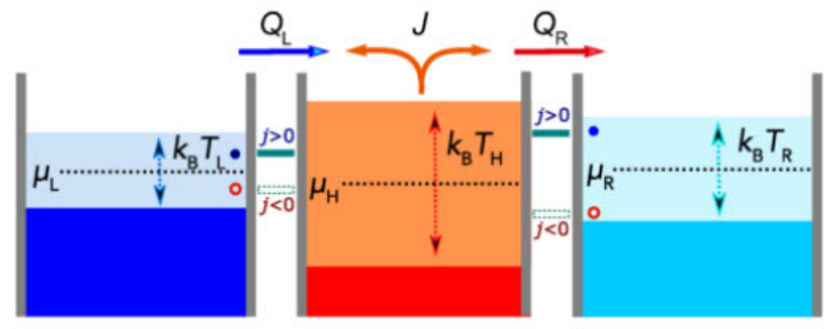
## An Autonomous Quantum Absorption Refrigerator



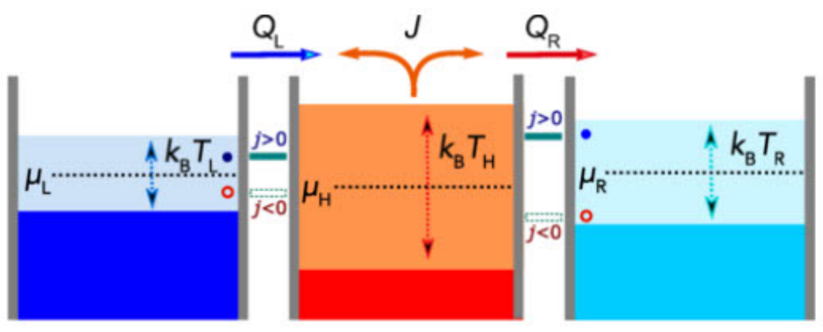
| Cold reservoir | Dissipative source | Hot reservoir |
|---|---|---|
| A fermionic lead | A fermionic cavity | A fermionic lead |
| Contributes particles, and energy. | Contributes energy in the form of heat | Contributes particles, and energy. |

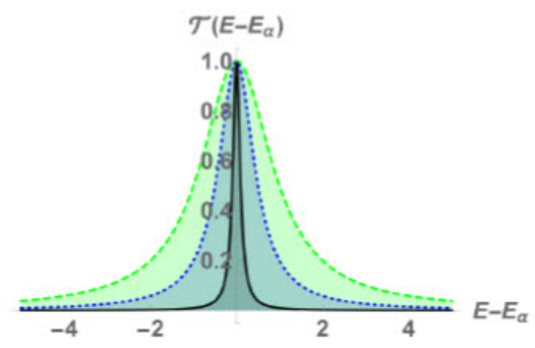
**Reservoirs,**

$$f(E-\mu_\alpha, T_\alpha) = \left(e^{\frac{E-\mu_\alpha}{k_B T_\alpha}}+1\right)^{-1}, \quad \alpha = \mathrm{L,R,H}.$$



## Landauer- Büttiker Scattering Approach





**The transmission function for the quantum dots:**

$$\mathcal{T}_\alpha(E) = \frac{\gamma^2}{(E-E_\alpha)^2+\gamma^2}.$$

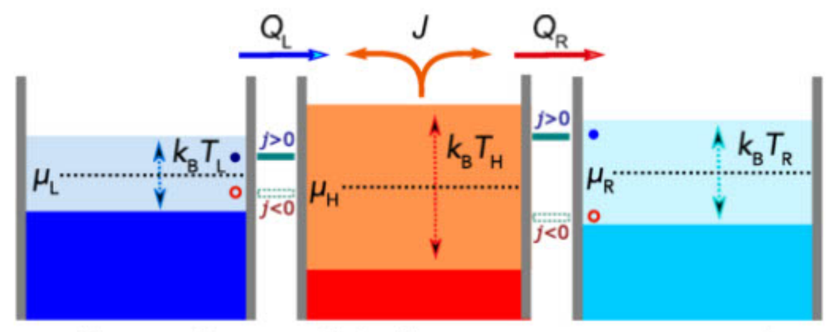
The particle current: $j_\alpha = \frac{2}{h}\int \mathrm{d}E\, \mathcal{T}_\alpha(E)[f(E-\mu_\alpha,T_\alpha) - f(E-\mu_\mathrm{H},T_\mathrm{H})],$

The energy current: $J_\alpha = \frac{2}{h}\int \mathrm{d}E\, E\mathcal{T}_\alpha(E)[f(E-\mu_\alpha,T_\alpha) - f(E-\mu_\mathrm{H},T_\mathrm{H})],$

The heat current: $Q_\alpha = J_\alpha - \mu_\alpha j_\alpha.$



## Conservation of Particle Current



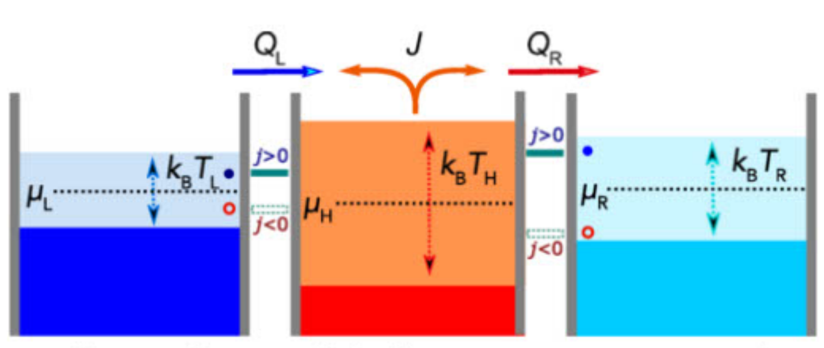
Cold reservoir | Dissipative source | Hot reservoir

$$j = \frac{\gamma}{\hbar}[f(E_\mathrm{L}-\mu_\mathrm{L},T_\mathrm{L}) - f(E_\mathrm{L}-\mu_\mathrm{H},T_\mathrm{H})],$$
$$= \frac{\gamma}{\hbar}[f(E_\mathrm{R}-\mu_\mathrm{H},T_\mathrm{H}) - f(E_\mathrm{R}-\mu_\mathrm{R},T_\mathrm{R})].$$

Allows us to solve for the chemical potential of the central hot cavity.



## Thermodynamic Laws



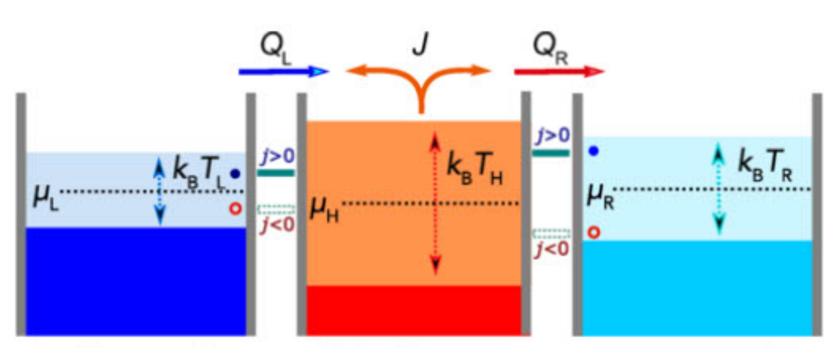
Cold reservoir | Dissipative source | Hot reservoir

The first law: $J + Q_\mathrm{L} + Q_\mathrm{R} = 0,$

The second law: $\frac{J}{T_\mathrm{H}} + \frac{Q_\mathrm{L}}{T_\mathrm{L}} + \frac{Q_\mathrm{R}}{T_\mathrm{R}} \leq 0.$



## Coefficient of Performance

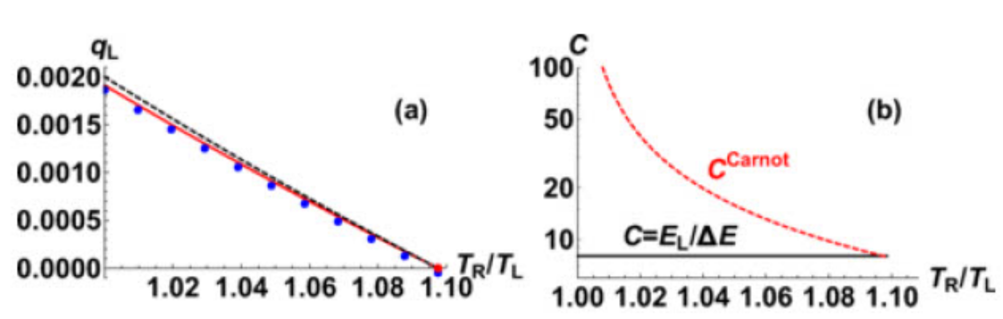


Cold reservoir | Dissipative source | Hot reservoir

$$J\left(\frac{1}{T_\mathrm{R}} - \frac{1}{T_\mathrm{H}}\right) \geq Q_\mathrm{L}\left(\frac{1}{T_\mathrm{L}} - \frac{1}{T_\mathrm{R}}\right) \implies C = \frac{Q_\mathrm{L}}{J} \leq \frac{T_\mathrm{R}^{-1} - T_\mathrm{H}^{-1}}{T_\mathrm{L}^{-1} - T_\mathrm{R}^{-1}} = C_\mathrm{Carnot}.$$



## Carnot Coefficient of Performance is Realized At Stopping Configurations where Cooling Power Goes to Zero.



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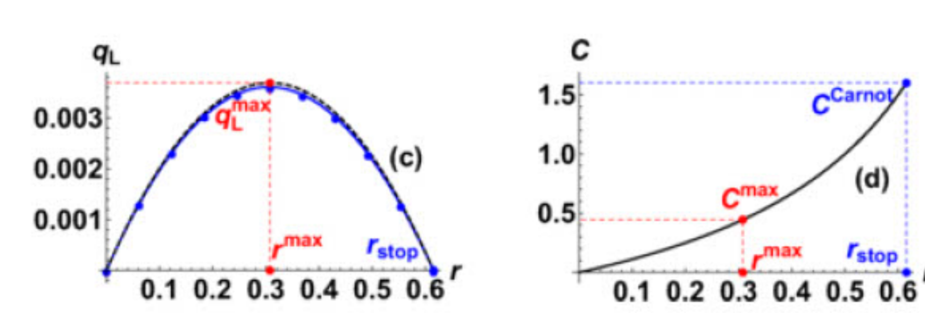

$r = E_\mathrm{L}/E_\mathrm{R}.$

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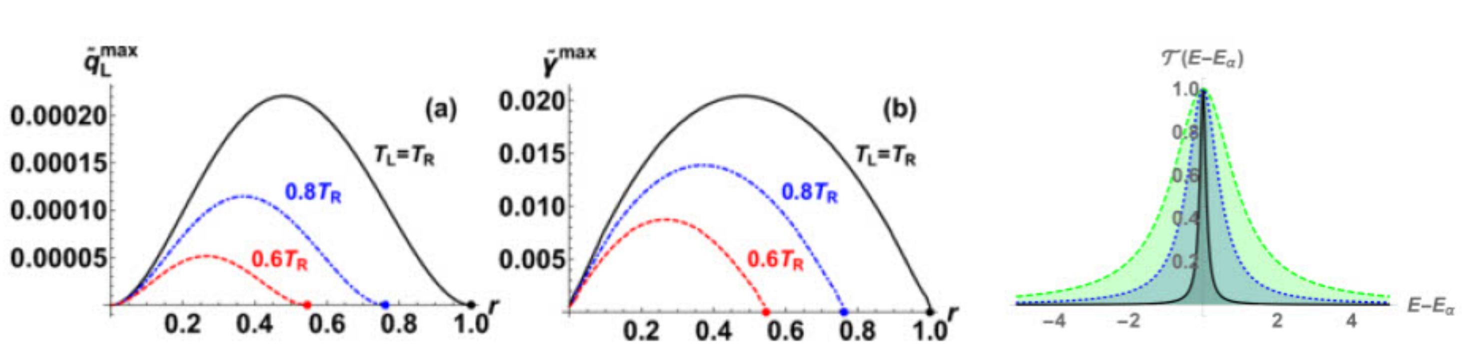
## Narrower Linewidth is Cooler



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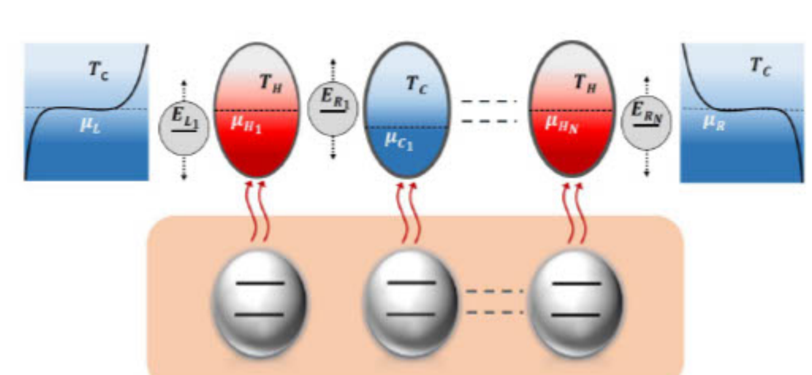
## Towards Thermal Control in Mesoscopic Physics



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