Enerģijas–laika nenoteiktības ietekme uz kvantu punktu apdzīvotības dinamiku

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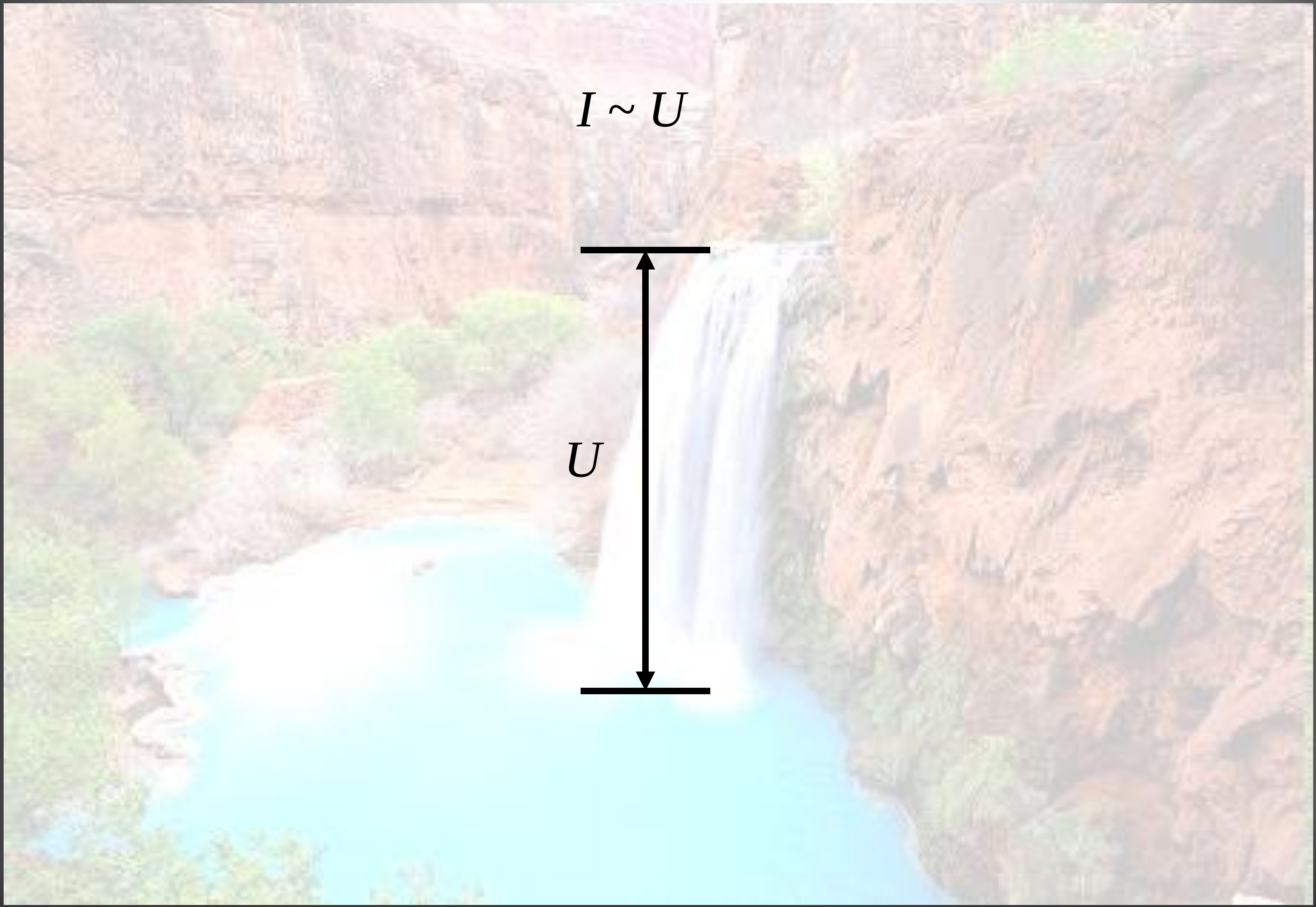
IEGULDĪJUMS TAVĀ NĀKOTNĒ

Projekts „Datorzinātnes pielietojumi un tās saiknes ar kvantu fiziku”
Līguma Nr. 2009/0216/1DP/1.1.1.2.0/09/APIA/VIAA/044

Strāva & DC transports



Kvantu sūkņi

Adiabātiska lādiņa pārnese

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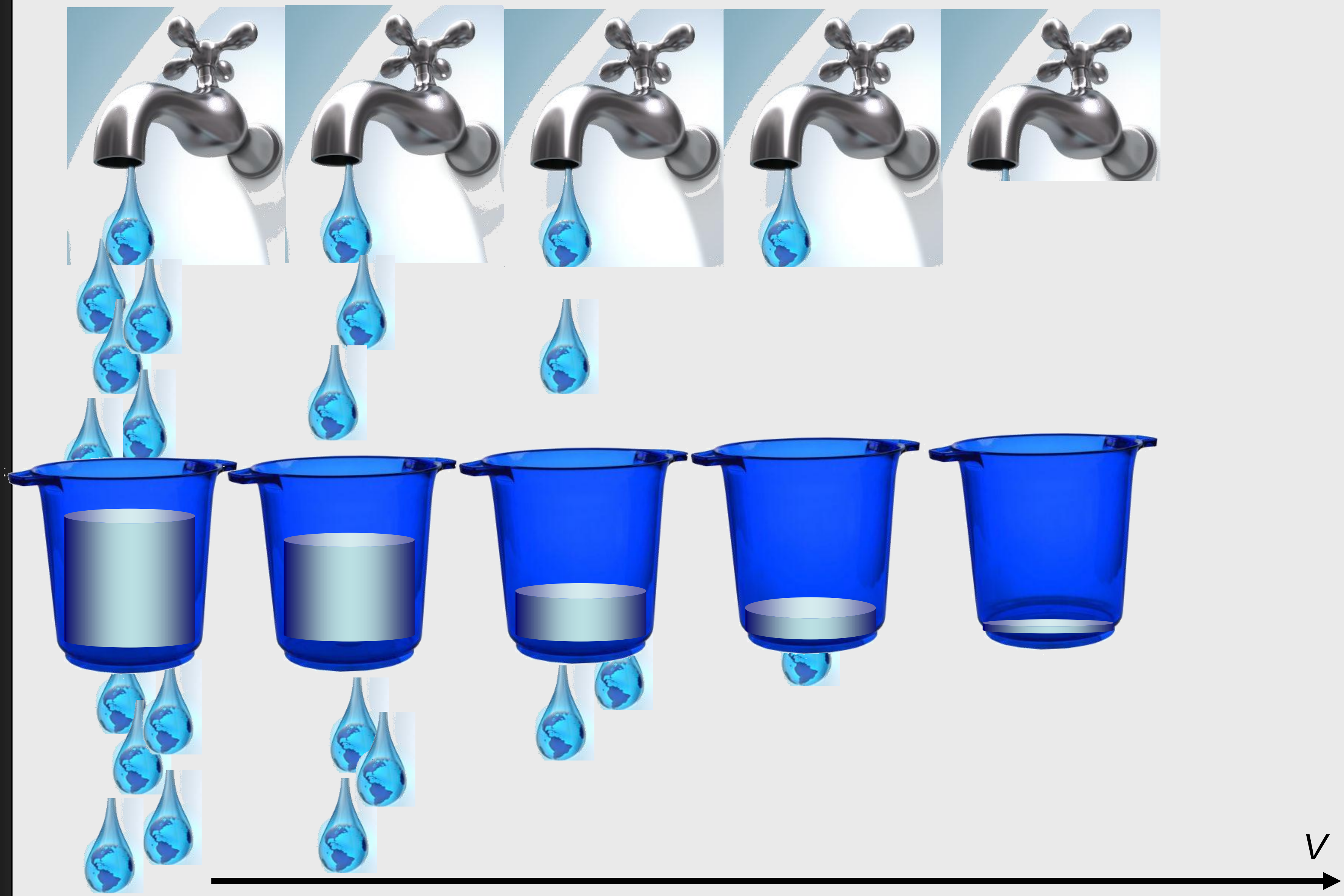
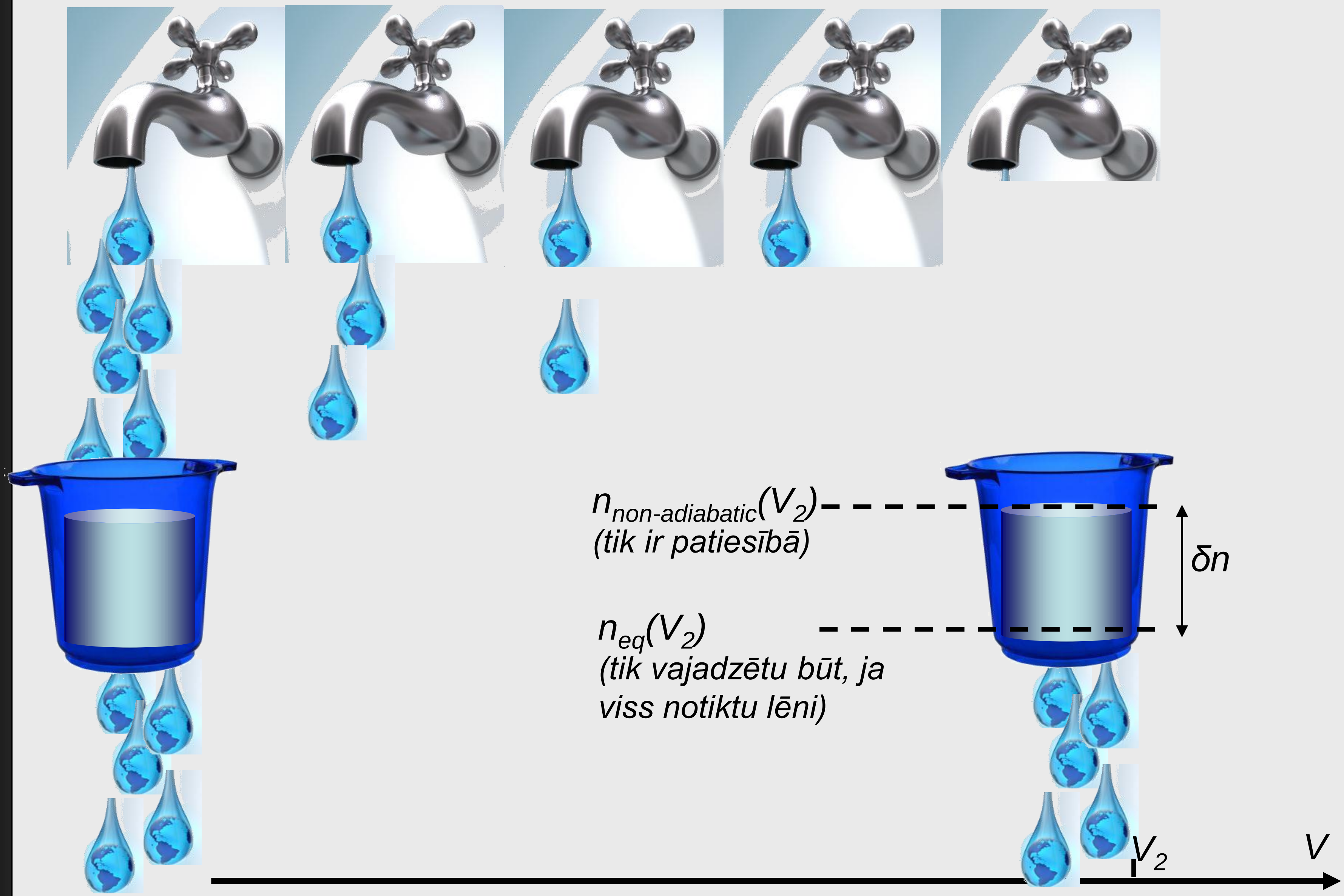
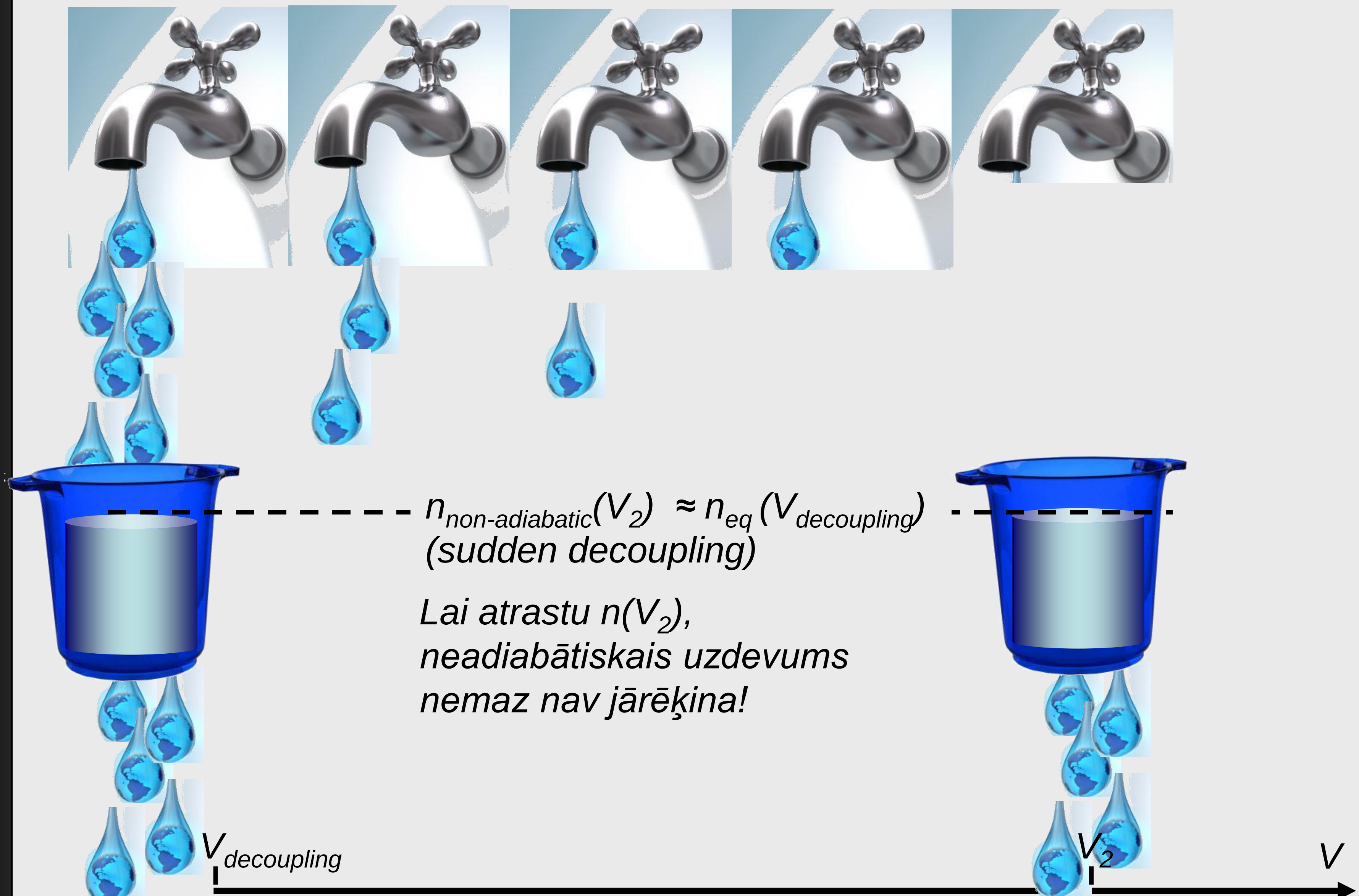


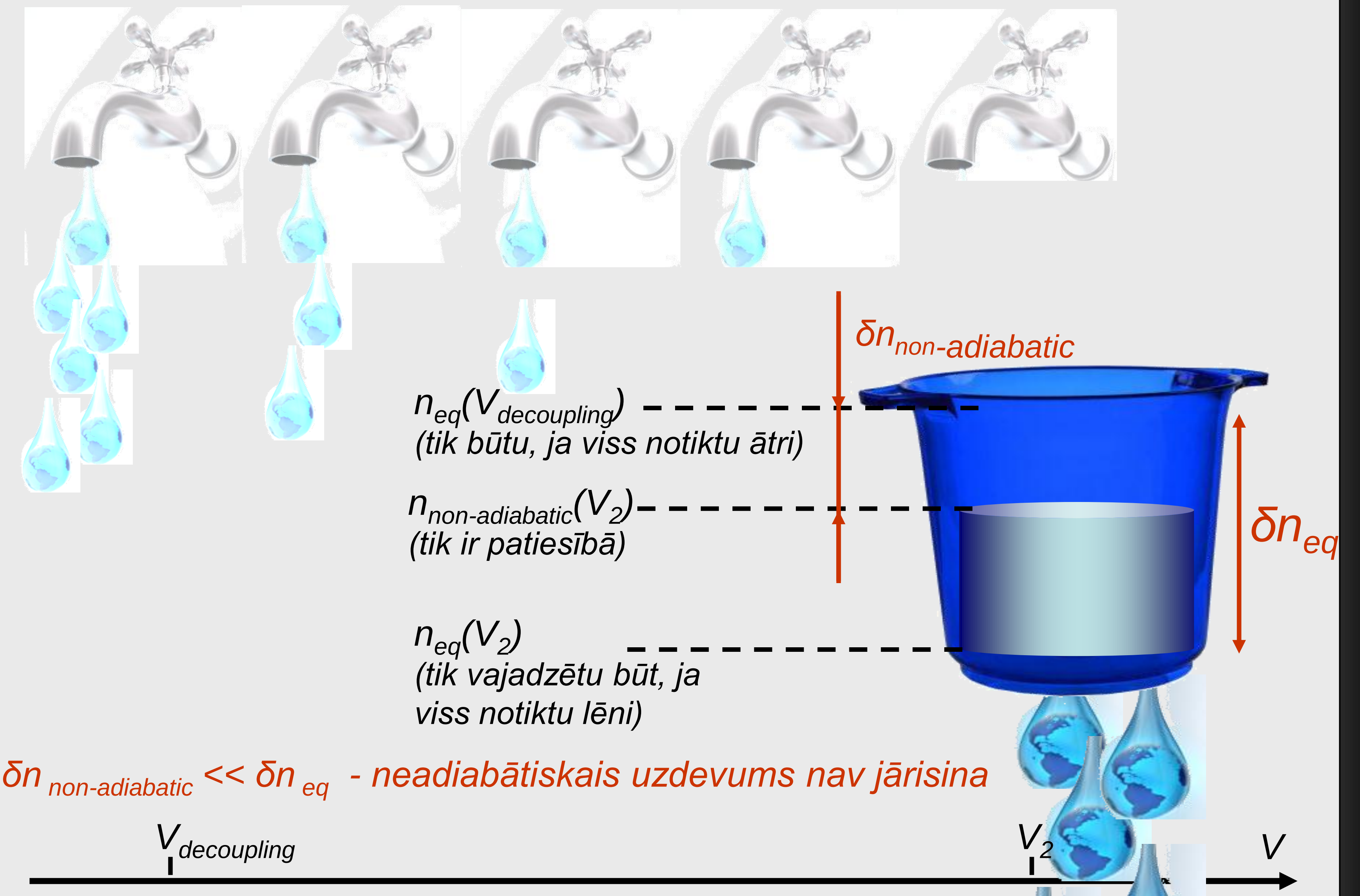
Neadiabātiska lādiņa pārnese



Neadiabātiska lādiņa pārnese

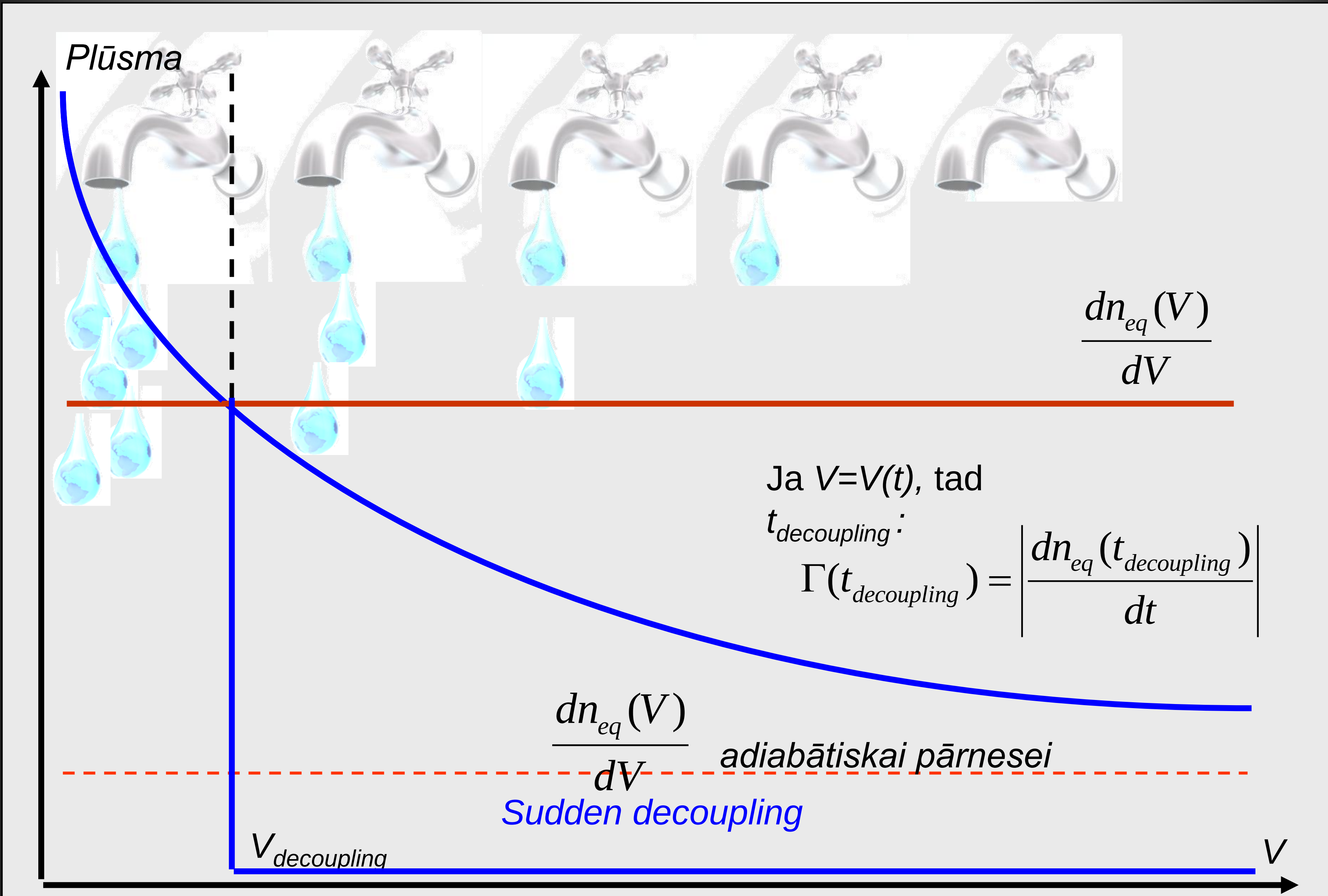


Vispārīgāks gadījums

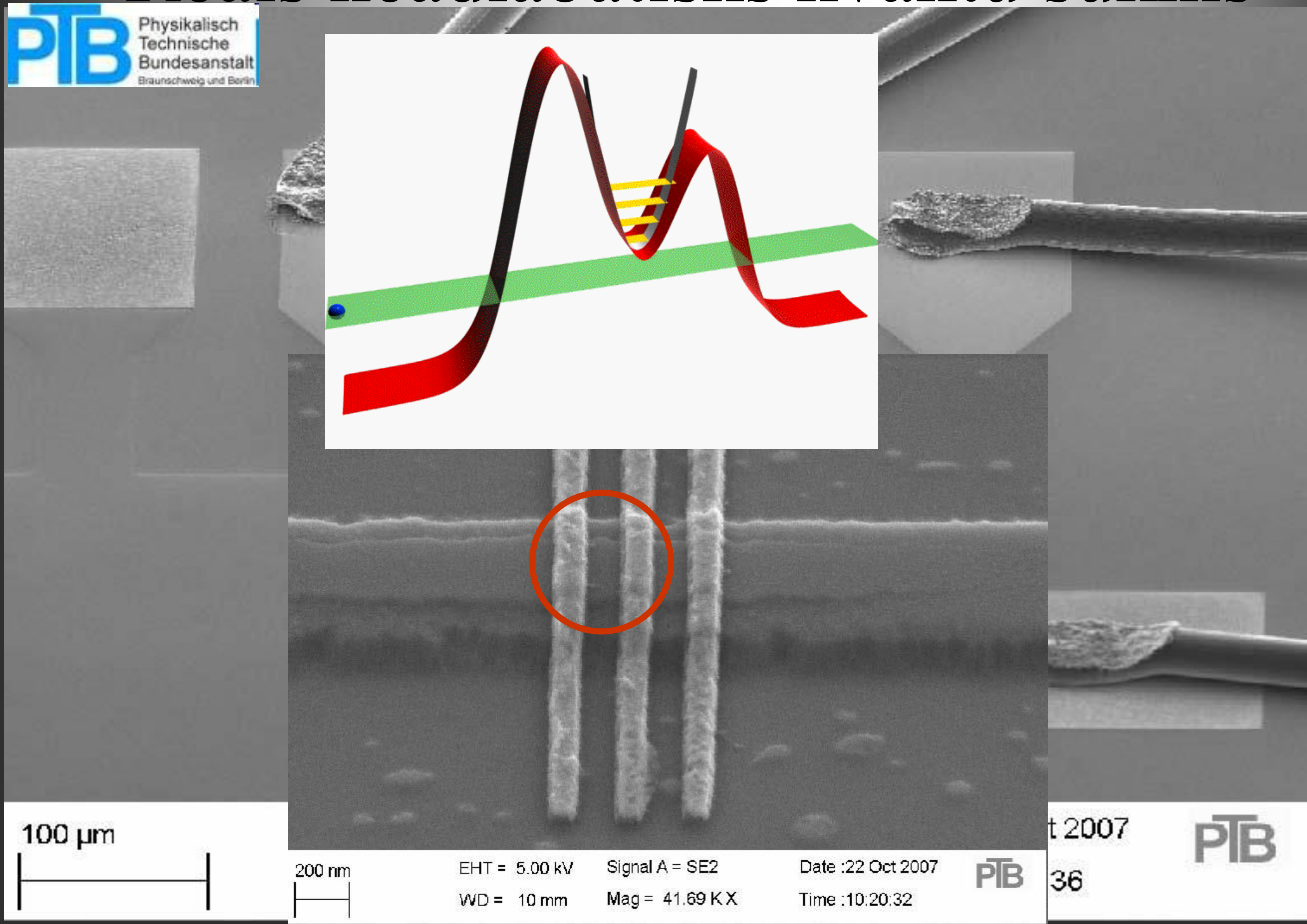


$\delta n_{non\text{-}adiabatic} << \delta n_{eq}$ - neadiabātiskais uzdevums nav jārisina

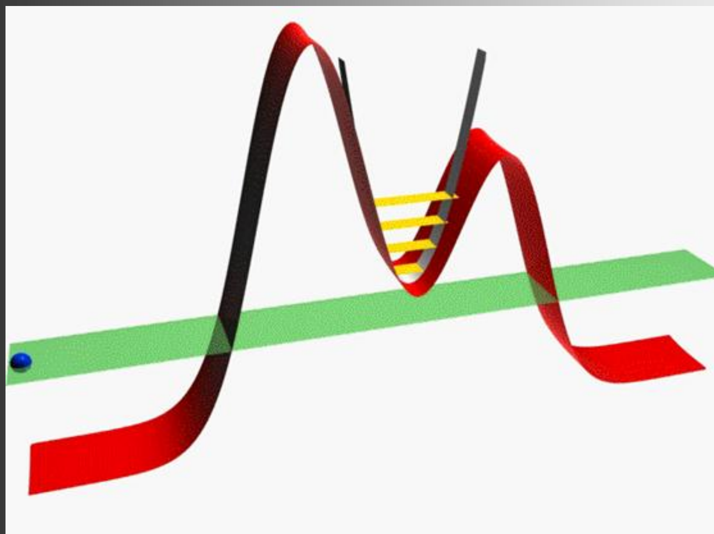
Vispārīgāks gadījums

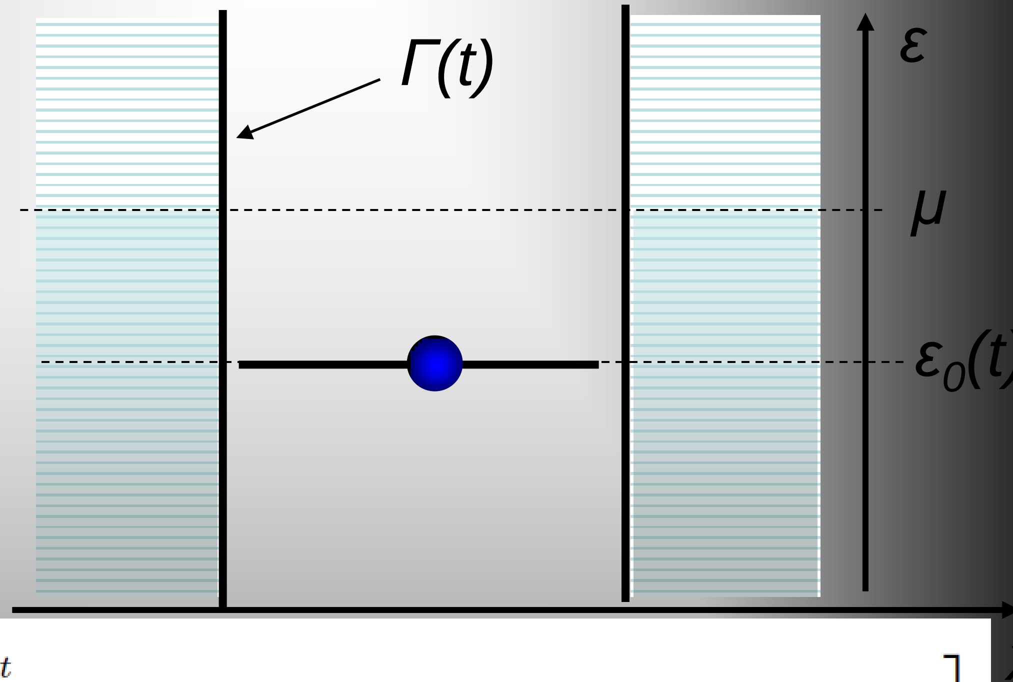


Reāls neadiabātisks kvantu sūknis



Neadiabātisks kvantu sūknis: modelis





$$e\langle\frac{dn}{dt}\rangle = -\frac{e}{\hbar}\left[\Gamma(t)n(t) + \int\frac{d\varepsilon}{\pi}f(\varepsilon)\int_{-\infty}^{t} dt_1 \mathrm{Im}\{\Gamma(t_1,t)/\hbar\exp(-i\varepsilon(t_1-t)/\hbar)G^R(t,t_1)\}\right]$$

$$G^R(t,t') = -i\Theta(t-t')\exp\left(-i\int_{t'}^{t} dt_1\varepsilon_0(t_1)/\hbar\right)\exp\left(-\int_{t'}^{t} dt_1\Gamma(t_1)/(2\hbar)\right) \qquad \Gamma(t_1,t) = \sqrt{\Gamma(t)\Gamma(t_1)}$$

$$f(\varepsilon) = \frac{1}{1+e^{\frac{\varepsilon-\mu}{kT}}}$$

A.-P. Jauho *Phys. Rev. B*, vol. 50, pp. 5528–5544, Aug 1994

Kvantu sūkņi: $\varepsilon_0(t) = \varepsilon_c + (t-t_c)\dot{\varepsilon}$ $\qquad \Gamma(t) = \frac{2\hbar}{\tau}e^{-2(t-t_c)/\tau}$

Atrisinājums

$$e\langle\frac{dn}{dt}\rangle = -\frac{e}{\hbar}\left[\Gamma(t)n(t) + \int\frac{d\varepsilon}{\pi}f(\varepsilon)\int_{-\infty}^{t}dt_1 \mathrm{Im}\{\Gamma(t_1,t)/\hbar\exp(-i\varepsilon(t_1-t)/\hbar)G^R(t,t_1)\}\right]$$

Sākuma nosacījums: $0 < n(-\infty) < 1$

Atrisinājums:

$$\langle n\rangle(t\to\infty) = \int d\epsilon f(\varepsilon)|I(\varepsilon)|^2$$

$$I(\varepsilon) = \sqrt{\frac{1}{4\pi\hbar/\tau}}\left(\int_{-\infty}^{\infty}d\tilde{t}_1 e^{\frac{-i[(\varepsilon-\varepsilon_c)\tilde{t}_1-\frac{1}{4}\dot{\varepsilon}\tau\tilde{t}_1^2]}{2\hbar/\tau}}e^{-\tilde{t}_1/2}e^{-\frac{1}{2}e^{-\tilde{t}_1}}\right)$$

$$\tilde{t}_1 = 2(t_1 - t_c)/\tau$$

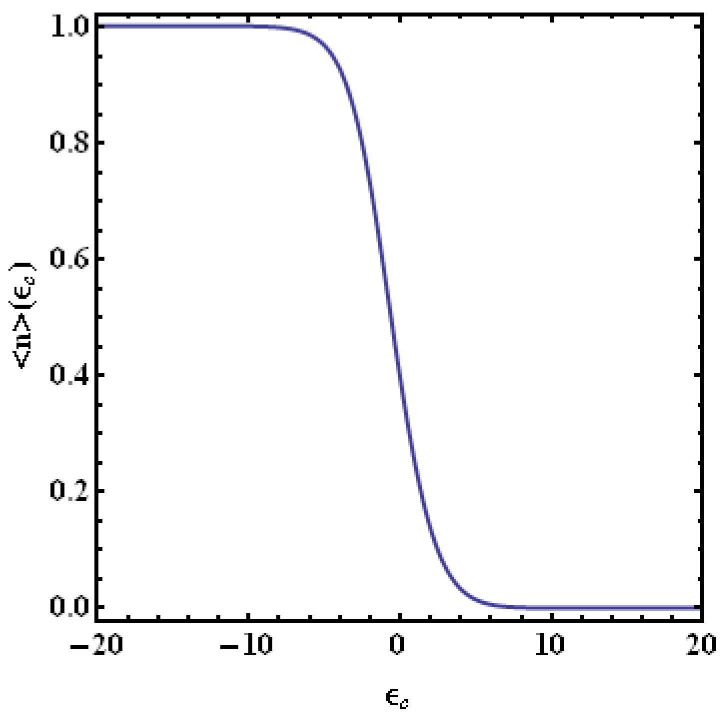
Atrisinājums. Fluktuācijas.

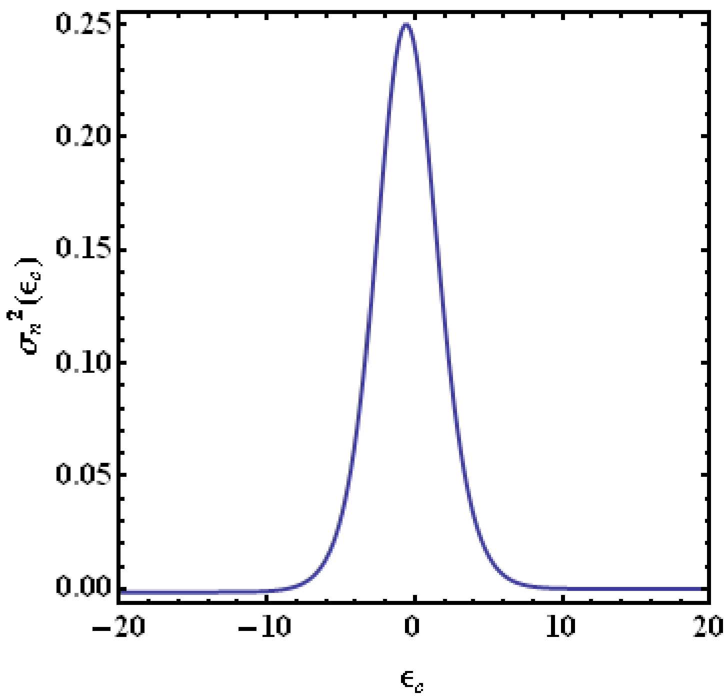
$$\langle n \rangle (t \to \infty) = \int d\epsilon f(\varepsilon) |I(\varepsilon)|^2$$

$$\langle n \rangle = \sum_i p_i n_i = p_0 \cdot 0 + p_1 \cdot 1$$

$$p_1 = \langle n \rangle$$

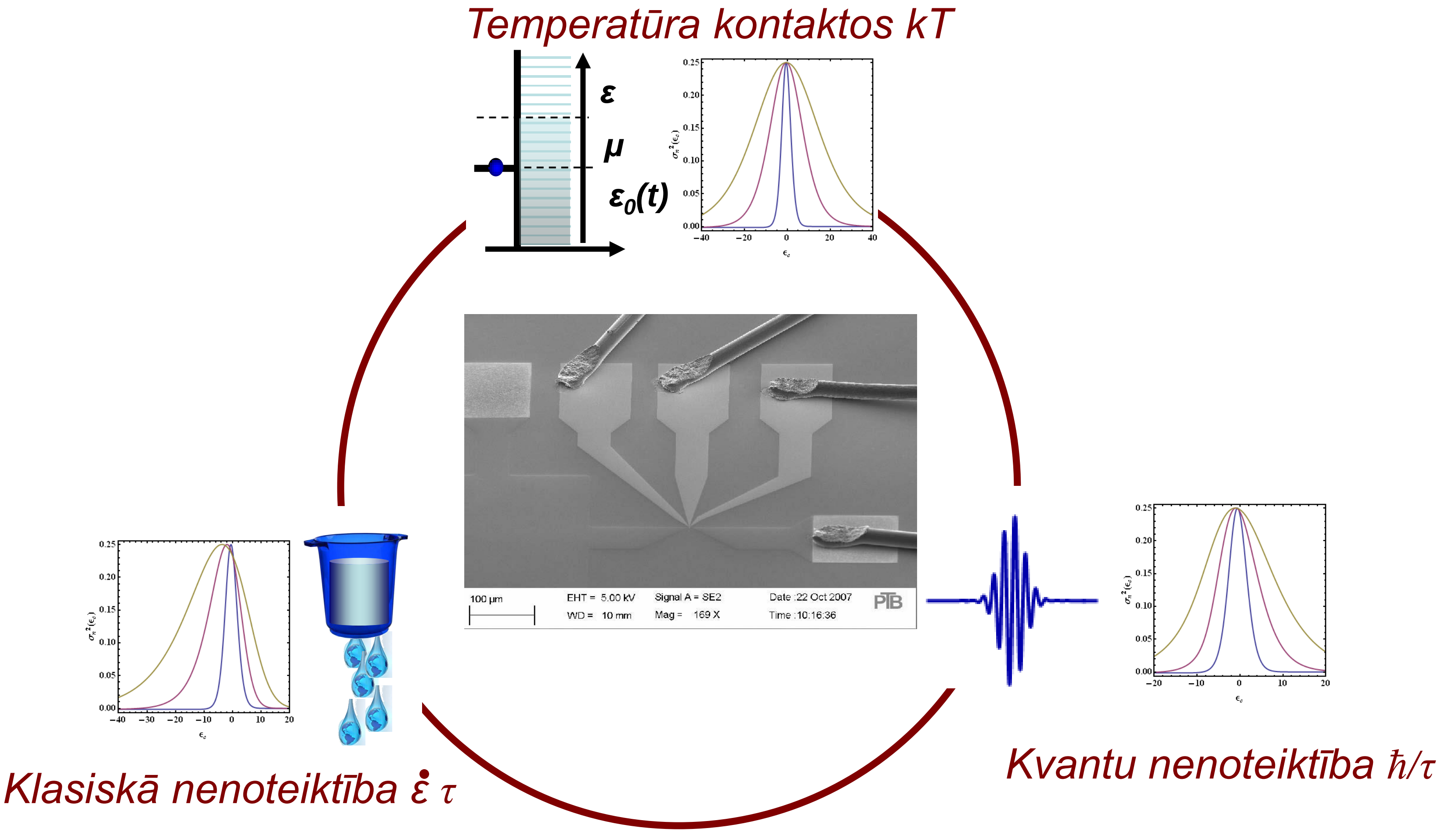
$$\sigma_n^2 = \langle n^2 \rangle - \langle n \rangle^2 = p_1 \cdot 1^2 - \langle n \rangle^2 = \langle n \rangle (1 - \langle n \rangle)$$



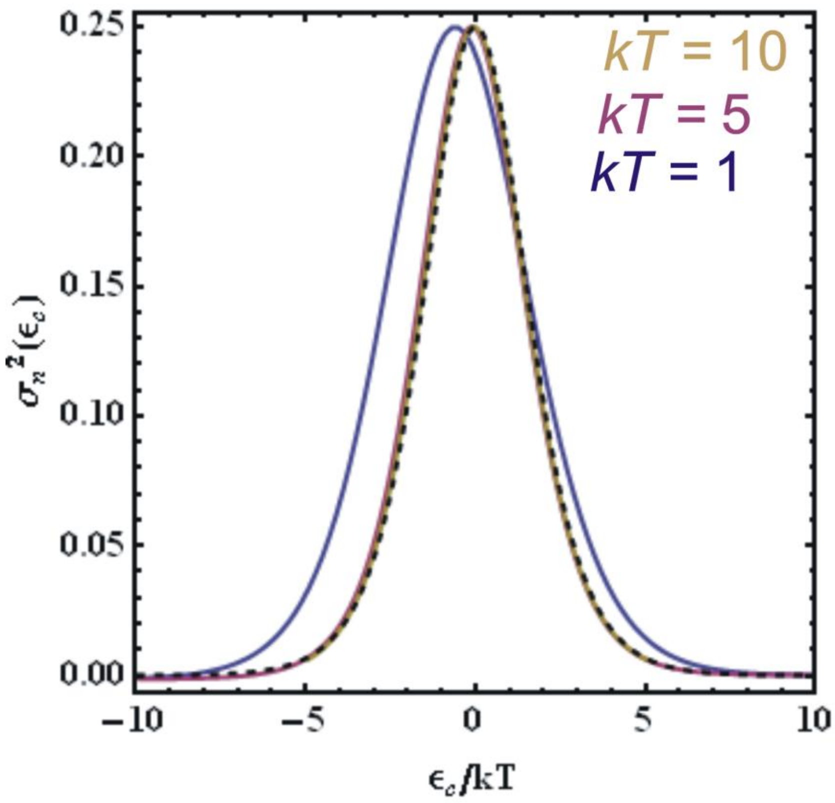


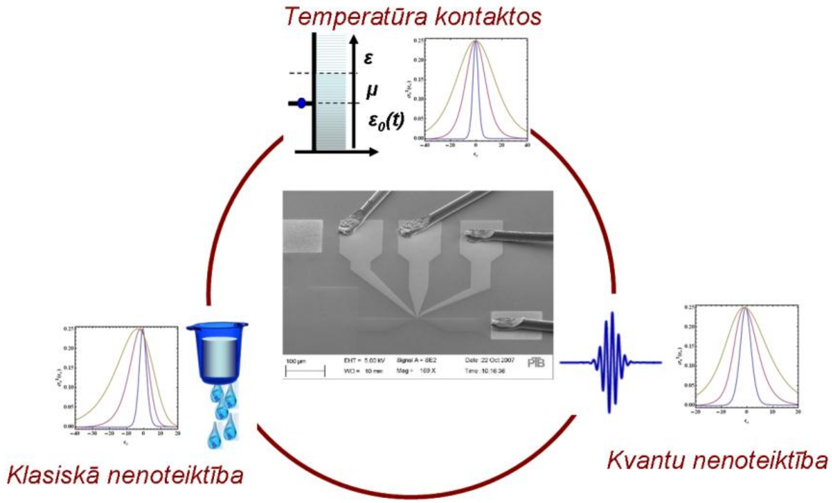
Atrisinājums. Fluktuācijas.

$$\langle n\rangle(t\to\infty) = \int d\epsilon f(\varepsilon)|I(\varepsilon)|^2 \qquad I(\varepsilon) = \sqrt{\frac{1}{4\pi\hbar/\tau}}\left(\int_{-\infty}^{\infty} d\tilde{t}_1 e^{\frac{-i[(\varepsilon-\varepsilon_c)\tilde{t}_1-\frac{1}{4}\dot{\varepsilon}\tau\tilde{t}_1^2]}{2\hbar/\tau}} e^{-\tilde{t}_1/2} e^{-\frac{1}{2}e^{-\tilde{t}_1}}\right)$$



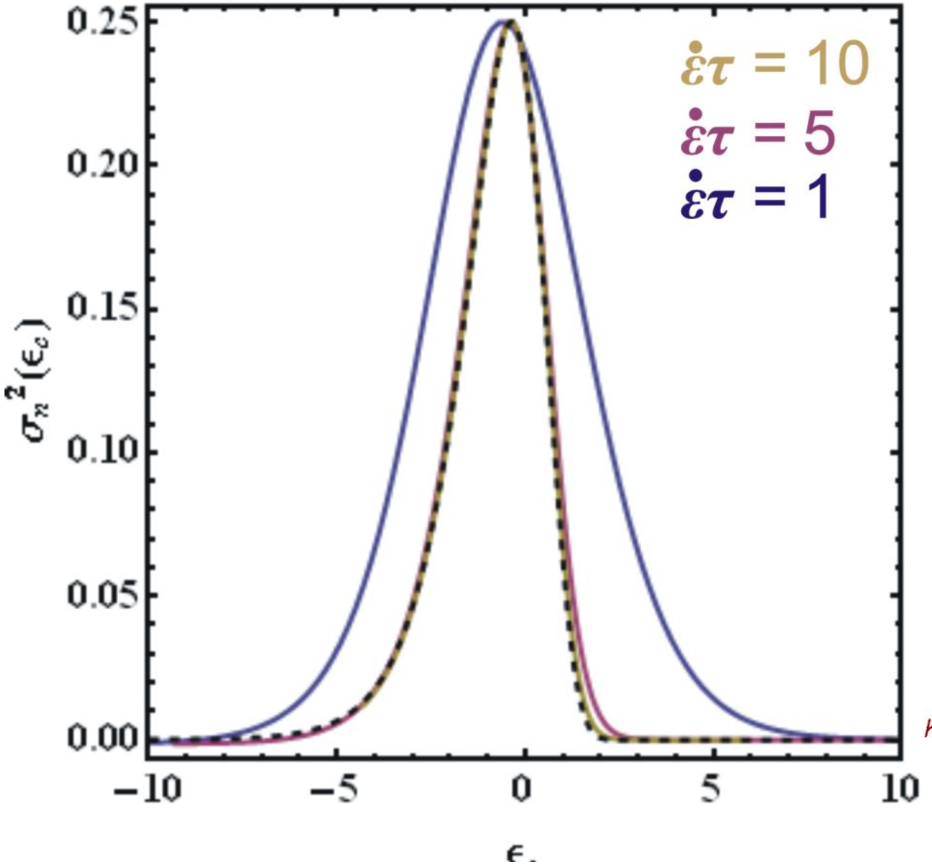
Temperatūras ietekme

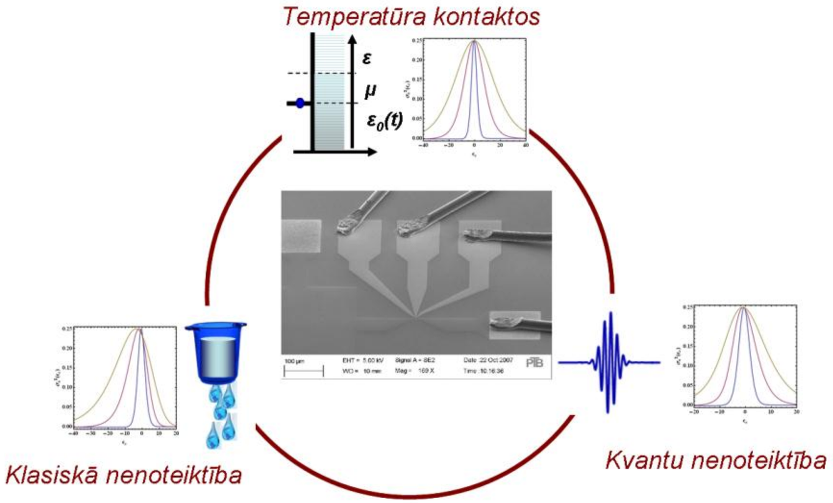




$$\langle n\rangle(t\rightarrow\infty)\approx\frac{1}{1+e^{\frac{\varepsilon_C}{kT}}}$$

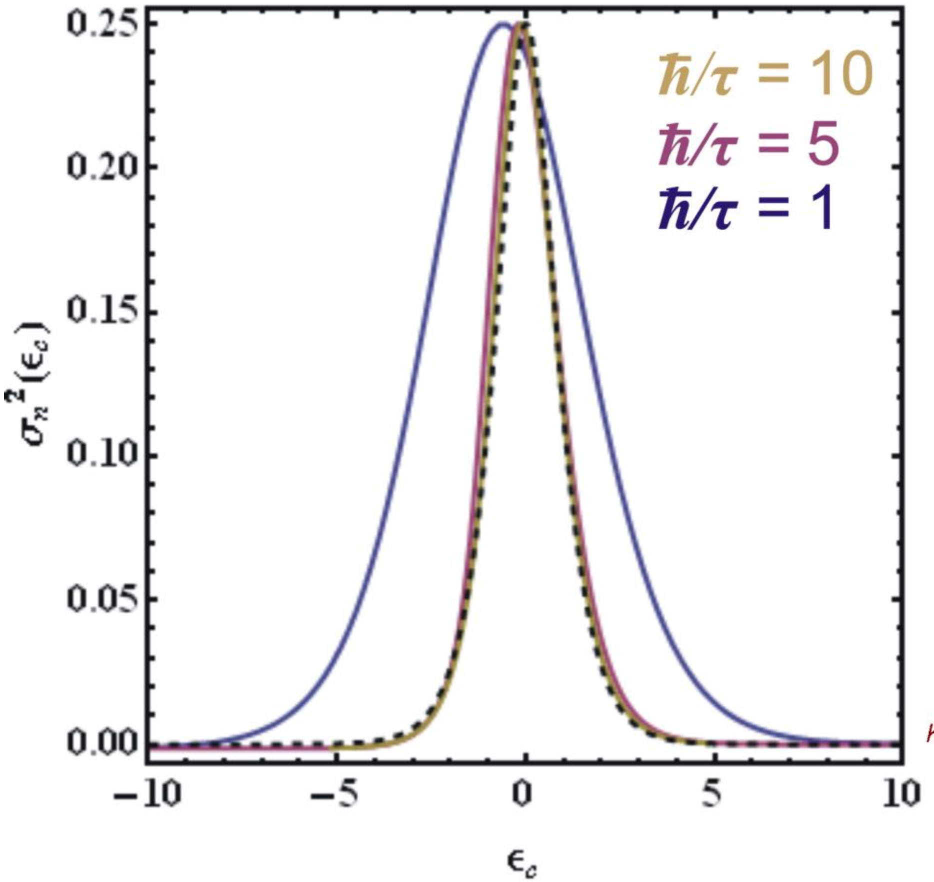
Klasiskās nenoteiktības ietekme

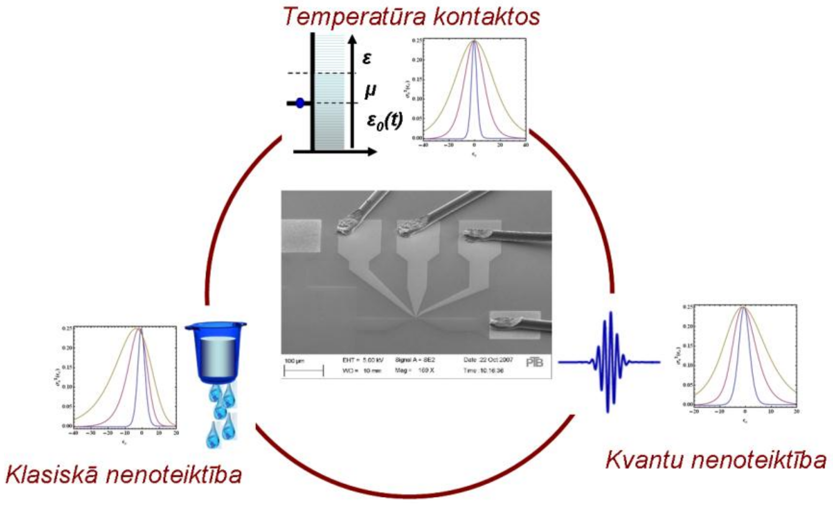




$$\langle n\rangle(t \to \infty) \approx \exp\left(-e^{\frac{2\varepsilon_C}{\dot{\varepsilon}\tau}}\right)$$

Kvantu (enerģijas - laika) nenoteiktības ietekme





$$\langle n\rangle(t\to\infty)=\frac{2}{\pi}\arctan e^{-\frac{\pi\varepsilon_0}{\Delta Q}}$$

Beigas. Paldies par uzmanību.