Negative differential conductance with symmetric set-up ?

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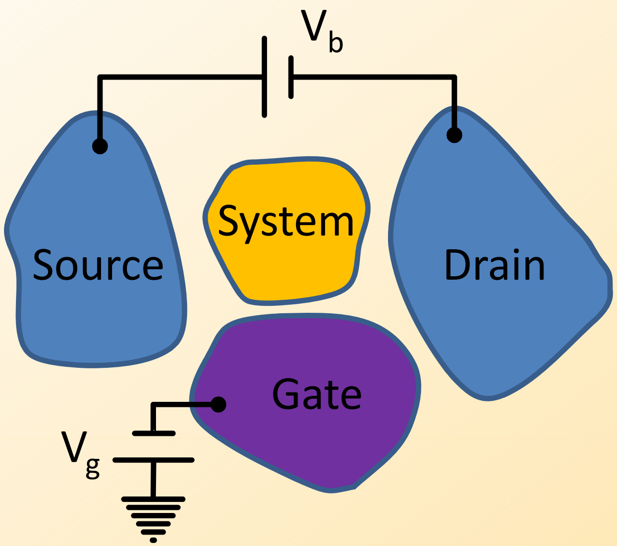
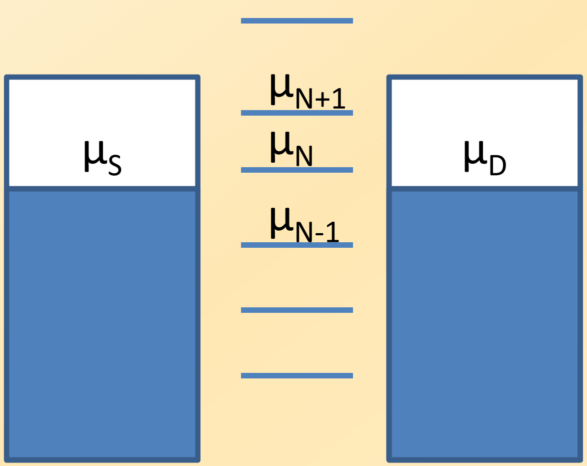
Single electron transistor

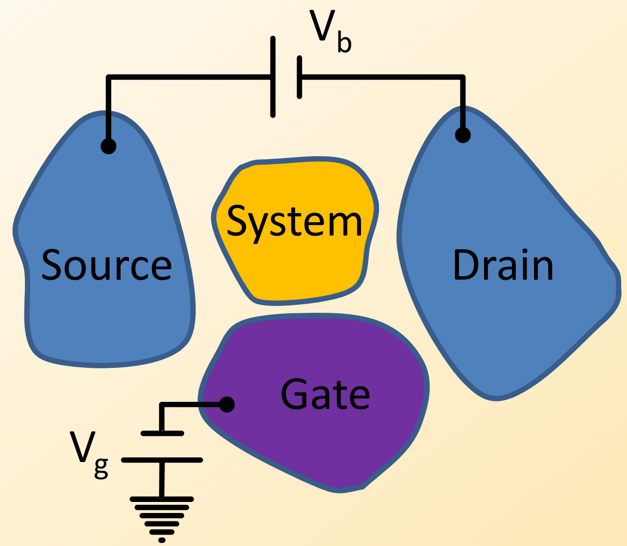


Small System size + weak System-Lead Tunnelling coupling → Strong e-e interaction on the System → Single electron control



$\mu_N = E_N - E_{N-1}$ The chemical potential of the System with N particles

Single electron transistor



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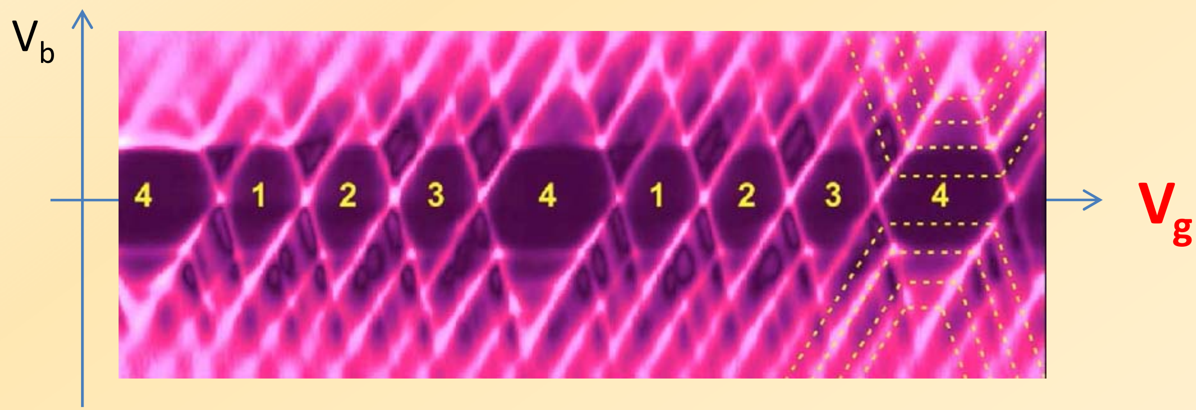

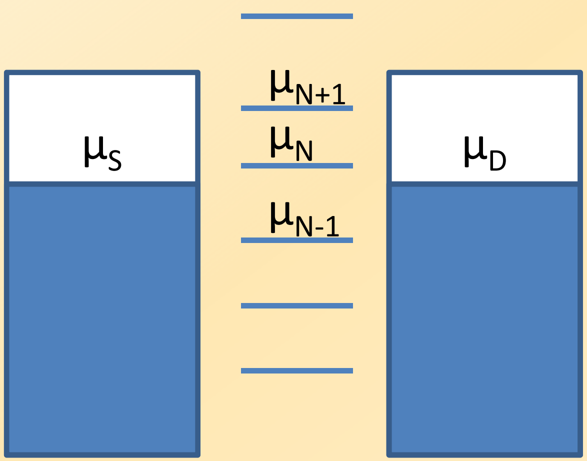

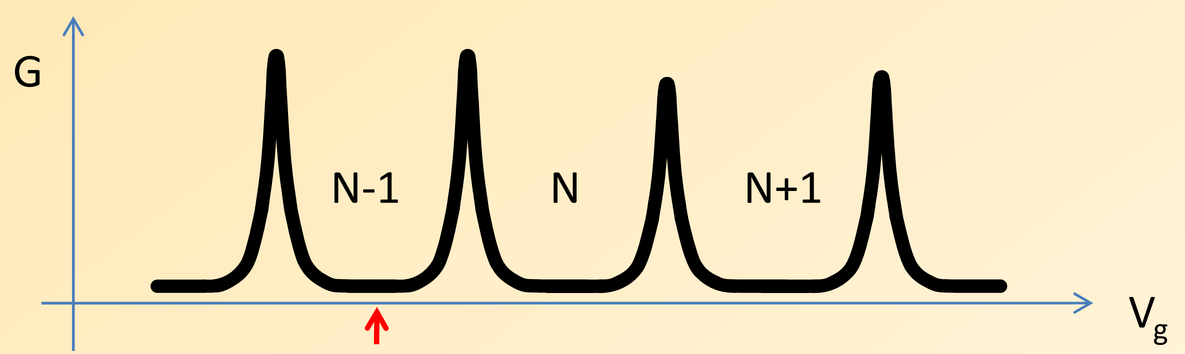

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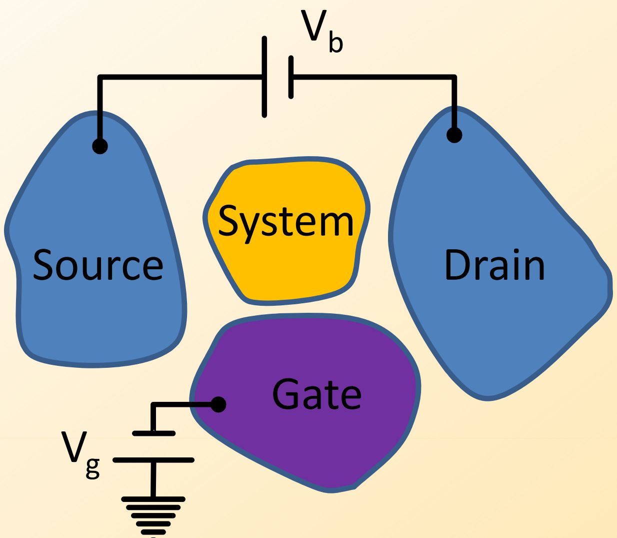

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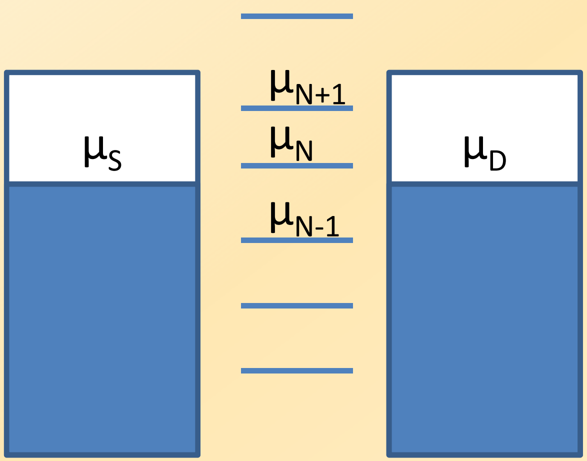
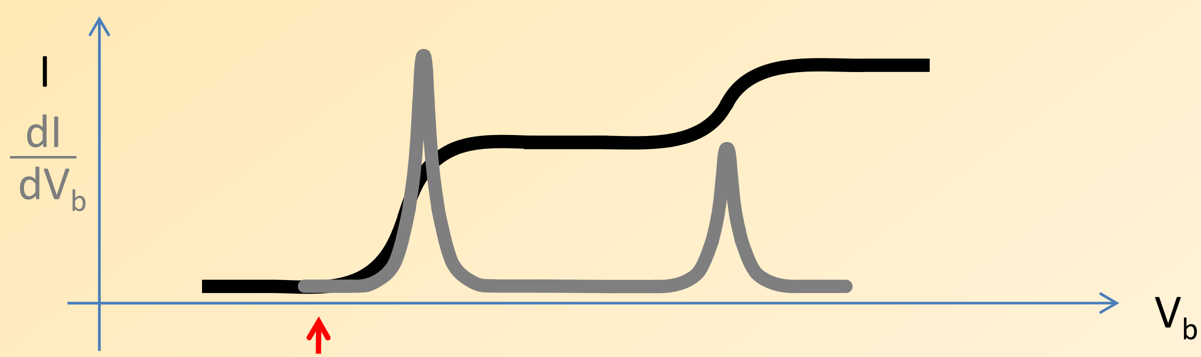
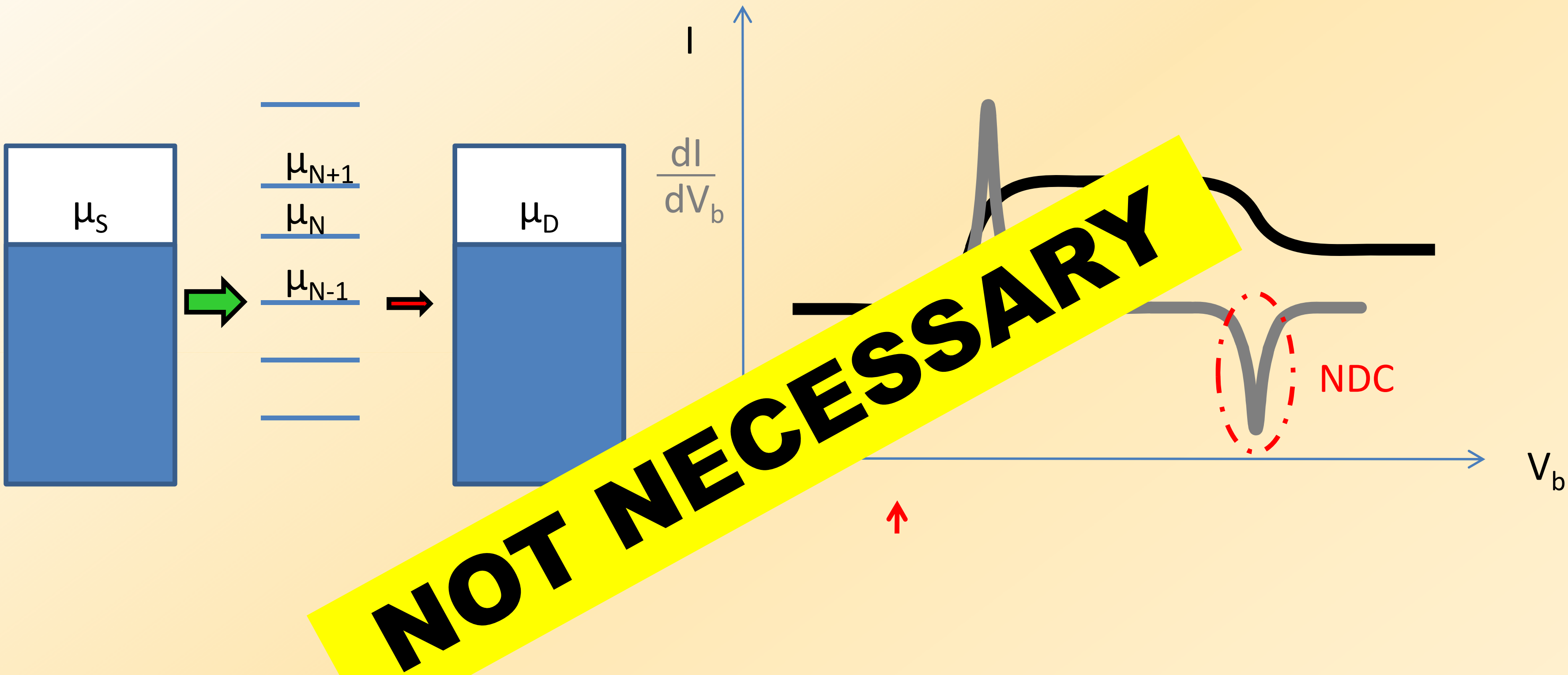




Negative Differential Conductance



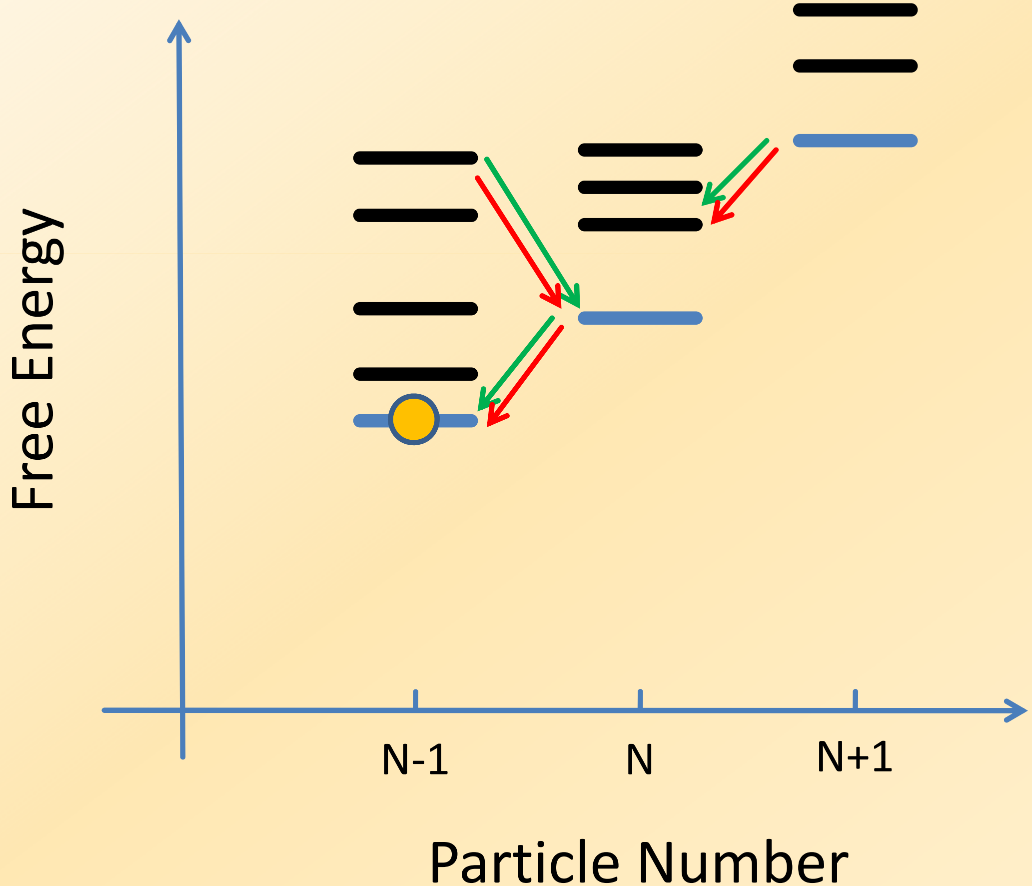
Negative differential conductance (NDC) is usually associated with a **strong asymmetry** in the coupling to the leads

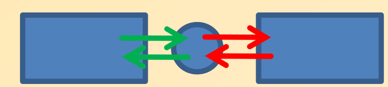
The free energy formulation

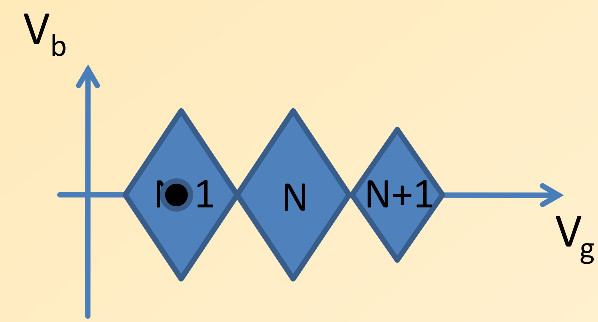
$F = H - \mu_0 N$ Free energy

Source transition

Drain transition







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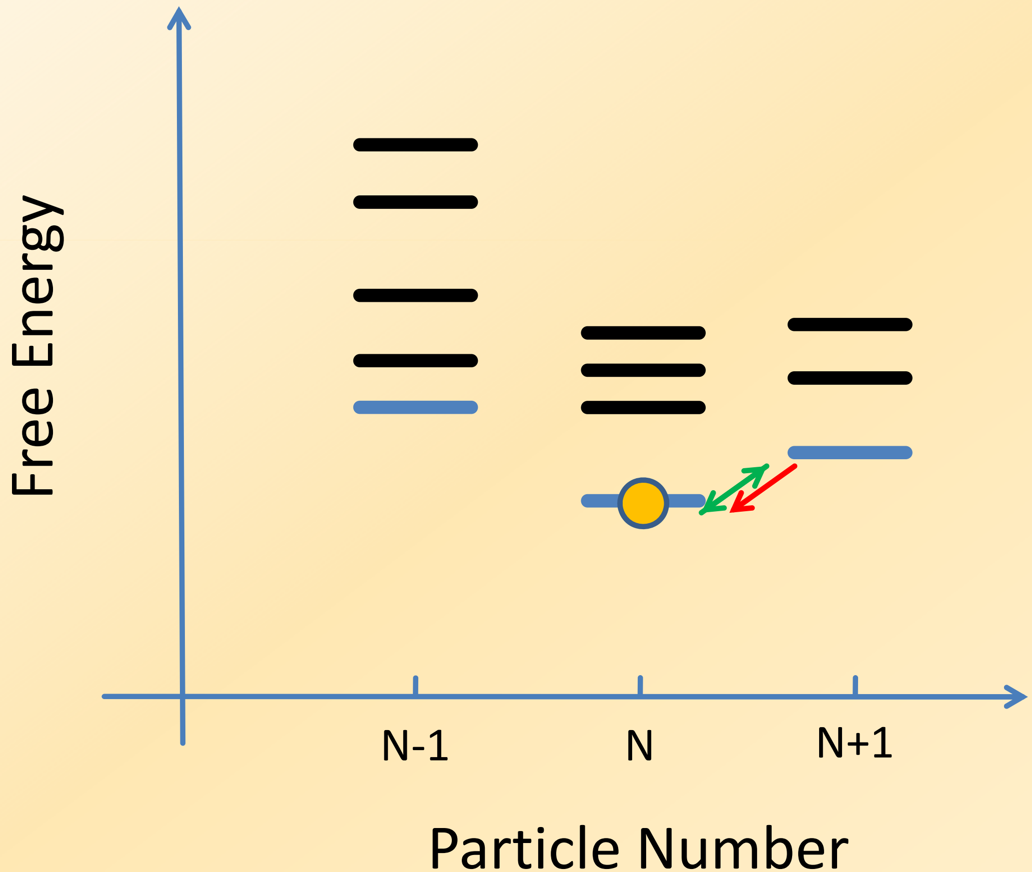
PRB, **82**, 125451 (2010)

The free energy formulation



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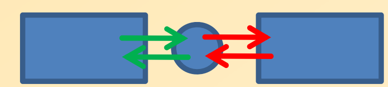

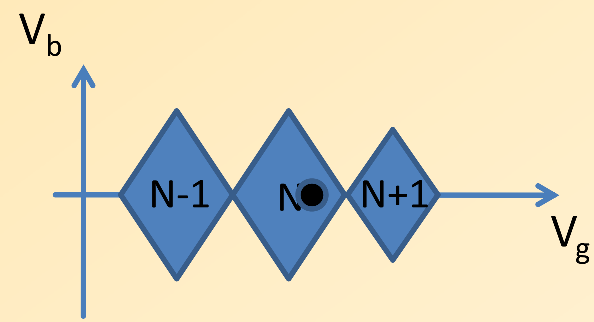

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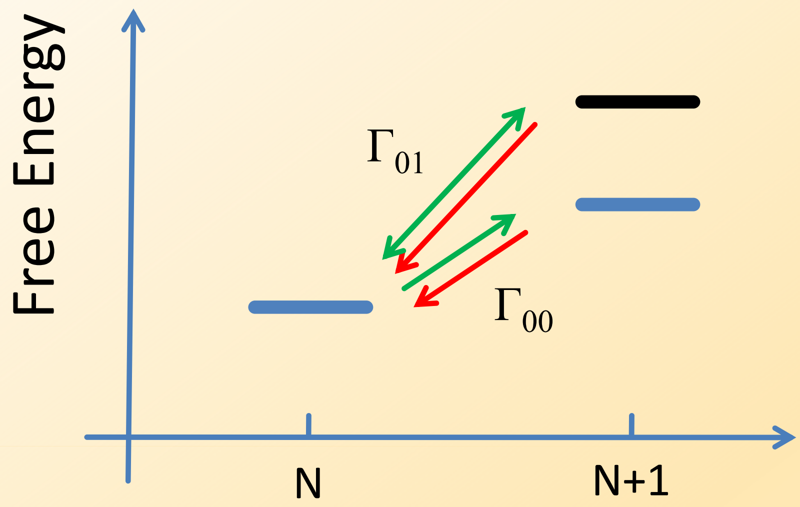
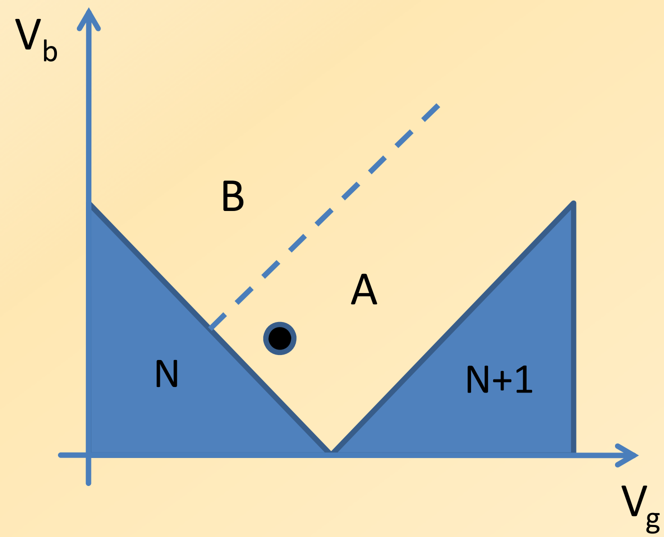
NDC with symmetric set-up





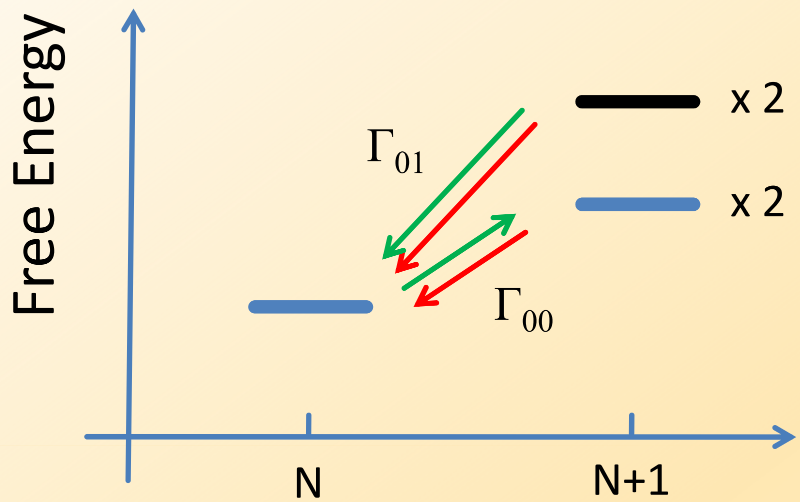
The dynamics is evaluated with the **master equation**: in the **stationary limit**

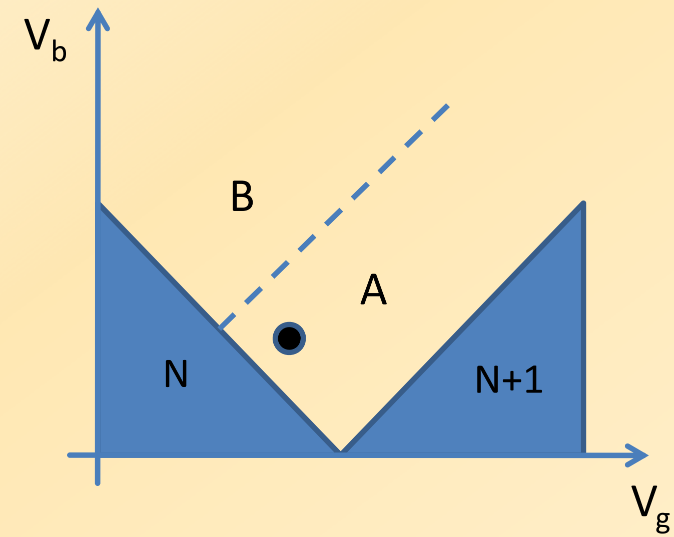
	$P_{N,0}$	$P_{N+1,0}$	$P_{N+1,1}$	Current
A	1/2	1/2	0	$\Gamma_{00}/2$
B	1/3	1/3	1/3	$1/3(\Gamma_{00}+\Gamma_{01})$

NDC if $I_B < I_A$

$$\Gamma_{01} < \Gamma_{00}/2$$

Role of the degeneracies





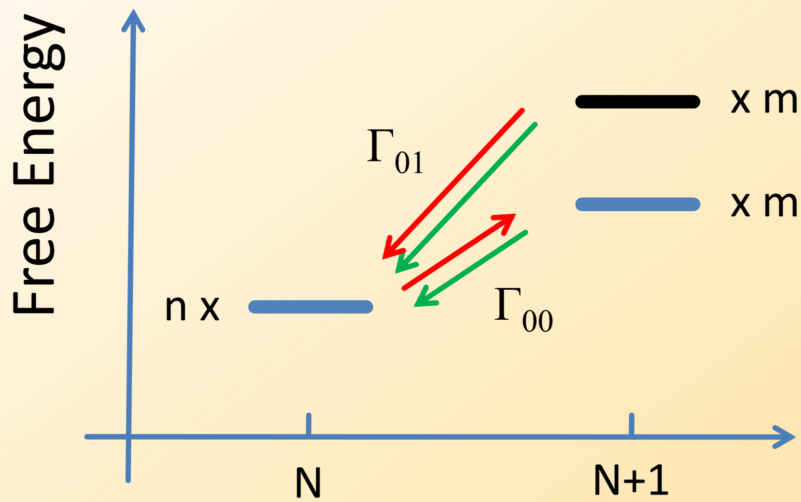
The dynamics is evaluated with the **master equation**: in the **stationary limit**

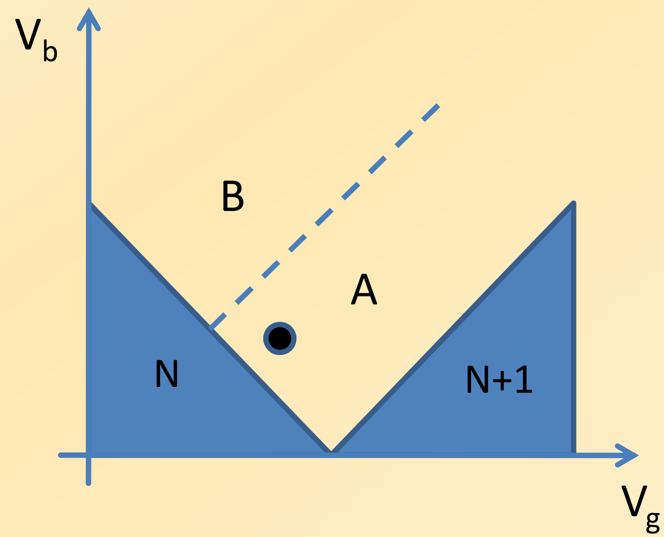
	$P_{N,0}$	$P_{N+1,0}$	$P_{N+1,1}$	Current
A	1/3	1/3	0	$2\Gamma_{00}/3$
B	1/5	1/5	1/5	$2/5(\Gamma_{00} + \Gamma_{01})$

NDC if $I_B < I_A$

$\Gamma_{01} < 2\Gamma_{00}/3$

Role of the degeneracies





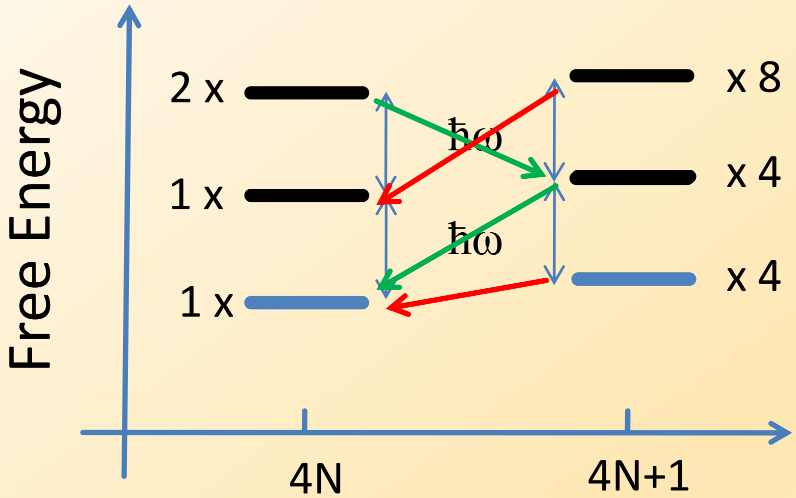
The dynamics is evaluated with the **master equation**: in the **stationary limit**

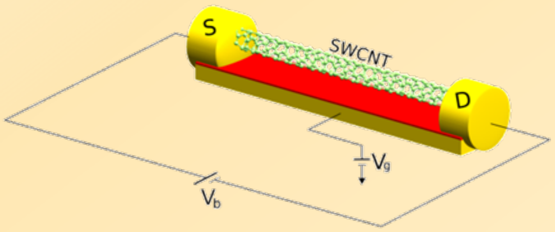
	$P_{N,0}$	$P_{N+1,0}$	$P_{N+1,1}$	Current
A	$\frac{1}{n+m}$	$\frac{1}{n+m}$	0	$\frac{nm}{n+m}\Gamma_{00}$
B	$\frac{1}{n+2m}$	$\frac{1}{n+2m}$	$\frac{1}{n+2m}$	$\frac{nm}{n+2m}(\Gamma_{00}+\Gamma_{01})$

NDC if $I_B < I_A$

$$\Gamma_{01} < \frac{m}{n+m}\Gamma_{00}$$

An example: a suspended CNT





The transition rates are proportional to product of Frack-Condon coefficients

$$\Gamma_{ij} = \prod_n FC^{(n)}(i, j; \lambda)$$

A. Yar, **AD**, S. Koller, and M. Grifoni, arXiv:1101.3892 (2011)

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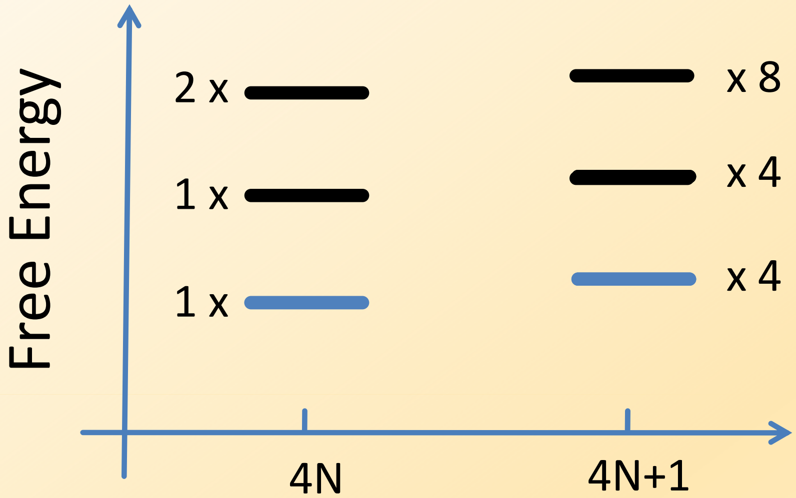

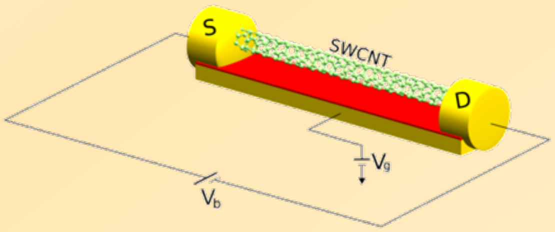

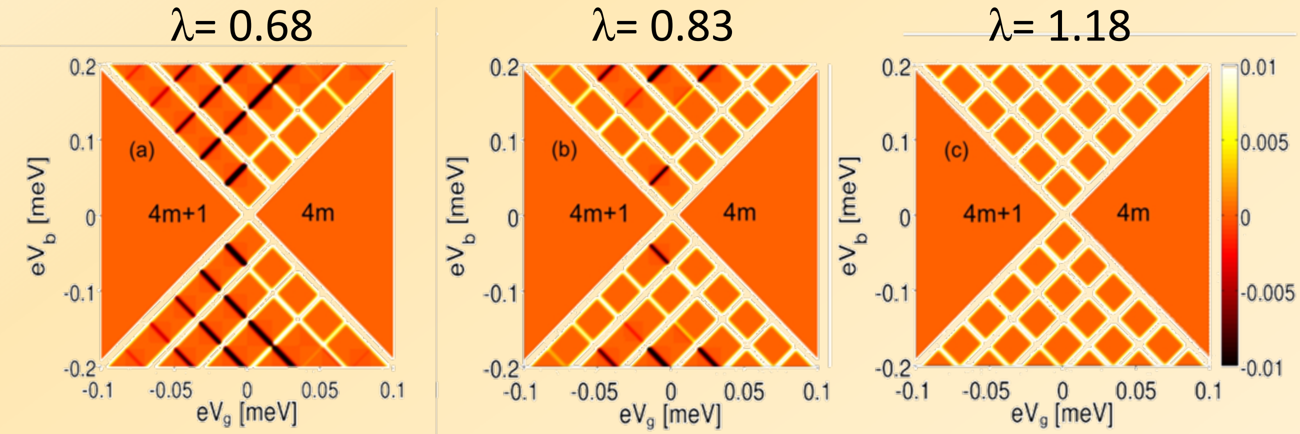

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Conclusions

Transport through a single electron transistor is conveniently described by transition between many-body states in the **free energy diagram**

The negative differential conductance is the result of a redistribution of probabilities between fast and slow channels thus:

It is possible also in a **completely symmetric** set-up .

It is related to the **degeneracies** of the many-body

Suspended carbon nanotube quantum dots exhibits the NDC presented here due to the interplay between Franck-Condon coefficients and spin/pseudospin degeneracies.

Thanks for your attention !