Evidence of anisotropic Kondo coupling in nanostructured devices

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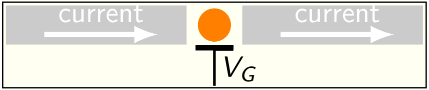
University of São Paulo

Stockholm, 19 September 2012

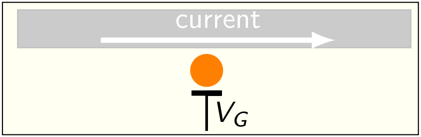
Nanostructured devices

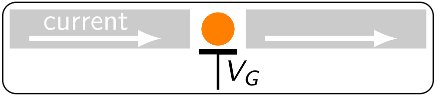
- Elementary geometries
  - Single electron transistor



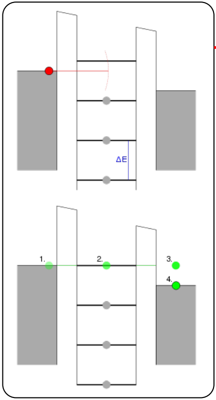
  - V_G controls dot occupation n_d

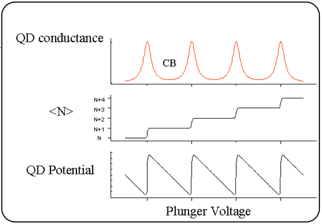
- Side-coupled device



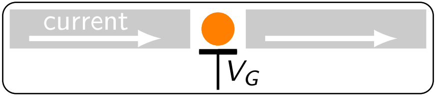


- Conduction only when n_{dot} is a half-integer





Coulomb blockade



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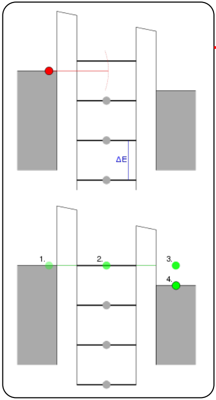
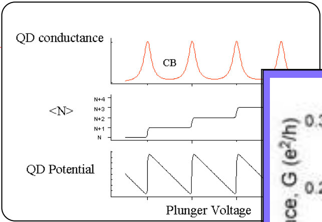
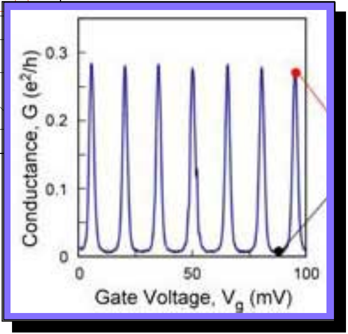
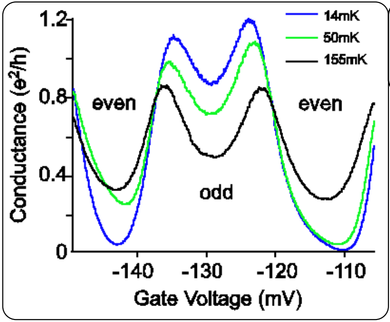
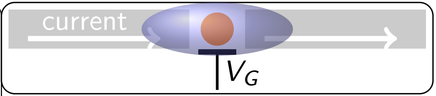




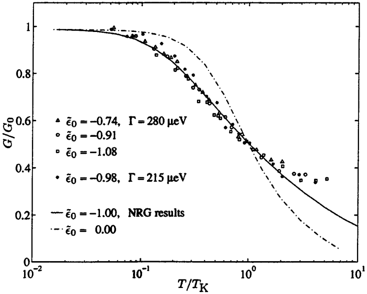


- Coulomb blockade can be lifted at very low T





Goldhaber-Gordon et al.,
PRL **81**, 5225 (1998)

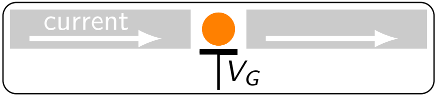


- Odd n_{dot}
  - Dot has magnetic moment
  - Conduction spins screen moment
  - Screening allows conduction

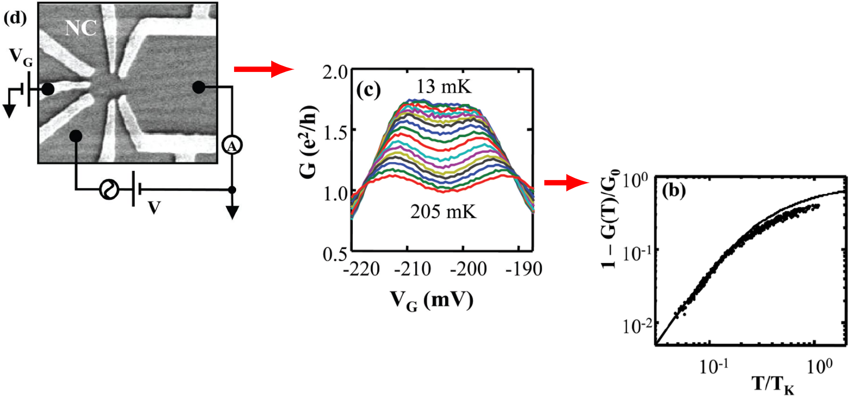
Outline of the talk

- Introduction
- More recent experimental results
- Theory
- Theory vs. experiment and a puzzle
- Conclusions

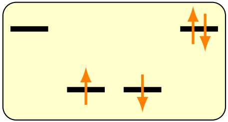
Ten years after 1998



Grobis et al, PRL **100**, 246601 (2008).



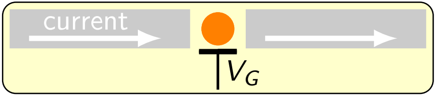
- Anderson Model

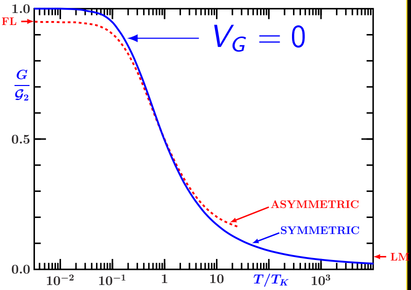


- $$H = \sum_k \epsilon_k n_k - \frac{U}{2}(n_{d\uparrow} - n_{d\downarrow})^2 + V_G n_d + V \sum_k (c_k^\dagger c_d + H.\ c.)$$

- $G = \mathcal{G}_2 G_S(\frac{T}{T_K})$

$$\mathcal{G}_2 \equiv \frac{2e^2}{h}$$





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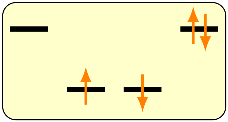

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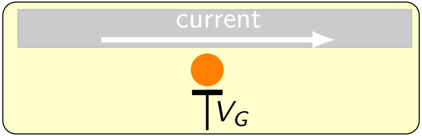
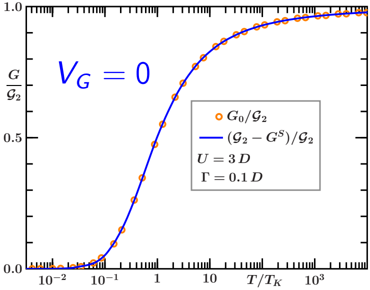
- $G = \mathcal{G}_2 \left[1 - G_S\left(\frac{T}{T_K}\right)\right]$





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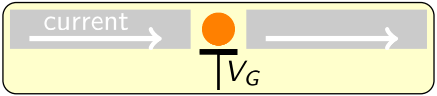
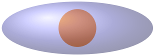
  - $V_G \neq 0$



$$G = \alpha G_S\left(\frac{T}{T_K}\right) + \beta\left[1 - G_S\left(\frac{T}{T_K}\right)\right]$$

Seridonio et al., EPL **86**, 67006(2009).

- $G(T \ll T_K) = \alpha = \kappa\mathcal{G}_2 \sin^2(\frac{\pi n_{LT}}{2}) \equiv G_{FL}$



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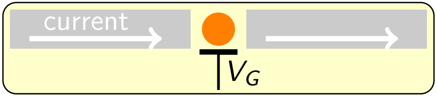

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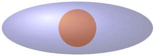

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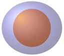
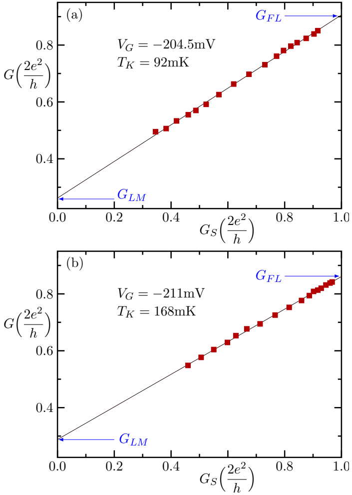


Comparison with experiment

- $G\left(\frac{T}{T_K}\right)$ maps linearly onto $G_S\left(\frac{T}{T_K}\right)$

$$G\left(\frac{T}{T_K}\right) = G_S\left(\frac{T}{T_K}\right) G_{FL} + \left[1 - G_S\left(\frac{T}{T_K}\right)\right] G_{LM}$$



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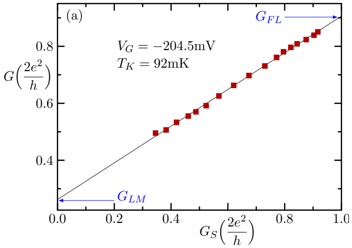
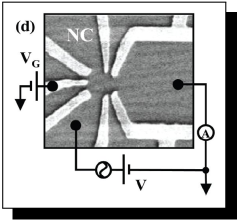
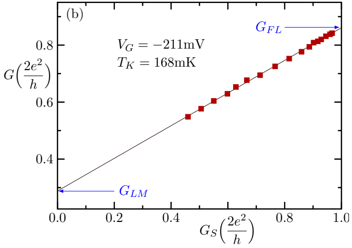
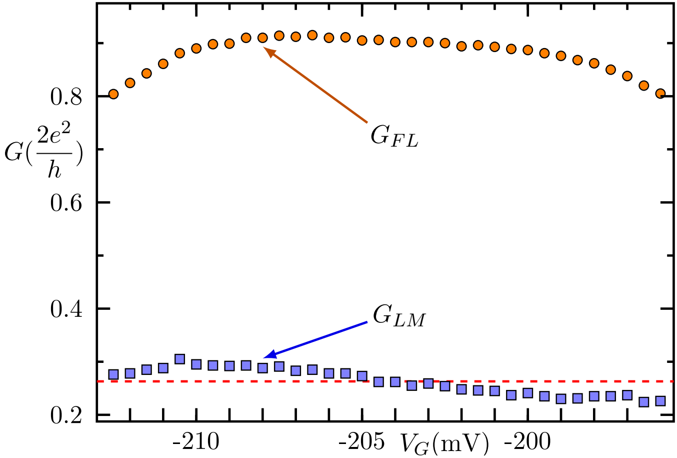






Comparison with experiment

- High (LM) and low (FL) temperaturas



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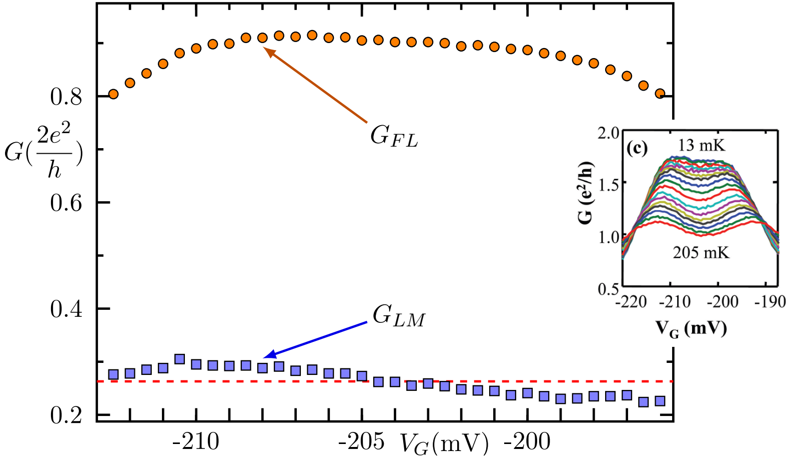
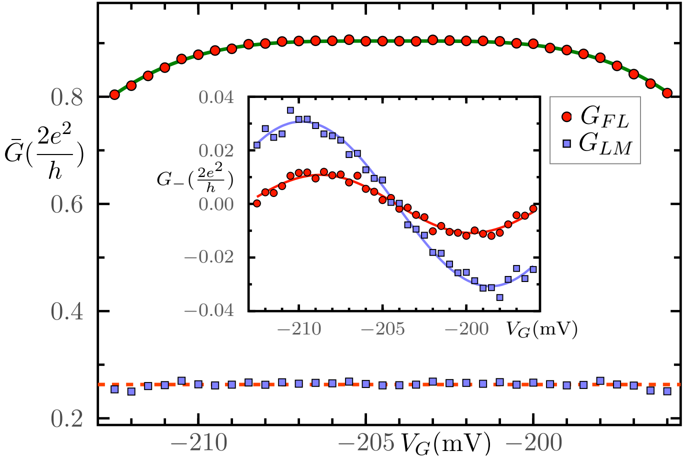


Comparison with experiment

- Symmetrized conductances at high (LM) and low T (FL)



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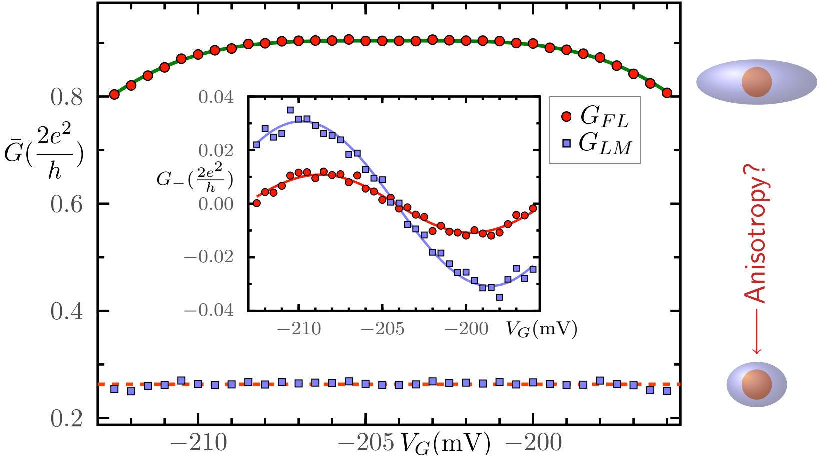
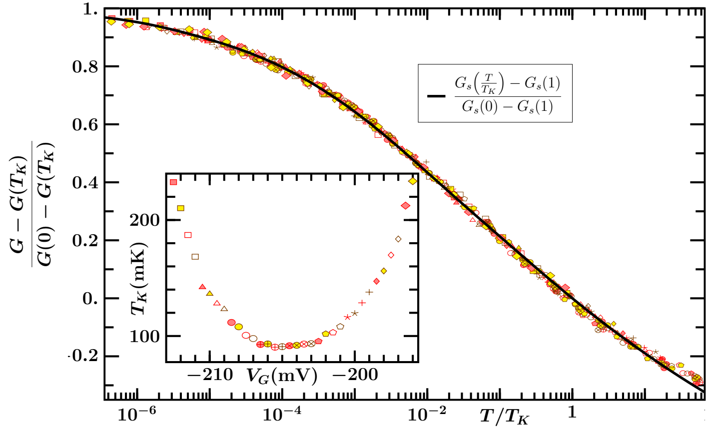


Comparison with experiment

- Results for 34 V_G's



Summary

- Anderson model describes experimental data very well
  - Thanks to universality
  - There are perturbations outside the scope of the model
- Must allow for partial screening at high T
  - Anisotropic Kondo coupling?