低温物理学

2009年５月21日

物性研究所

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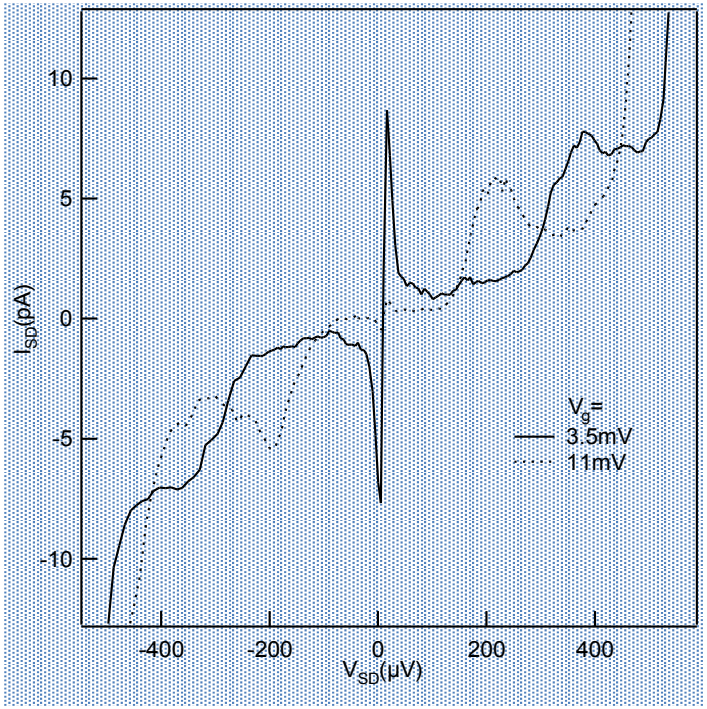
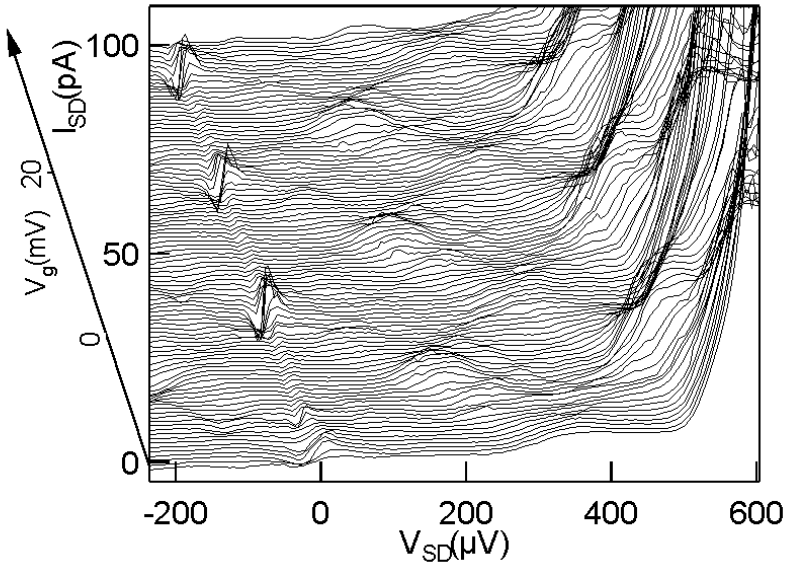
超伝導電流の制御

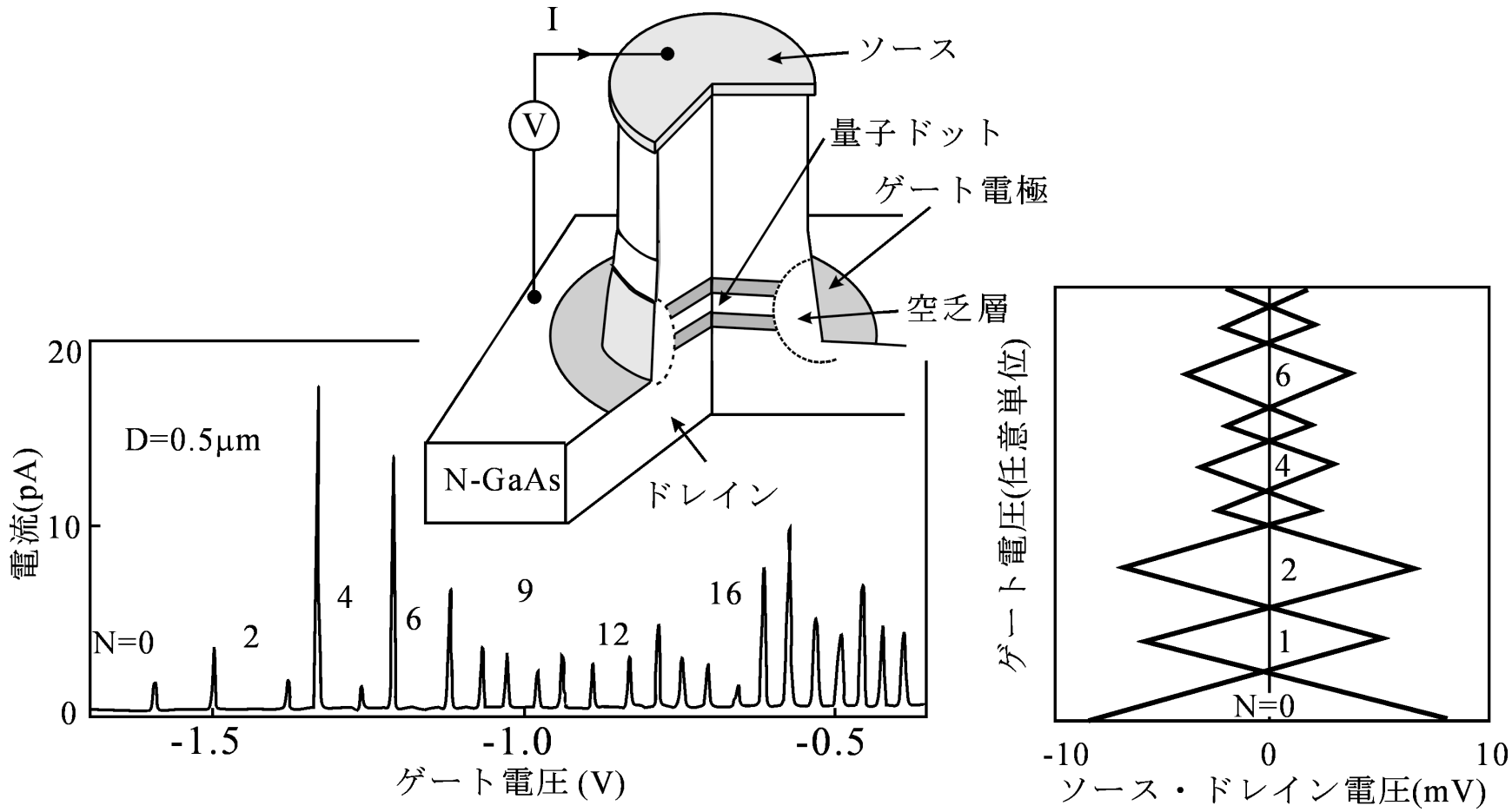
$$J_{\mathrm{Max}} = \frac{2e}{\hbar}\frac{E_1 E_2}{2E_J}\sin\theta$$

$$J_{\mathrm{Min}} = \frac{2e}{\hbar}\frac{E_1 E_2}{4E_C}\sin\theta$$





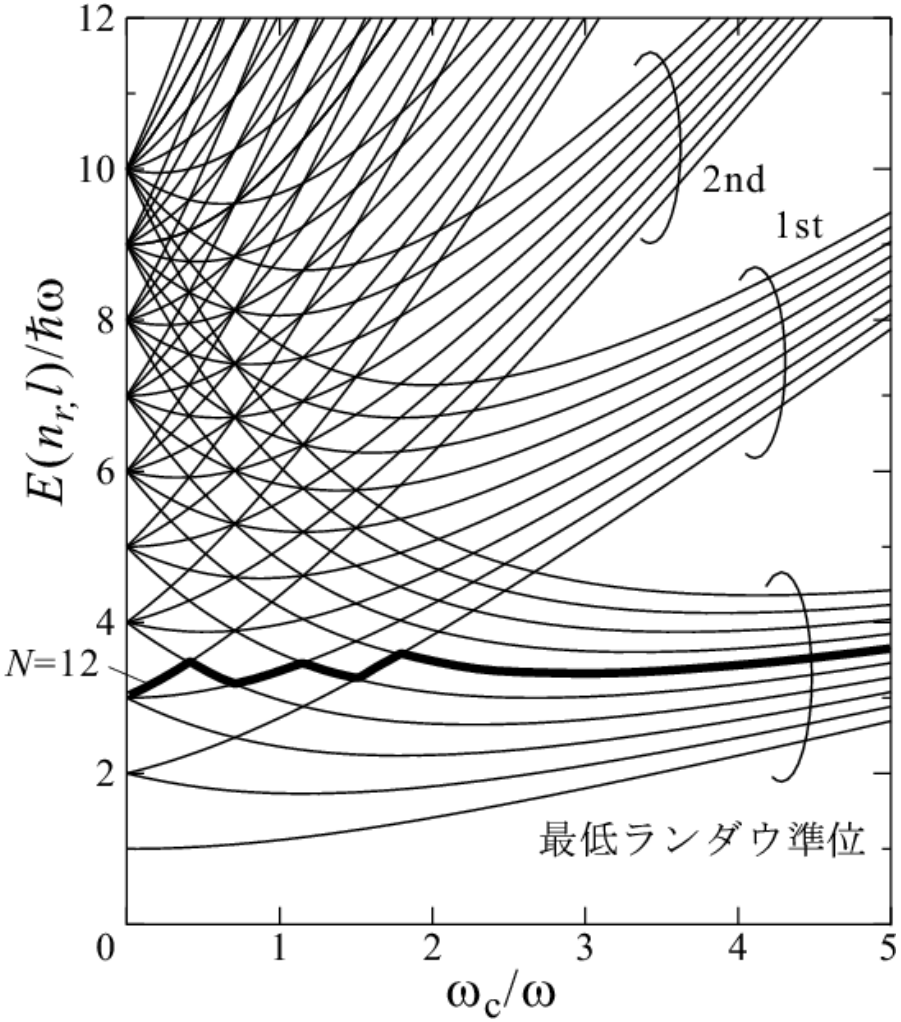
縦型量子ドット：調和ポテンシャル原子

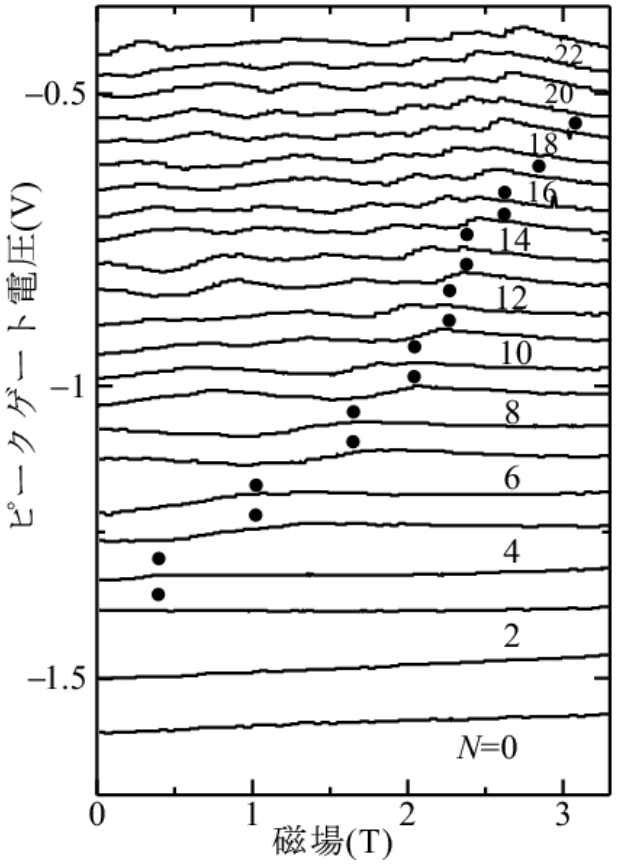


Fock-Darwin State

$$E(n_r, l) = \hbar\Omega(2n_r + |l| + 1) + \hbar\omega_c l/2$$

$$\Omega \equiv \sqrt{\omega^2 + (\omega_c/2)^2}$$

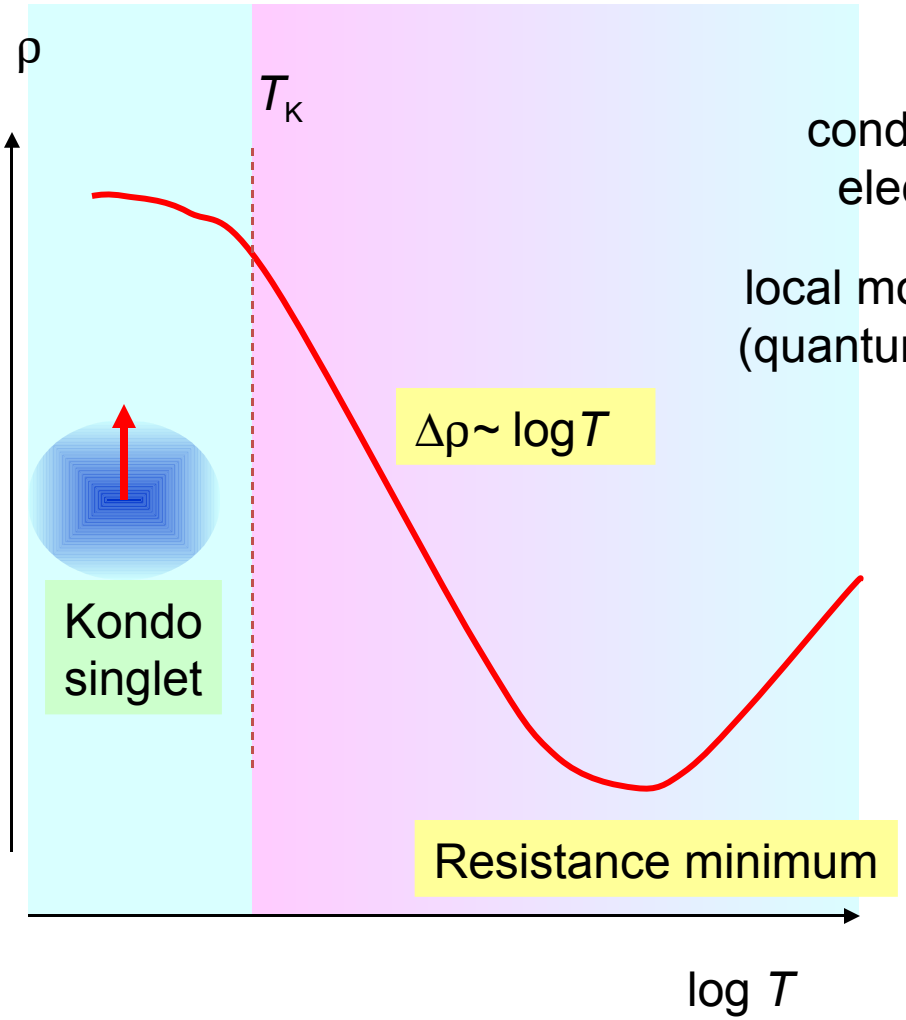


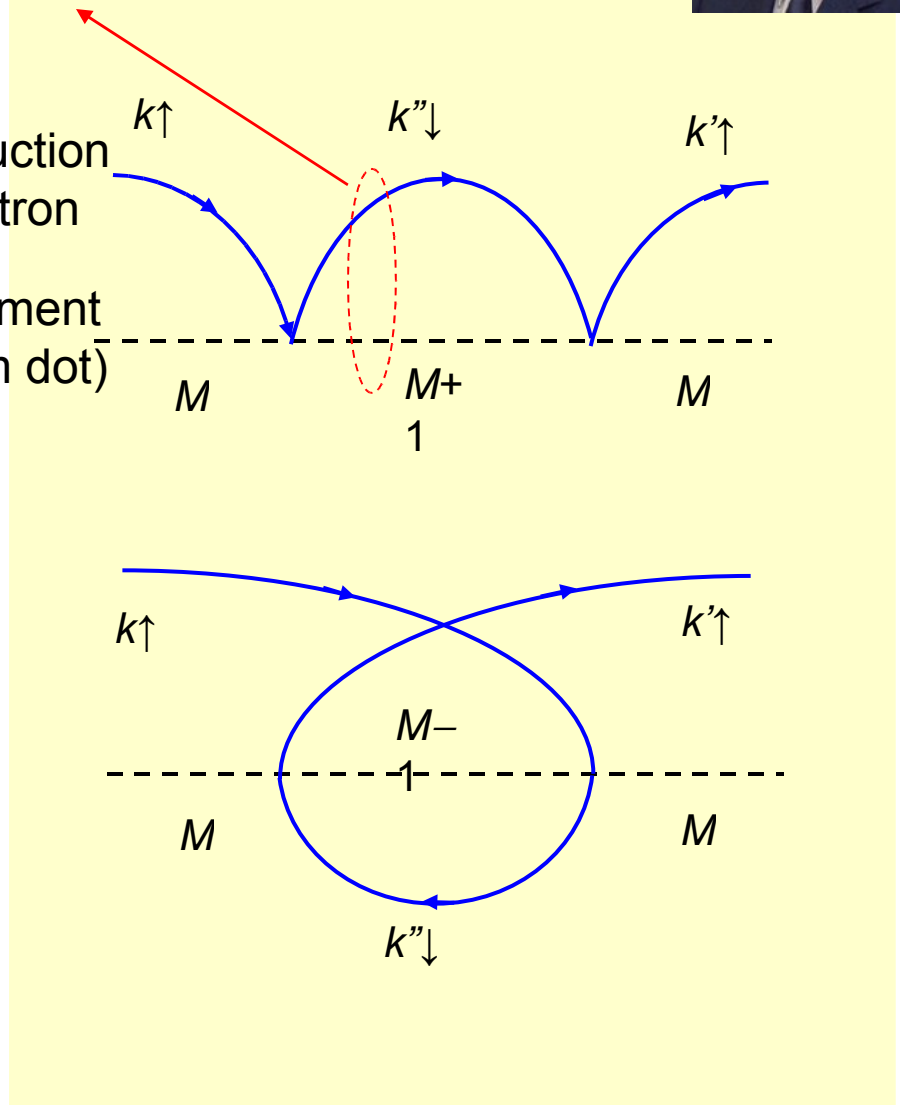


The Kondo effect in dilute magnetic compounds

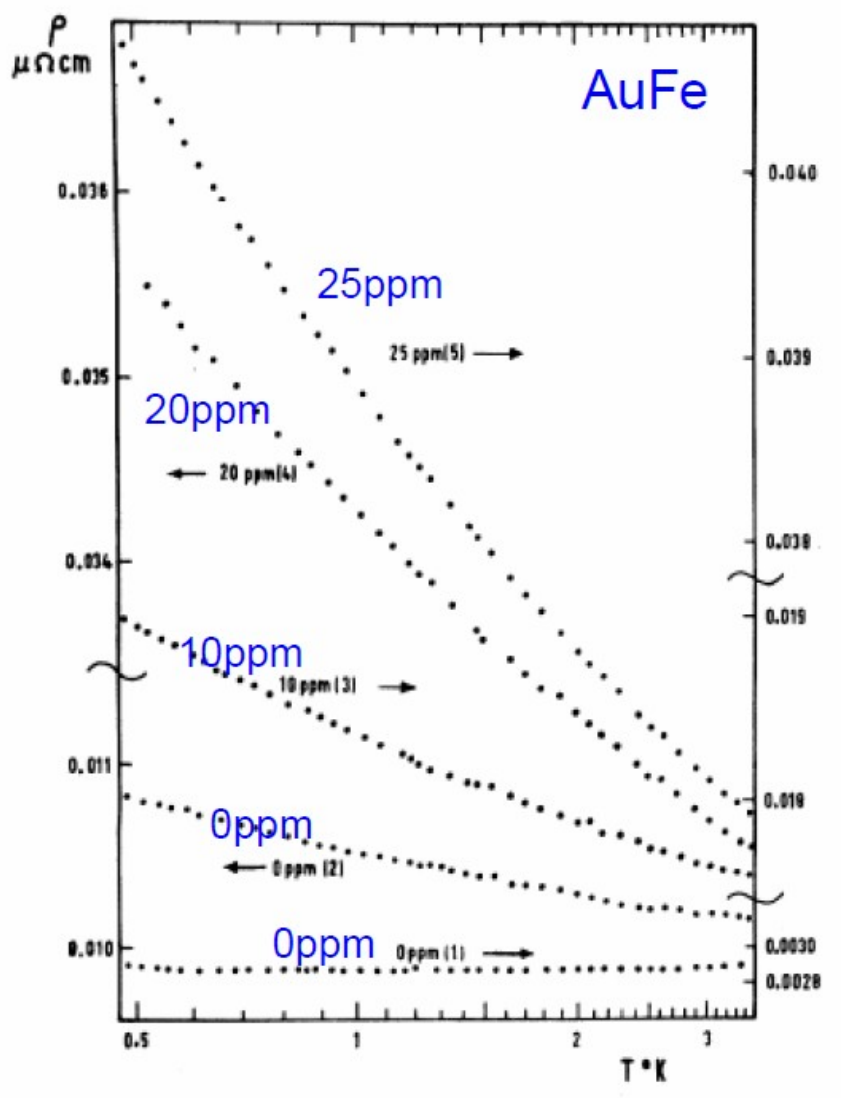
$$\frac{1}{\sqrt{2}}\left(|s\uparrow\rangle|d\downarrow\rangle - |s\downarrow\rangle|d\uparrow\rangle\right)$$

Jun Kondo





The Kondo effect in dilute magnetic alloy



The Kondo singlet

Yosida's variational ground state A. Yoshimori, PR168 (1967)

Kondo singlet

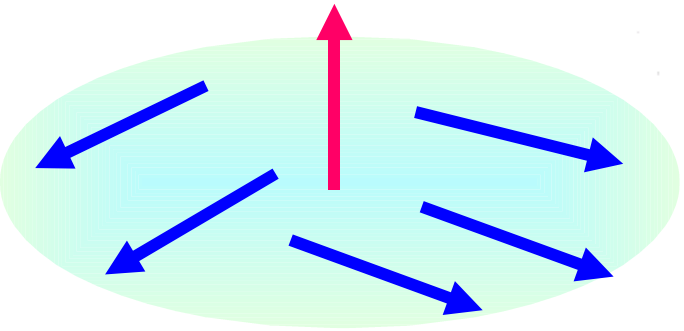
$$\psi = \{ \sum_k [\Gamma_k{}^{\alpha} a_{k\downarrow}{}^{\dagger}\alpha + \Gamma_k{}^{\beta} a_{k\uparrow}{}^{\dagger}\beta] \longrightarrow \left(|s\uparrow\rangle |d\downarrow\rangle - |s\downarrow\rangle |d\uparrow\rangle \right)$$

$$+ \sum_{k_1k_2k_3} [\Gamma_{k_1k_2k_3}{}^{\alpha\downarrow} a_{k_1\downarrow}{}^{\dagger} a_{k_2\downarrow}{}^{\dagger} a_{k_3\downarrow}\alpha + \Gamma_{k_1k_2k_3}{}^{\beta\uparrow} a_{k_1\uparrow}{}^{\dagger} a_{k_2\uparrow}{}^{\dagger} a_{k_3\uparrow}\beta$$

$$+ \Gamma_{k_1k_2k_3}{}^{\alpha\uparrow} a_{k_1\downarrow}{}^{\dagger} a_{k_2\uparrow}{}^{\dagger} a_{k_3\uparrow}\alpha + \Gamma_{k_1k_2k_3}{}^{\beta\downarrow} a_{k_1\uparrow}{}^{\dagger} a_{k_2\downarrow}{}^{\dagger} a_{k_3\downarrow}\beta]$$

$$+ \cdots \} \psi_v,$$

Fermi State



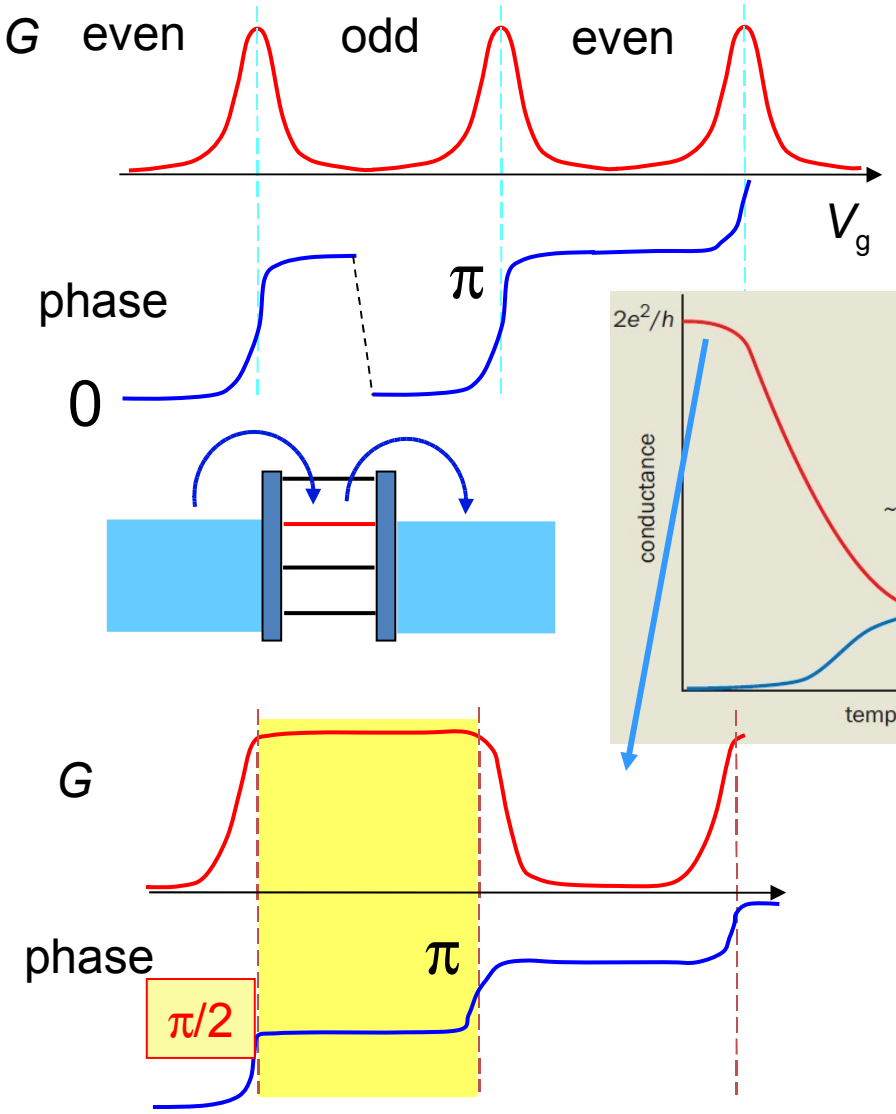
Magnetic impurity : Screened by a Kondo cloud

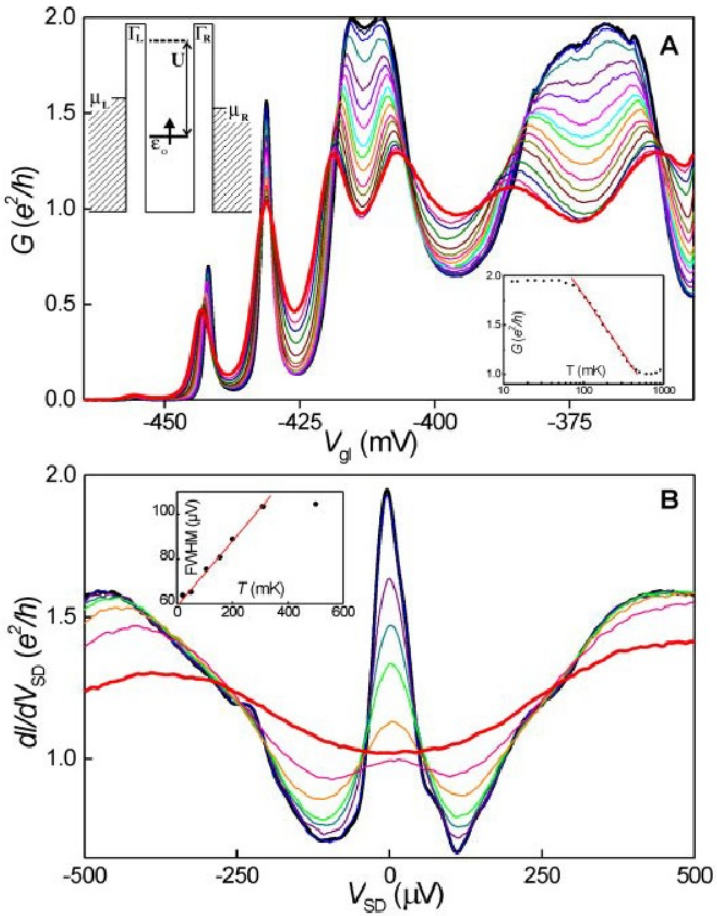
Single body resonance waves → Quantum coherence between multiply scattered → Spatially localized state, discrete energy levels

Many body resonance energy in spin ← multiple scattering with many electrons of the same (Fermi energy) with quantum entanglement

Spatially localized state, energy level is the same as the

The Kondo effect in quantum dot systems





W. G. van der Wiel et al.
Science **289**, 2105 (2000).