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ФИАН

Spin susceptibility of interacting electrons in 2D:

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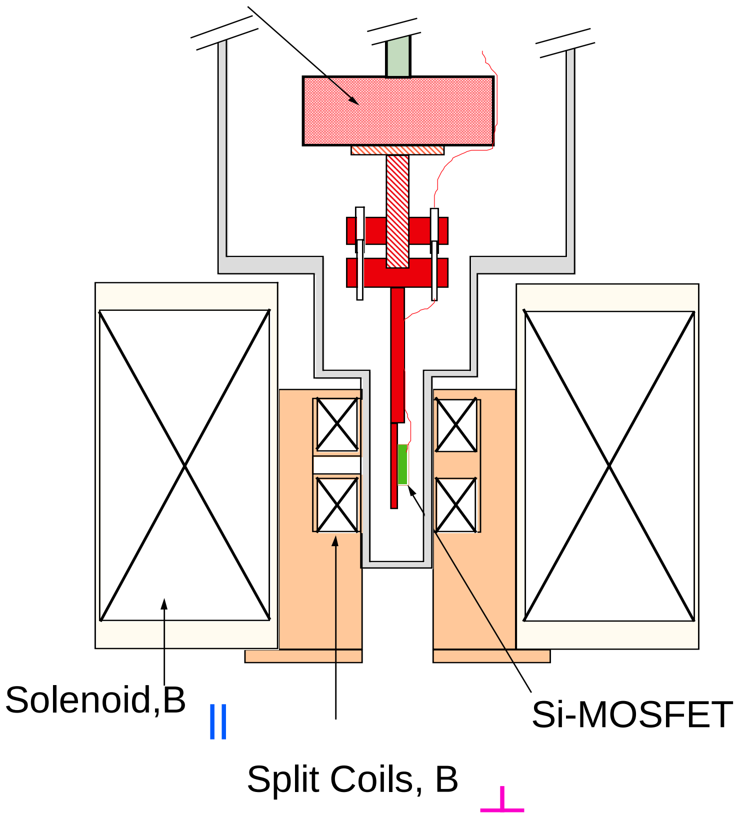
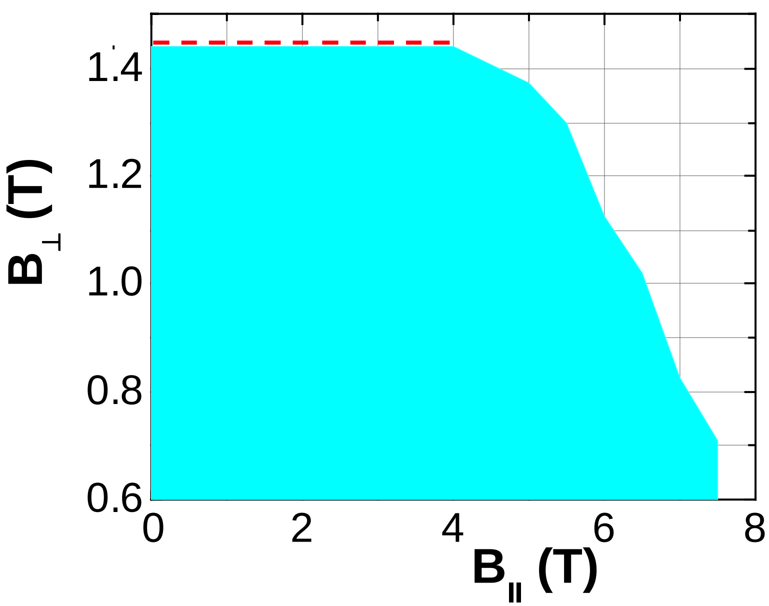
Outline

Direct measurements of χ , m^* and g^*-factor of mobile electrons.
Renormalization of χ^*, m^*, and g^* with r_s
Absence of a spontaneous magnetization at $n = n_c$
Test of the FL coupling constants F_0^a and F_1^s, determined from SdH

Experimental Setup

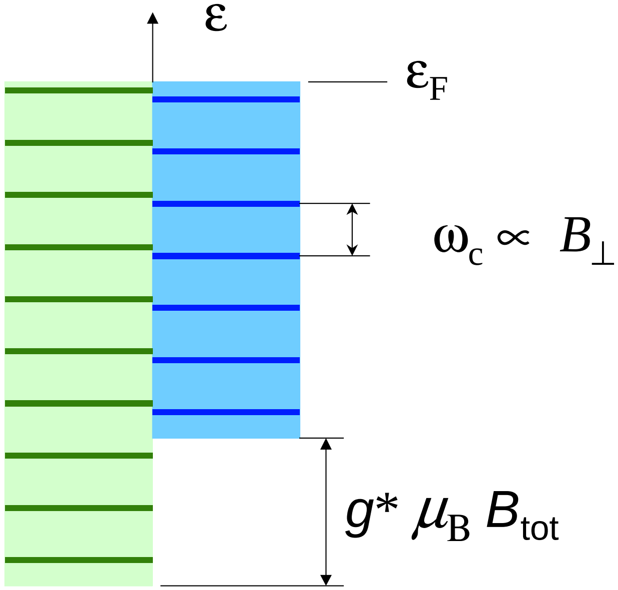




Gershenson et al. Physica E (2002).

How it works:

the beating period $\propto$ to the difference of densities for spin-up and spin-down electrons:



$$n_\uparrow - n_\downarrow = \frac{\chi^* B_{tot}}{2\mu_B}$$

$$= eB_{tot}\frac{g^* m^*}{h}$$

$$B_{tot} = \sqrt{B_\perp^{\ 2} + B_\parallel^{\ 2}}$$

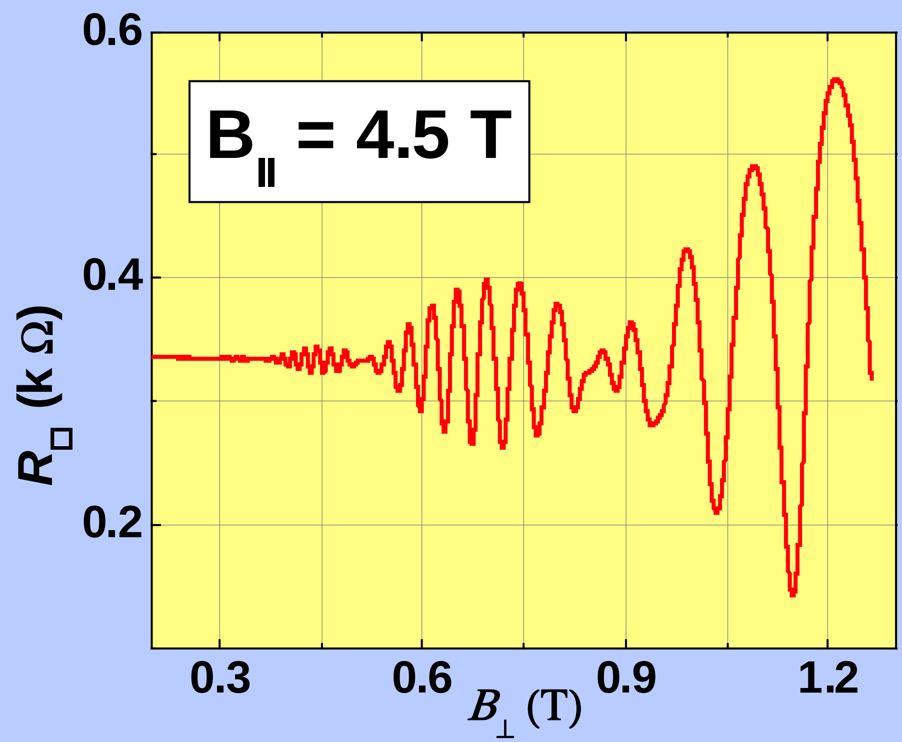
Assumption: $\hbar\omega_C \ll \varepsilon_F$

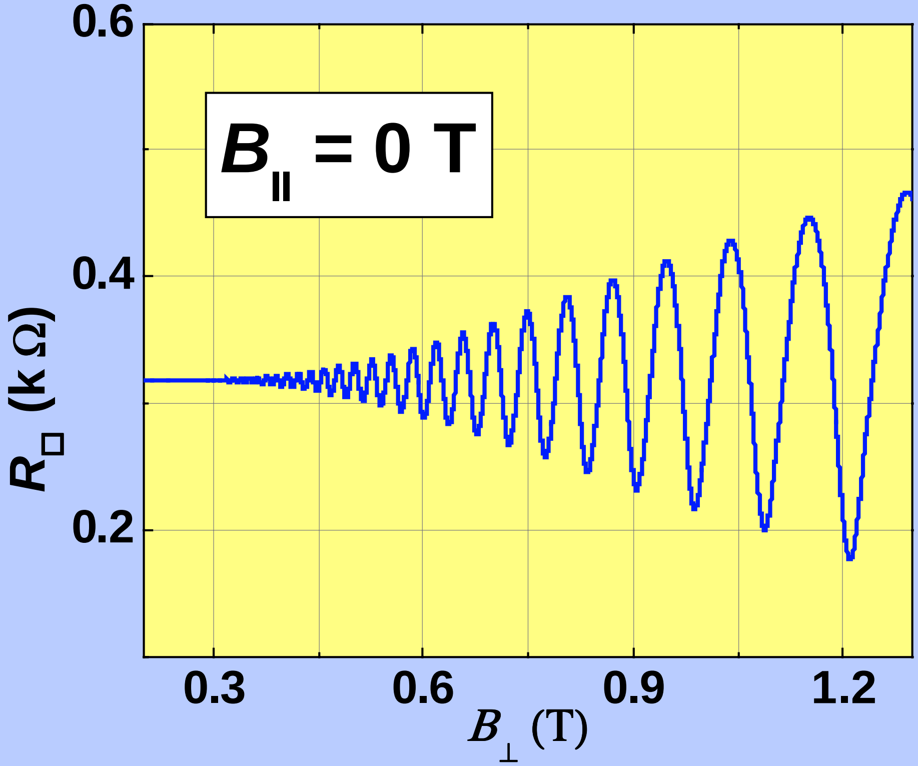
$$\frac{\Delta\rho_{xx}}{\rho_{xx}} \ll 1$$

Examples of SdH oscillations for zero and non-zero in-plane field

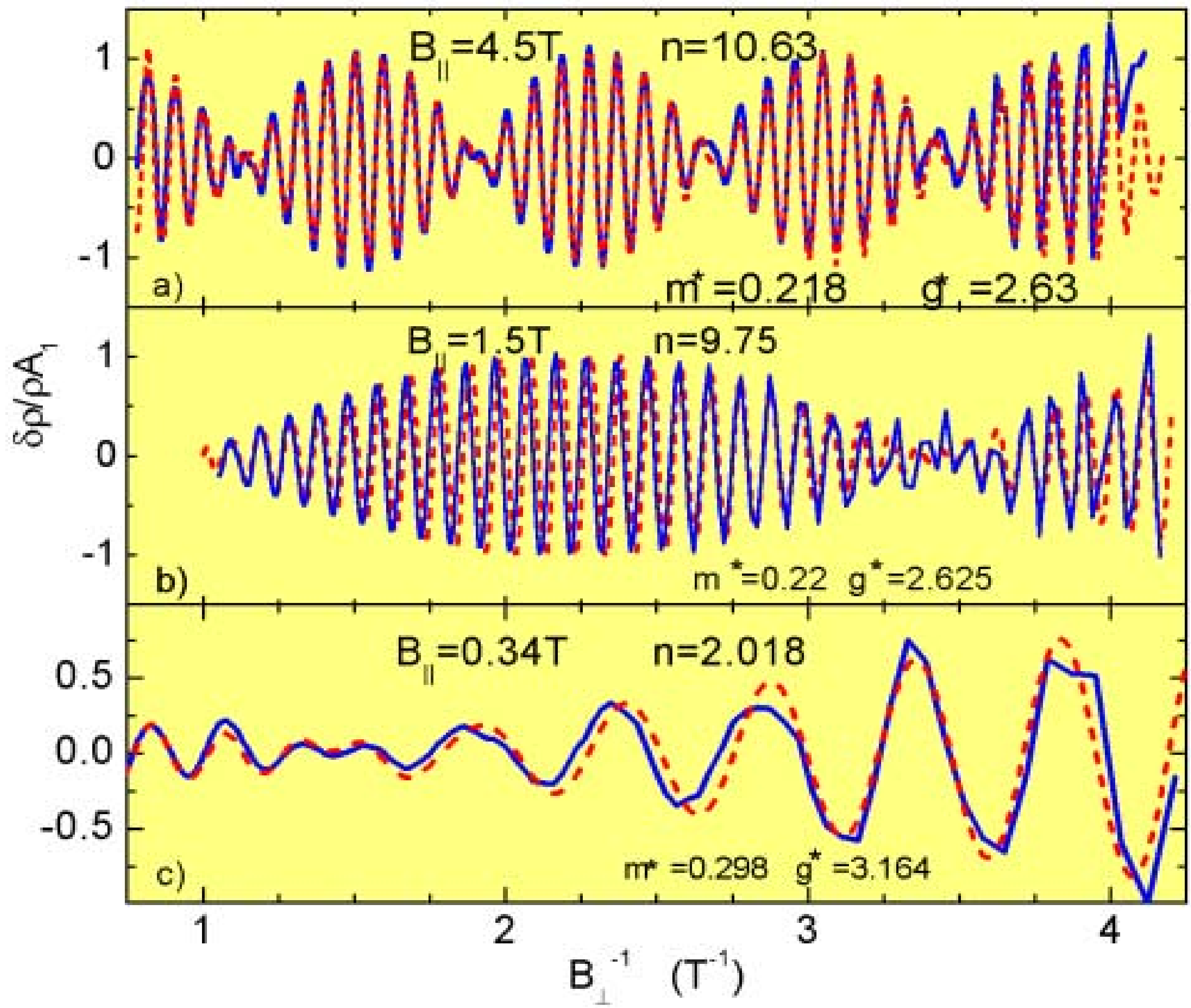
n = 10.8x10^{11} cm^{-2},

r_s = 2.5





Examples of SdH oscillations with normalized amplitude



Pudalov et al., PRL (2002)

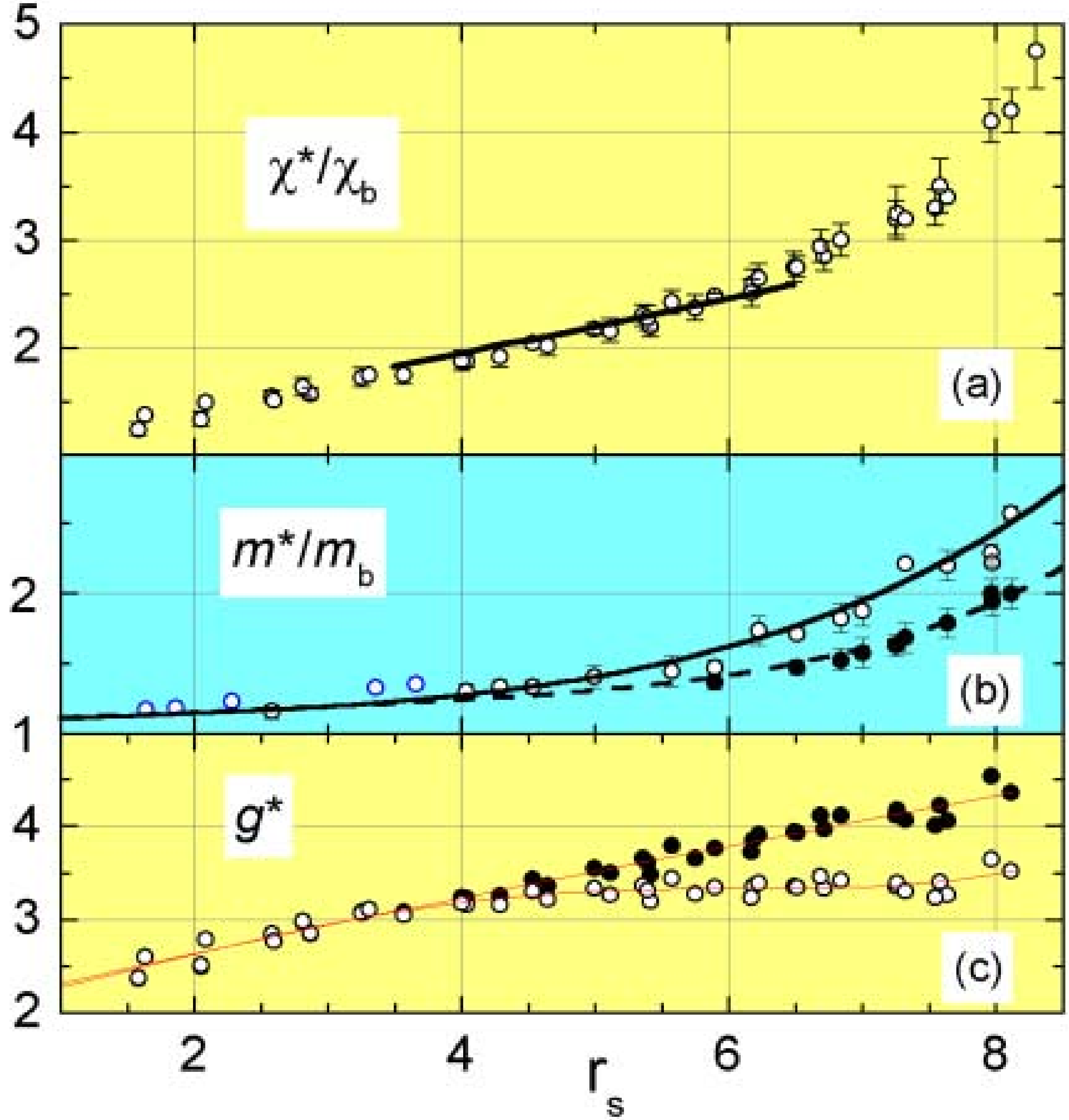
Resulting $\chi^* \sim g^* m^*$

Effective mass m^*
and

g^*-factor

Two possible values for m^* (in two assumptions):

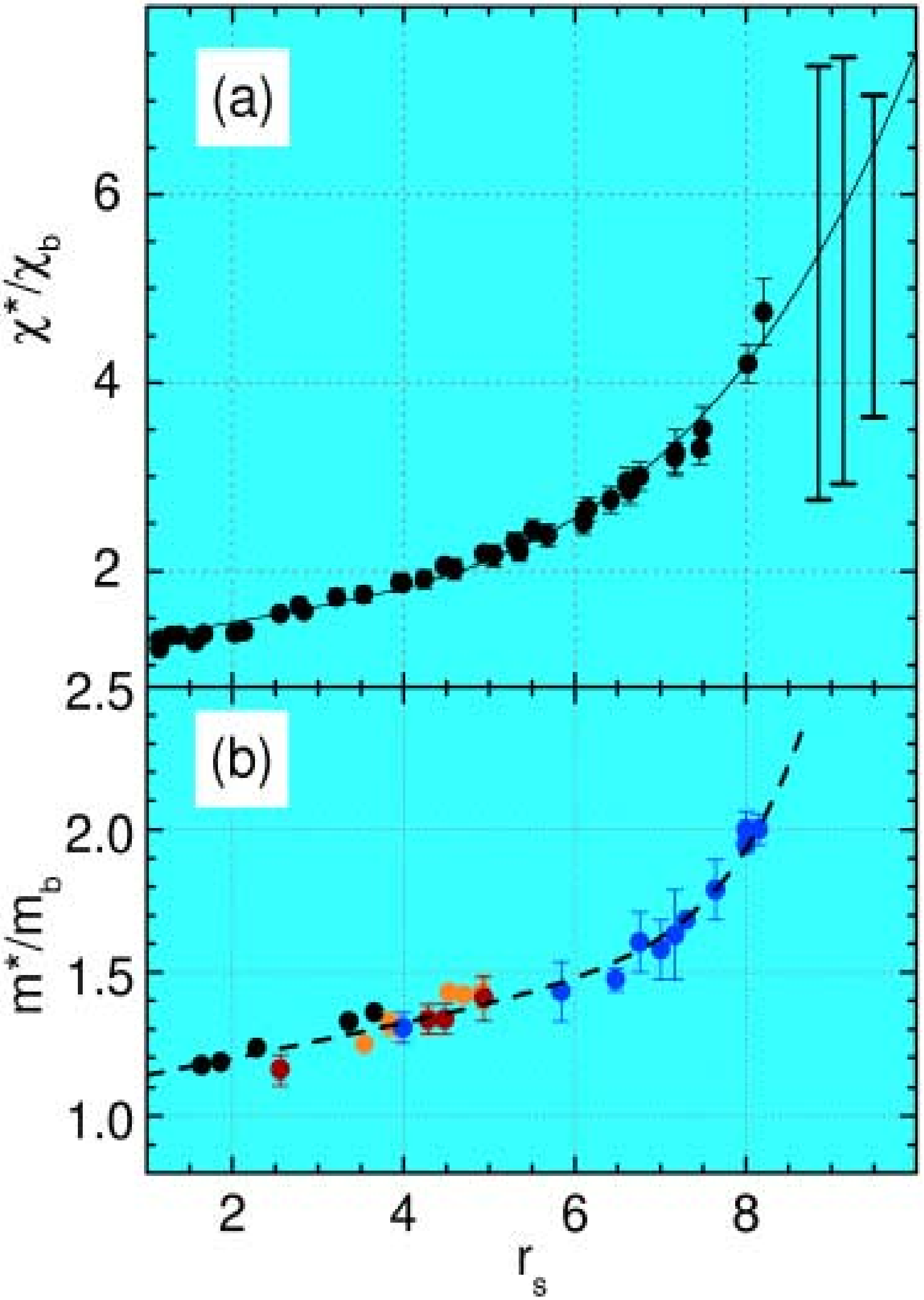
Pudalov et al., PRL (2002)

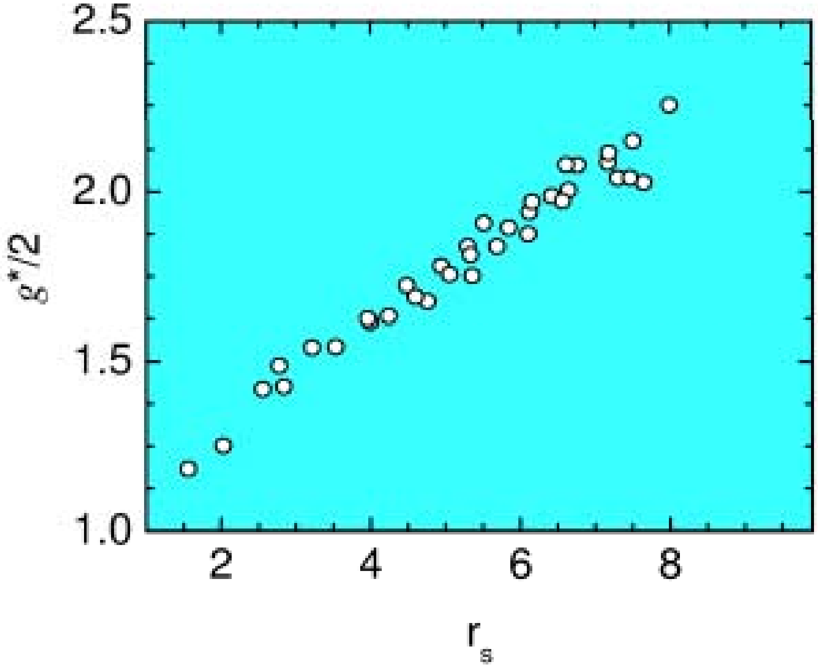


high m^*– for T_D being T-independent and **low** m^*- for $T_D \sim \rho(T)$

Recent thery of magnetooscillations (Martin et al, cond-mat/0302054) supports the **lower** *m** and **higher** *g** values:

NB:
χ^* is sample-independent (<2%),
*m** is sample-dependent (~10%)





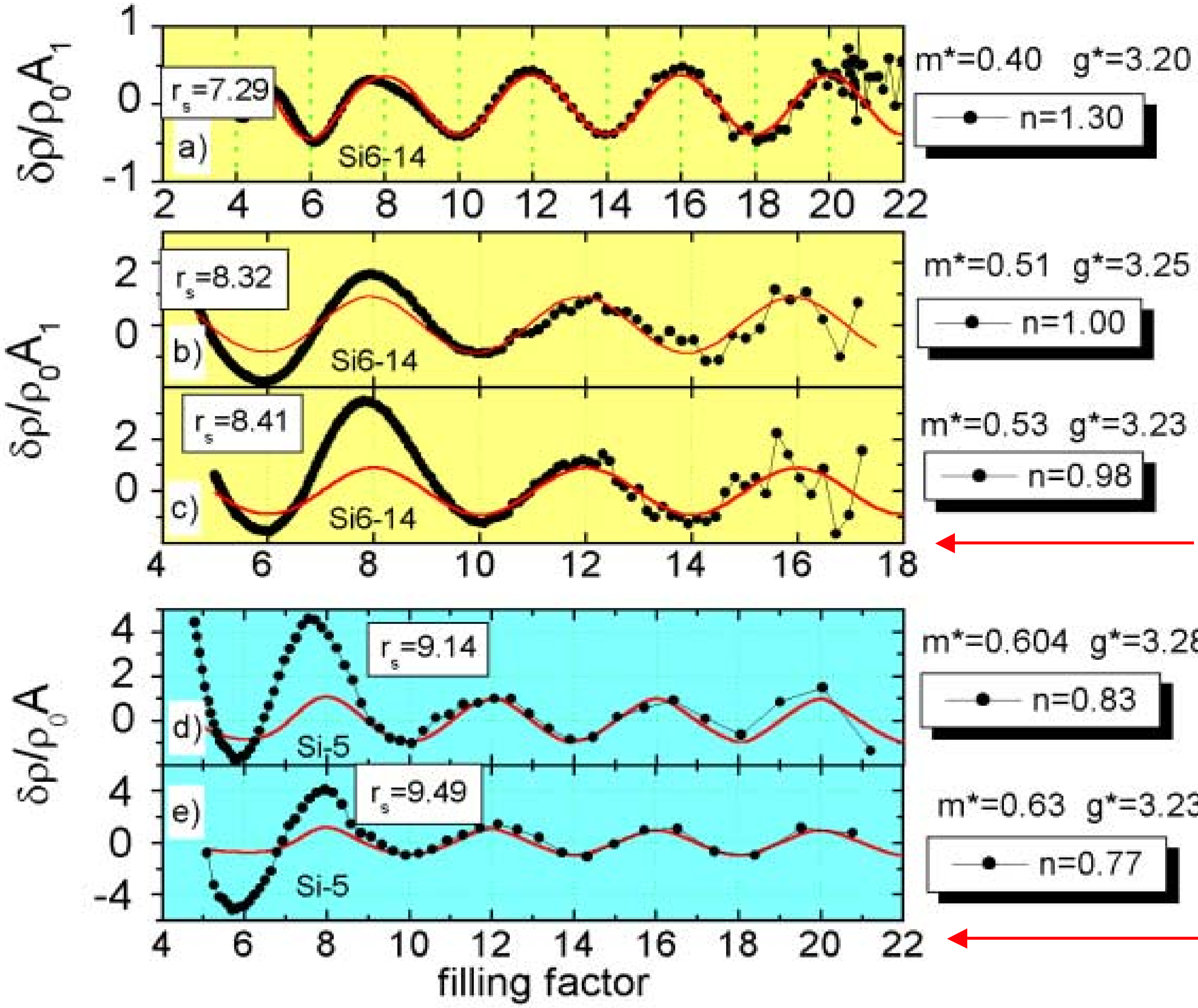
Absence of a spontaneous spin polarization for densities down to $7.7x10^{10}cm^{-2}$, including the critical density n_c

SdH periodicity in weak perpendicular fields depends only on the Landau level degeneracy (i.e., flux quantum) and is non-renormalized!

Experiment:

SdH oscillations have a periodicity, which correponds to the presence of the two spin subbands, for all densities, down to n_c. Hence, the **2D system is unpolarized down to n_c**

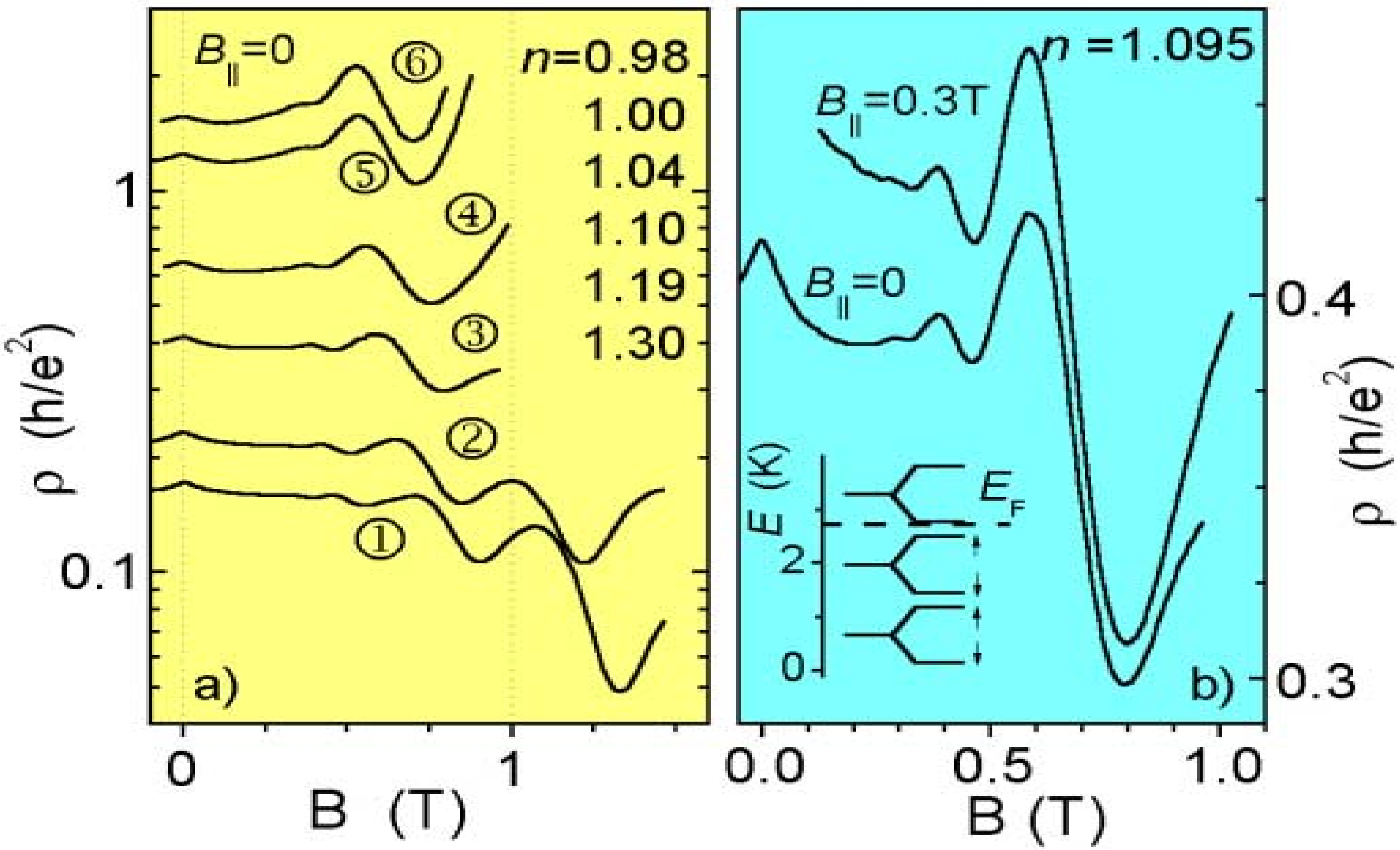
SdH oscillations at low densities



Sample Si6-14 $\boldsymbol{n = n_c}$

Sample Si15 $\boldsymbol{n = n_c}$

Both, row SdH data at $n \approx n_c$

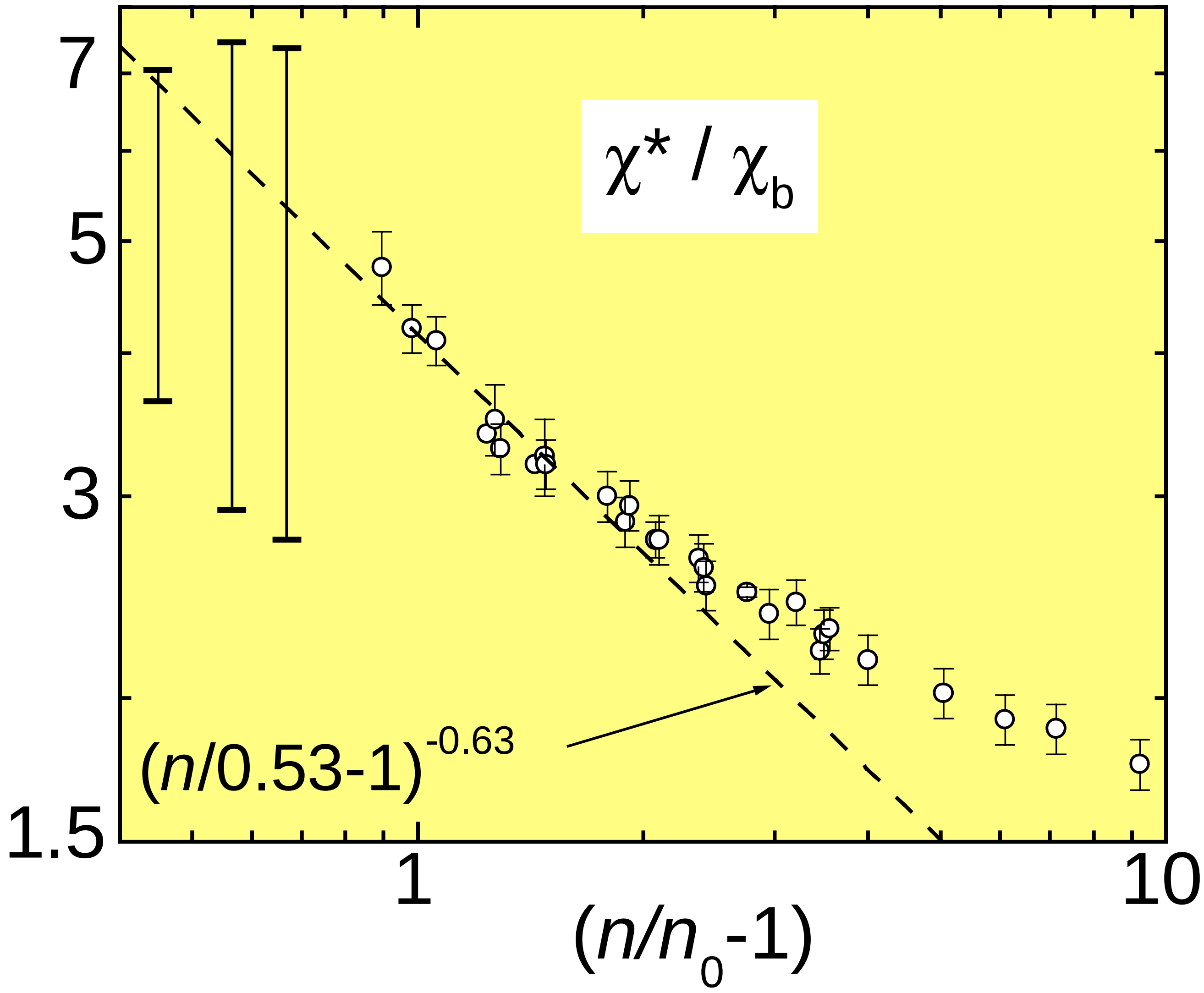


and the phase (sign) of SdH oscillations set an upper limit for the ratio of the Zeeman-to-cyclotron energy, < **3/2**:

$\chi^*/\chi_b < 8$ at $n=n_c=7.7\text{x}10^{10}\text{cm}^{-2}$

Pudalov et al, cond-mat/0110160

n = 0.53x10^{11} is the highest density at which $\chi^*(n)$ may be viewed as a critical dependence

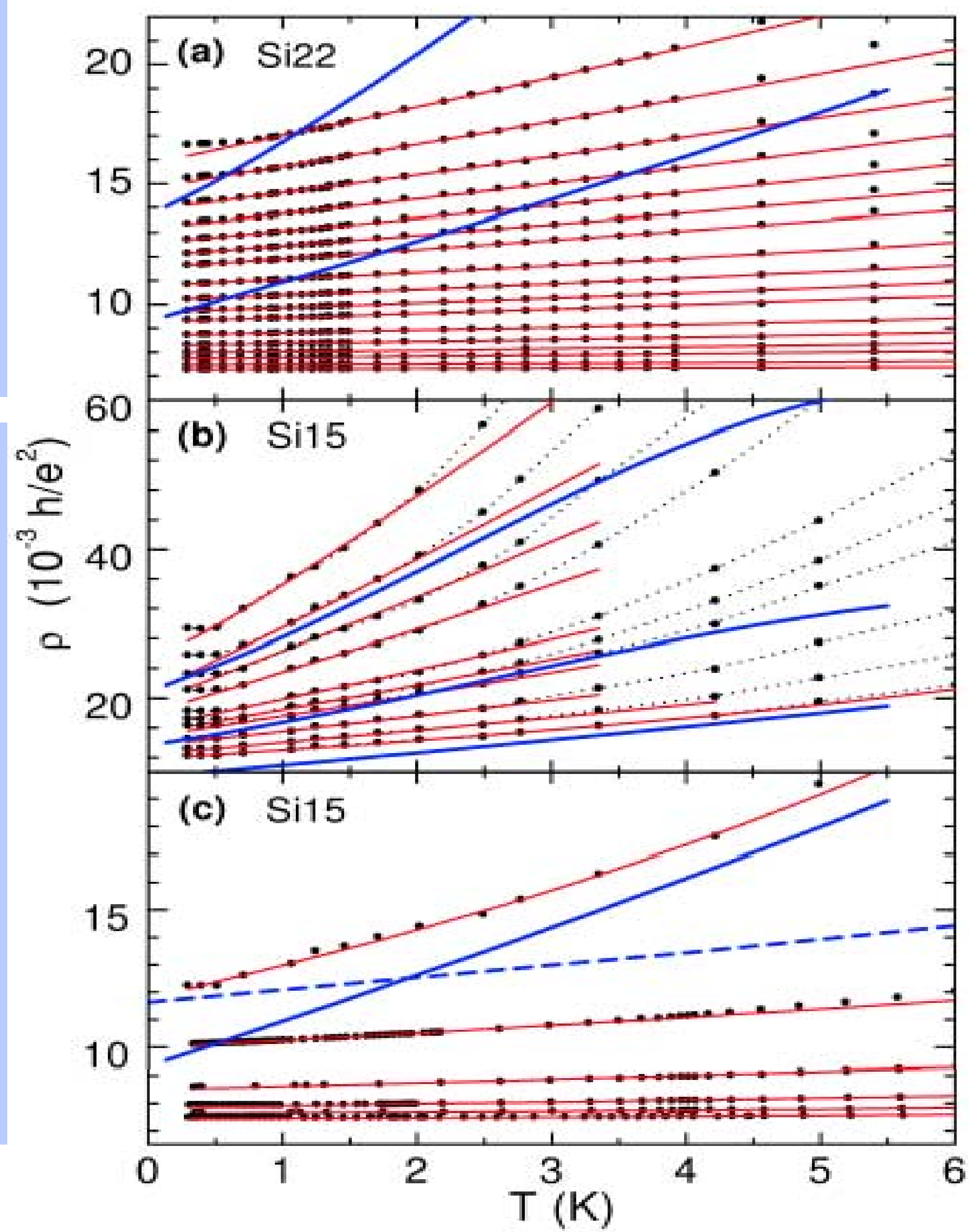


Test of the F_0^a and F_1^s values, determined from χ^* and *m**

Dots – experimental data

Red lines - 1^{st} order in *T* & high orders in interactions, using F_0^a and F_1^s values

Blue lines – numerical RPA, to all order in *T.*



Pudalov et al, PRL 2003

Conclusions

1) Using the crossed field technique, renormalized χ^*, m^*, and g^* values are deteremined in the range r_s=1-9.5

1) For different samples, the period of SdH corresponds to the 4-fold degeneracy of spin/valleys (unpolarized system) at all densities, up to r_s=9.5.

2) In particular, the 2D-MIT at $n=n_c$ at B=0 is not accompa-nied by a complete spontaneous polarization (P_0=1) of spins or valleys. An upper estimate is P_0<0.15 at n_c.

3) A divergence might occur at a universal sample-independent density $n < 0.5\text{x}10^{11}$, for both m^* and χ^*, with same critical indeces >0.5.

4) The FL coupling constants F_0^a and F_1^s, determined from SdH, provide very good none-parameter quantitative agreement of the ρ(T) data in the ballistic *T*-range with theory