Эффект Холла в системе с магнитными примесями $La_{1-x}Ce_xB_6$ ($x \leq 0.1$)

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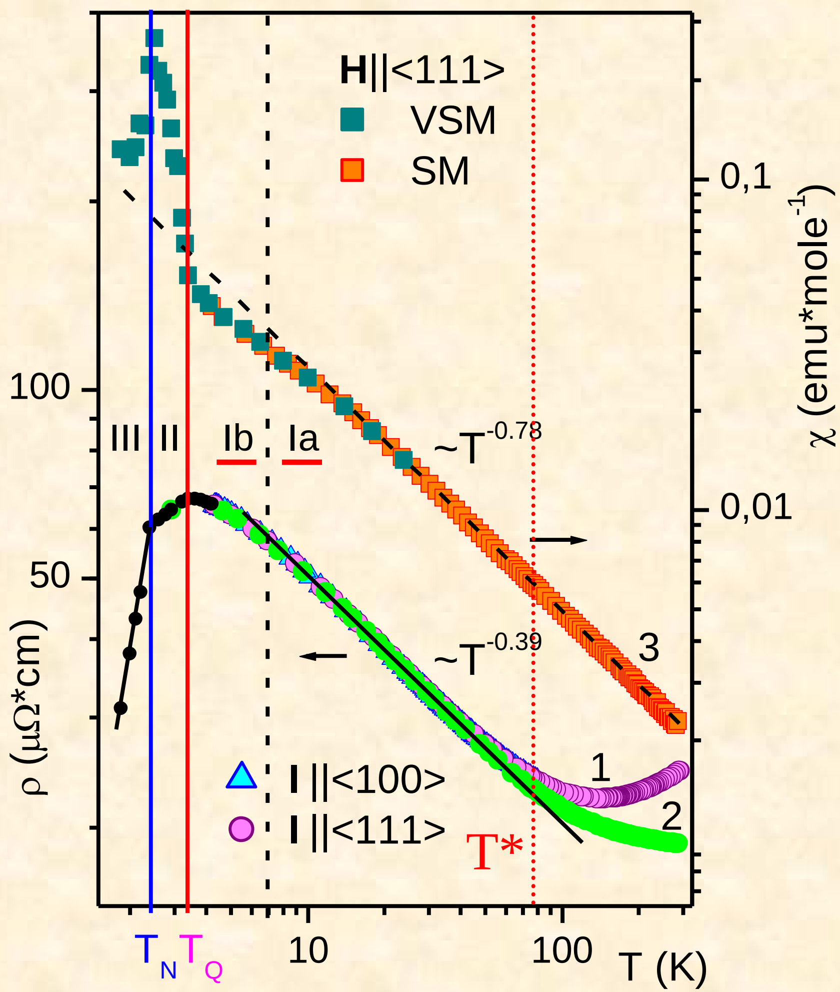
Possible scenario of magnetism in CeB_6



$T^* \approx$ 80K CDW formation

Ia **7-80K**- DOS renormalization (spin-polarons)

Ib **3.3-7K**- spin polaron- ferron transmormation

T_Q=3.3K - SDW transition (decoupling of Ce^{3+} LMM and SDW)

II **2.3-3.3K** - SDW-phase with embedded Ce^{3+} LMM

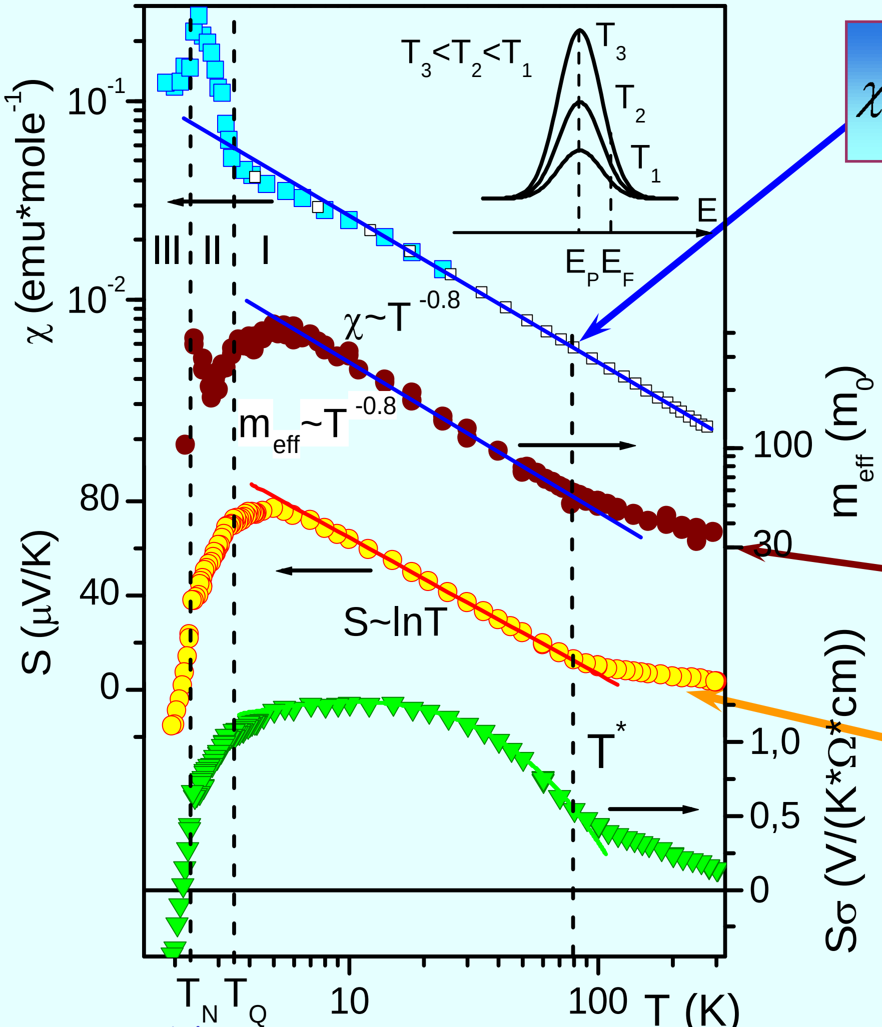
T_N =2.3K- AFM transition in the Ce^{3+} LMM system

III **T<2.3K** - AFM-phase

N.E.Sluchanko et al., JETP 104 (2007) 120

DOS renormalization in CeB_6

Spin-polaron resonance in vicinity of Fermi level



$$\chi_p(T)=\frac{1}{2}g^2\mu_B^{\,2}N(E_F)\approx\frac{1}{4}g^2\mu_B^{\,2}\frac{m_{\rm eff}{}^*k_F}{\pi^2\hbar^2}$$

Quasielastic peak in neutrons' spectra -
$\Gamma(T)/2=\hbar/\tau_{eff}(T)$

$R_H(T)$, $\rho(T)$

$$m_{eff}{}^*(T)=e\,\tau_{eff}(T)/\mu_H(T)$$

$$S_d(T)\approx\frac{\pi^2k_B^{\,2}}{3e}T\left[\frac{\partial\ln N(E)}{\partial E}+\frac{\partial\ln\tau(E)}{\partial E}\right]_{E_F}$$

$N(E_F)$ increases drastically!

??? Stoner-like criterion $U\cdot N(E_F)\geq 1$???

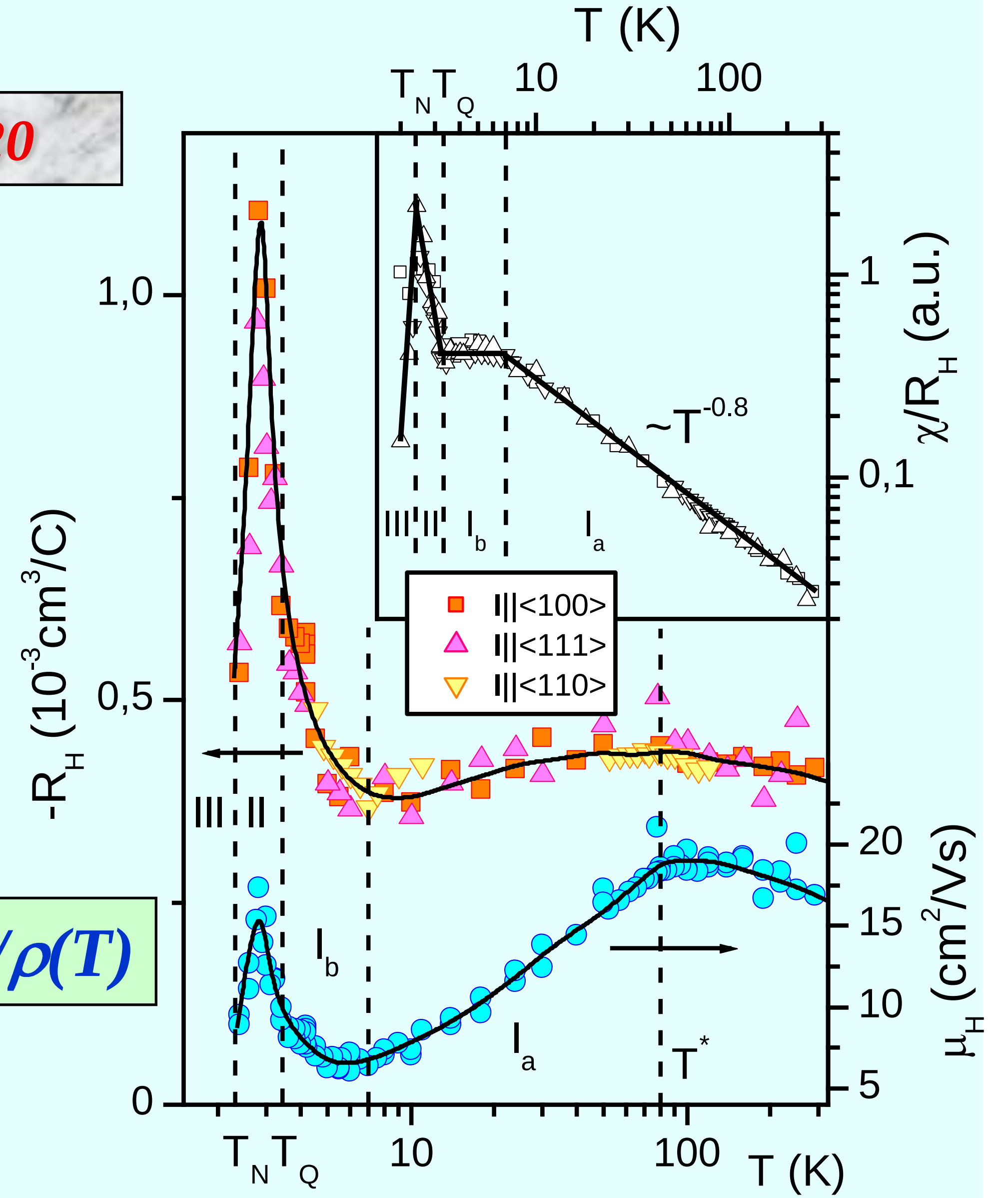
Hall coefficient of CeB_6

N.E.Sluchanko et al., JETP 104 (2007) 120

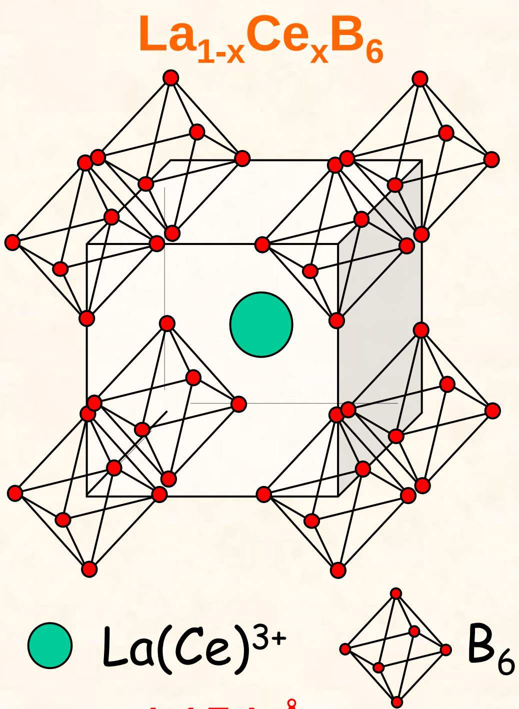
$R_H(T) \approx const < 0$

contradicts to the predictions of Kondo-lattice and skew-scattering models

$\mu_H(T)=R_H(T)/\rho(T)$



Properties of $La_{1-x}Ce_xB_6$

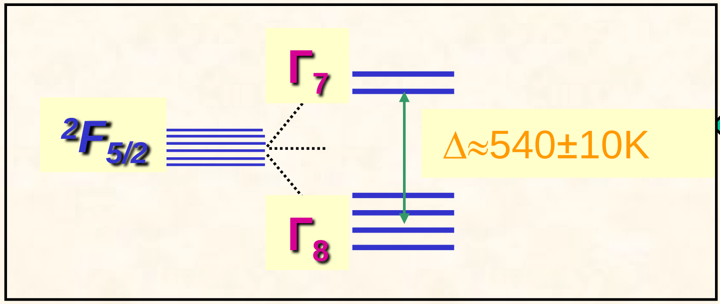


a ≈ 4.154 Å

It is commonly believed that $La_{1-x}Ce_xB_6$:

1. So-called ***dilute Kondo system (Kondo-impurity limit)*** with $n_e >> n_{4f}$ and very small Kondo temperature $T_K \approx 1K$
2. Γ_8- quartet ground state
3. 4f (LMM)- paramagnetism of nearly independent Ce^{3+} magnetic moments

Inelastic neutron scattering experiments in CeB_6 -
*M.Loewenhaupt et. al., JMMM, **52**(1985)245*
Raman scattering data-
*G.Guntherodt et. al., JMMM, **52**(1985)245*



The $La(Ce)^{3+}$ ion is weakly bound and sits in a rigid three-dimensional boron "cage".

Dilute Kondo behavior of resistivity $La_{1-x}Ce_xB_6$???

N.Sato et al., JPSJ, 54 (1985) 1923

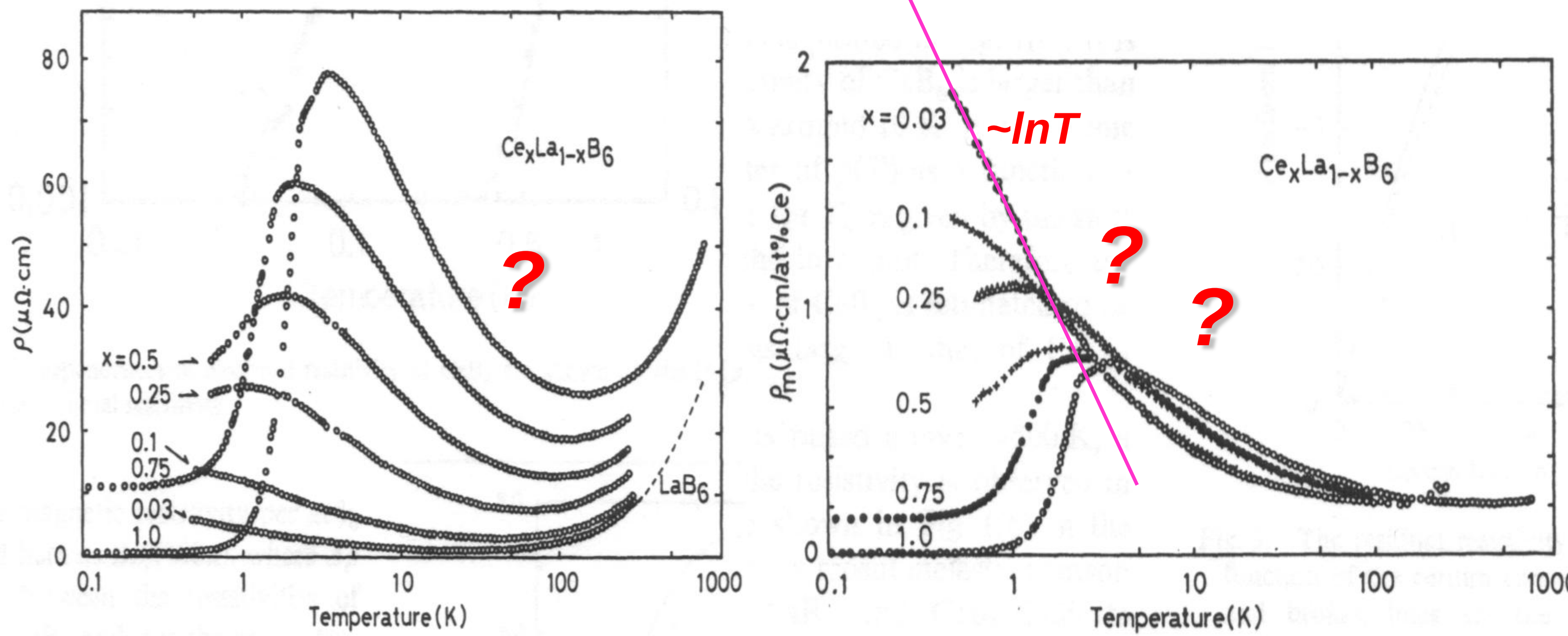
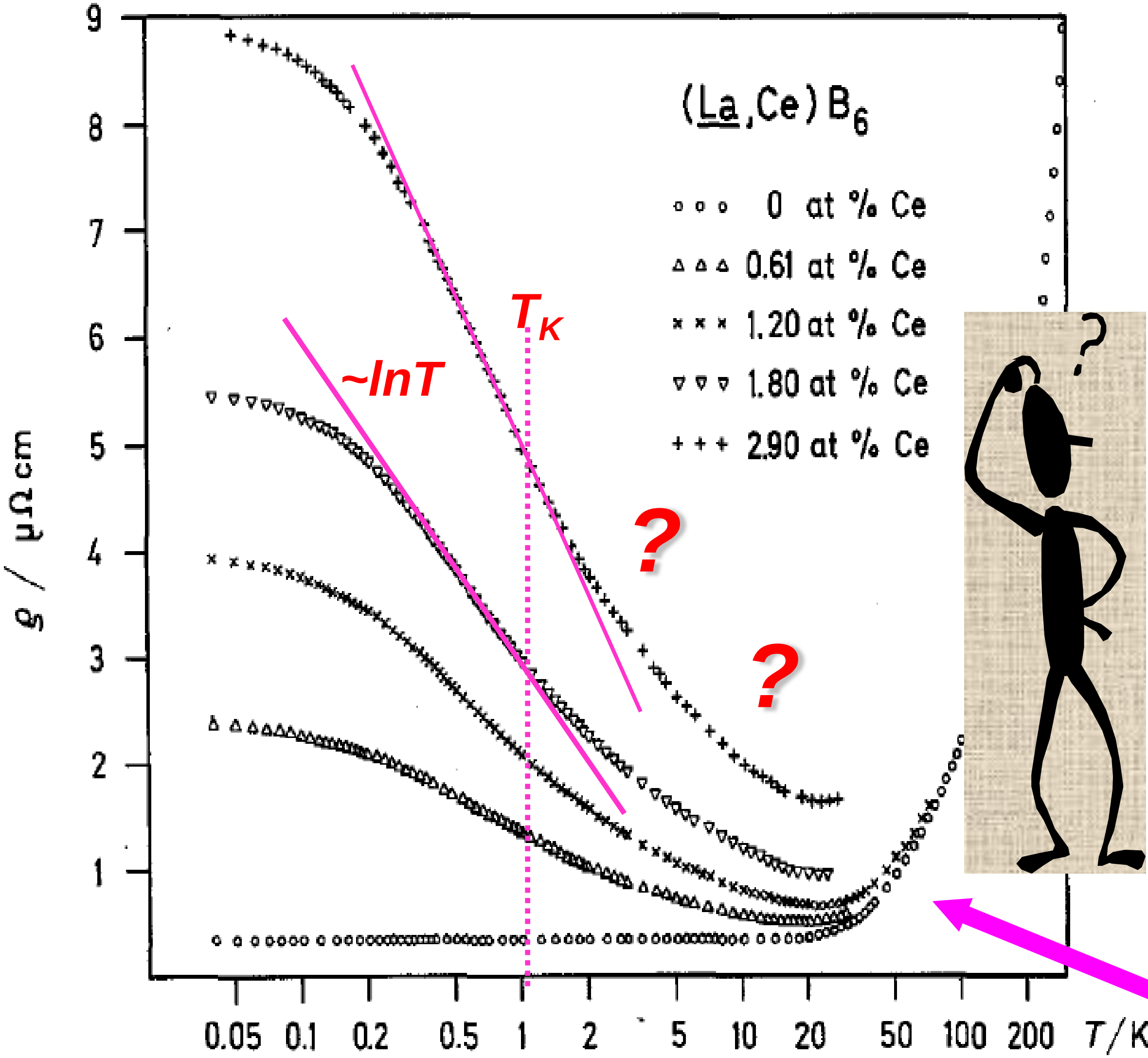


Fig. 1. (a) Temperature dependence of electrical resistivity of $Ce_xLa_{1-x}B_6$. The direction of the current is parallel to ⟨110⟩ for $x=1$, 0.1, 0.03, ⟨100⟩ for $x=0.75$, 0.5 and ⟨111⟩ for $x=0.25$.
(b) The magnetic resistivity defined as $\rho_m \equiv (\rho - \rho_{LaB6})/(100x)$ is shown as a function of temperature.

Dilute Kondo behavior of resistivity $La_{1-x}Ce_xB_6$???



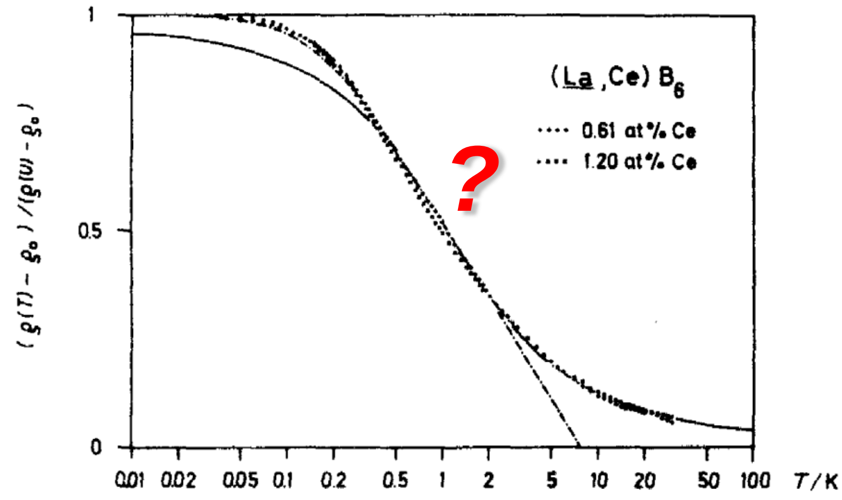
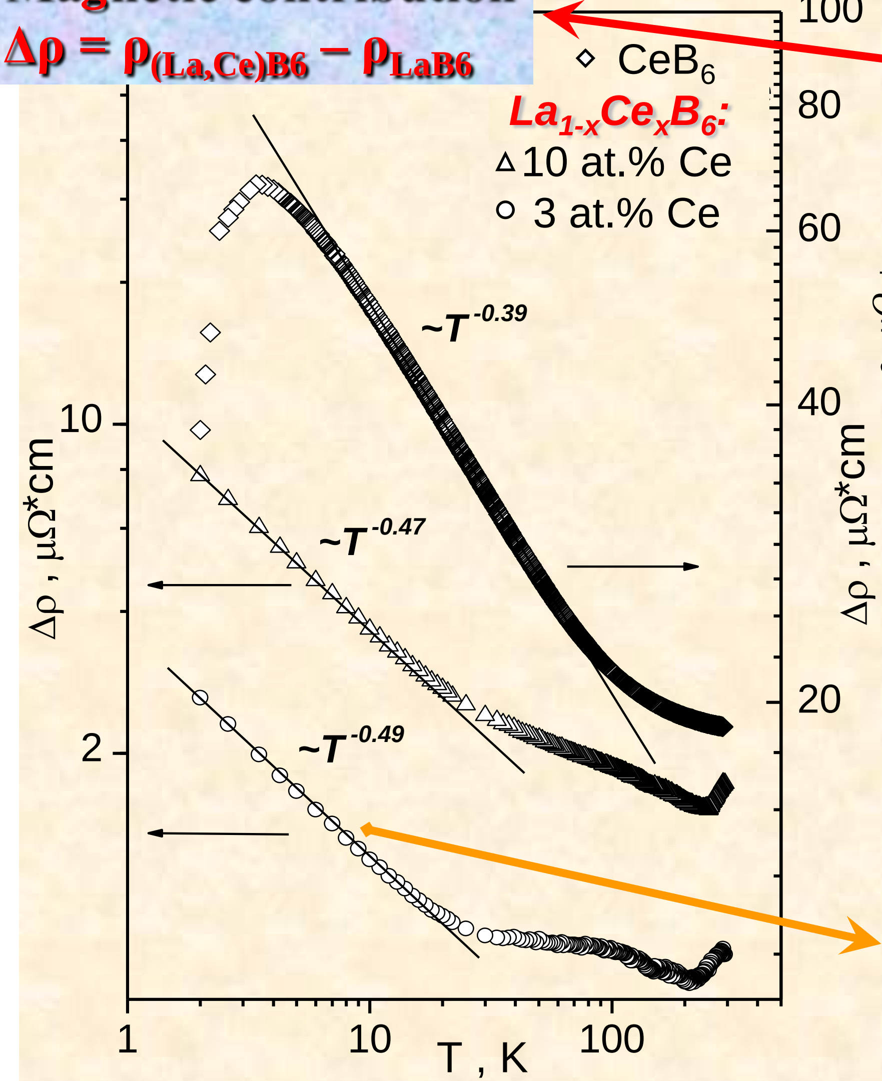


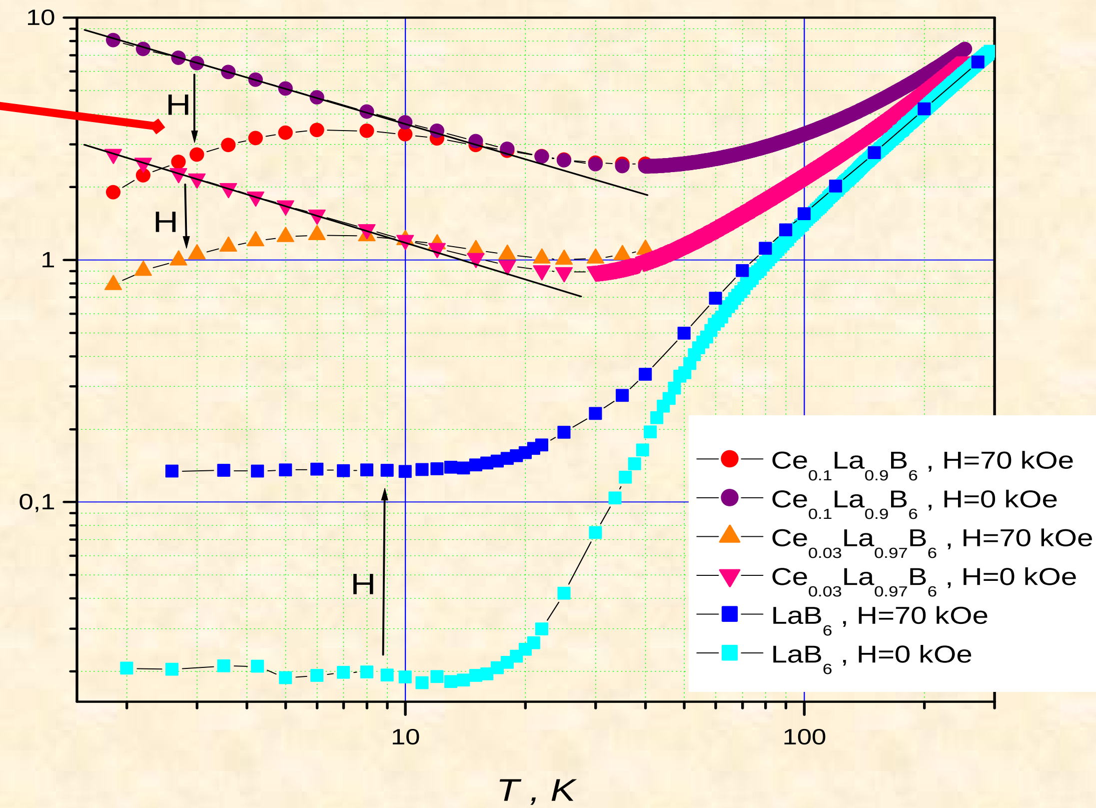
FIG. 2. Normalized temperature dependent part of the resistivity $[\rho(T)-\rho_0]/[\rho(0)-\rho_0]$ v temperature T. Solid curve: Hamann fit with $S=0.3$ and $T_K = 1.05$ K. Dashed–dotted curve: empirical expression for $T \leqslant T_K$.

K.Winzer, SSC, 16 (1975) 521
K.Samwer, K.Winzer, Z.Phys.B, 25 (1976) 269

Resistivity of $La_{1-x}Ce_xB_6$

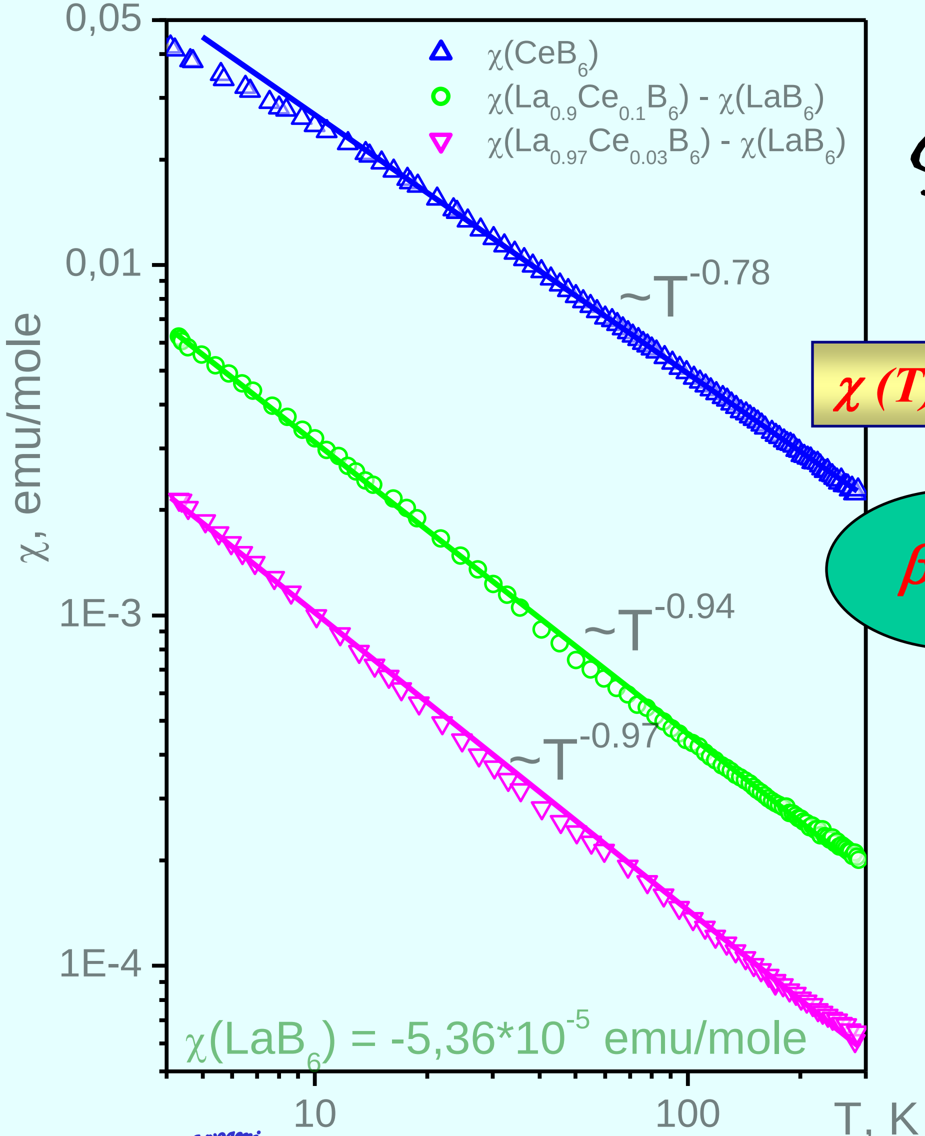
Magnetic contribution
$\Delta\rho = \rho_{(La,Ce)B6} - \rho_{LaB6}$

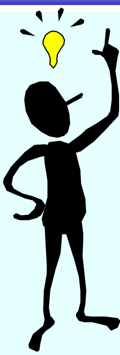




$\rho \sim T^{-1/\eta}$ with exponent **$1/\eta$=0.39±0.02 (CeB_6)** and **0.47-0.49** (**$La_{1-x}Ce_xB_6$** in the range **$x \leq 0.1$**)
weak localization type behavior
W.L.McMillan, Phys. Rev. B, **24**, 2739 (1981)
instead of Kondo-type $\rho(T)$ logarithmic temperature dependence

Magnetic susceptibility temperature dependencies of $La_{1-x}Ce_xB_6$



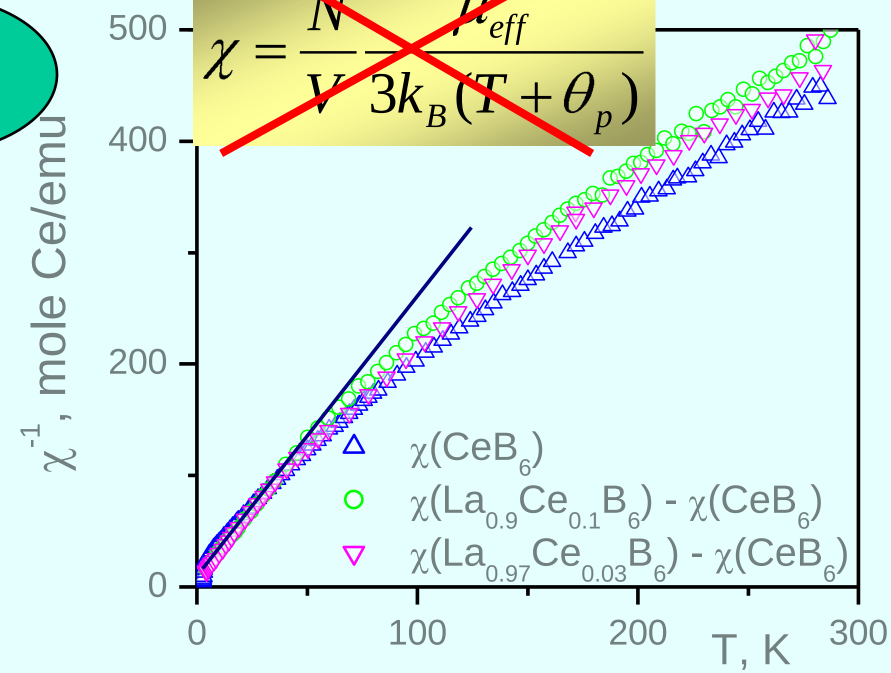


$\mu_{eff} \approx 1.0\mu_B$ for CeB_6
in the interval 5-220K
Inelastic neutron scattering experiments-
S.Horn, F.Steglich, M.Loewenhaupt et. al., Z.Phys.B, 42(1981)125

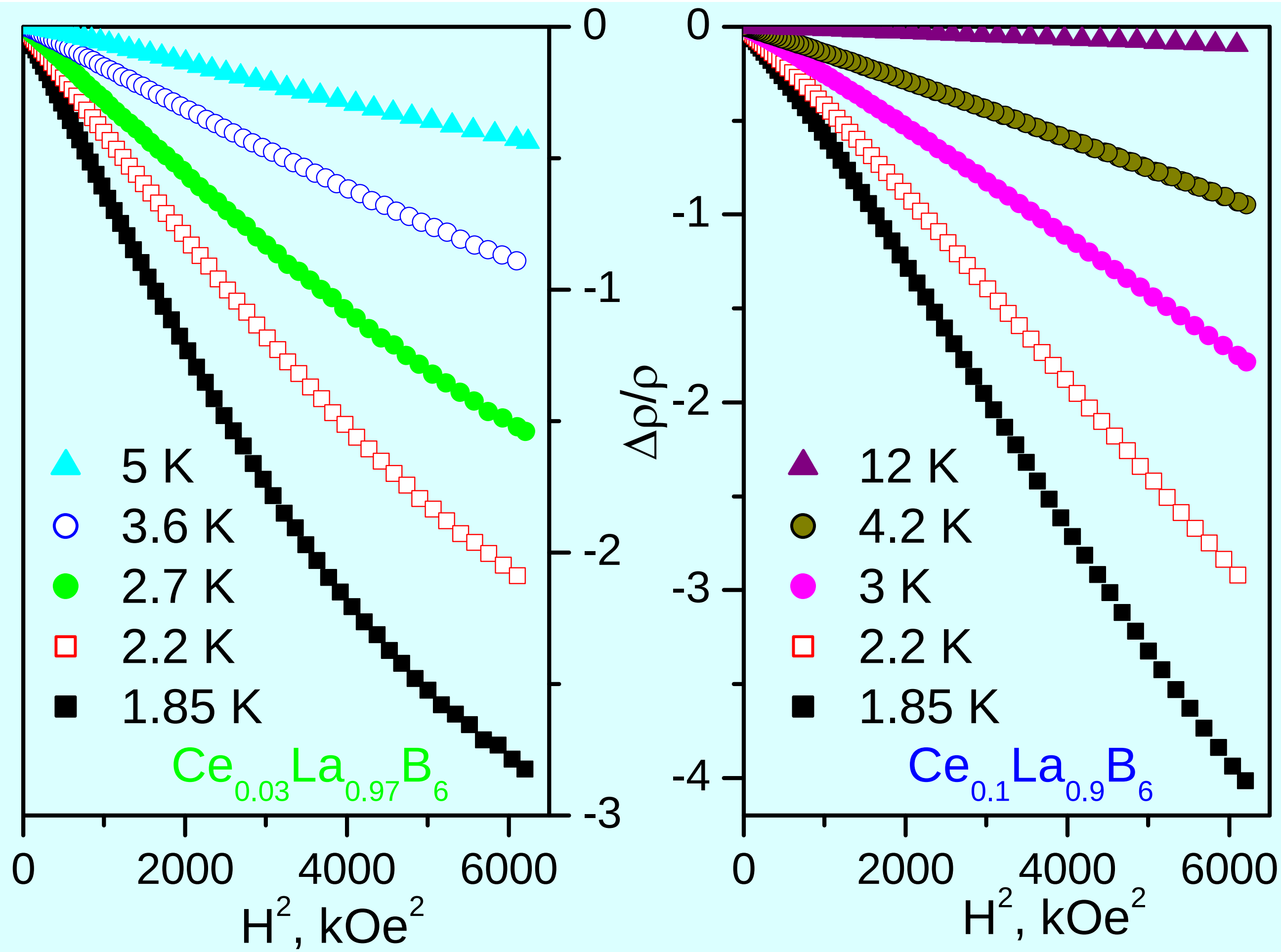
$\chi(T) \sim T^{-\beta} \sim \rho^2 \sim T^{-2\alpha}$ instead of Curie-Weiss law

$\beta=2\alpha$

$$\cancel{\chi = \frac{N}{V}\frac{\mu_{eff}^2}{3k_B(T+\theta_p)}}$$



Magnetoresistance of $La_{1-x}Ce_xB_6$



$-\Delta\rho/\rho \sim H^2$

CeB_6 , $CeAl_2$

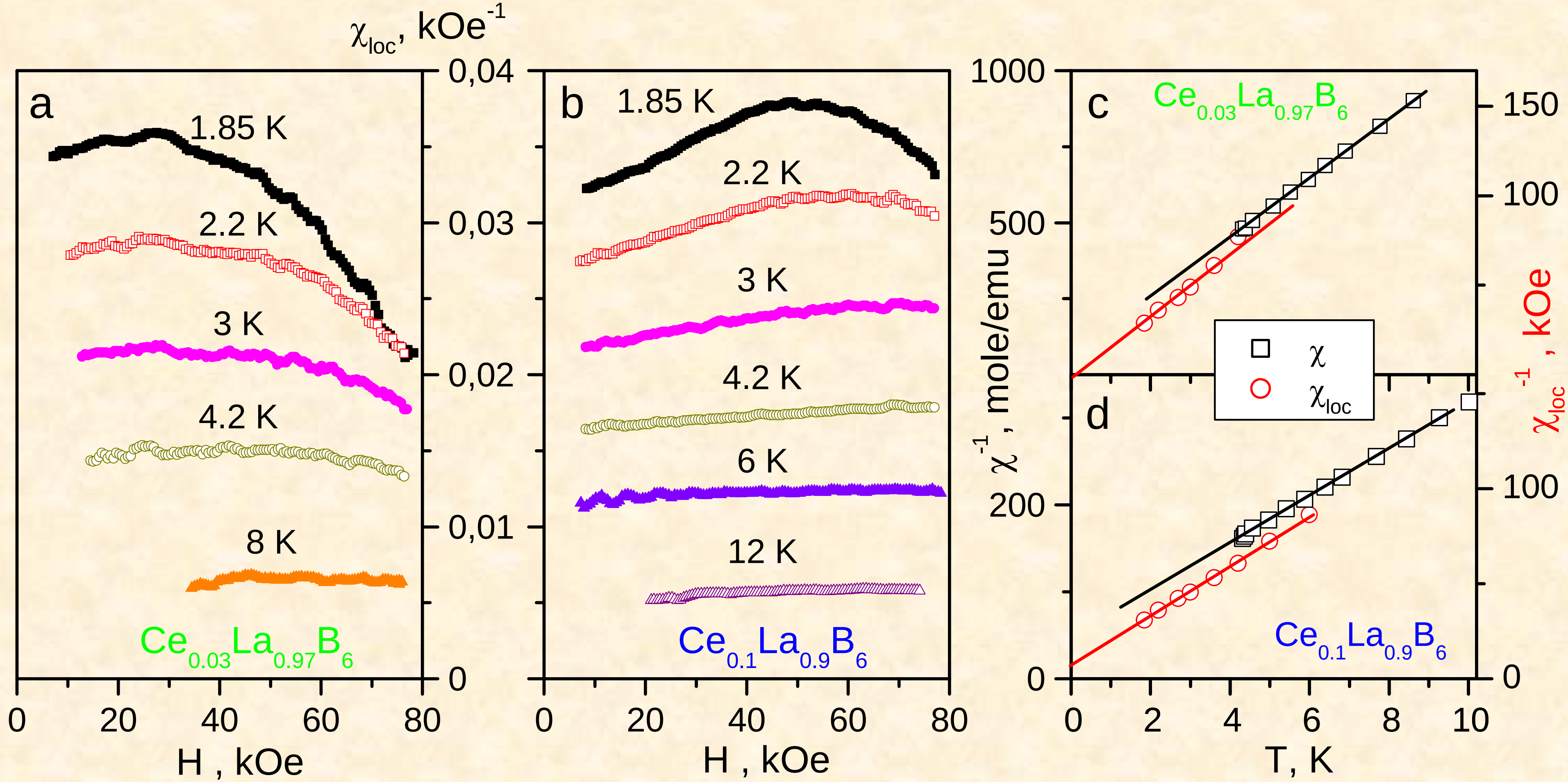
A.V.Bogach et al, JMMM **300** e1 (2006)
A.V.Bogach et al, J.Sol.St.Ch. **179** 2819 (2006)
A.V.Bogach et al, Physica B **378** 769 (2006)
N.E.Sluchanko et al, JETP **104** 120 (2007)

K.Yosida, Phys. Rev., 107 (1957) 396.

$-\Delta\rho/\rho = 0.61\langle M\rangle^2/S^2 = \beta M_{loc}^2 \sim \beta \chi_{loc}^2 H^2$

$\chi_{loc}(T,H) = (1/H(d(\Delta\rho/\rho)/dH))^{1/2}$

Local magnetic susceptibility of $La_{1-x}Ce_xB_6$



K.Yosida, Phys. Rev., 107 (1957) 396.

$$\chi_{loc}(T,H)=(1/H(d(\Delta\rho/\rho)/dH))^{1/2}$$

$$-\Delta\rho/\rho \approx \beta M_{loc}^2 \approx \beta \chi_{loc}^2 H^2$$

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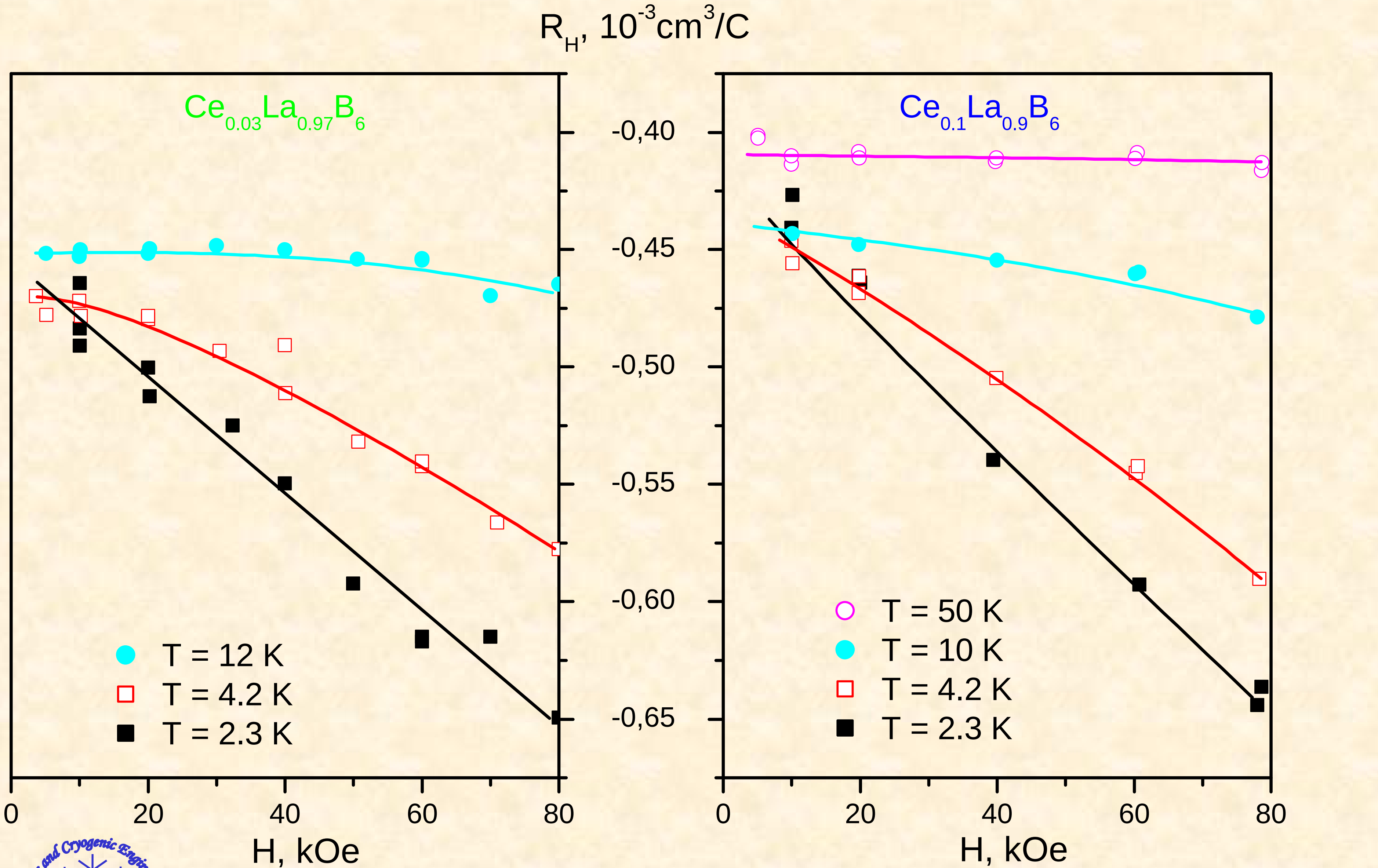
Hall coefficient field dependencies of $La_{1-x}Ce_xB_6$



Hall coefficient temperature dependencies of $La_{1-x}Ce_xB_6$