8th International Workshop on Anomalies in Hydrogen / Deuterium Loaded Metals
13-18 October 2007 - Catania - Sicily - Italy

PdH(D,T)x system: are excess of enthalpy and superconductivity two concurrent phenomena affected by stoichiometry x ?

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Something New on PdH system

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2000
First evidence of the existence of a new phase in PdH system

γ phase

ELSEVIER

30 October 2000

PHYSICS LETTERS A

Physics Letters A 276 (2000) 122–126

www.elsevier.nl/locate/pla

Temperature coefficient of resistivity at compositions approaching PdH

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Abstract

Measurements have been made of the temperature coefficient of resistivity, λ, versus hydrogen concentration, H/Pd, at very high concentrations in the Pd–H system. Unusually high hydrogen compositions were achieved using an electrochemical loading procedure which allowed stable Pd–H systems to be obtained. It is well known that increasing the H/Pd concentrations leads to three different phases (α, α + β, β), respectively, in the Pd–H system; the β phase is thought to end in an asymptotic limit. Possible evidence that a new phase (γ) exists, bordering the β phase at compositions H/Pd > 0.9 is reported and discussed.

1. Introduction

Hydrogen and its isotopes dissolve in many metals occupying interstitial sites in the host lattice, most often producing an expansion of the lattice. Each interstitial H(D,T) causes displacement of the metal atoms from their original sites and the resulting crystal lattice distortions give rise to a series of changes in physical properties. In particular, interstitial hydrogen ions affect the electrical resistance of the host metal [1,2]. New electron scattering centers are created in metallic hydrides when interstitial vacancies are occupied by H(D,T). This leads to a change in the residual resistance which can manifest itself even at room temperature (Fig. 1) [3,4]. In the case of palladium this is the most important contribution considered in the overall changes observed.

As would be expected the temperature coefficient of resistivity, λ, changes with hydrogen concentration, H/Pd, in palladium. Information regarding the λ coefficient for corresponding H(D)/Pd ratios is well known up to a concentration of H(D)/Pd < 0.7 as shown in Fig. 2 [5,6]. The physical behaviour of hydrogen loaded and deuterium loaded palladium is very similar. Due to the instability of the Pd–H(D) system at higher H(D)/Pd concentrations there are no available data for λ corresponding to loading ratios greater than H(D)/Pd ≈ 0.7.

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PII: S0375-9601(00)00654-X

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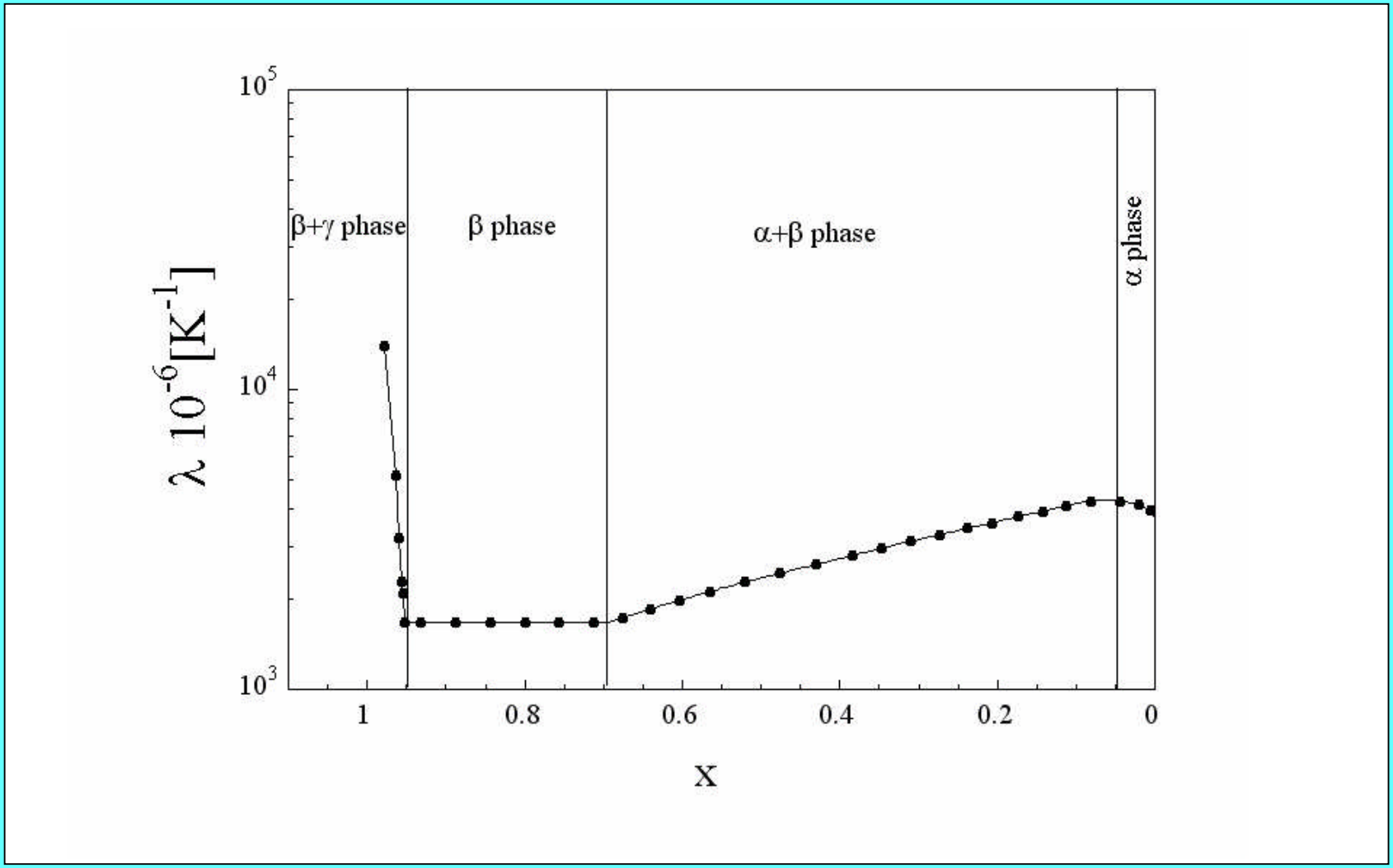

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α phase in the stoichiometry range $0 < x < 0.05$

$\alpha+\beta$ phase in the stoichiometry range $0.05 < x < 0.70$

β phase in the stoichiometry range $0.70 < x < 0.95$

$\beta+\gamma$ phase in the stoichiometry range $x > 0.95$

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This results has been replicated and confirmed by *D. Garbelli, L. Gamberale, F. Fontana* at PIRELLI LABS

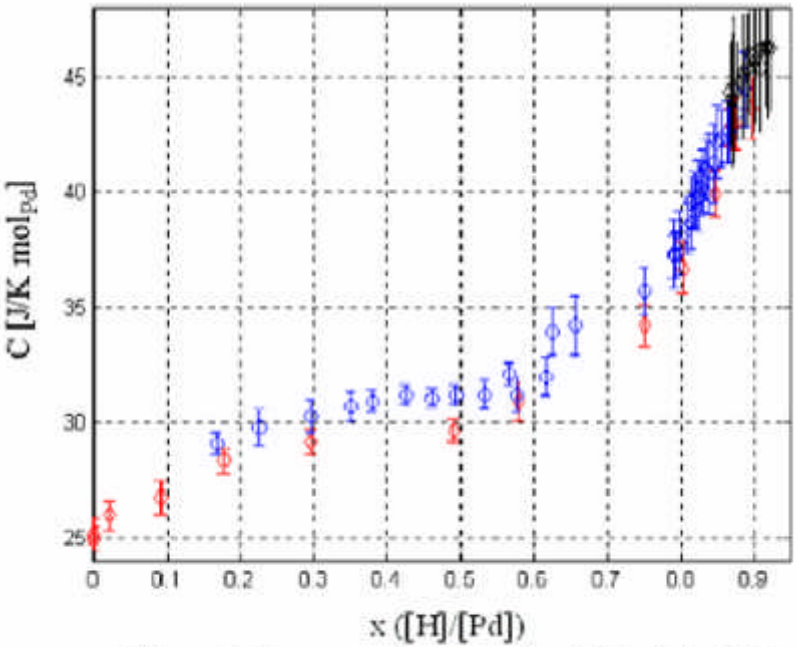


Figure 2 Heat capacity per mole of Pd of the PdH_x system as a function of hydrogen loading.

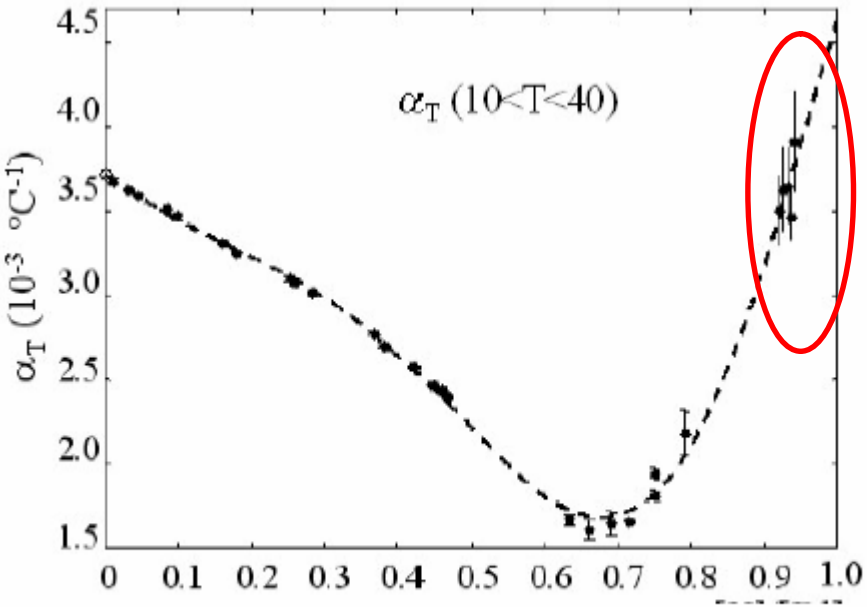
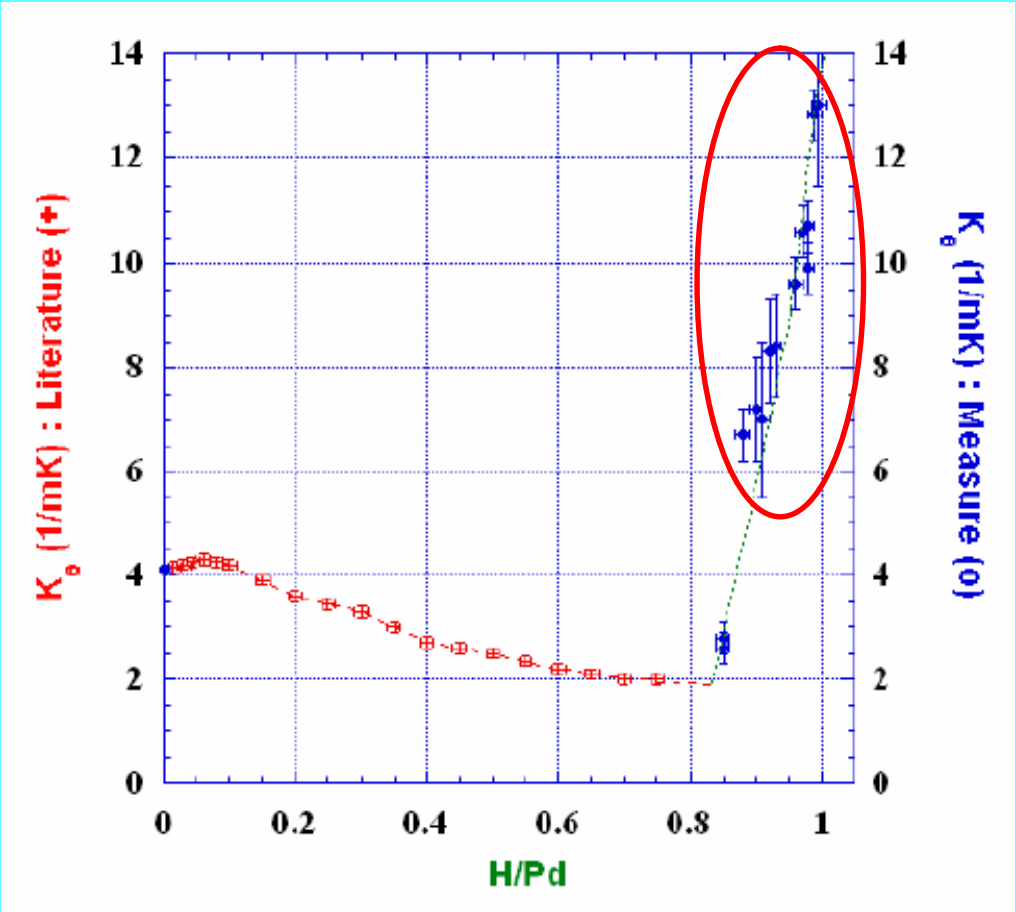


Figure 0: Thermal coefficient of resistance as a function of hydrogen loading.

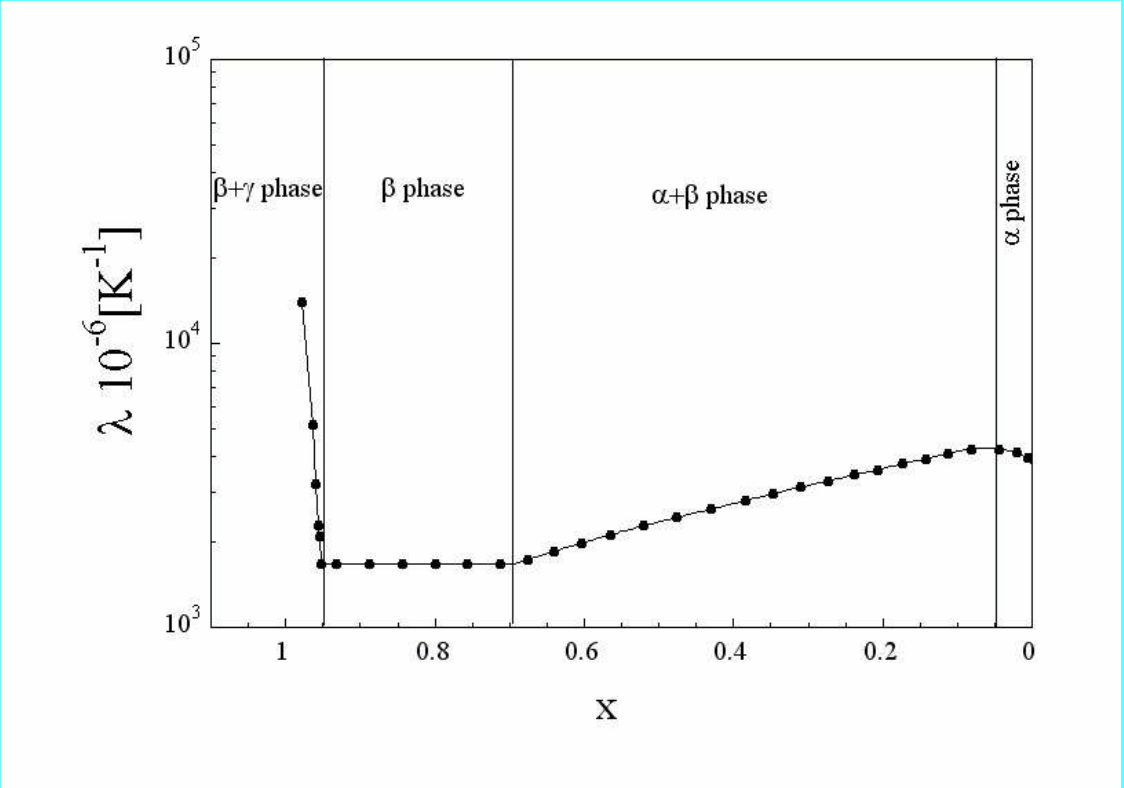
2002

This results has been replicated and confirmed by *A. Spallone, P. Marini, V. Di Stefano* at LNF-INFN

2005



Questions
When the β+γ phase terminate?



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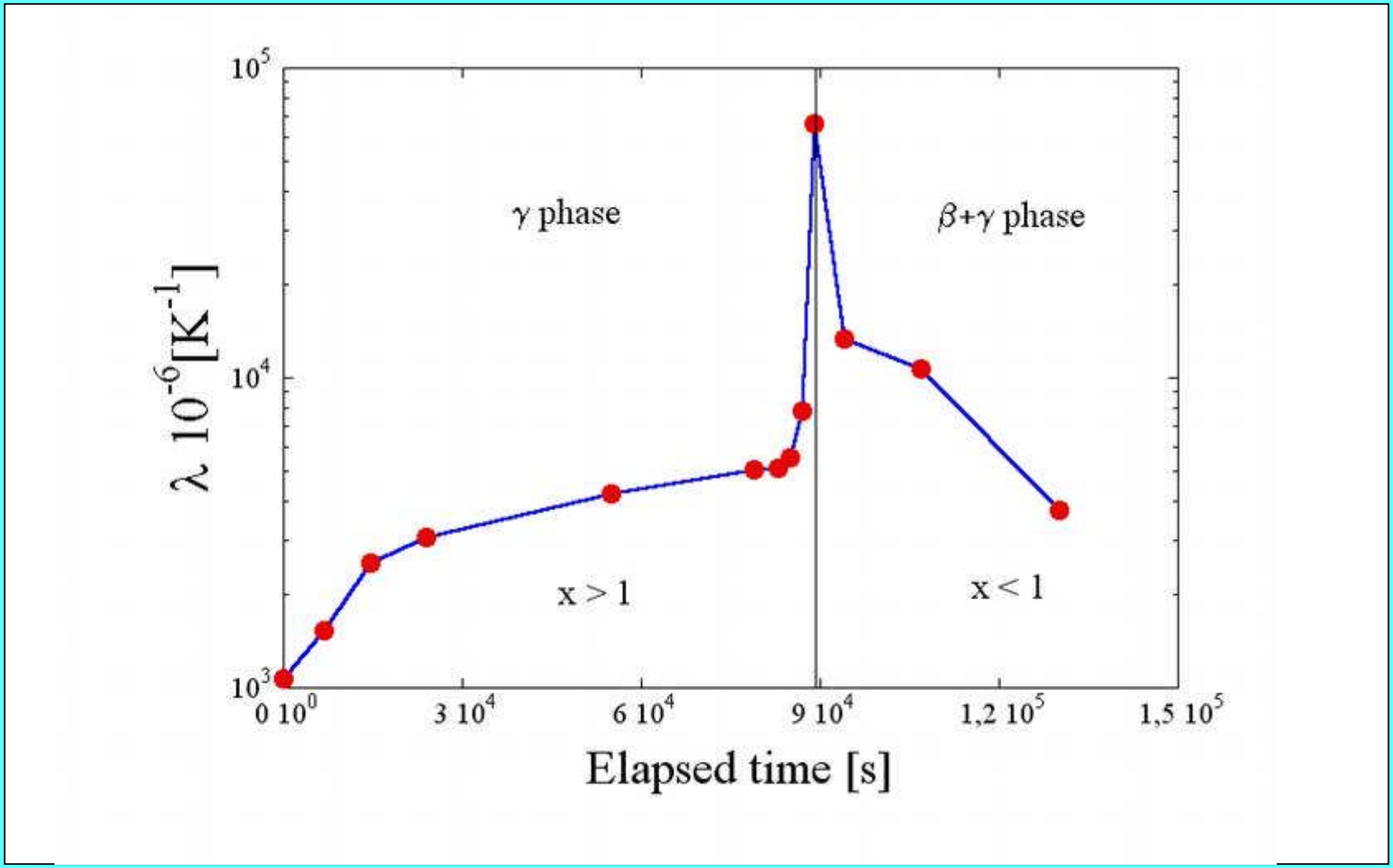

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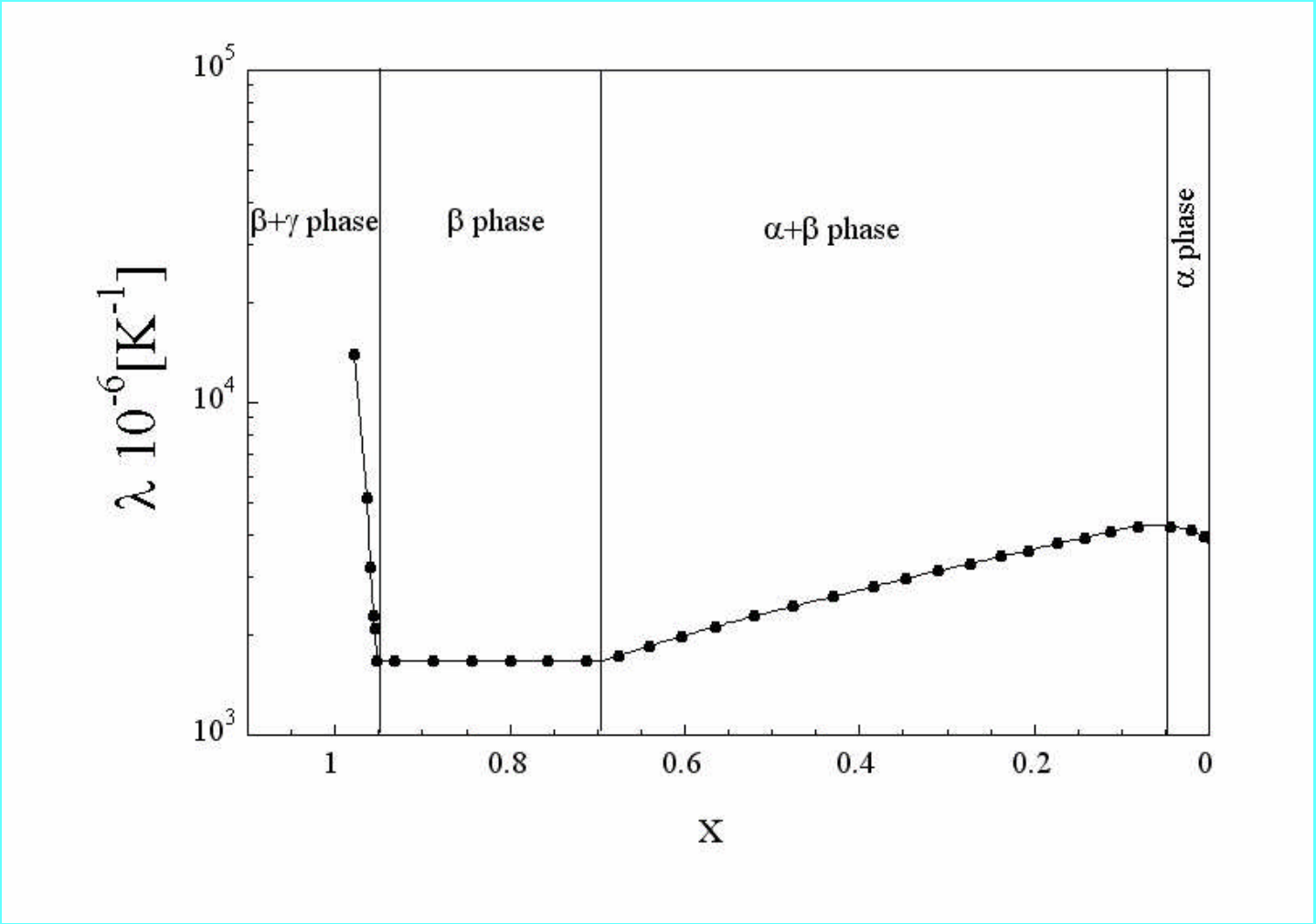
2003 Braz. Jour. of Physics v.34 (2004) 1177



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It will be important to have a replication and confirmation of the presented results on the β phase end in PdH system.

INFN ?
SRI ?
PIRELLI ?
ENEA ?
?

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What is happening in the γ phase

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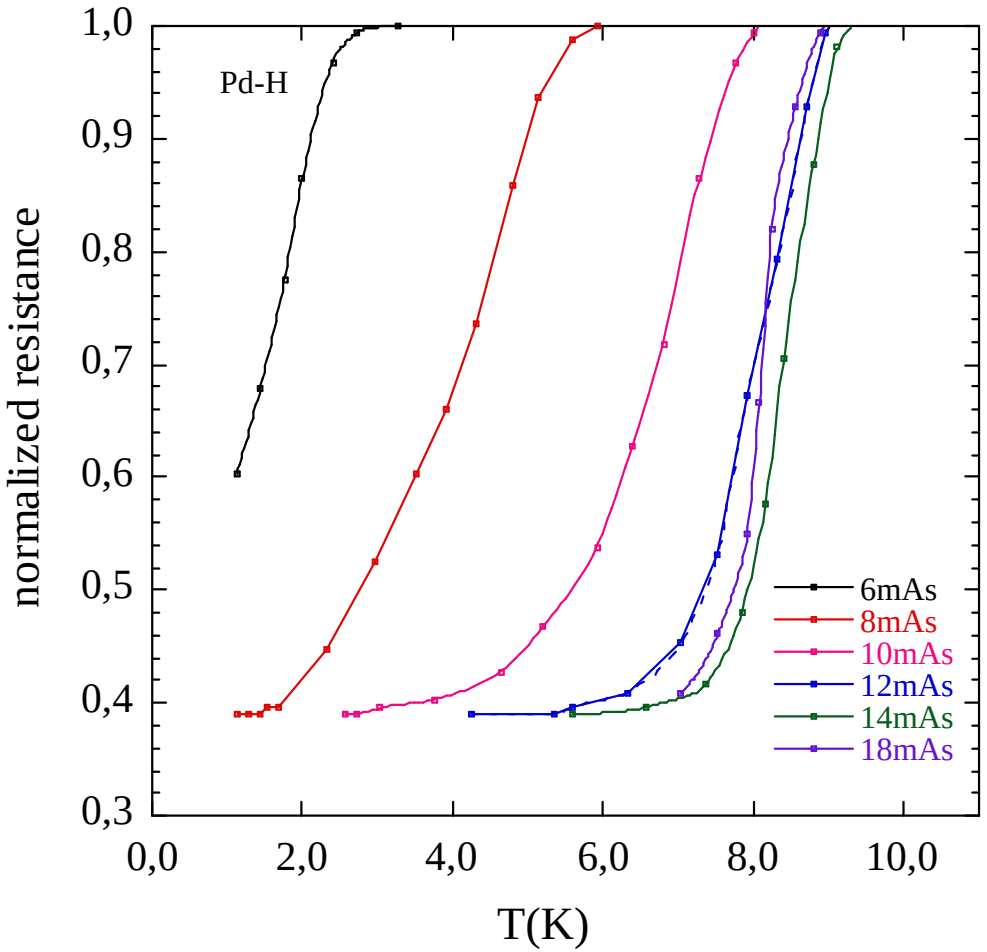
[B. Stritzker and W. Buckel, Z. Phys. 257, 1-8 (1972)]



β and β+γ phases

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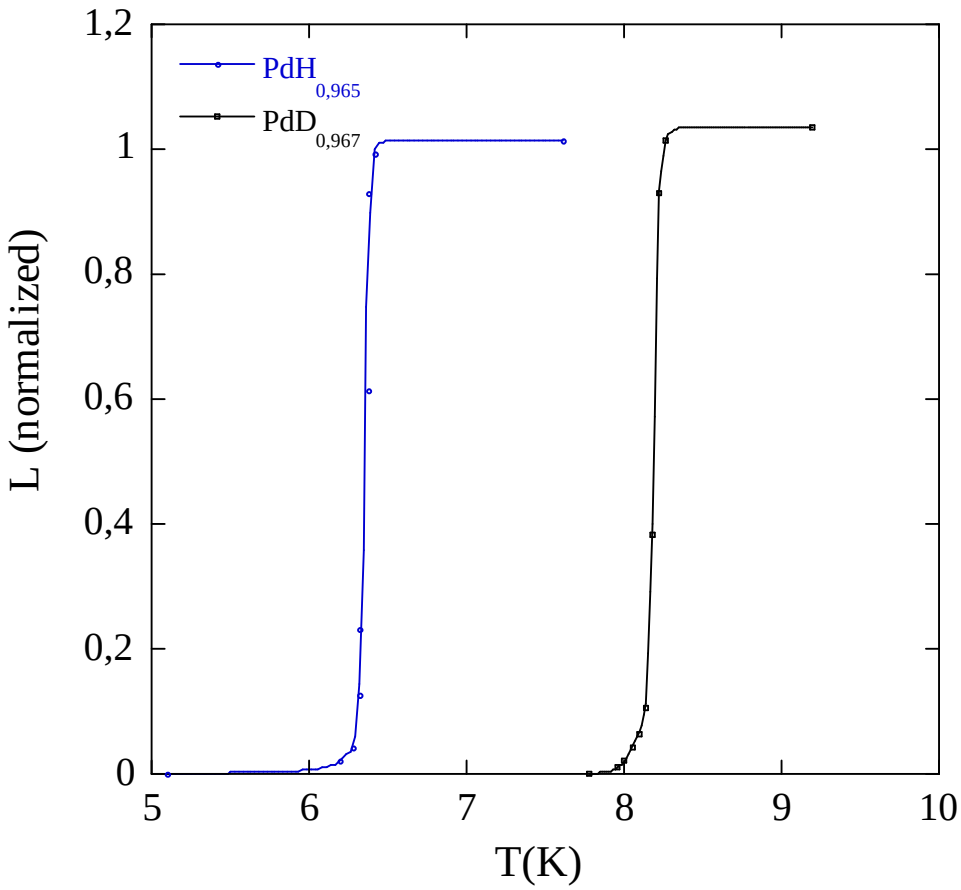
[J.E. Schirber and C.J.M. Northrup Jr, Phys. Rev B 10 3818 (1974)]



β+γ phase

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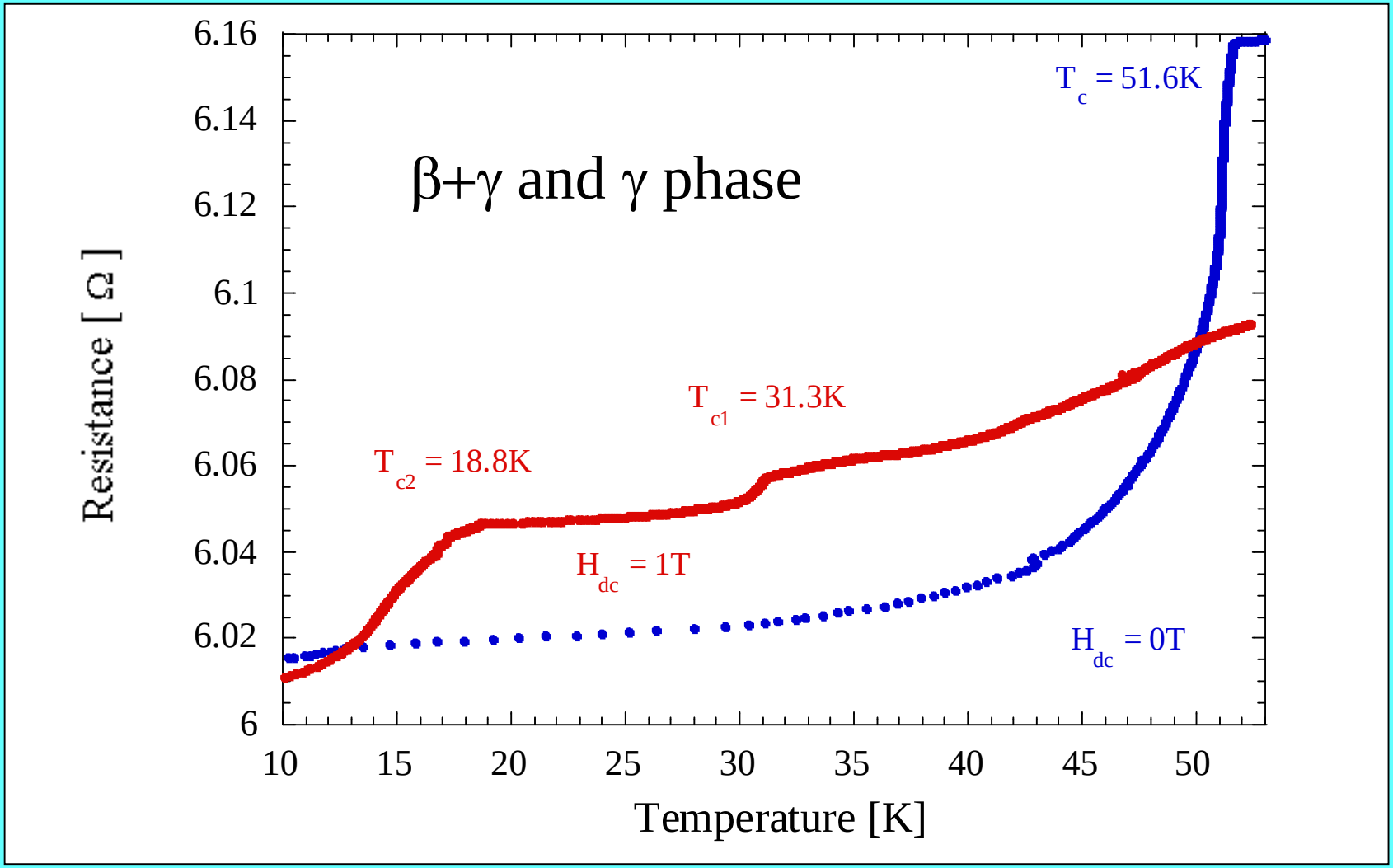

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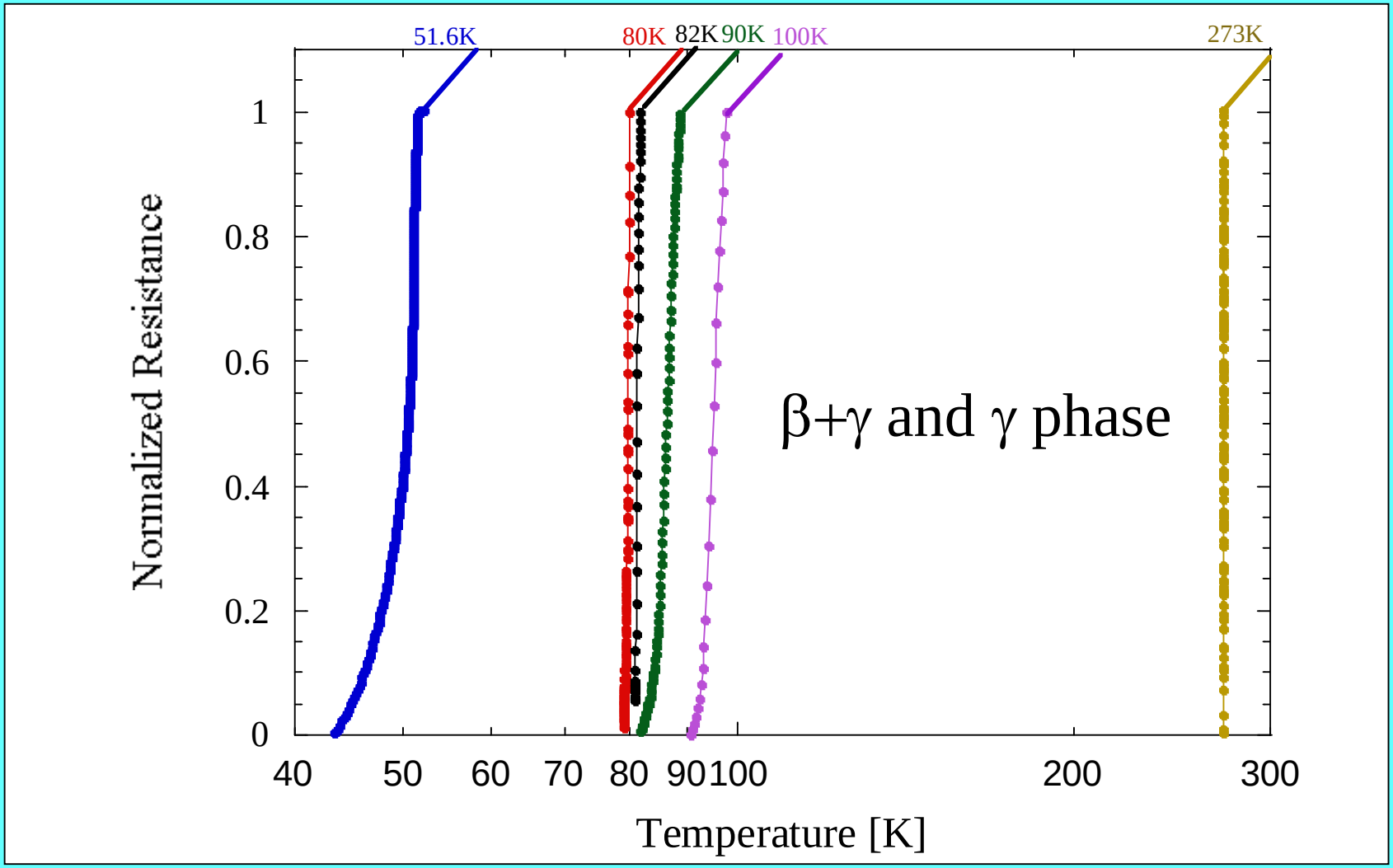

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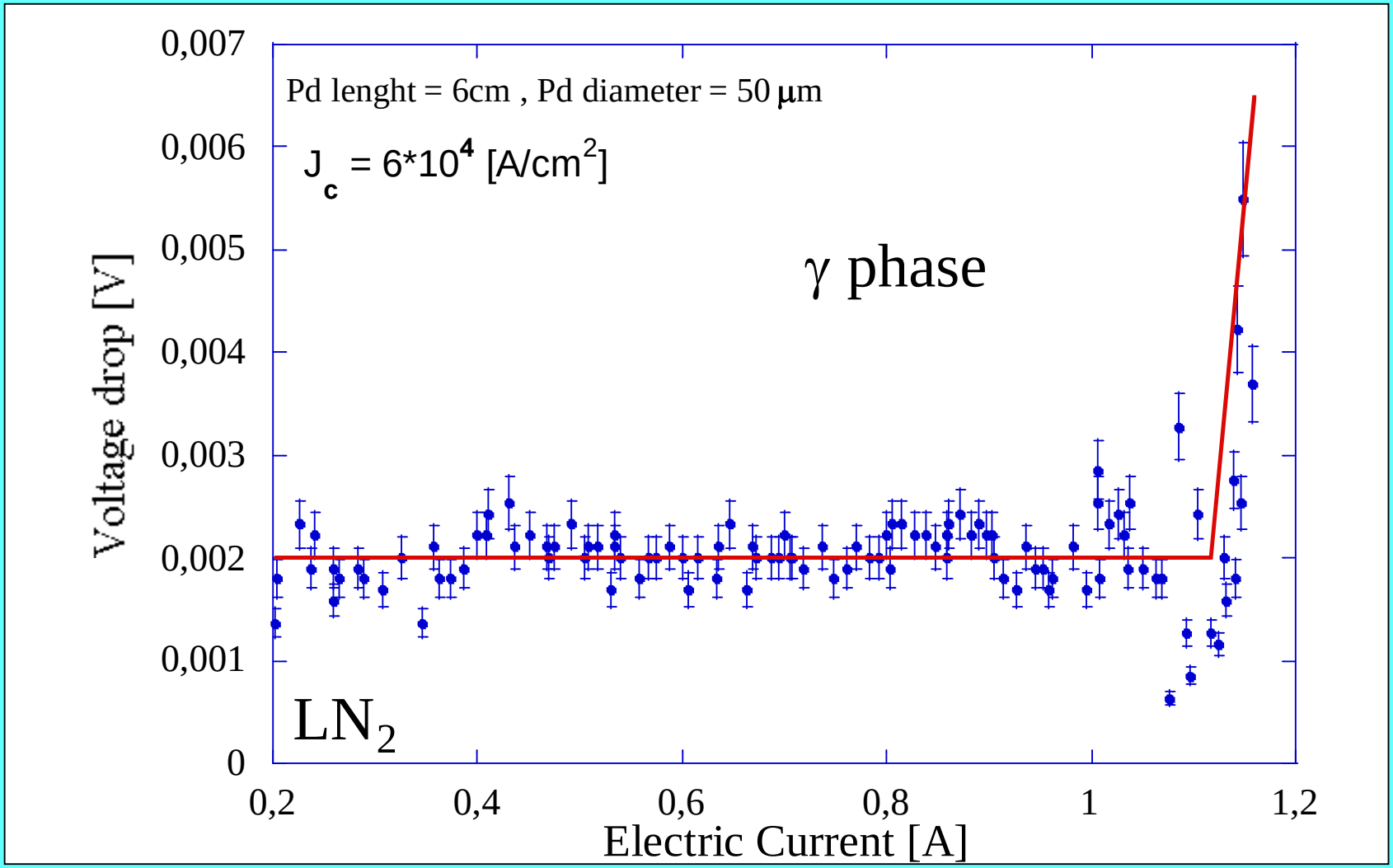

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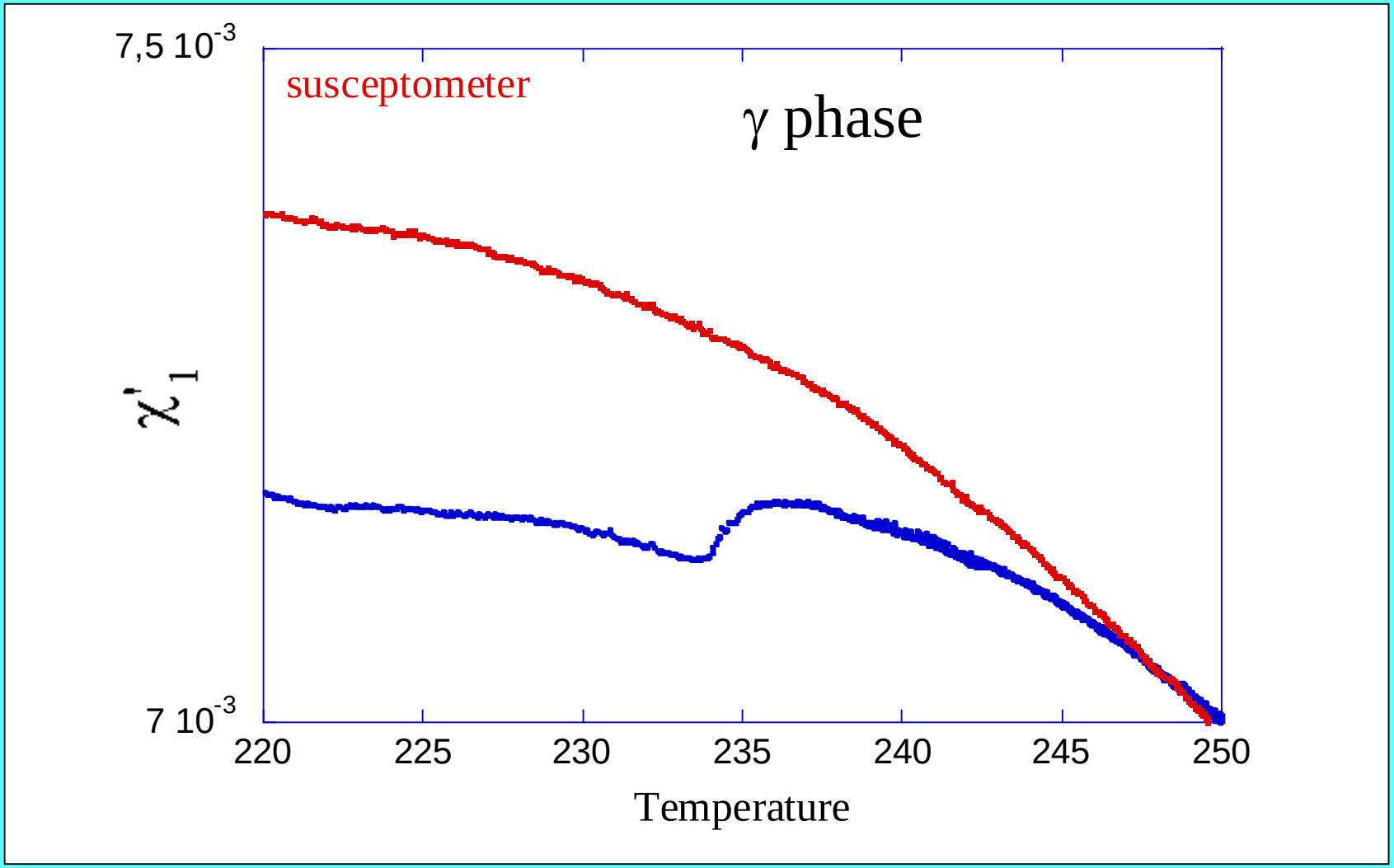

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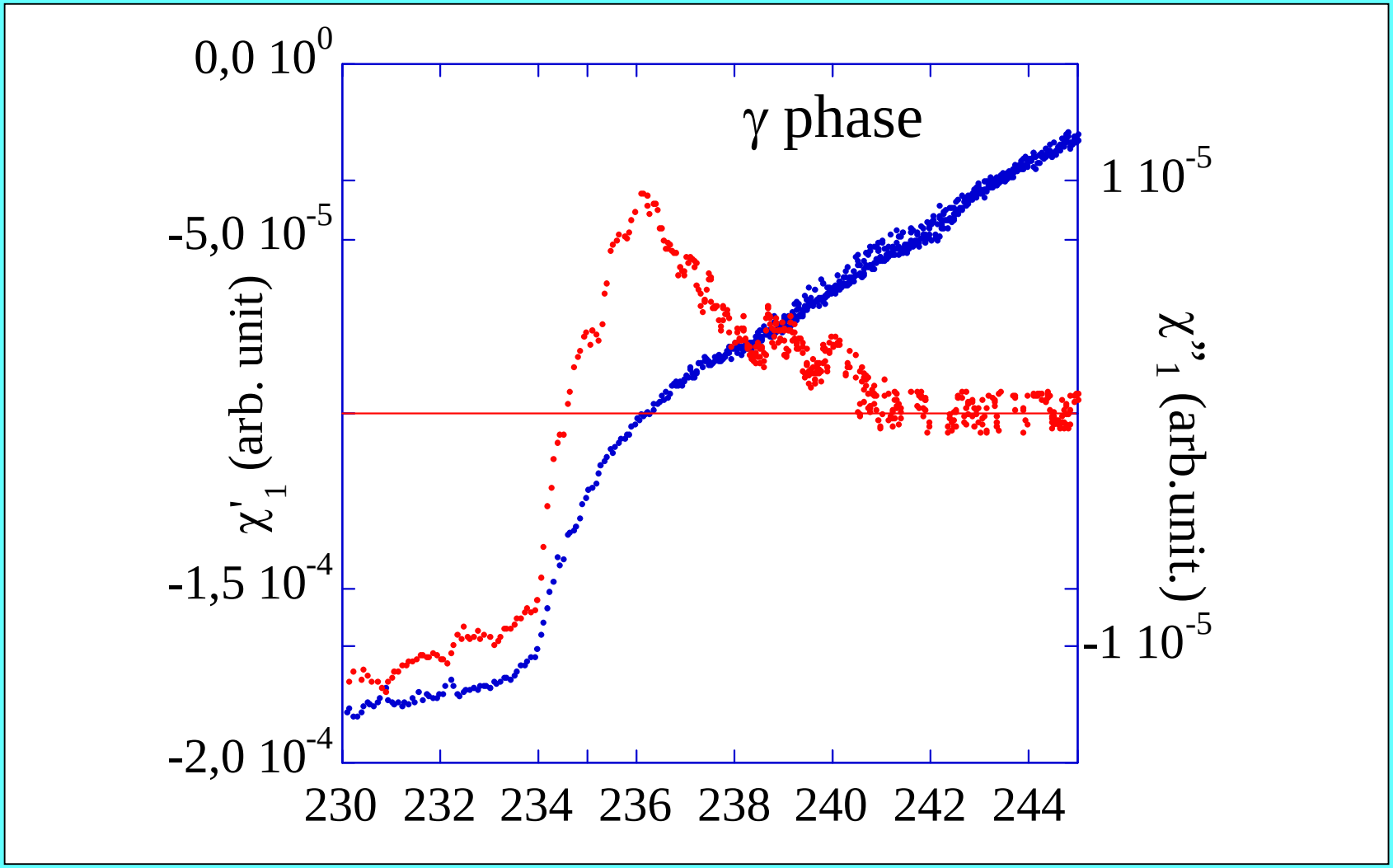

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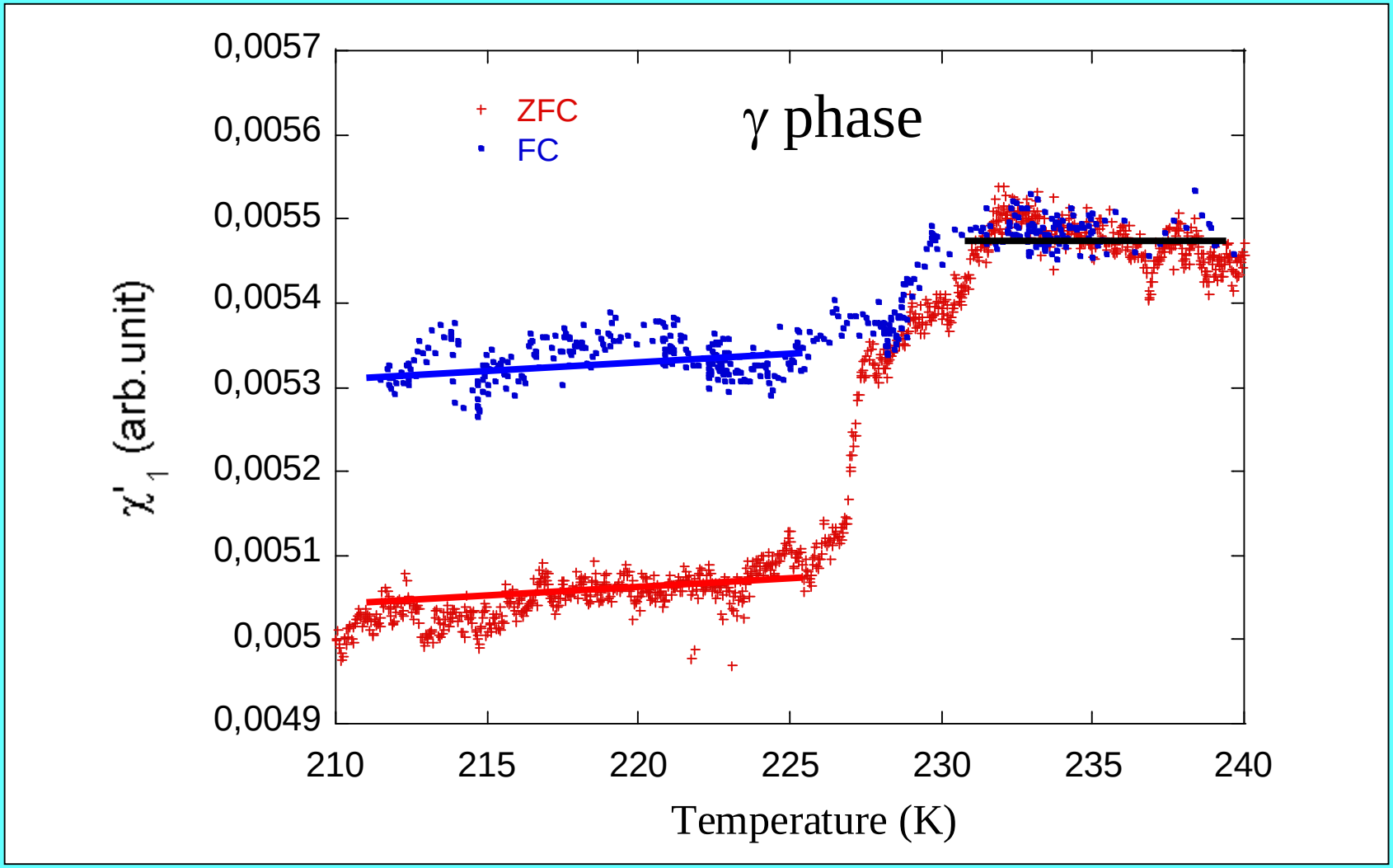

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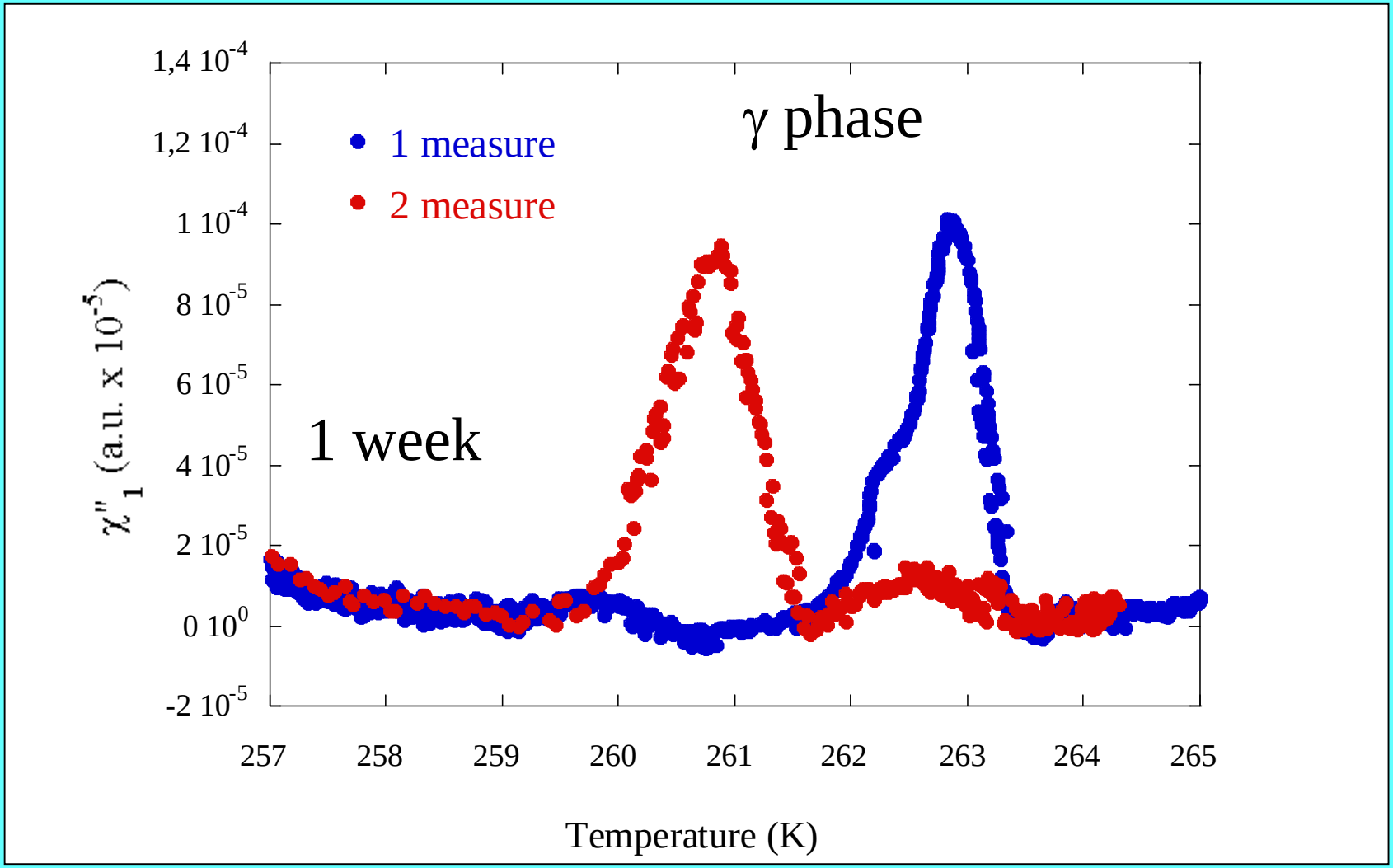

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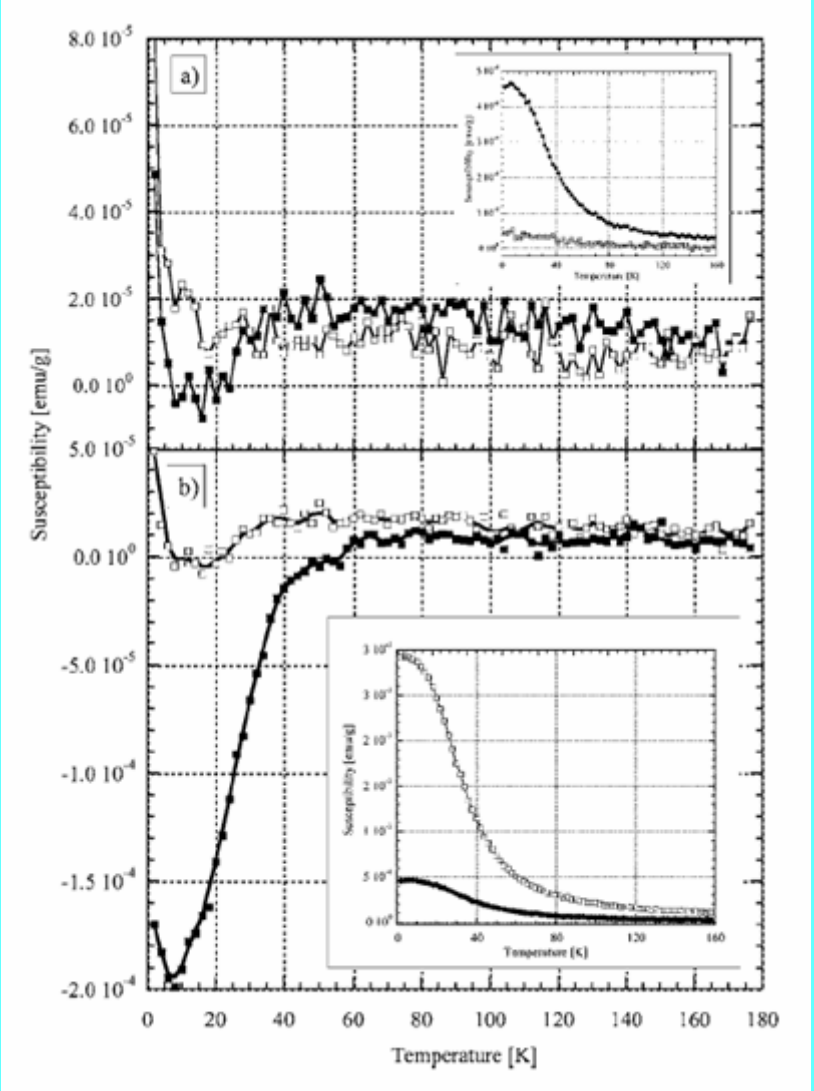
2005

A.Lipson, B.J.Heuser, C.Castano, G.Miley, B.Lyakhov, A.Mitin

$T_c \sim 60K$

PHYSICAL REVIEW B **72**, 212507 (2005)



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2006

K. P. Sinha

Proposal of theory explaining our HTCS results in PdHx system

Nat. Acad. Sci. Lett. 29 (3-4): 125-129 (2006)

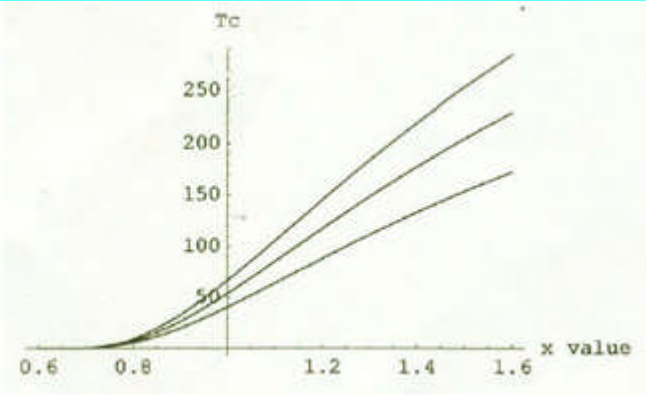

Fig. 1: T_c(in K) against x for three values of ω_l {500K, 700K, 900K}, ω_{ph} = 300K., λ_{ph} = 0.15, λ^*_l = 0.85.

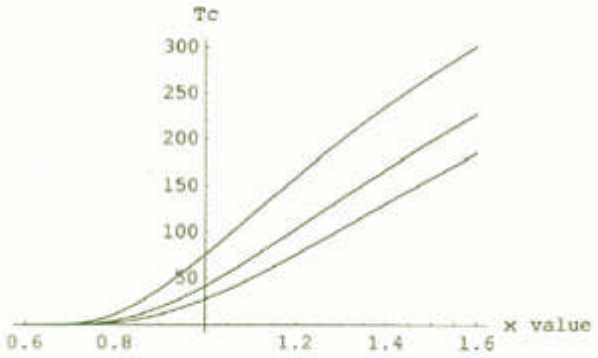

Fig. 2: T_c(in K) against x, For ω_{ph} = 300 K, ω_l = 900 K, λ_{ph} = 0.15, λ^*_l = {0.6, 0.7, 0.9}

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Superconductivity

Entropy $\longrightarrow$ 0

Excess of Enthalpy

Entropy $\longrightarrow$ ∞

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To obtain excess heat
in Cold Fusion
we suggest to consider a
stoichiometry window
and not a
stoichiometry threshold

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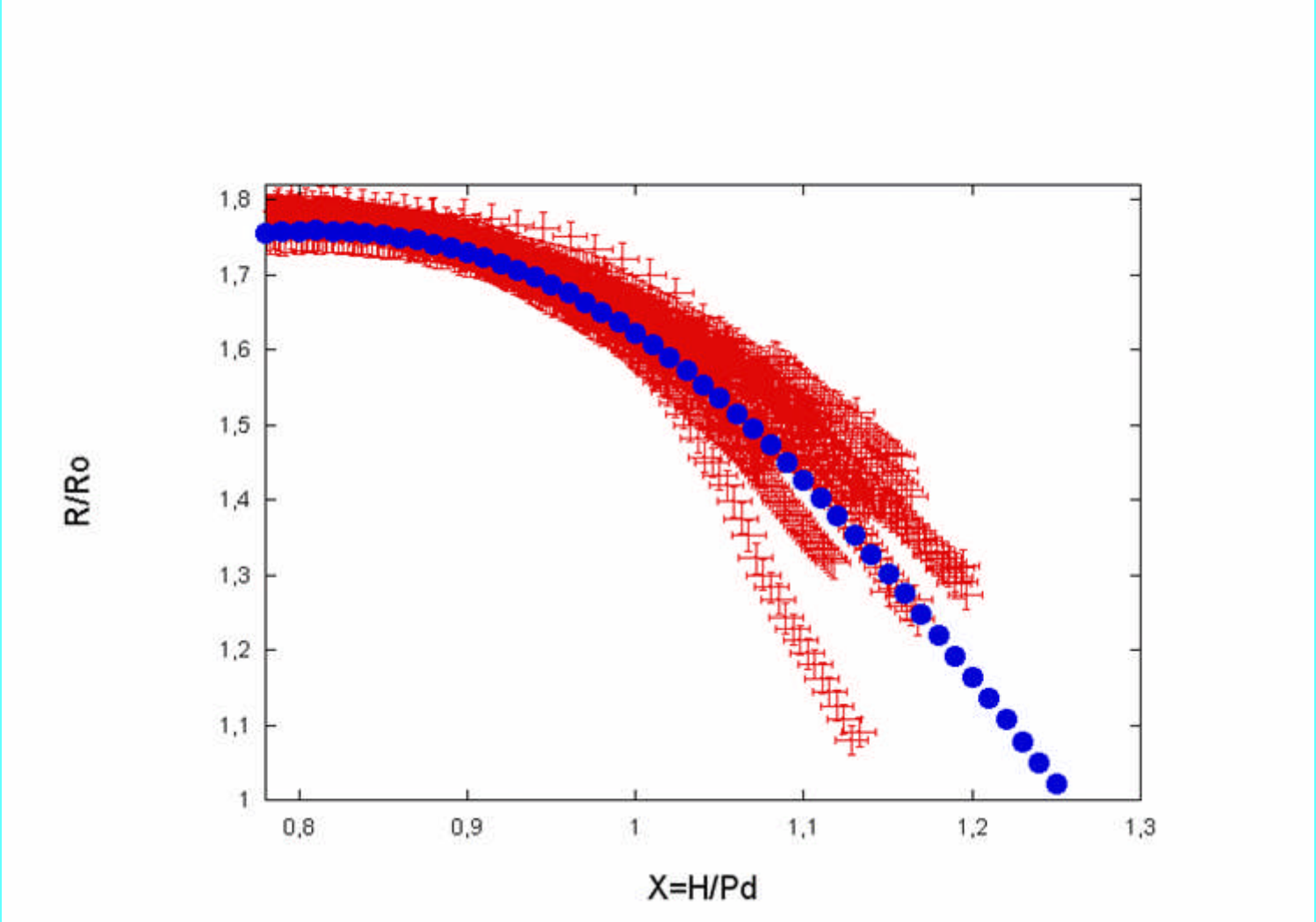

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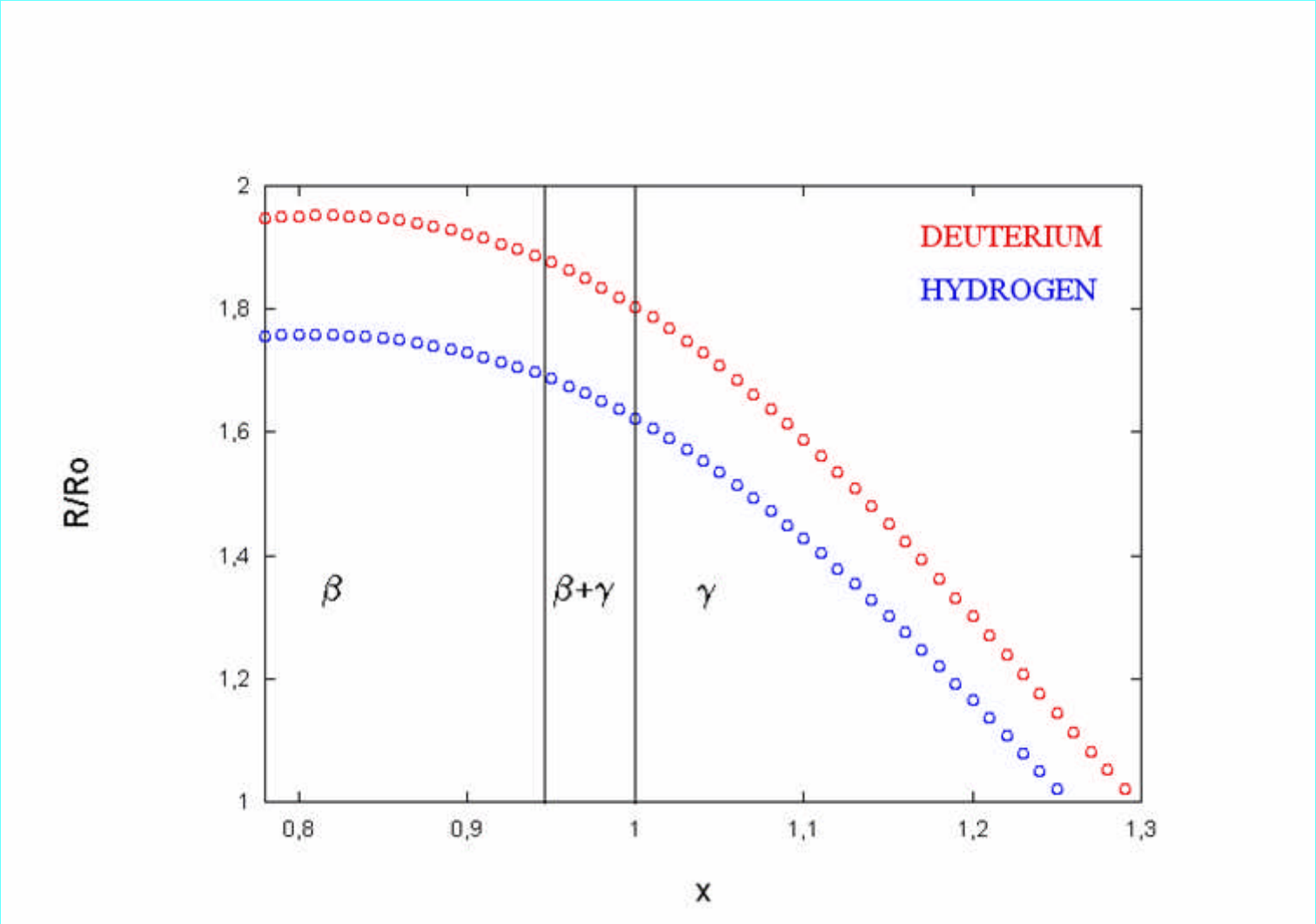

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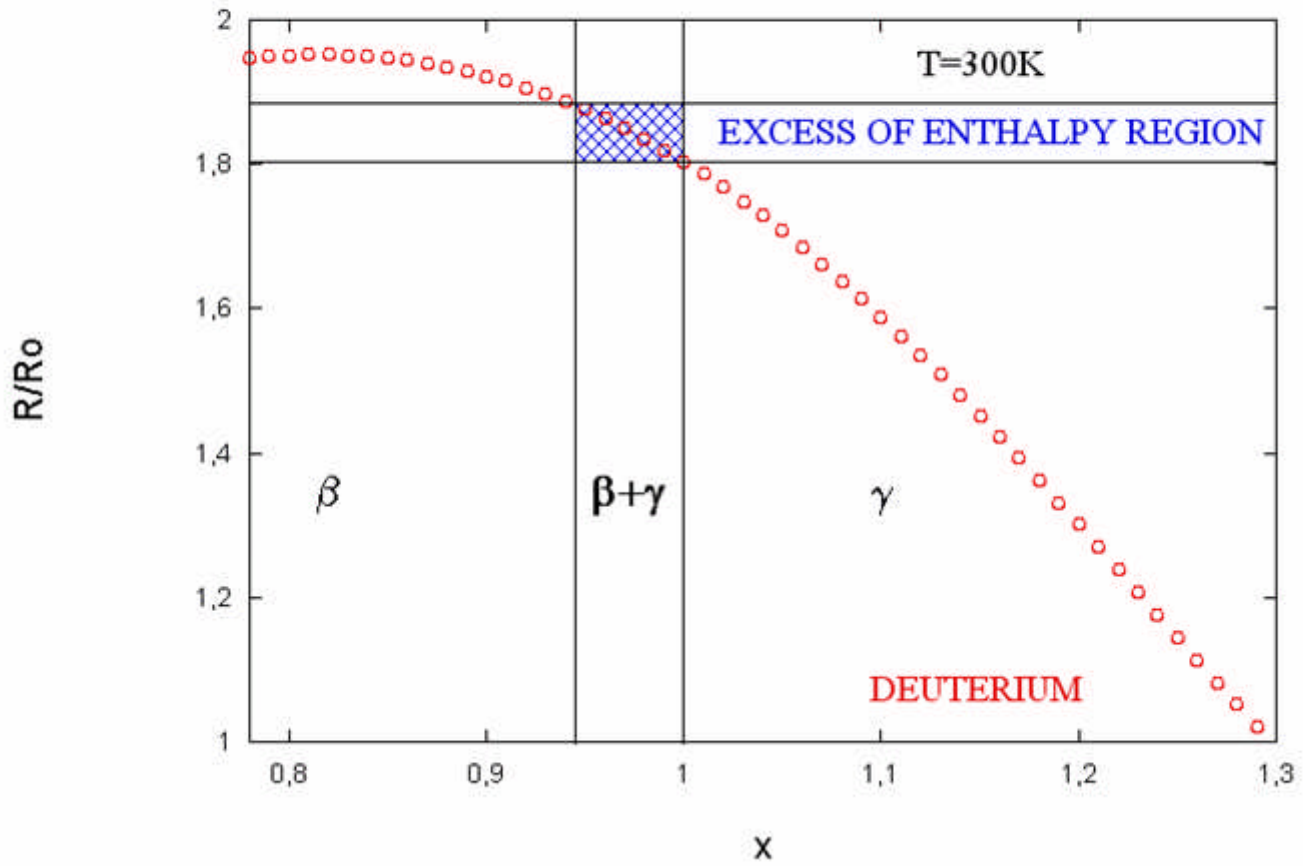

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Conclusion

To increase the reproducibility of excess enthalpy in PdD_x a stoichiometry window is proposed

To hold the stoichiometry x in the window, dynamic conditions are necessary:
deuterium fluxing , low dimensionality samples

To increase the stoichiometry window, high temperature are suggested:
GAS instead of ELECTROCHEMICAL experiments

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Phenomenological Model

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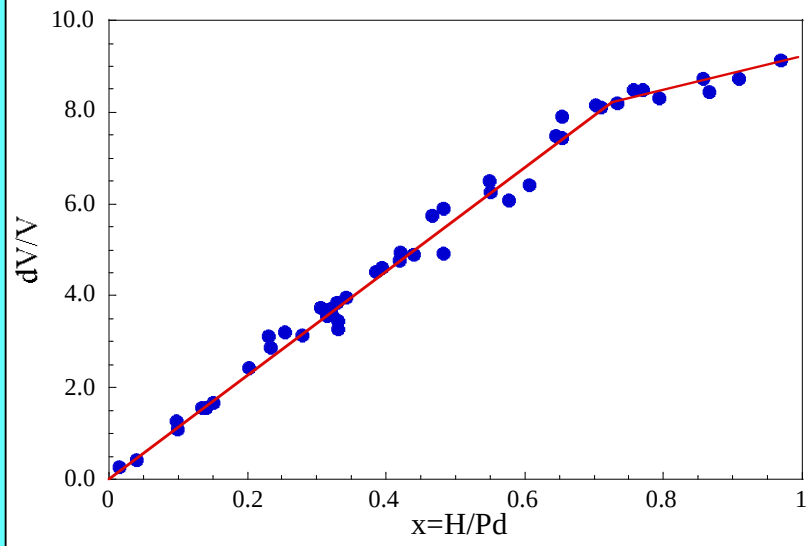

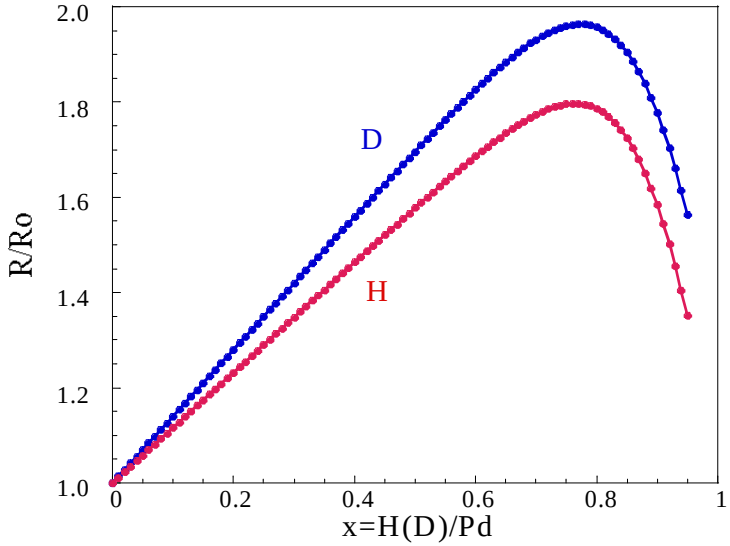

$$\left(\frac{R(x)}{R_o}\right)_l = 1 + \lambda \cdot x$$

$$\left(\frac{R(x)}{R_o}\right)_e = \beta e^{-\gamma(x-x_o)}$$

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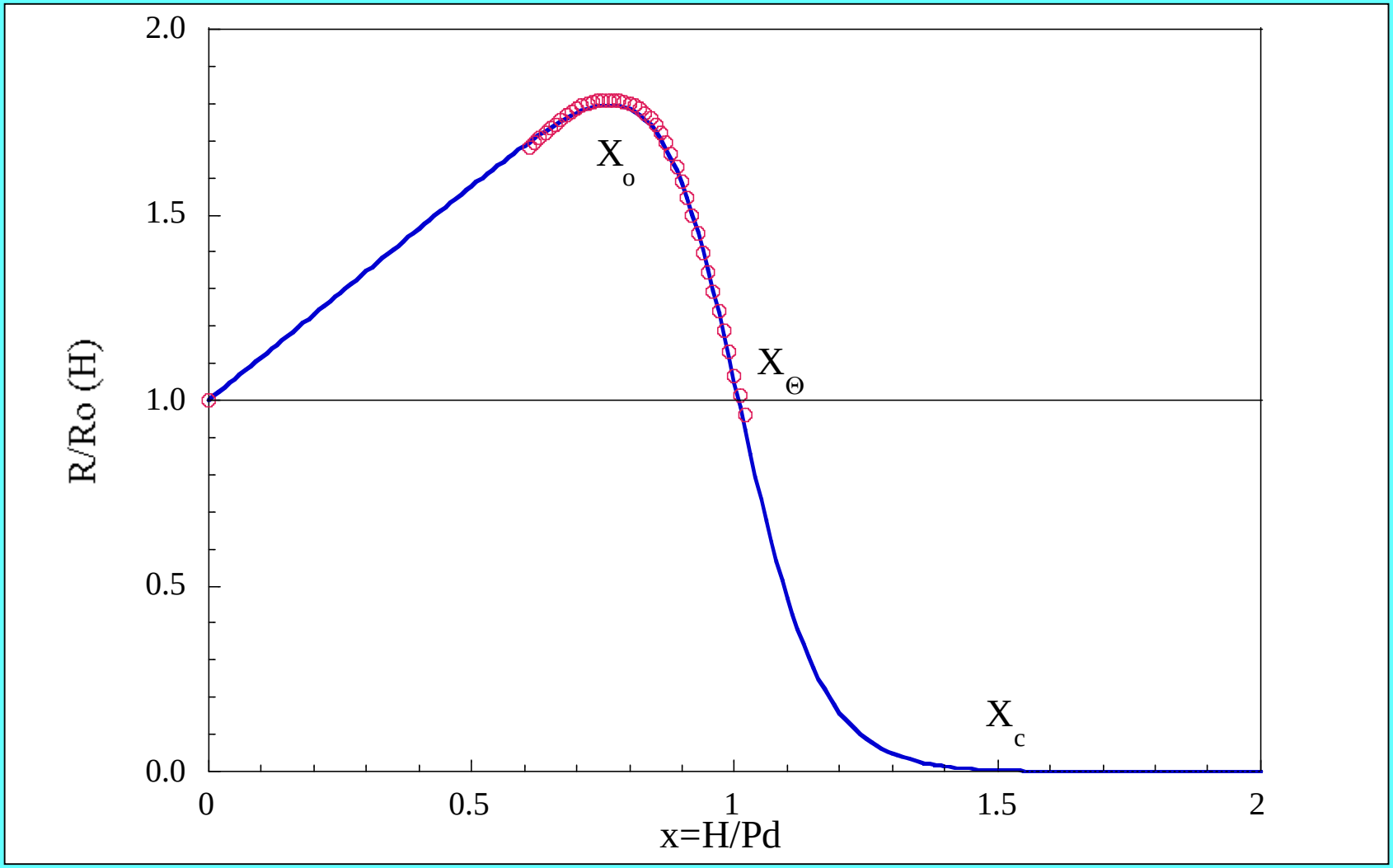

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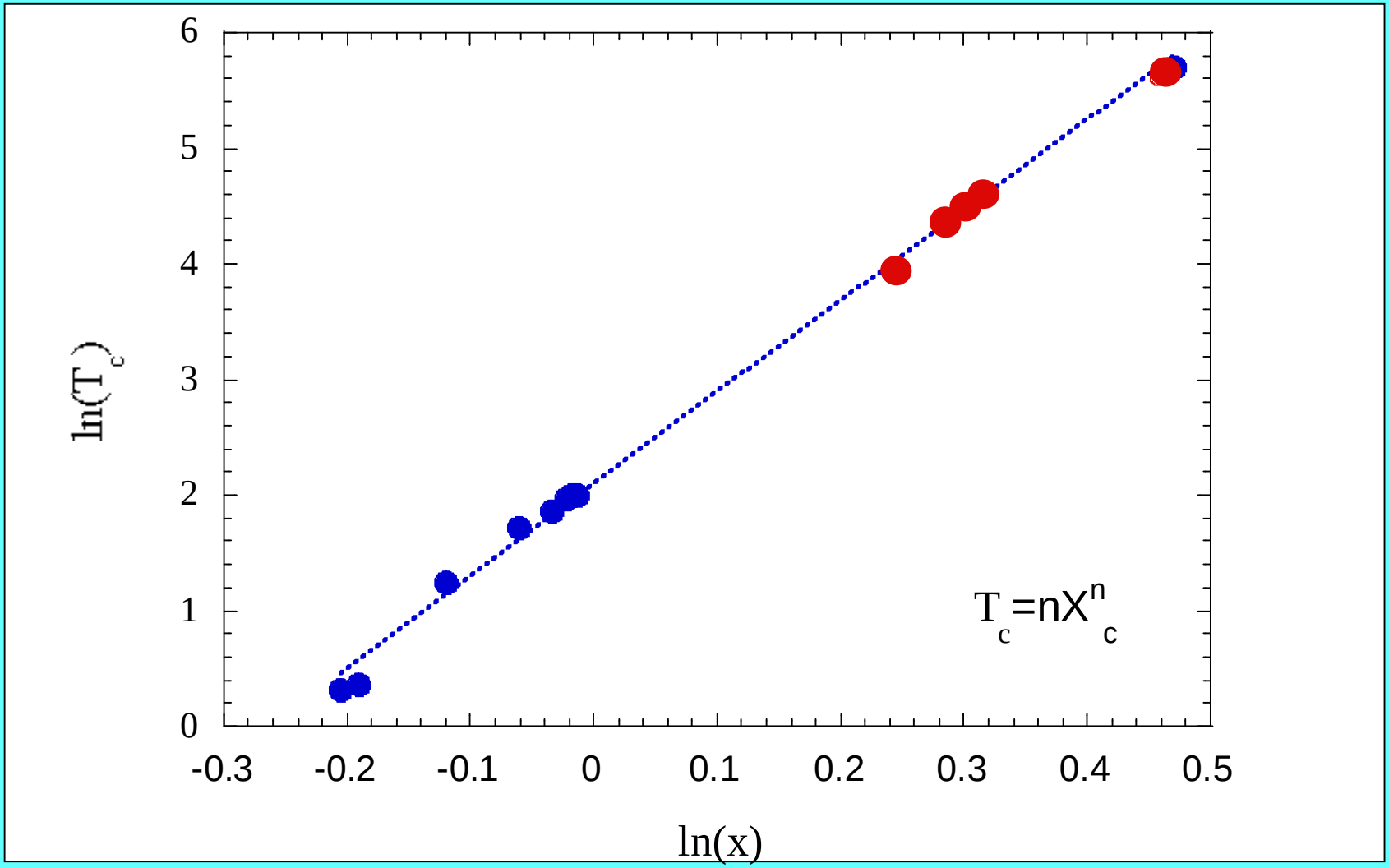

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