Room-temperature superconductivity - or not?

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[*] *presenting*
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2 March 2023

arXiv:2201.07686 (2022), Open Access, Open Data

Matter and Radiation at Extremes **7**, 048401 (2022), Open Access, Open Data

Int. J. Modern Phys. B 2375001 (2022), Open Access, Open Data

Slides of this presentation : https://dirkvandermarel.ch/science/slides2march/

Introduction

Published susceptibility and "raw" data

Diagnosis of the published susceptibility

Diagnosis of the "raw" data

Summary

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Introduction

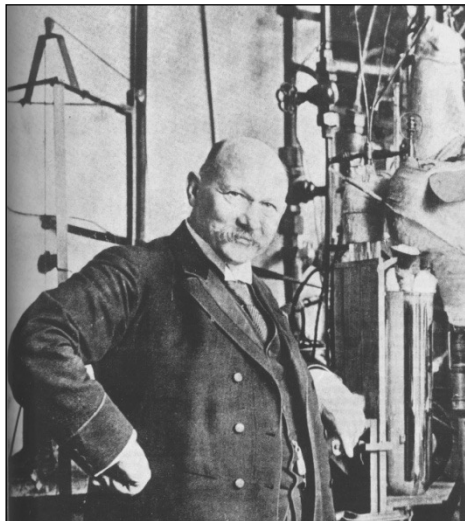
Resistivity

Susceptibility

Faraday's law

(1a) zero resistance => (1b) Perfect diamagnetism

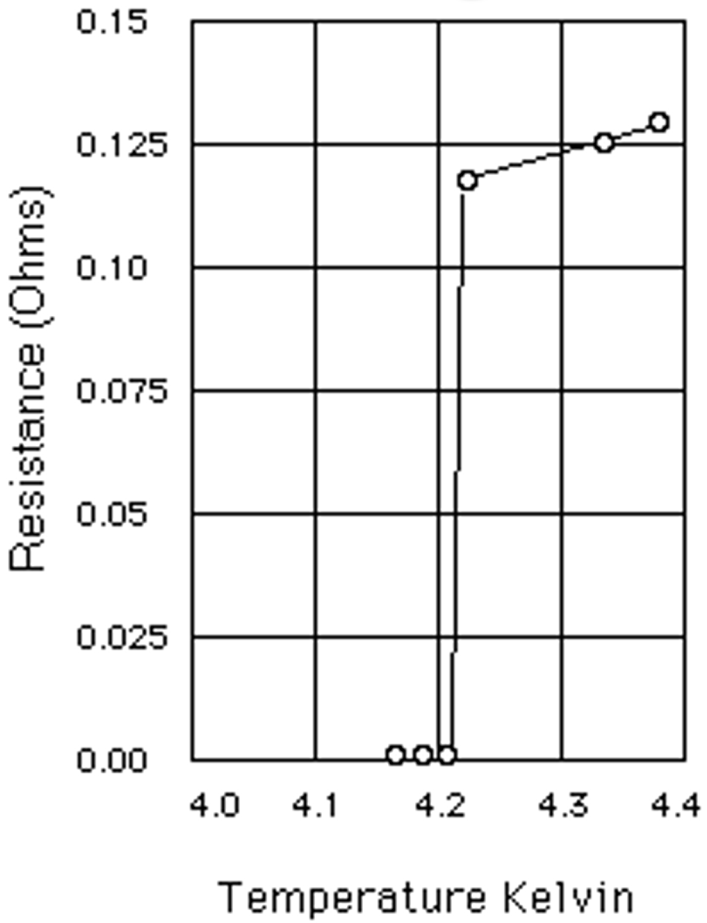
$V/I = 0$ $\chi = -1/4\pi$



H. Kamerling Onnes

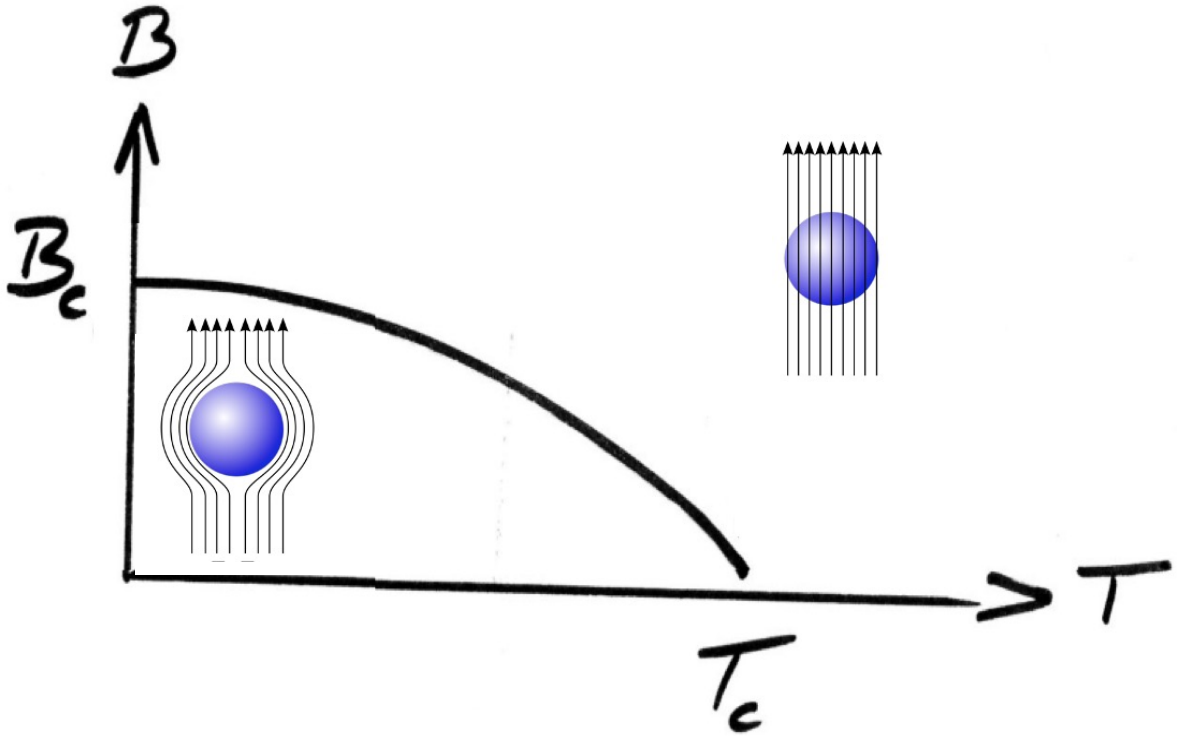
1911

Hg

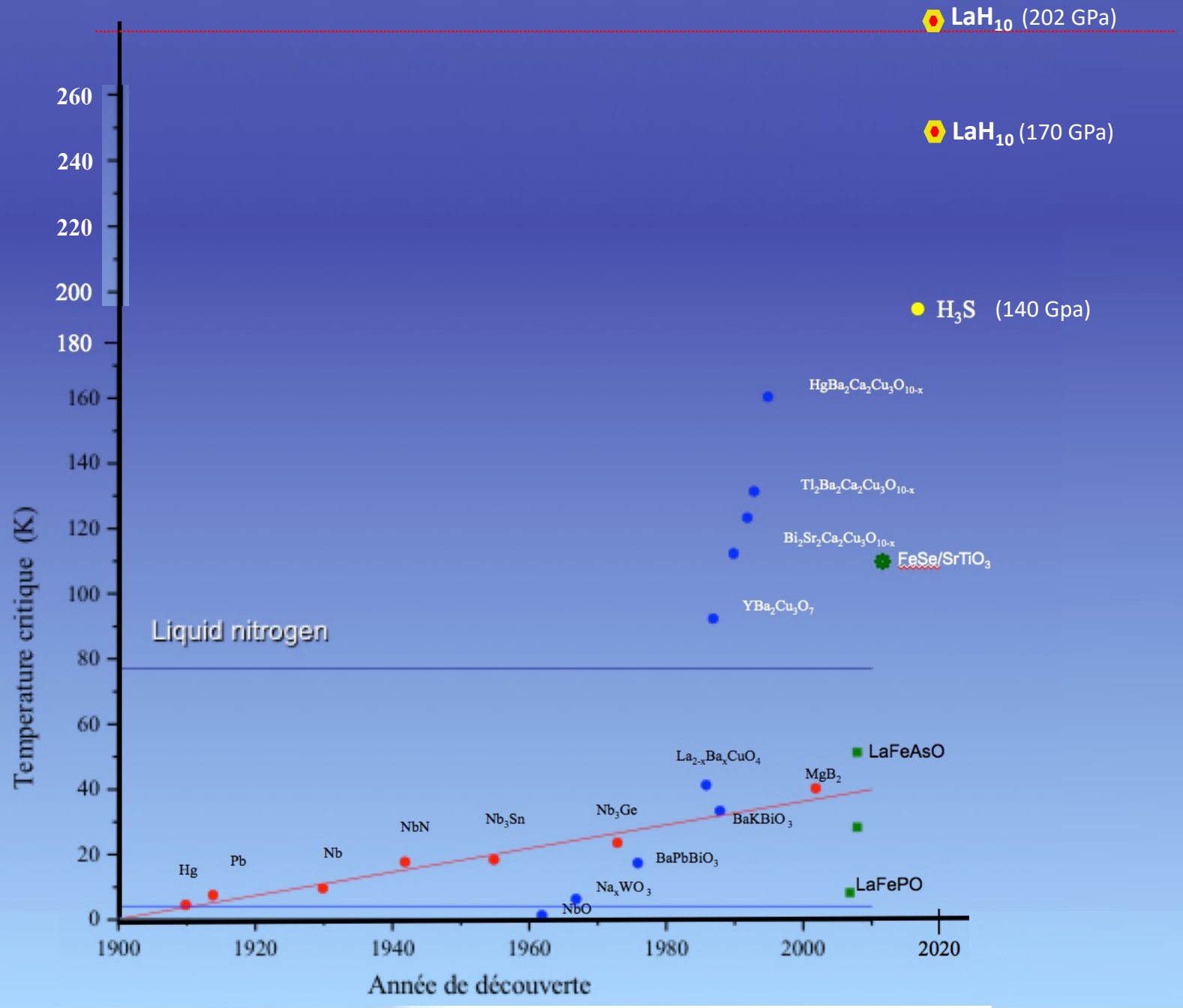


(2) Meisner effect

$B = 0$



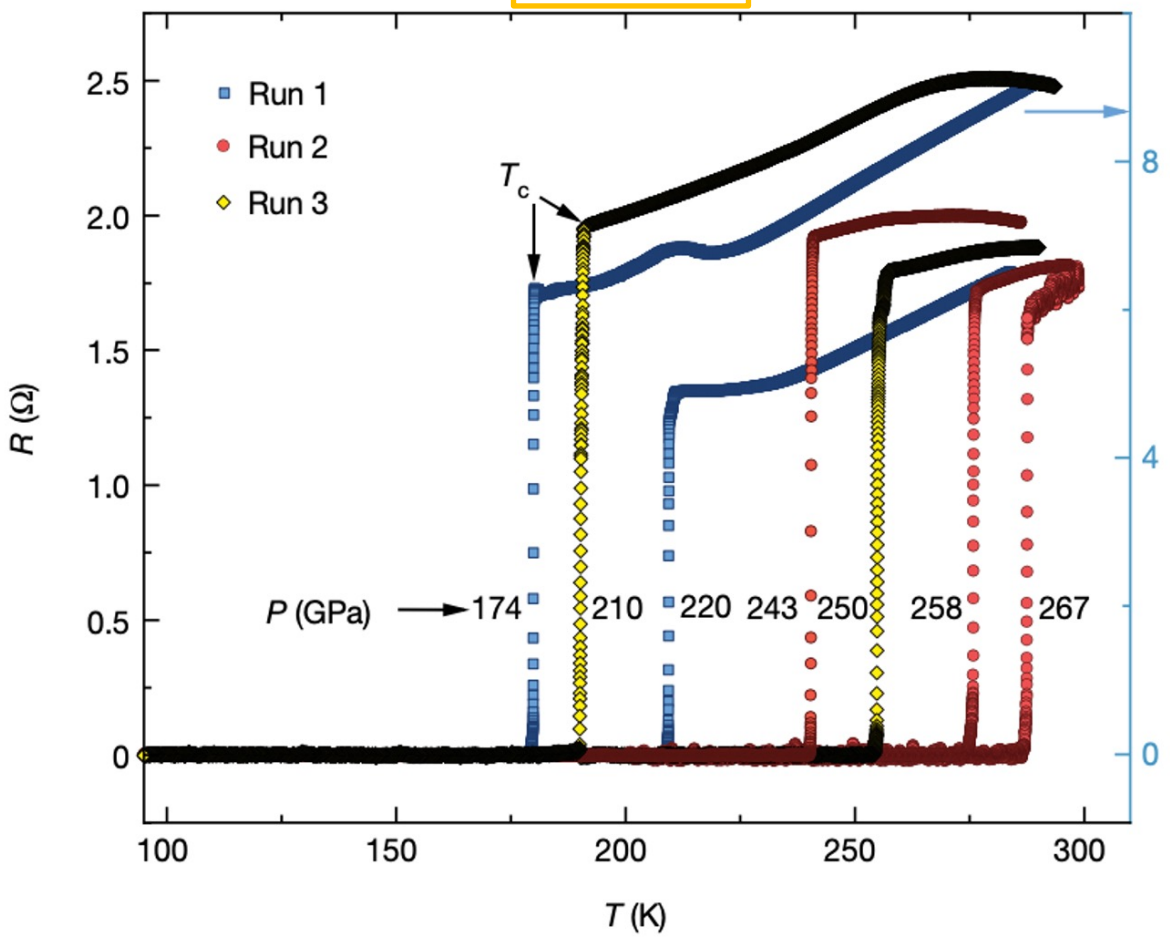
Toward superconductivity at room temperature



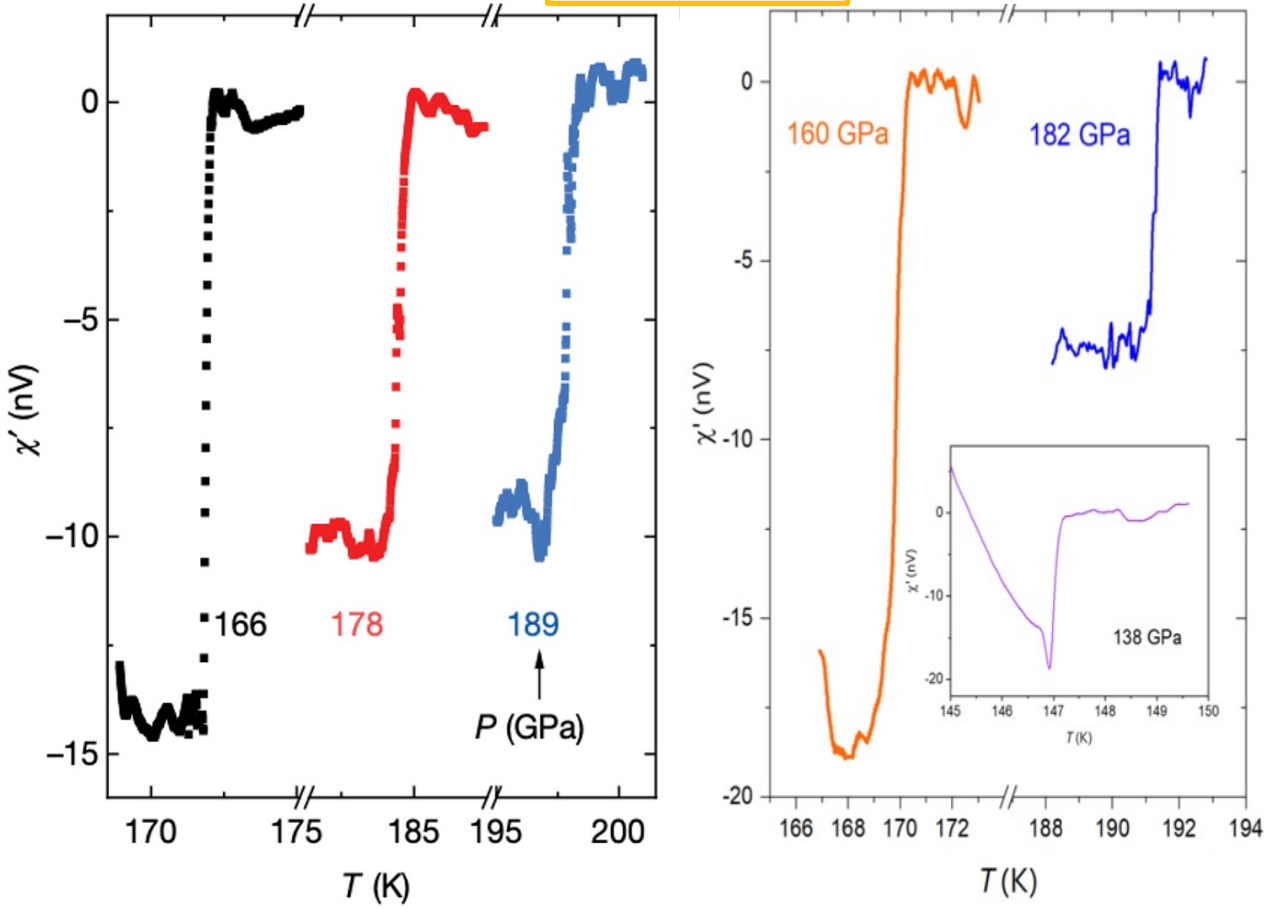
Introduction

14 october 2020: ***Room-temperature superconductivity in a carbonaceous sulfur hydride***, E. Snider, N. Dasenbrock-Gammon, R. McBride, M. Debessai, H. Vindana, K. Vencatasamy, K. V. Lawler, A. Salamat & R. P. Dias, *Nature* **586**, 373

Resistivity



Susceptibility



"The background signal, determined from a non-superconducting C–S–H sample at 108 GPa, has been subtracted from the data."

Published susceptibility and "raw" data

25 december 2021: R. P. Dias and A. Salamat (*arXiv*:**2111**.15017) provided tables of

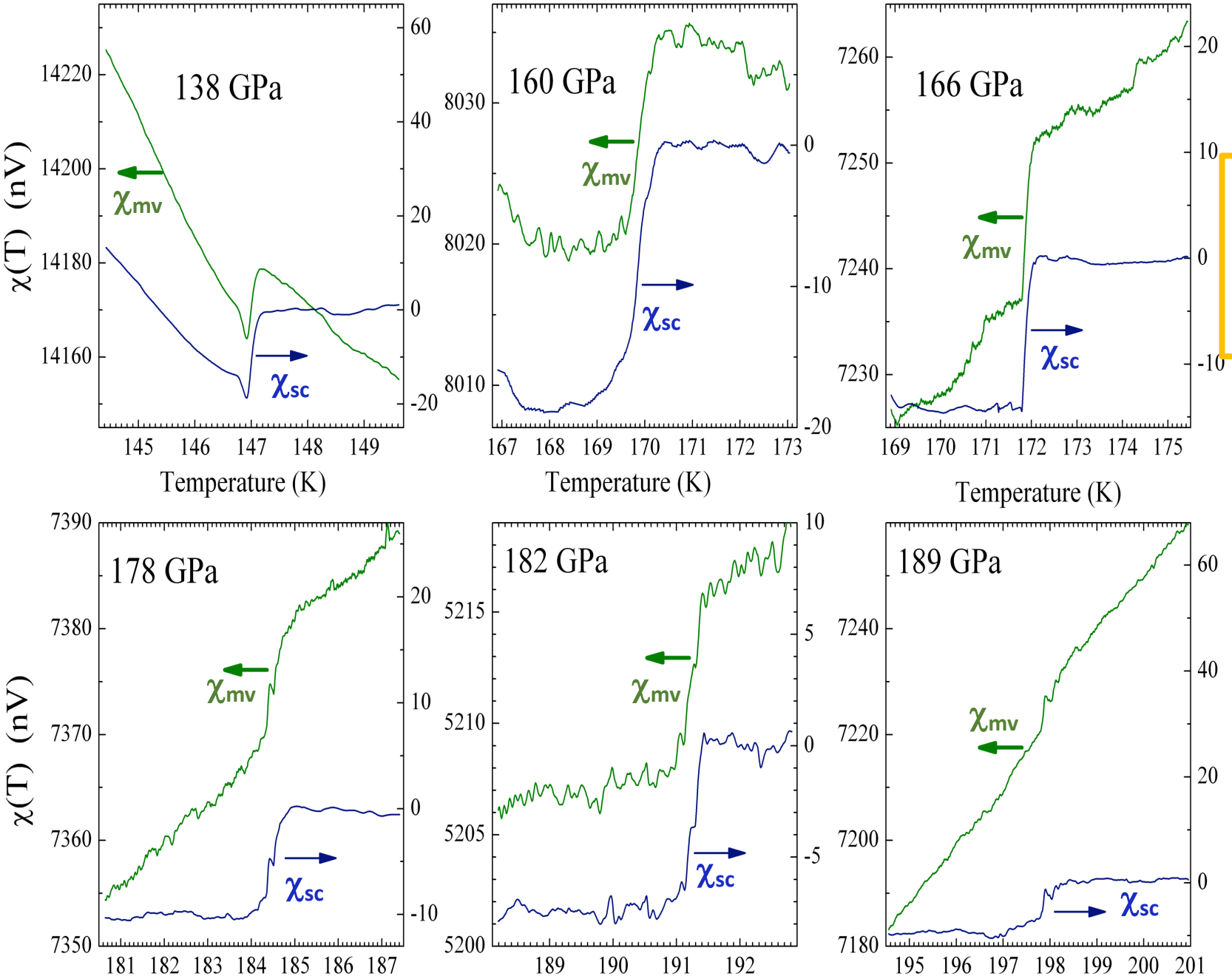
(i) "Measured" Voltage ("Raw" data) : $\chi_{mv}(T)$

(ii) "Superconducting Signal" (background-corrected data) : $\chi_{sc}(T) = \chi_{mv}(T) - \chi_{bg}(T)$

Not provided, but straightforward to calculate from $\chi_{mv}(T)$ and $\chi_{sc}(T)$:

(iii) Background susceptibility : $\chi_{bg}(T) = \chi_{mv}(T) - \chi_{sc}(T)$

Published susceptibility and "raw" data



JE Hirsch, *Preprints* , 202112.0115 (2021)

The noise conundrum

$\chi_{sc} = \chi_{mv} - \chi_{bg}$

χ_{mv} and χ_{bg} **are supposedly independent**

=> $noise_{sc} \geq noise_{mv}$

The data indicate

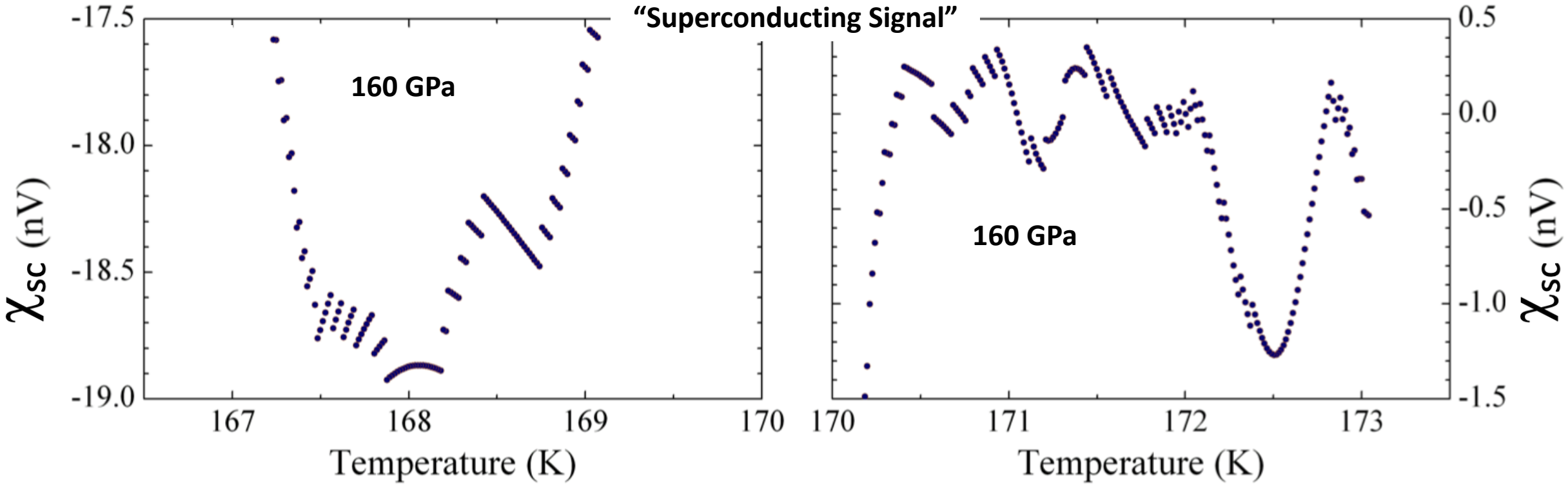
$noise_{sc} < noise_{mv}$

Possible solution: Perhaps χ_{sc} has been smoothed ?

Objection: Smoothing is not compatible with sharp features in some of the χ_{sc} data, *e.g.* the jump at 171.8 K for 166 GPa

Diagnosis of the published susceptibility

Smoothing is also not compatible with this....



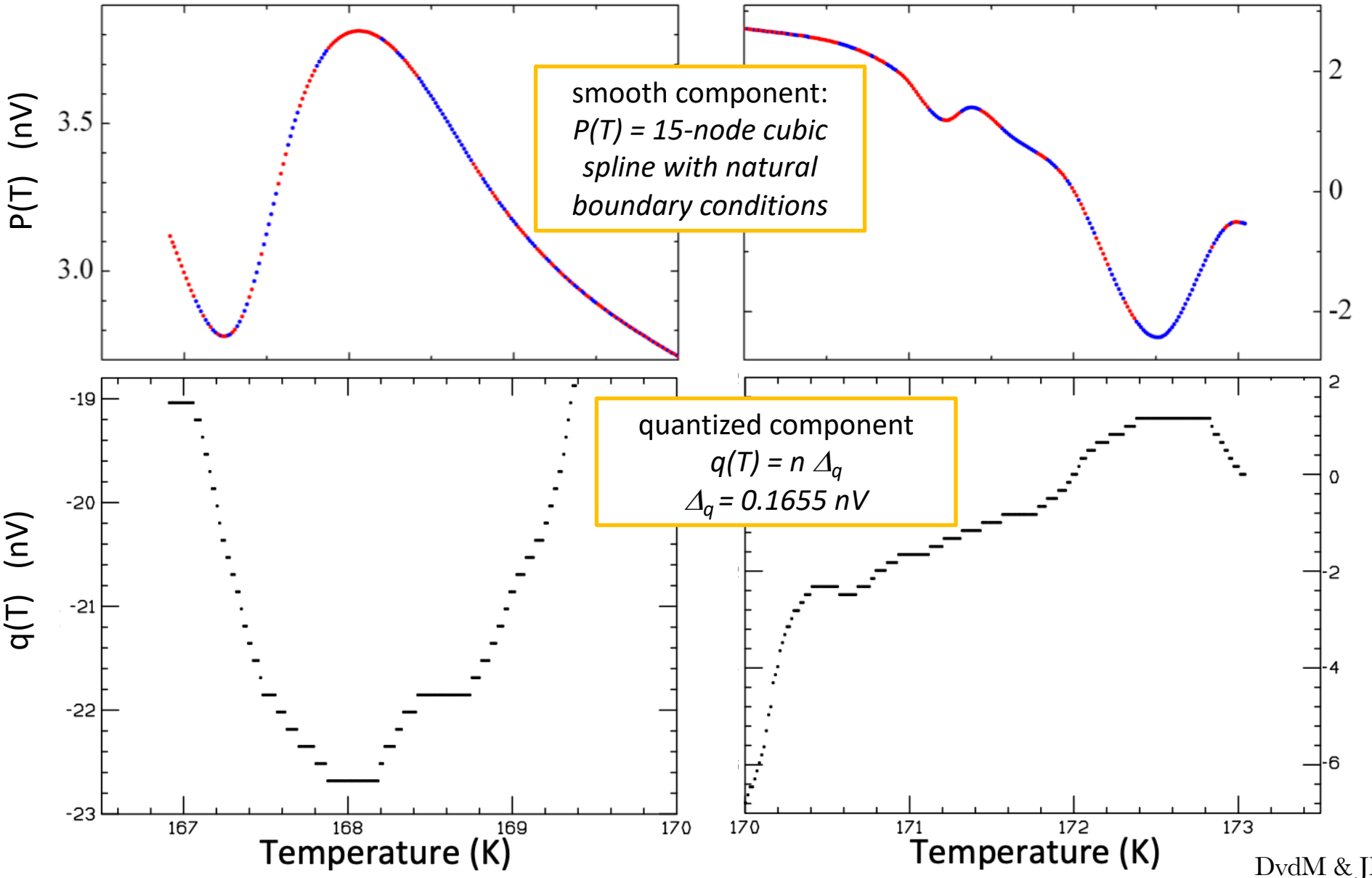
Replotted from table 5 in R. P. Dias and A. Salamat, *arXiv*:**2111**.15017v2 (2021)

DvdM & JE Hirsch, arXiv:2201.07686v1 (2022)
ibid., IJMPB 2375001 (2022)

Diagnosis of the published susceptibility

"Superconducting Signal" at 160 GPa

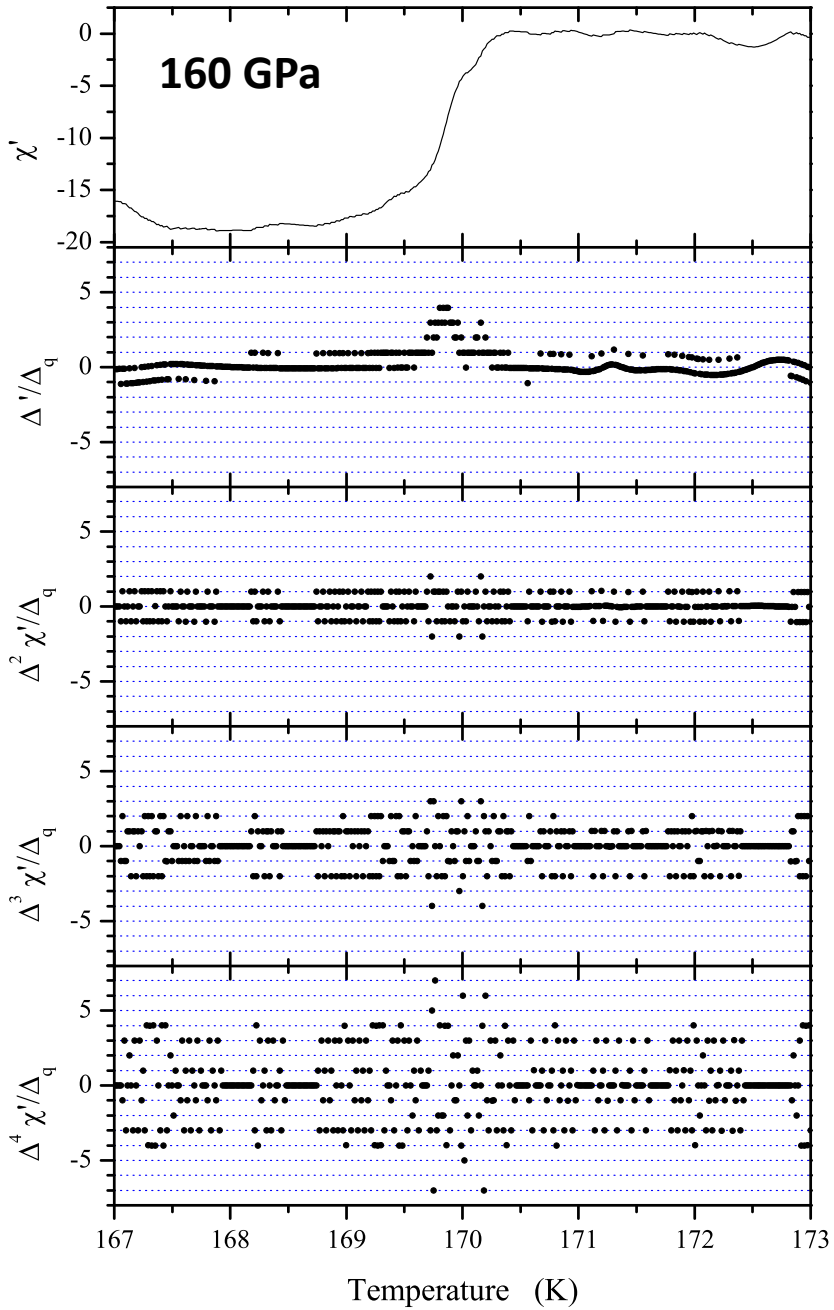
Superconducting Signal = quantized component + smooth component : $\chi_{sc}(T) = q(T) + P(T)$



DvdM & JE Hirsch IJMPB 2375001 (2022)

Diagnosis of the published susceptibility

$$\Delta^n \chi'_\alpha(j) = \Delta^{n-1}\chi'_\alpha(j) - \Delta^{n-1}\chi'_\alpha(j-1)$$



DvdM & JE Hirsch IJMPB 2375001 (2022)

Diagnosis of the "raw" data

138 GPa

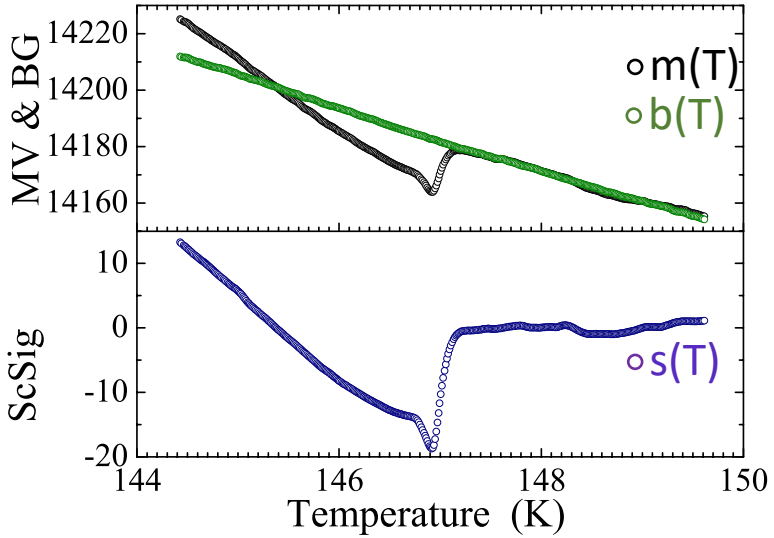
1^{t} and 4th discrete derivatives

auto-correlations cross-correlations

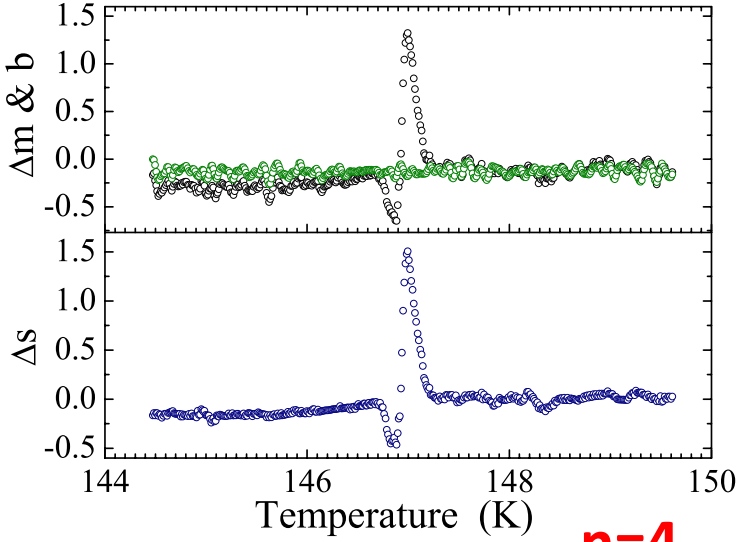
$$\Delta^n \chi'_\alpha(j) = \Delta^{n-1}\chi'_\alpha(j) - \Delta^{n-1}\chi'_\alpha(j-1)$$

$$g^{(n)}_{\alpha;\beta}(j) = \sum_{k}^{N-1} \Delta^n \chi'_\alpha(k)\Delta^n \chi'_\beta(j+k)$$

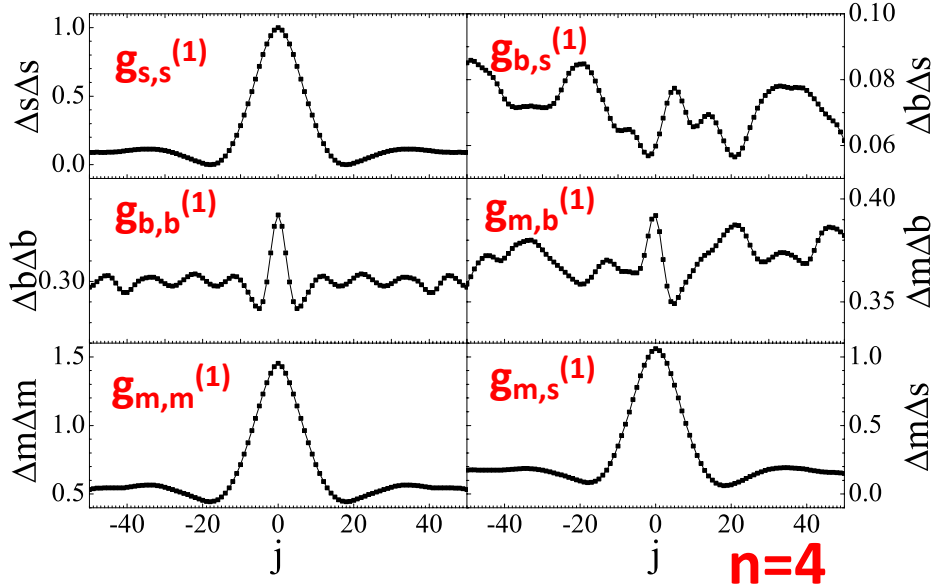
n=0



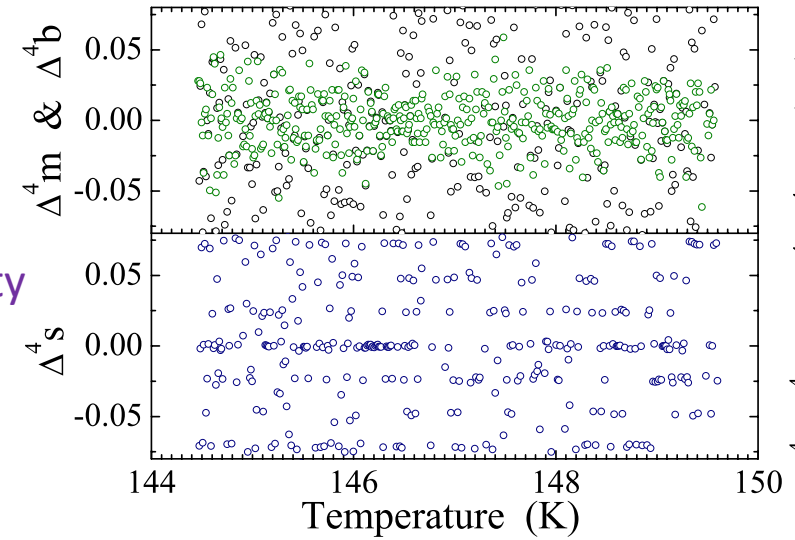
n=1



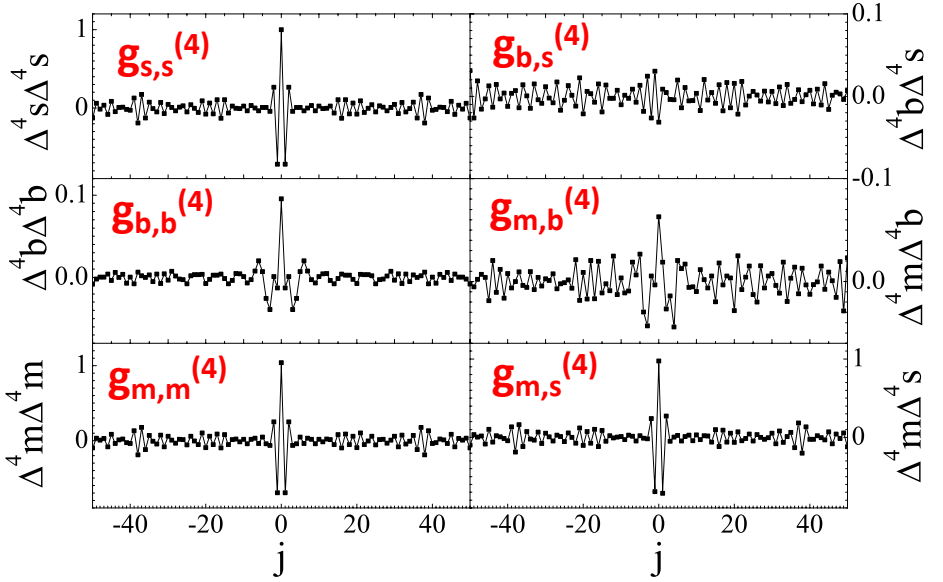
n=1



n=4



n=4



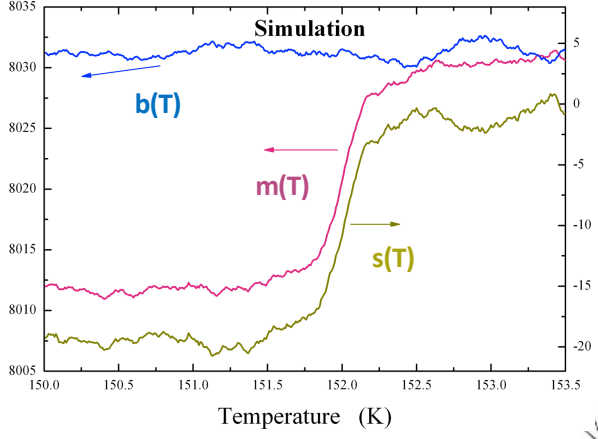
m(T): "raw" susceptibility

b(T): background susceptibility

s(T): background-corrected susceptibility

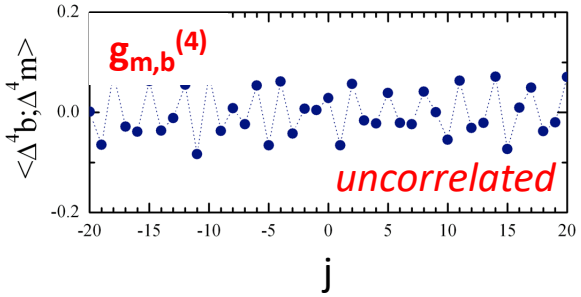
DvdM & JE Hirsch IJMPB 2375001 (2022)

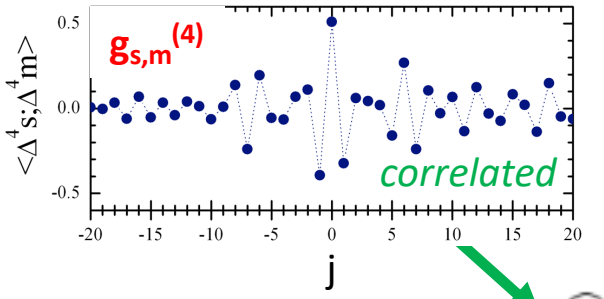
Correlation between
simulated raw data = m(T)
simulated background = b(T)
BG-corrected data = s(T)

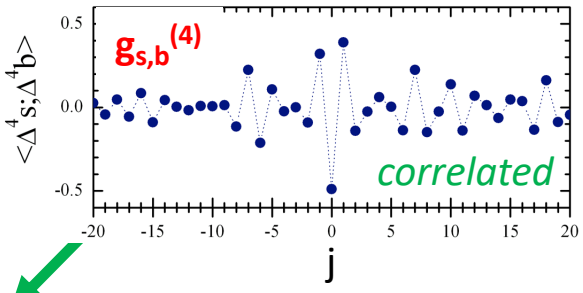


m(T)

b(T)



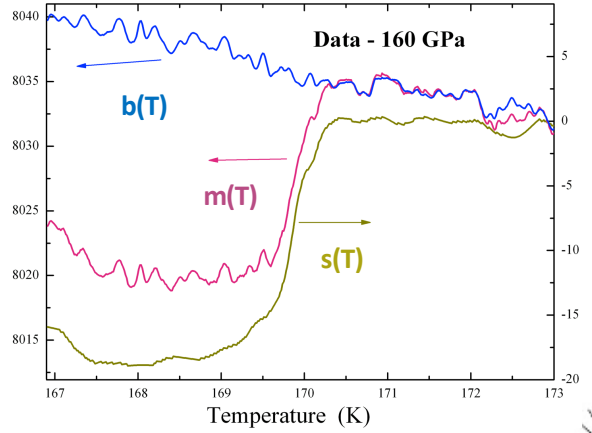




s(T)

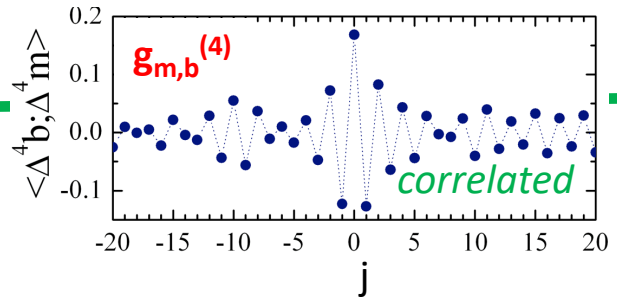
s(T) = m(T) – b(T)

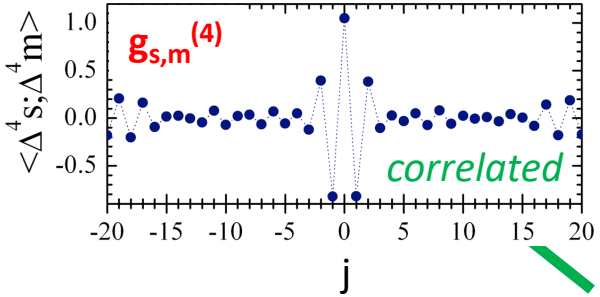
Correlation between
"raw" data = m(T)
background data = b(T)
BG-corrected data = s(T)
reported in
Nature 586, 373 (2020)
arXiv:2111.15017 (2021)

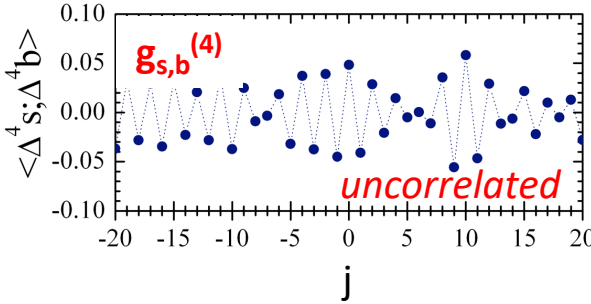


m(T)

b(T)







s(T)

m(T) = s(T) + b(T)

Summary

1. The susceptibility data published in *Nature* **586**, 373 (2020) are noise-free and have a sawtooth profile

2. The method by which the susceptibility data were corrected for a background signal is not correctly described in *Nature* **586**, 373 (2020). One and half year later two of the authors provided a different description in *arXiv*:**2201**.11883 (28.1.2022), which

(i) is insufficiently documented

(ii) does not explain the pathological features of the published "superconducting signal"

3. The protocol that has been used to generate the "raw" data ("measured" voltage) is, for all 6 reported pressures:

"raw" data = published "superconducting signal" (noise-free) + featureless curve (noise-full)

Consequences

- Physics is about phenomena that can be reproduced under identical conditions.

- To make this possible, it is of crucial importance that scientific publications provide an accurate description of the methods of data acquisition and analysis, and of the data themselves.

- The incomplete and contradictory information provided in *Nature* **586**, 373 (14.10.2020), *arXiv*:**2111**.15017 (25.12.2021) and *arXiv*:**2201**.11883 (28.1.2022) inhibits reproduction and/or verification by other researchers of the claimed room temperature superconductivity in CSH.

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