Disconnect between published ac magnetic susceptibility of a room temperature superconductor and measured raw data

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In ref. [1], we pointed out that certain anomalies observed in the published data for ac magnetic susceptibility of a room temperature superconductor reported in Nature 586, 373 (2020) [2] would be cleared up once the measured raw data were made available. Part of the measured raw data were recently posted in arXiv:2111.15017 [3]. Here we report the results of our analysis of these raw data and our conclusion that they are incompatible with the published data. Implications of these results to the claim that the material is a room temperature superconductor are discussed.

I. INTRODUCTION

On October 14, 2020, Snider et al reported the discovery of the first room temperature superconductor, carbonaceous sulfur hydride, hereafter called CSH [2]. If this is true, it represents a major scientific breakthrough. "A superior test of superconductivity" [2] demonstrating superconductivity was claimed to be the detection of sharp drops in the ac magnetic susceptibility. Figure 1 shows the results published in that paper in Figs. 2a and Extended Data Fig. 7d giving susceptibility versus temperature for 5 different pressures.

The curves shown in Fig. 1 were obtained from the subtraction of two independent measurements, namely "raw data" and "background signal", according to the equation

$$data = raw\ data - background\ signal. \quad (1)$$

According to the caption of Fig. 2a of [2], "*The background signal, determined from a non-superconducting C-S-H sample at 108 GPa, has been subtracted from the data*". Neither of these independent measurements were given in the paper nor in the supplemental material for the 5 pressures shown in Fig. 1.

In addition, the inset of Extended Data Fig. 7d, shown in the inset in the right panel of Fig. 1, reportedly presented "raw data" for still another value of the pressure, 138 GPa, according to the caption of the figure [2].

For more than one year, starting on November 12, 2020, we have attempted to obtain the raw data and background signal that were used to obtain the measurements shown in Fig. 1 from the corresponding author and coauthors. Details of this saga are described in ref. [1]. Finally, on December 1, 2021, part of those data, namely the measured raw data for the three curves shown on the left panel of Fig. 1, as well as for the inset on the right panel of Fig. 1, were made public in ref. [3] by two of the authors of ref. [2]. Neither the background signal data for the 5 curves shown in Fig. 1, nor the raw data for the two curves shown on the right panel of Fig. 1, that we also requested more than a year ago, have been made available yet.

Nevertheless, given the raw data and the data, we can

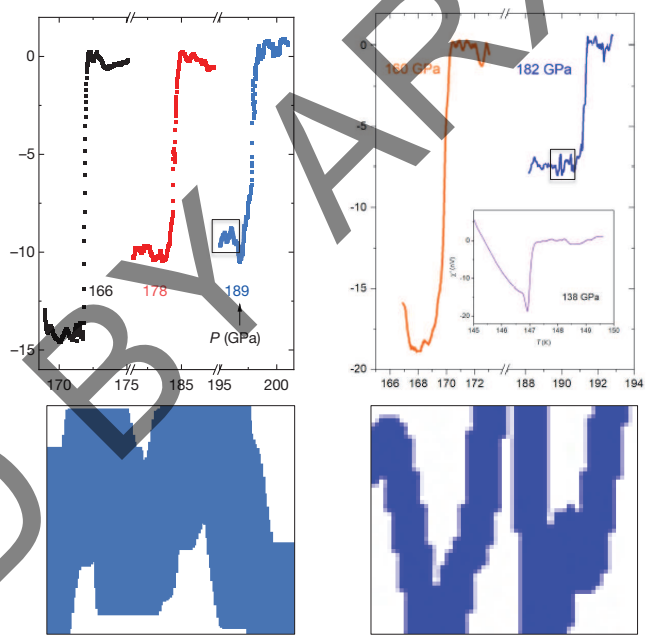

FIG. 1: The top right and left panel show curves for ac magnetic susceptibility of CSH at five different pressure values reported in ref. [2] Figs. 2a and Extended Data Fig. 7d respectively. The inset in the right panel shows raw data reported in ref. [2] for another pressure value. The lower left and right panels show enlarged versions of the upper panels, enclosed by small rectangles in the upper panels. They will be discussed later in the text.

extract the background signal from the relation

$$background\ signal = raw\ data - data. \quad (2)$$

Figure 2 shows what the raw signal data given in ref. [3] and the background signal resulting from Eq. (2) look like, without high resolution. The qualitative behavior is as expected: there are drops in the raw data superposed to an approximately linear background. By subtracting the background, the data on the left panel of Fig. 1 result, where the drops become much more noticeable.

In ref. [1] we suggested that various questions that we raised in that paper and in an earlier paper [4] about the validity of the magnetic susceptibility measurements reported in ref. [2] would find answers once the authors