Analysis of ac magnetic susceptibility data of a room temperature superconductor

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In Ref. [1] Snider *et al.* reported room temperature superconductivity in carbonaceous sulfur hydride (CSH) under high pressure. Recently the data for the temperature dependent ac magnetic susceptibility shown in figures of Ref. [1] have appeared in the form of tables corresponding to different pressures [2]. Here we provide an analysis of the data for a pressure of 160 GPa.

I. INTRODUCTION

In Ref. [1] it is reported that a material termed carbonaceous sulfur hydride (hereafter called CSH) is a room temperature superconductor. Data for resistance versus temperature and ac susceptibility versus temperature at six different pressures show drops suggesting superconducting transitions. Recently two of the authors of Ref. [1] have posted the numerical values of the data for the ac susceptibility curves (hereafter $\chi'(T)$) published in Ref. [1] as well as the underlying raw data on arXiv [2]. The raw data and data are called "Measured Voltage" and "Superconducting Signal" respectively in Ref. [2]. Here we give an analysis of the ac susceptibility data for pressure $p = 160$ GPa. Other analysis of the susceptibility data in Ref. [2] were presented by one of us in Refs. [3–5]. The analysis presented in Sect. II of this paper was presented earlier in Ref. [6].

II. ANALYSIS OF THE 160 GPA DATA

Fig. 1**a** shows the data for $\chi'(T)$ for one of the curves shown in Extended Data Figure **7d** of Ref. [1], corresponding to pressure 160 GPa. The numerical values are given in the second column of Table 5 of Ref. [2] (labeled "Superconducting Signal"). A superconducting transition appears to take place around $T = 170\ K$. In Fig. 1 panels **c** and **d** these data are shown on a 15 times expanded y-axis. Because of the steep rise at 170 K the regions above and below 170 K need to be displayed in separate panels. A similar zoom of the 160 GPa curve was previously shown in Fig. 9 of Ref. [5]. One of the striking features is a series of discontinuous steps. These steps are directly visible to the eye in the temperature ranges where $\chi'(T)$ has a weak temperature dependence. However, they are also present in the range where $\chi'(T)$ rises steeply as a function of temperature, as can be seen by calculating the difference between neighboring points

$$\Delta\chi(j) = \chi(T_j) - \chi(T_{j-1}). \tag{1}$$

This quantity, shown in Fig. 1 **b**, exhibits an intriguing "aliasing" effect in the "shadow curves" displaced vertically by integer multiples of 0.16555. To make this crisp, the vertical axis of Fig. 1 **b** corresponds to $\Delta\chi(j)/0.16555$. Clearly this is a set of curves vertically offset by an integer $n = -1, 0, 1, 2, 3$ and 4.The most systematic offsets in sign and size occur between 169.6 K and 170.1 K.

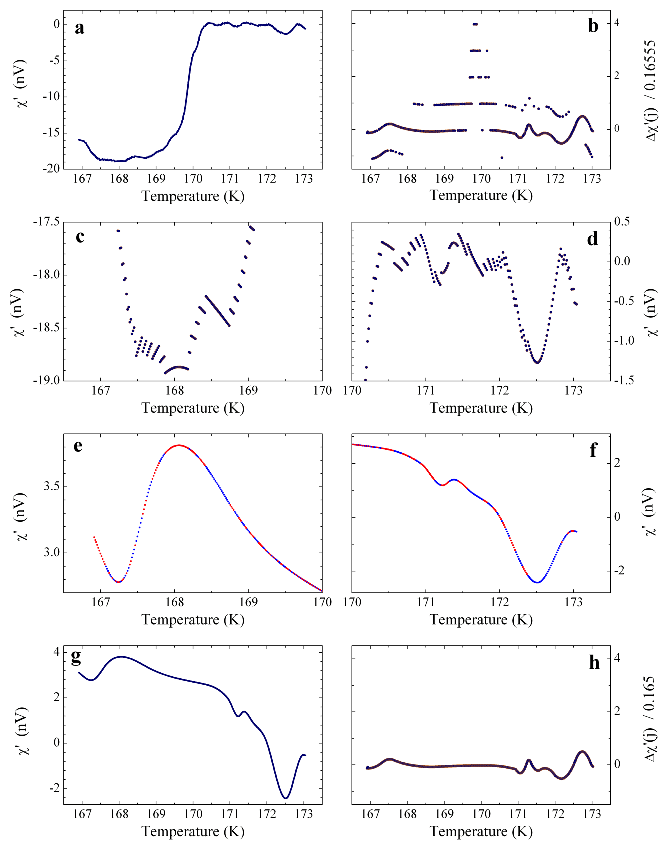

FIG. 1: **a**, Susceptibility data ("Superconducting Signal") for CSH at pressure 160 GPa, from the numerical data of Table 5 of Ref. [2]. **b**, The difference between neighboring points of panel **a** divided by 0.16555. **c** and **d**, The data of panel **a** on an enlarged scale. **e**, **f** and **g**, The data of panels **c**, **d** and **a** after unwrapping with integer multiples of 0.16555. The different colors of panels **e** and **f** refer to disconnected segments of panels **c** and **d**. **h**, Same as panel **b** but now using the unwrapped data of panel **g**. The same vertical scale is used as for panel **b**.

By shifting continuous segments of the curves by an amount $0.16555n$, with n integers that can be read off from Fig. 1**b**, it is a simple and straightforward task to 'unwrap' the vertical offsets [7]. The result for the two