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. 1a 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

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

This quantity, shown in Fig. 1b, 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. 1b 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.

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