On the Author Correction to "Magnetic field screening in hydride superconductors"

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Ref. [1] reported measurements of diamagnetic moment versus magnetic field for sulfur hydride and lanthanum hydride under pressure in its Figs. 3a and 3b respectively, claiming that they provide evidence that the samples are superconducting and allow to infer the value of the lower critical magnetic fields as function of temperature. Ref. [2] explained that several *linear* transformations were used in obtaining the data shown in Figs. 3a and 3b of Ref. [1] from the measured data shown in Figs. 3e and S10, and 3f and S11 of Ref. [1] respectively, including subtraction of a significant diamagnetic background. Here we show that those statements are contradicted by facts. This invalidates the claim of Ref. [1] that Figs. 3a and 3b of Ref. [1] are evidence for superconductivity in these materials.

From the deviation of linear dependence of magnetic moment on magnetic field for LaH_{10} under pressure shown in Fig. 1, reproduced from Fig. 3b of Ref. [1], the authors extracted values of critical field versus temperature. As the Author Correction to Ref. [1] recently published [2] explains, the data shown in Fig. 1 are not measured data. Rather, they were obtained from measured data by a set of linear transformations. Ref. [2] explains that linear transformations would *"not affect the onset of the deviation of the M(H) virgin curve from the linear dependence"* on magnetic field.

The latter statement is correct. It necessitates that the transformation is truly linear, if the transformation is not linear the statement is clearly invalid. For the virgin curve, one point is fixed at the origin, since there is no magnetization for zero applied field. In Fig. 1 we have connected the origin and the point for the T=80K curve for LaH_{10} at field H=100 mT by a straight red line. Note that all the points for the magnetic moment for T=80K for fields between 0 and 100 mT fall below the straight red line.

The data for Fig. 1 were obtained from measured data shown in Fig. 3f of Ref. [1]. In Fig. 2 we show a portion of those data. The three blue curves correspond to T=80K, as the blue points in Fig. 1. The middle blue curve is the virgin curve, starting with zero moment at zero field. We have connected that point with the moment at field H=100 mT by a straight red line.

It can be seen in Fig. 2 that some of the measured points fall below the straight red line and some fall above. This is different from the blue points in Fig. 1, that are all below the straight red line connecting the points at zero field and 100 mT field.

Given any linear transformation of the data points in Fig. 2, we can redraw the red line so that it passes through the transformed points at 0 mT and 100 mT, and again some of the data points will fall below the new straight line and some above. Thus, the blue points in Fig. 1 could not have originated from a linear transformation nor from a set of linear transformations applied to the blue points in Fig. 2, as Ref. [2] claimed. If the transformation used to obtain the curve shown in Fig. 1 from the curve shown in Fig. 2 was nonlinear, the procedure used to extract the critical field from the data in Fig. 1 is clearly invalid.

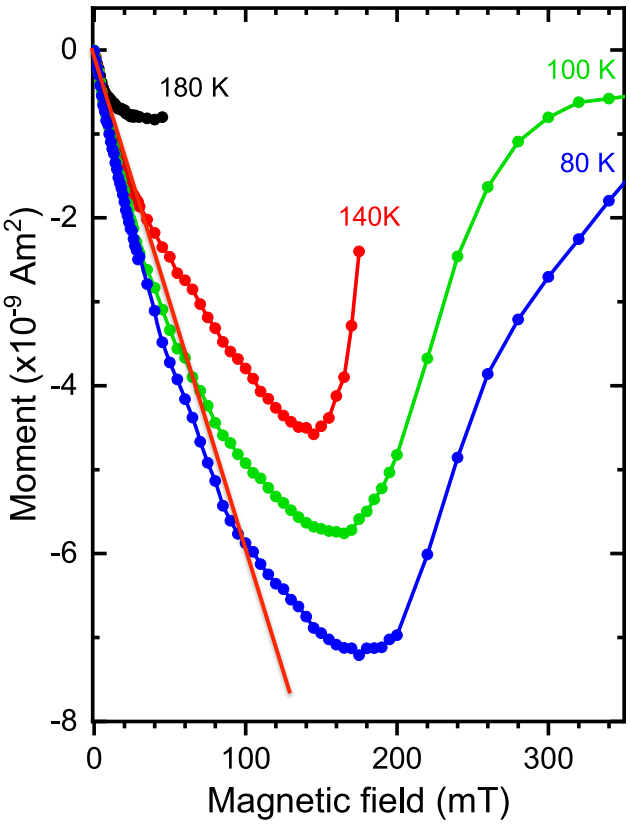

FIG. 1: Magnetic moment of LaH_{10} under pressure versus magnetic field, from Fig. 3b of Ref. [1]. We have added the straight red line connecting the origin with the magnetic moment at field 100 mT for the curve for temperature 80K (blue points).

The same is true for magnetization data of H_3S shown in Fig. 3a of Ref. [1], supposedly derived through linear transformations of the data shown in Figs. 3e and S10 of Ref. [1]. In Fig. 3 we show data for the hysteresis cycle for H_3S at 140 K, from Fig. S10 of Ref. [1]. We have connected the points for zero magnetic field and 100 mT with a straight red line. It can be seen that about half the points for fields between 30 mT and 100 mT are above the red line and half are below. Instead, the lower left

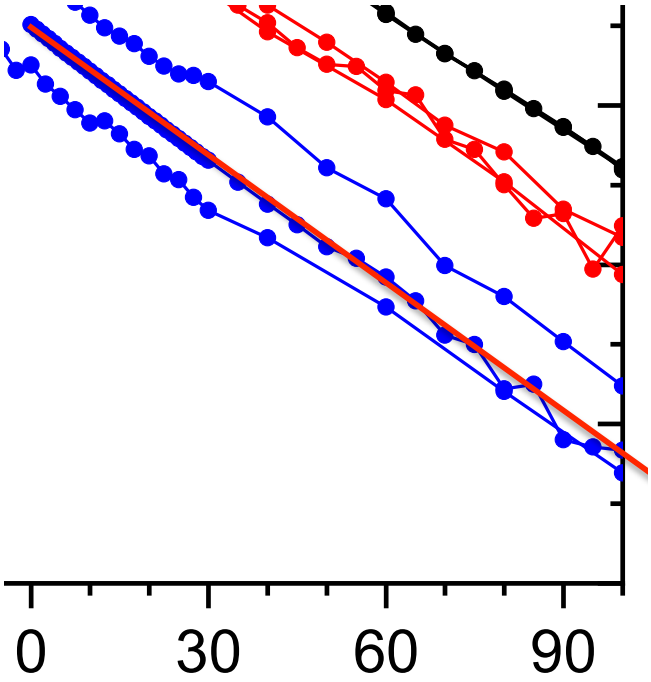

FIG. 2: Magnetic moment of LaH_{10} under pressure versus magnetic field, from Fig. 3f of Ref. [1]. The center blue curve is the virgin curve for temperature 80K. We have added a straight red line connecting the origin with the magnetic moment at field 100 mT for the virgin curve for temperature 80K (blue points). The numbers on the bottom axis give the magnetic field in mT.

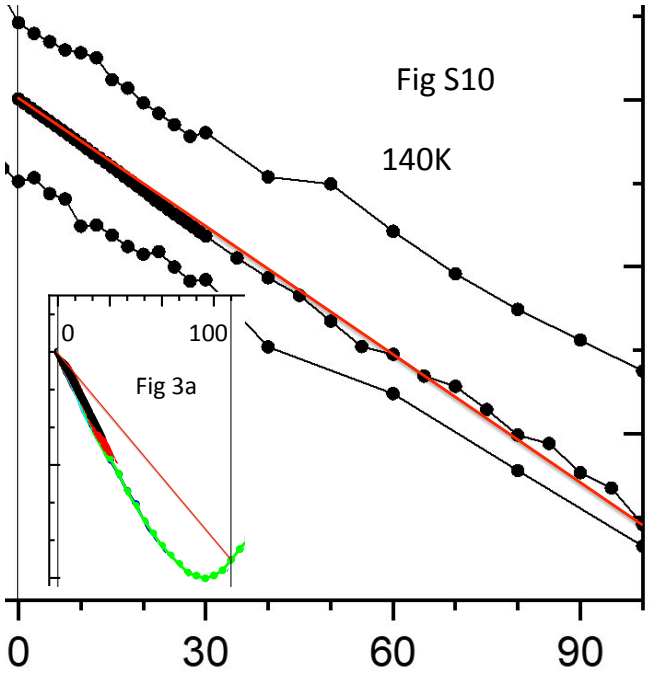

FIG. 3: Magnetic moment of H_3S under pressure versus magnetic field for temperature 140K, from Fig. S10 of Ref. [1]. The center black curve is the virgin curve. We have added a straight red line connecting the origin with the magnetic moment at field 100 mT. The numbers on the bottom axis give the magnetic field in mT. The inset at the lower left shows the magnetic moment from Fig. 3a of Ref. [1] at 140K supposedly obtained after linear transformations, the red line in the inset connects the points at field 0 and 100 mT.

inset shows the data derived from these measurements through supposedly linear transformations shown in Fig. 3a of Ref. [1]. It can be seen that all the green points in the curve lie below the straight red line connecting the points for 0 and 100 mT. It is obvious that those points cannot results from linear transformations performed on the data shown in the main body of the figure. The same is easily seen to apply to the magnetization data for H_3S at temperature T=100K shown in Figs. 3a and 3e of Ref. [1]. The curves are clearly not connected by linear transformations.

Therefore, the origin of the curves in Figs. 3a and 3b of Ref. [1] is not what the paper and its Author Correction states it is. What the origin of those curves is is unknown. If the transformations used to obtain them from measured data were nonlinear, as the analysis in this paper suggests, it would not be possible to extract values of critical field from deviations from linearity, as Ref. [1] does. More generally, the data shown in Fig. 3a and 3b cannot be interpreted as showing physical properties of the samples, since their relation to the measured data is unknown. They certainly cannot be used to infer the values of the critical field shown in Figs. 3c and 3d of Ref. [1], a central result of Ref. [1], unless the relation of the data shown in Figs. 3a and 3b with the measured data can be clearly established.

To clarify the relation between the data in Figs. 3a and 3b and the measured data the authors of Ref. [1] should release their measured data for examination by readers. We have requested access to those data on January 11, 2023, and repeatedly therafter. The data have not been released. We conclude that in the absence of disclosure of the measured data, Ref. [1] has no credibility.

Discussion of other aspects of the magnetization data of Ref. [1] and its Author Correction [2] and their implications for the question whether or not they provide evidence for superconductivity in these materials is given in Ref. [3].

Acknowledgments

The author is grateful to F. Marsiglio for collaboration in related work.

[1] V. S. Minkov et al, "Magnetic field screening in hydrogen-rich high-temperature superconductors", Nat Commun 13, 3194 (2022).

[2] V. S. Minkov et al, "Author Correction: Magnetic field screening in hydrogen-rich high-temperature superconductors", Nat Commun 14, 5322 (2023).

[3] J. E. Hirsch and F. Marsiglio, "On magnetic field screening and trapping in hydrogen-rich high-temperature superconductors: unpulling the wool over readers' eyes", arXiv:2309.02683 (2023), J Supercond Nov Magn (2023) https://doi.org/10.1007/s10948-023-06622-4.