High temperature conventional superconductivity. Experimental aspects

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Since the discovery of superconductivity at 203 K in H_3S[1] similar or higher transition temperature was reported in many hydrogen-rich compounds under ultra-high pressure[2]. The superconductivity was proved by different methods, in particular by detecting zero resistance and expulsion of the magnetic field in the measurements of the temperature dependence of the magnetic susceptibility. Determination of the structure of the new hydrides with synchrotron X-ray diffraction is the basis of our studies. Remarkably, the results are in agreement with theoretical predictions and calculations[2] and there is overwhelming evidence of the conventional s-wave superconductivity in the hydrides at high pressures, which we will summarize. A part of the report will concern persistent criticism and even the attempts to disqualify the results supporting superconducting state [3-9]. The arguments can be summarized as the following: the thermal hysteresis in the measurements of resistance; absence of broadening of the transition with magnetic field; absence of reliable magnetic measurements. These claims are apparently rooted in misunderstanding and misinterpretation of the high pressure experiments.

We address these issues by considering the related experiments in more detail in comparison with the published papers and include new important results on magnetic susceptibility. We show that arguments against the superconductivity in Refs [3-9] are can be either refuted or explained.

References

1 Drozdov, A. P., Eremets, M. I., Troyan, I. A., Ksenofontov, V. & Shylin, S. I. Conventional superconductivity at 203 K at high pressures. *Nature* **525**, 73 (2015).
2 Flores-Livas, J. A. *et al.* A perspective on conventional high-temperature superconductors at high pressure: Methods and materials. *Physics Reports* **856**, 1-78 (2020).
3 Hirsch, J. E. BCS theory of superconductivity: it is time to question its validity. *Phys. Scr.* **80** 03570 (2009).
4 Hirsch, J. E. & Marsiglio, F. Meissner effect in nonstandard superconductors. *arXiv:2101.01701v3* (2021).
5 Hirsch, J. E. & Marsiglio, F. Absence of magnetic evidence for superconductivity in hydrides under high pressure. *arXiv:2103.00701v1* (2021).
6 Hirsch, J. E. & Marsiglio, F. Nonstandard superconductivity or no superconductivity in hydrides under high pressure. *Phys, Rev, B* **103** 134505 (2021).
7 Hirsch, J. E. & Marsiglio, F. Flux trapping in superconducting hydrides under high pressure. *arXiv:2104.03925* (2021).
8 Hirsch, J. E. & Marsiglio, F. Intrinsic hysteresis in the presumed superconducting transition of hydrides under high pressure. *arXiv:2101.07208v1* (2021).
9 J.E.Hirsch & F.Marsiglio. Absence of magnetic evidence for superconductivity in hydrides under high pressure. *Physica C: Superconductivity and its Applications* **584**, 1353866 (2021).