Journal of Superconductivity and Novel Magnetism (2023) 36:1085–1086
https://doi.org/10.1007/s10948-023-06563-y

EDITORIAL

Short Note on the Observation of Ambient Condition Room Temperature Superconductivity in Nitrogen-Doped Lutetium Hydride

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Published online: 5 May 2023

The field of superconductivity has attracted eight Nobel prizes so far—five for experimental discoveries and three for theoretical advance. Since the discovery of superconductivity, the quest for materials which show superconductivity at ambient conditions has been a major priority. The observation of superconductivity at room temperature (RT) in N-doped lutetium hydride [1] has therefore attracted much excitement, but also a number of open questions; for example, a recent comment [2] notes the limitations of the experimental techniques used in [1] to confirm superconductivity at RT—these are mostly limited to measurements of zero electrical resistivity using a standard four-probe electrical technique. However, ultimate proof of superconductivity requires the observation of a non-decaying (i.e., persistent) supercurrent in a ring geometry as executed by Kamerlingh Onnes in 1914 [3]. Furthermore, an ideal superconductor will show infinite electrical conductivity as well as perfect diamagnetism [4]. In view of the limited verification methods in [1] and points raised in [2–4] and elsewhere, this short note highlights reports of RT superconductivity in the literature that spectacularly backfired.

The story goes back to the discovery of high-temperature superconductivity in the cuprate family of materials [5]. In 1990, the claim of near RT superconductivity in Ni-doped ErBaCuO at 200 K [6] could not be reproduced. More recently, several groups have reported high-temperature superconductivity in metal hydrides [7, 8], attracting much interest and unresolved questions [9]. Although huge interest resulted following the report of RT superconductivity in a silver–gold composite [10], this result generated concerns [11]. A further example is K-doped organic *p*-triphenyl with a superconducting transition above 120 K [12].

The most recent report of RT superconductivity in N-doped lutetium hydride [1] is already attracting widespread debate [2, 13, 14]. Compared to other metal hydrides which show in situ superconductivity that stabilizes under high pressures [7, 8], N-doped lutetium hydride [1] is potentially more practical since the superconducting state seems to stabilize under relatively modest pressures and the material is stable under ambient conditions. Although other examples could be highlighted, this short note aims to bring out the fact that the materials world can be elusive with reproducibility often at risk. We note that Ming et al. [13] and Shan et al. [14] have very recently reported the absence of superconductivity in N-doped lutetium hydride down to 10 K.

Lutetium is an expensive element and, moreover, precise control of H and N doping levels within the proposed superconducting unit cell [1] is an uphill task to achieve. Considering the points raised in [2, 13, 14], the superconducting materials community has to think carefully before investing time and energy into N-doped lutetium hydride. As a matter of priority, the authors of [1] should try to get their materials and superconductivity results independently verified. This is all the more important since the same research group have recently had their other claim of ambient condition superconductivity in carbonaceous sulfur hydride withdrawn [15]. There are many interesting questions to investigate [16–20] and a complete protocol of material synthesis should be made publicly available as soon as possible. Finally, we highlight the very recent finding in [21], which investigates the magnetic properties of lutetium metals (Lu and LuH_2) showing a paramagnetic–ferromagnetic spin glass transition

The recent report of superconductivity at ambient conditions (*Nature* **615**, 244 (2023)) has once again sparked the race for the discovery of other room temperature (RT) superconductors. This short note discusses the report of RT superconductivity in N-doped lutetium hydride and highlights other similarly high-temperature results in the literature.

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near 200 and 240 K. Such a phase transition is remarkably close to RT and could occur at higher temperatures in related materials. Reported transitions could be linked to the interesting features seen in the diamagnetic and heat capacity (Cp) response in N-doped lutetium hydride in [1].

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