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A critical approach to the ultradense hydrogen hypothesis

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In a recent article in this journal (Holmlid et al. 2023) it is claimed that the formation of 'ultradense hydrogen' (UDH) and the subsequent annihilation of protons by protons may have contributed to creating a hot and dry Venus. The claims on UDH have been put forward by the same (principal) author in a number of publications which state its purported properties with a bearing on astrophysics (Holmlid 2017, Holmlid 2018, Holmlid 2019). The history of UDH can be traced back by e.g. starting from a review (Holmlid and Zeiner-Gundersen, 2019) and from the references therein.

The remarkable properties attributed to UDH should have drawn the attention of the scientific community. None of these articles have generated a response in the scientific literature. In a nutshell the properties are stated to be: A proton-proton (or deuteron-deuteron) distance down to 0.5 pm; a density of 100 kg/cm^3 (more than five orders of magnitude larger than ever achieved in high pressure experiments on metallic hydrogen); a prolific muon source (10^{14}/s) through proton-proton annihilation. The mechanism invoked for muon production in UHD was at one point also given as antiproton-proton annihilation, notably with no explanation of the origin of the antiprotons. Also the annihilation process was claimed to be set off in different ways; by a laser, by switching on a fluorescent lamp or to occur spontaneously, depending on the publication.

In the articles (Holmlid et al. 2023) and (Holmlid 2017, Holmlid 2018, Holmlid 2019) it is implied that UDH is a well established aggregation state of hydrogen. Here we would like to point out that this is not the case. UDH is highly controversial and not compatible with the structure of matter as we know it, which is successfully described by the very well established formalism of quantum mechanics (see for example the authoritative work on spectroscopy (Herzberg 1989) for properties of hydrogen molecules). UDH is also inconsistent with known properties of bulk hydrogen. The properties of bulk hydrogen have attracted large interest, both of fundamental nature (Wigner and Huntington 1935) and also for reasons motivated by application in the emerging hydrogen economy. The metallic state of hydrogen, predicted in (Wigner and Huntington 1935) is only reached under extremely high pressure at which the density of hydrogen reaches values around 0.6 g/cm^3, many orders of magnitude below the densities quoted by Holmlid and collaborators. The absence of any indication of UDH in bulk hydrogen is so much more significant since it is claimed to be the lowest energy state of hydrogen.

Another and equally strong contra-indication for UDH is that the annihilation of protons by protons, which is claimed to occur after formation of the UDH phase, would violate the conservation of baryon number. Such violation has never been observed in dedicated searches and neither in particle physics experiments. In the former large masses of water have been monitored for spontaneous decays of protons, setting a lower limit on the lifetime of the proton of 10^{30} years (Workman et al. 2022). In the latter, protons are collided at energies where they approach each other to distances down to fractions of a femtometer. No violation of baryon number has been observed in these experiments which are performed at the major accelerator facilities in the world. In UDH proton-proton distances are claimed to be on the order of a picometer, i.e. more than a thousand times larger than those covered in the high energy experiments, but proton annihilation is nevertheless claimed to occur due to their proximity.

There is therefore solid evidence against UDH. We would like to point out that there is also no credible evidence in favor of the existence of ultradense hydrogen. Replications of the experiments that are said to produce UDH have never been achieved, in spite of attempts (see: Aasen et al. 2022). In a private communication the authors of this paper informed us that they never found any evidence for muon production or UDH, in spite of dedicated efforts.

We will not endeavour into re-iterating the flaws in the claims on UDH here, but refer the readership of this journal to a paper illustrating the experimental and instrumental procedures employed, see (Holmlid and Olaffson 2015), where, for instance, so-called Kurie plots are used for calibration and measurement, where in fact the distributions shown are not Kurie plots at all. In two recently published comments we detailed our concerns on the quality of the articles underlying the claims for the existence of UDH (Hansen and Engelen 2023 - 1, Klavs Hansen and Jos Engelen 2023 - 2). Another comment can be found on ArXiv (Klavs Hansen, Jos Engelen 2022)

Finally we suggest that, as long as these experiments are not reproduced by independent research groups and the violation of the above-mentioned conservation of baryon number remains unexplained, one should refrain from including the UDH in interpretations of astrophysical topics.

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