Energy, Sustainability and Society

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Response to the comment "Are claims of cheap muon production correct?" by K. Hansen and J. Engelen, Energy Sustain. Soc., 2023

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Abstract

It is shown that muons are generated from decay of the mesons created by baryon annihilation reactions in ultra-dense hydrogen H(0), based on numerous previous publications and one patent. The cost of the muons in energy is 500 times lower than from production in particle accelerators; therefore, they are considered to be cheap. We argue that ordinary scientific publications are more suitable for proving or disproving scientific results than comments with no new information.

K. Hansen and J. Engelen have published two comments [1, 2] on arXiv on two of my papers (published with coauthors), one in AIP Avances [3] and one in Physica Scripta [4] (this latter one being a review covering 50 published papers). I have published my responses also on arXiv [5, 6]. Most of the H&E comments here have already been answered in these responses. Anyone can read the science in the 65 published papers on H(0) and I cannot use so much space as would be required to once more reply to the H&E questions. A few further questions are answered at the end of this response. I will first focus on the important question that H&E asked in their title. The answer is: the claims of cheap muon production are indeed correct. The cost of the muons has recently even been published as cited below. There is a clear link from ultra-dense hydrogen H(0) to baryon annihilation and meson creation and finally to muon generation.

If H&E are unable to understand the publications on H(0), we cannot occupy space with that here. Other scientists are making progress on this at present. The important point is that H(0) exists and can be produced easily[7]. A few very important experiments on H(0) which H&E have never mentioned are the emission rotational spectra of H(0) in Refs.[8, 9], also summarized in the review [4]. These results give the bond distances in H(0) with a precision of a few femtometers for spin states $s = 2$,3 and 4. For example, the bond distance in state $s = 2$ is 2.245 ± 0.003 pm. Thus, there is no doubt about the existence and general properties of H(0). Baryon annihilation in H(0) has been proved with a precision of 0.1% in the energy conservation cycles [10, 11] which is not understood by H&E, since they believe that energy is not conserved. The meson creation from annihilation has been proved by accurate decay time measurements [10, 12] with error limits of < 1% for charged pions, charged kaons and long-lived neutral kaons. Finally, it is well-known that the decay of these mesons produces muons, so that the link from H(0) to muons is complete. To be

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absolutely sure, we have checked the decay time of the muons with accurate results [13]. In addition, novel methods of detecting muons have already been developed [14]. Since only negative muons are useful for muon-catalyzed fusion, the sign of the muons has been studied experimentally from two different aspects [15, 16]. The muon generator is patented [17]. The cost of producing the muons has recently been published [16] to be a factor of 500 lower when using H(0) rather than any accelerator-based method.

Thus, cheap muons are indeed produced. The cost is just one aspect; it is even more important that methods exist to make fusion energy available ***now*** in the form of muon-catalyzed fusion. However, this has been denied by strong forces both inside and outside the scientific community. The use of all resources for fusion research on non-sustainable D + T fusion instead of sustainable muon-induced fusion may be a fatal mistake for humanity. Please note that muon-induced fusion was discovered in 1957, but since it is useless for weapons, no further technical development took place until after 2000. This is the sad truth.

The description of muon-catalyzed fusion given by H&E in their comment is wrong on several points, but neither of the authors has worked in this field, so they apparently do not understand the physics. They state that break-even has not been reached with this method. There is a publication from 2015 which shows over break-even [18]. This is the first report on over break-even energy generation by any fusion method. H&E discuss the D + T reaction in muon-catalyzed fusion, but this reaction will probably never be used. The important point is that muon-catalyzed fusion can use cheap, sustainable and readily available deuterium as a fuel [19]. However, they avoid the important points completely.

H&E state that in my experiments, a very simple YAG laser was used, but a little later in their text they suggest that it was a very high-power laser which facilitates the acceleration of the fragments from H(0) to energies of several hundred eV. Such an acceleration due to emitted electrons can never produce the observed acceleration of neutral fragments. Such an acceleration by the laser would likely not give the observed result of several well-defined energies. Therefore, H&E should write a paper on how this could be possible. I would never try to publish such an impossible explanation of the experimental results, while the explanation which was used in terms of Coulomb explosions agrees very well with experiments and was publishable. The lack of publications by H&E on these subjects give their comments low credibility. A more scientific approach with ordinary publications would be far better than writing unsupported comments on published papers.

H&E also state that the meson signals I have published are due to (electronic) noise from the laser. They say that such noise is common. I will not discuss the bad quality of the lasers they used, but the noise from my laser is low, of the order of 1 mV into 50 Ω. This noise level is published and can also be observed in the numerous published figures. Likewise, they stated that repeated measurements of time constants with values of 25.92 ± 0.04 ns, 14.81 ± 0.05 ns, etc., are due to noise from the laser. Their statement is incredible. These time constants have also been measured by a differential current coil [11, 12, 15] which only detects a real charged particle current in the beam and which is insensitive to any laser noise. Any expert reading my publications will notice this and draw the correct conclusion, that the signals are real. In addition, several other tests have been published like moving the laser beam slightly on the target which removes the meson beam signal when the lining up of the beamline is disturbed. Any noise from the laser would still reach the detector. These basic checks have of course been done in every experiment. A beginner in the field will certainly make all the errors that H&E have done, but such errors are not publishable.

That H&E do not observe or do not understand the use of the current coil in the meson measurements but instead insinuate that I have made beginners' errors, demonstrates the extremely low quality of their comments. Their comments are full of errors at a basic level, but most of these errors have already been answered in my previous responses [5, 6].

Just one example. H&E stated:"The purported properties of the ultra-dense hydrogen are all based on measurements of flight times of charged particles emitted from hydrogen-covered surfaces. The time-of-flight spectra produced in these experiments are poorly resolved, with a resolution on the order of $\Delta m/m \sim 1$,..". This short text contains numerous errors which I have explained twice before in my previous responses but H&E seem unable to understand. The properties of H(0) are based also on the rotational spectra [8, 9] and on several variations of the laser fragmentation method. The flight times are measured for both charged and neutral particles. Such a signal cannot be obtained from a"hydrogen covered surface" but only from H(0). The time-of-flight spectra are well-resolved, since they are intrinsic energy spectra given by the Coulomb explosions in the H(0) molecules. H&E should blame the H(0) molecules for the bad resolution. H&E then suddenly start to discuss the mass resolution of the energy spectra as if they were mass spectra. This shows that they do not understand mass resolution, energy resolution and their relation especially not for neutral fragments. The main results are for

neutral fragments, not for ions. Once again, their lack of solid workmanship is obvious.

H&E stated that ultra-dense hydrogen H(0) does not exist in any phase diagram for hydrogen. This is not unexpected. A phase diagram for H(0) has not yet been constructed and it will obviously not be the same as a phase diagram for covalently bonded hydrogen gas molecules H_2 (which H&E refer to as well known) or for hydrogen atoms H. There exists no implication of their statement.

One more amusing case is H&E's worry about the radiation protection in my laboratory, which has forced them to complain to my university (to the vice-chancellor) and to my department. H&E state in their comment here that the radiation from our annihilation reactor should be detectable by a GM detector, since the radiation is ionizing However, neutral kaons are not ionizing and the muons and pions have energy close to their ionization minima and are not detectable in this way. When we do not observe any radiation with a GM meter, H&E suppose that there are no nuclear processes in H(0). With more suitable detectors than GM, it is no problem to detect particle radiation, such as muons and pions, but the intensity is low and the radiation is harmless even close to a working annihilation reactor. As always, it is the intensity of the radiation which is important. Of course, mesons and muons are also much less harmful than the neutrons which would be emitted if we studied fusion. This is one reason why we are mainly developing annihilation energy generation at present, using ordinary hydrogen as a fuel [19].

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