Spontaneous ejection of high-energy particles from ultra-dense deuterium D(0)

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A B S T R A C T
High-energy particles are detected from spontaneous processes in an ultra-dense deuterium D(0) layer. Intense distributions of such penetrating particles are observed using energy spectroscopy and glass converters. Laser-induced emission of neutral particles with time-of-flight energies of 1–30 MeV u⁻¹ was previously reported in the same system. Both spontaneous line-spectra and a spontaneous broad energy distribution similar to a beta-decay distribution are observed. The broad distribution is concluded to be due to nuclear particles, giving straight-line Kurie-like plots. It is observed even at a distance of 3 m in air and has a total rate of 10⁷–10¹⁰ s⁻¹. If spontaneous nuclear fusion or other nuclear processes take place in D(0), it may give rise to the high-energy particle signal. Low energy nuclear reactions (LENR) and so called cold fusion may also give rise to such particles. Copyright © 2015, Hydrogen Energy Publications, LLC. Published by Elsevier Ltd. All rights reserved.

Introduction

Several published studies from our group prove the formation of massive particles with >10 MeV u⁻¹ energy in the laser-initiated processes in ultra-dense deuterium D(0) [1–6]. Such high particle energies indicate nuclear fusion or other nuclear processes. Ultra-dense deuterium D(0), previously named D(−1), exists in several different spin levels as shown by time-of-flight (TOF) experiments [7]. The most common level with spin quantum number s = 2 has a measured D–D distance of 2.3 pm in good agreement with theory [7]. Due to the extreme density of D(0), it is expected to be an excellent fuel for nuclear fusion by inertial confinement fusion (ICF) [2,5,8]. The density is so high that further compression is not needed to reach fusion conditions, but only an igniting laser pulse. The particles ejected from the laser-initiated processes give rise to lepton pair production [9]. Also gamma radiation is observed from these nuclear processes [10]. The total energy in the ejected particles which are mainly neutral is so large that the fusion process is close to break-even [3,5]. We have used standard particle detection methods to observe penetrating high-energy particles and their energy distributions from D(0) from the laser-induced processes (submitted). Here we report on the spontaneous signals observed by standard particle methods [11,12] utilizing glass converters for the detection. This gives the possibility to increase the particle signal strongly and also to observe the location of signal generation with the help of a photomultiplier detector.

The main interest of D(0) may be in its future use as an efficient fusion fuel, as seen from the first report of this which was published in this journal [13]. However, the
present study is of course more limited in its scope, and only a few important aspects are discussed here. One unexpected aspect of the existence of ultra-dense hydrogen (which is formed from protium [7,14], deuterium or tritium) is that it may cause instabilities in large-scale laser-induced fusion experiments [8]. Such experiments compress a hydrogen fuel pellet to high pressure and temperature for example with the “world’s most powerful laser” at the National Ignition Facility (NIF) [15]. This is done to reach ignition of fusion, but the result is not so encouraging probably due to instabilities in the compressed fuel. Thus the relation of D(0) to other aspects of nuclear fusion is quite complex and not easily covered here.

One important aspect of the present study is that high-energy, unstable particles are observed to be ejected from ultra-dense deuterium D(0). A few types of methods have been used previously to form particles with energy in the MeV range from hydrogen by fusion or other nuclear processes. These high-energy particles are normally stable particles like protons and neutrons, not unstable particles giving beta-decay distributions as reported here. Such particles are only ejected by energetic means, by intense laser pulses [15–17] or by application of a high voltage to the system. The most common type of method is certainly plasma methods like the one used under the name inertial electrostatic confinement (IEC). Such devices have also been developed for nuclear fusion [18,19]. The first and most well-known example of this type of device is the “fusor” [20]. Similar devices are used for generation of neutrons for isotope production.

Another aspect of the present study is that particle ejection is here observed to occur spontaneously from deuterium, in fact from ultra-dense deuterium D(0). Only one similar report has been found [21] where energetic alpha particles (several MeV) were ejected from a Pd containing solid surface during spontaneous deuterium desorption. Similar systems have also been shown to contain very high densities of hydrogen [22]. In some systems where high-energy processes like nuclear processes are believed to exist, like in so called cold fusion and low energy nuclear reactions (LENR) [23,24], the lack of energetic particle emission is often used as an argument that nuclear processes are not involved. From the results presented here, it appears possible that energetic particle emission does exist, but that it has avoided detection since only neutron emission has been systematically sought for. Also, many particles ejected in our experiments are indeed neutral (not mainly neutrons) and for this reason difficult to detect.

Theoretical background

Ultra-dense deuterium D(0) is a quantum material at room temperature. It is described in several publications, with detailed studies of the structure of D(0) [7,25] and also of its protium analog p(0) [14]. The name is changed recently to D(0) instead of D(−1), since the material is not inverted (this assumption motivated the negative sign). Instead, it is a spin-based Rydberg matter [7] with angular momentum l = 0 for the electrons. It is shown to be both superfluid [26] and superconductive (Meissner effect [27] observed) at room temperature [28]. D(0) may involve formation of vortices in a Cooper pair electron fluid as suggested by Winterberg [29,30]. Due to the measured very short D–D distances of 2.3 pm [25,31], the density of D(0) is very high, in fact higher than the density of hydrogen fuel for fusion believed possible by any compression method. Thus, it should be possible to initiate nuclear fusion by relatively weak laser pulses in the D(0) material [1–5]. It is likely that the main process initiated by the laser pulse is a transition from level s = 2 with D–D distance of 2.3 pm, to level s = 1 with theoretical distance 0.56 pm [7,8] from where fusion or other nuclear reactions are spontaneous. In muon catalyzed fusion, the D–D distance is of similar size, and the rate of fusion is close to 109 s−1 [32]. If this transition to level s = 1 can take place spontaneously, a spontaneous nuclear process is possible similar to the one named LENR [23,24]. Several studies have proved the formation of MeV particles from D(0) during laser impact under conditions useful for ICF [1–6]. Particle energies up to 20 MeV u−1 have been observed [3,6]. Recent studies (submitted) show that most high-MeV particles are neutral, possibly cluster fragments Hn(0) of ultra-dense matter H(0) [14] with a typical size of only a few pm.

Ultra-dense deuterium D(0) is a spin-based type of Rydberg Matter (RM) [7]. While ordinary (orbital angular momentum l) based Rydberg matter has l > 0 for its binding electrons [25], this ultra-dense matter has l = 0 and s > 0 (1, 2, 3,…) the spin quantum number for the bonding electrons. Thus, the electrons which give the ultra-dense matter structure have no orbital motion, but only a spin motion. This electron spin motion may be interpreted as a motion of the charge with orbit radius rq = N2mc2 = 0.192 pm and with the velocity of light c (“zitterbewegung”) [33]. This spin motion is centered on the D atoms and may give a planar structure for the D–D pairs as in the case of the planar clusters for ordinary Rydberg matter. This means that the interatomic distance in ordinary Rydberg matter which is d = 2.9 l2 a0 is replaced by d = 2.9 s2 rq for the ultra-dense matter, as shown by direct measurements [7]. Here, 2.9 is a constant determined numerically for ordinary Rydberg matter [34] and confirmed experimentally by radio frequency spectroscopy [35,36]. The Bohr radius is indicated as a0. The spin-circling electrons give a shielding of the nuclei which keeps the material together, as in the case of ordinary Rydberg matter.

The mechanism of formation of ultra-dense matter starts with the formation of higher normal Rydberg matter levels (l = 1–3), which are formed spontaneously at the catalyst surface used [25]. This mechanism is depicted in Fig. 2 in Ref. [8]. It implies that the ultra-dense type is formed from ordinary Rydberg matter levels l = 1–3 falling down to the lower energy ultra-dense states. The process of interchange D(l = 0) ↔ D(l = 1) between ultra-dense matter and ordinary Rydberg matter in l = 1 [37] is even observed to give oscillations in real time [38]. The details of the simultaneous angular momentum couplings and transformations under such changes have not yet been worked out.

It is expected that neutrons will be ejected from a nuclear fusion process. However, only relatively small but significant fluxes of neutrons have been detected in experiments using laser-induction. The most important factor is the large density of D(0), which makes it difficult even for neutrons to leave the
material without numerous collisions with the deuterons [2,4]. Mean free paths as short as 150 nm even for 14 MeV neutrons can be calculated [4]. It is also possible that other nuclear processes but normal D + D fusion dominate. By selecting the layer thickness correctly, it is however possible to observe ejected ⁴He and ³He after collisions with D clusters by time-of-flight [39]. In the present study, the D(0) layer thickness was considerably higher than in that study. Since D(0) is superfluid and forms a layer on the target, it will transport energy rapidly to its surface from where particles are ejected in the form of a sheath [3,6]. This will only allow observation of H(0) cluster fragments, possibly in the form of mesons and leptons like electrons.

Experimental

The layout of the normal setup is shown in Fig. 1. The source for producing D(0) is shown in Fig. 1 and is an integrated target and production unit (here called D(0) generator), with gas feed from below. Potassium-doped iron oxide catalyst samples [40,41] in the generator form D(0) from deuterium gas (99.8%) at a pressure below 100 mbar. The small vacuum chamber has a base pressure of 10⁻³ mbar. A Nd:YAG laser with pulse energy of <0.4 J could be used to initiate the spontaneous signal, with 7 ns long pulses at 1064 nm and 10 Hz repetition rate. The laser beam was focused with an f = 40 mm lens at the D(0) layer.

The detector part is used in two different forms. When it is mounted on the apparatus as shown in Fig. 1, a plastic scintillator (PS) precedes the photo-multiplier (PMT). The PS is also the vacuum window. An Al foil of thickness 10–20 µm is mounted inside the chamber in front of the scintillator giving a light-tight enclosure. A glass filter is mounted between the PS and the PMT and functions as a converter for the high-energy particles. The glass converter is normally a metal-ion containing blue-green glass filter (Schott BG3, 3 mm thick). The PS gives mainly blue photons (maximum emission at 423 nm). The PMT is Electron Tubes 9128B with single electron rise time of 2.5 ns, electron transit time 30 ns, end-window cathode, and linear focused dynode structure. The PMT with the jacket for the glass filters is shown in Fig. 2. The PMT is mounted outside the vacuum in a light-tight metal container built from standard vacuum components. PMT high voltage is
1600 V. A preamplifier (Ortec VT120) with bandwidth 10–350 MHz and gain 200, and a pulse-shaping amplifier (Ortec 440A) with shaping time 0.5 µs were used. The signal from the PMT is analyzed by a 2048 channel multi-channel analyzer (MCA) (Ortec EASY-MCA-2k with Maestro software) for the MCA spectra of 500 s length. The second form of the detector consists of the glass converter and the PMT inside a light-tight metal container (built from standard vacuum components) with a 3 mm thick Al blind flange in front of the glass converter. This unit is moved into various positions in the laboratory. For testing purposes, several types of glass converters were used in front of the PMT. An Al foil with 20 µm thickness was also sometimes used as a filter to remove visible photons and ions at energies below 1 MeV. When the converter is to be changed, the PMT enclosure is opened and closed in darkness. Another pulse-shaping amplifier (Ortec 575A, gain 5), another PMT of the same type and new blue-filters were used to check that the behavior was unchanged. The PMT socket construction was also checked and measured. An older MCA was also used, giving the same beta-like distributions.

The electron energy scale of the PS is calibrated by measuring the beta emission from a $^{137}$Cs probe (37 kBq, Gammadata, Uppsala, Sweden) inserted into the apparatus in front of the PS with the detector sitting close to the target (left-hand bottom in Fig. 1). Measurements are made in air both with and without an Al foil in front of the scintillator, with no observable change in the slope of the beta signal. The shifting of the beta signal with the blue-filter is verified, showing that the behavior was unchanged. The PMT socket construction was also checked and measured. An older MCA was also used, giving the same beta-like distributions.

In Table 1, some ranges of electrons and protons in Al and in the plastic scintillator material are collected [42]. The ranges for deuterons and He ions are approximately as large as for protons with the same velocity.

### Results

At the start of a run with D$_2$ gas admission into the apparatus, the signal out from the PMT with PS and glass converters is low as seen in the spectrum indicated “initial” in Fig. 3. After 1 h in that run, the signal increased a factor of 40 as shown by the higher curve in Fig. 3. This behavior is reproducible and is due to slow processes in the glass converter, which will be described elsewhere. In Fig. 3, the signal in the range channels 300–800 is constant. This part of the spectrum is due to photons from the PS caused by high-energy particles, for example a muon signal from the upper atmosphere. It is important to observe that the signal increase at channels 50–300 is not accompanied by any change in the PS background signal at channels 300–800, thus the signal increase is not due to a change in total amplification in the PMT or the electronics.

The glass filter functions both as a filter for visible light and as a converter for particles like muons (forming for example gammas and electrons). This is demonstrated in Fig. 4, where the glass filter is removed in one of the spectra. Removing the filter shifts the background signal in the PS to higher energies, and decreases the signal strongly (in this case by a factor of 5) at channels 0–200. A similar example is shown in Fig. 5 with the detector separate from the apparatus and PS. This means that the background distribution at channels 200–800 is constant. This part of the spectrum is due to photons from the PS caused by high-energy particles, for example a muon signal from the upper atmosphere. It is important to observe that the signal increase at channels 50–300 is not accompanied by any change in the PS background signal at channels 300–800, thus the signal increase is not due to a change in total amplification in the PMT or the electronics.

The high signal in the channel range 0–200 for example in Figs. 3 and 5 is concluded to be formed by a particle flux from the experiments with ultra-dense deuterium D(0). It varies with many conditions for example the location of the detector in the laboratory, the status of the experiments, coverage of

### Table 1 – Ranges for a few energies of electrons and protons in the materials used. The ranges of D and He are approximately factors of 2 and 4 respectively than the ranges for protons. Data from the databases at NIST [42] and from manufacturer’s data [46].

<table>
<thead>
<tr>
<th>Particle</th>
<th>Energy (MeV)</th>
<th>Range in D(0) (nm)</th>
<th>Range in Al (µm)</th>
<th>Range in plastic scintillator (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e$^-$</td>
<td>0.01</td>
<td>0.008</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>e$^-$</td>
<td>0.03</td>
<td>0.058</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>e$^-$</td>
<td>0.1</td>
<td>0.49</td>
<td>69</td>
<td>150</td>
</tr>
<tr>
<td>e$^-$</td>
<td>0.3</td>
<td>2.9</td>
<td>410</td>
<td>700</td>
</tr>
<tr>
<td>e$^-$</td>
<td>1.0</td>
<td>15</td>
<td>2040</td>
<td>4000</td>
</tr>
<tr>
<td>p</td>
<td>0.3</td>
<td>0.009</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>p</td>
<td>1</td>
<td>0.08</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>p</td>
<td>3</td>
<td>0.66</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>p</td>
<td>10</td>
<td>3.9</td>
<td>630</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Fig. 3** – Start of an experimental run with detector on chamber. The initial spectrum is the background observed after 1–2 days of inactivity. The high spectrum is observed after 1 h. Note the background from the plastic scintillator (PS).
the detector with lead plate and the properties of the converter material. The detailed function of the converter will be reported elsewhere. The important point of interest here is that the signal observed is not a background signal from the PMT, since it can be amplified of the order of 100 times by the addition of a glass converter inside the PMT container. The signal is clearly due to penetrating particles which also interact with the metal container holding the PMT: the proximity and nature of the metal parts in the container (Al or steel) strongly influence the signal intensity generated in the PMT. A small fraction of these particles may be from space or the upper atmosphere, but the signal is much too large to have this origin. Thus, a large part of the intensity is from the laboratory. No ordinary particles like gamma radiation from the building material in the laboratory or from other laboratories in the building match the observations.

The shape of the signal both on the chamber as in Fig. 1 and at a distance of a few meters gives more information. See examples in Figs. 6 and 7. The shape of the distribution is the same, independent of the total signal and its amplification. (High energy intensity may also be observed at channels above No. 200). Plots of the square root of the signal against the energy (channel No.) thus similar to Kurie plots give a straight line with zero intensity cutoff at 175 ± 3 channels. This is correct both for the direct signal and for the signal minus an initial signal background of the type in Fig. 3. These linear plots indicate that the signal observed as the low-energy distribution in the MCA is due to a broad particle energy distribution, similar to that given to the electron in a beta decay[11,43]. Thus the broad distribution reflects the redistribution of the total energy in a nuclear process over at least two particles, so that only the maximum energy Q is constant. For each set of particles formed by this process, the total energy is split up between the particles. Thus, Q is here equal to the energy of 175 channels, which would be equal to

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**Fig. 4** — Effect of the blue-filter with detector at chamber. With blue-filter, the background in the PS is shifted to lower energies (absorption in the filter) while the signal at channels 0–200 is increased strongly.

**Fig. 5** — Effect of the blue-filter with separate detector. Three high-intensity spectra measured in order 1 to 3, with time between to just change the filter. No background from PS.

**Fig. 6** — Signal with detector on chamber, spontaneous signal at channels 40–180, difference between signal with and without blue-filter. Linear and square root plots, giving signal Q value at approximately 173 channels.

**Fig. 7** — Signal with detector separate from chamber at 3 m distance, spontaneous signal at channels 40–180, square root of signal plotted. Q value at approximately 177 channels.
117 keV using the electron energy scale from $^{137}\text{Cs}$ calibration of the PS. The conversion factor for the glass converter is unknown but probably much larger, corresponding to particle energies of MeV size similar to those measured by time-of-flight in vacuum [3,6].

A signal of a similar shape is observed also without glass converter in Figs. 4 and 5, but much lower. This signal is apparently due to particle conversion in the glass envelope of the PMT of the same type as taking place in the glass converters. (A thick clear glass plate instead of the blue-filter gives a similar but slightly smaller signal). One example with the detector at 3 m distance from the apparatus is shown in Fig. 8, spectrum 2. The other spectra in that figure are measured consecutively before and after spectrum 2. They show also very high particle energies, similar to laser-induced spectra when the detector is mounted on the chamber. Such laser-induced pulses have been shown (submitted) to be due to particles delayed by gas in the chamber and with the PS scintillation energy shifted by the blue-filter. The particles observed here in Fig. 8 have apparently moved to the detector, before interacting with the structure in the detector. That the particles from the blue-filter have the same energy as the scintillations of the ions in the PS is probably a coincidence.

Other glass filters and filters of other materials function also well as converters, with one further example in the three consecutive energy spectra in Fig. 9. Also two identical filters simultaneously give an interesting behavior, as seen in Fig. 10. There, the spectrum using two blue-filters is taken as number 2 of three consecutive spectra. That the signal in spectrum 2 is not just doubled but increased further indicates that the interaction of the particles with the glass material is complex. Such conversion processes have also been tested by other filters. In Fig. 11, four consecutive spectra are shown (starting with no filter, from the top of the list) where a grey filter with optical density OD2 is used separately and also combined with a blue-filter. In the lower panel, it is shown that the grey filter (transmission thus only 1%) both decreases the number of counts (but less than a factor of 10) at low energies relative to the blue-filter and shifts the intensity at large energies to the left, to lower energies. This energy shift is much less than a factor of 100, and the decrease in the number of counts is also much less than a factor of 100. Thus, the main signal both at high and low energies is not caused by photons in the visible range, but by high energy photons or electrons which are only partially absorbed or scattered by the grey filter.

These mechanisms have been checked further. The grey filter can be placed on the other side of the blue-filter, outside the blue-filter from the PMT. This gives a signal similar to the blue-filter alone, thus with no interaction of the grey filter with the particles or photons from the blue-filter. A 20 μm
thick Al foil is also used between a blue-filter and the PMT, with little influence on the signal. Thus, the signal in the PMT is not caused by visible photons or by heavy particles like protons. When filters are used outside the metal enclosure for the detector, no effects are observed. All these tests indicate that the transformation of the particles that in the end give the signal in the PMT is initiated in the metal enclosure and the converter. The facile particle penetration through steel walls could indicate muons.

From the number of counts per second, the total rate of the particle generation has been calculated. The measured signal is $10^2 - 10^5$ s$^{-1}$ in the PMT detector. This means a total particle generation of $10^7 - 10^{10}$ s$^{-1}$. This corresponds to less than 5 μmol per year of particles which is reasonable relative to the much larger amount of deuterium used in the generators.

In the spectra, sharp almost mono-energetic peaks are often detected. One example is shown in Fig. 12, but such peaks are also seen in Fig. 7 and in spectrum 3 in Fig. 8. A previous study [44] concluded that similar (laser-induced) peaks are due to energetic particles decaying inside or just outside the PMT in the detector. This means that a well-defined energy is deposited in one type of particle in the PMT, giving a well-defined signal response. This conclusion was reached by letting the particles pass through different Al foils, with practically no change in the peak position in the energy spectrum, and by realizing that the particles into the PMT had passed through the 10 cm long PS without losing any energy. Thus, the broad distributions described above certainly show the kinetic energy of particles formed in the converter, while the line spectra may show the decay energy inside the PMT. It is of course also possible that the two features are due to different particles which behave differently in the converters.

**Discussion**

Spontaneous formation of penetrating particles is not known previously from a deuterium containing material, but it is observed here easily and reproducibly in a large number of experiments. The particles are observed even at a distance of a few meters in air. They are probably ejected with energy in the range 1–20 MeV u$^{-1}$. This is concluded from the previous experiments with laser-induced time-of-flight [3,6,9] and MCA energy measurements (submitted) [44]. The particle energy distributions are here of similar shape with and without laser running. It is not yet possible to measure the energy of the spontaneous particles by time-of-flight. Thus, the identification is based on the similarity in shape of the energy distributions with and without laser running. It is not yet possible to measure the energy of the spontaneous particles by time-of-flight. Thus, the identification is based on the similarity in shape of the energy distributions with and without laser running. This could mean that this spontaneous signal is in fact due to other particles entering in the detector. However, it is not necessary to explain the results in this way but it is sufficient to assume just one type of penetrating particle which produces charged detectable particles.

On the target and on other surfaces in the apparatus, layers of ultra-dense deuterium exist. The clusters that constitute this material are excited and fragmented by the laser light (when used) and give fast fragments both due to CE processes and nuclear fusion. Nuclear fusion is not thought to be initiated by a high temperature due to the laser, but by the transfer from the normal level $s = 2$ to the level $s = 1$ with D–D distance 0.56 pm [7,8], from where fusion or other nuclear processes are spontaneous. A laser pulse is one type of disturbance
which can initiate this process. When the process has started, it can continue until the material is depleted. This is not unlikely, since the excess energy from the fusion itself will excite other neighboring clusters which trigger the transfer to the $s = 1$ level, giving further nuclear processes. The same type of disturbances may also give the CE processes in the ultra-dense layer studied in several publications [1–7].

It is here on the other hand not thought possible to observe electron emission at high temperature as reported (submitted) with laser-induction [44]. The relevant observations there were of an exponentially decreasing signal towards higher energy in channels 120–270. This was interpreted as an electron distribution since it shifted with the blue-filter as expected for a multiphoton process in the PS. Most results presented here are found with a separate detector, thus with no such electron flux and no PS, and the results like in Figs. 3 and 4 do not show such a distribution.

Since the signal observed by using glass converters has not been reported by other groups, the results have been checked carefully by changing apparatus parts for example using other devices like other PMTs, MCAs, amplifiers, HV supplies and filters. No large changes have been observed in the behavior. The crucial, quite astonishing experiment is of course the strong change of the signal by changing or removing the converter in front of the PMT in darkness. Such a change does not give any change in other parts of the apparatus but possibly in the PMT mounting. If a contact fault existed for example in the PMT socket which could be influenced by the slight motion of the PMT during the converter removal or change, it should be directly observable as a shifting of the spectra on the energy scale since the amplification in the PMT would change. No such effect has ever been observed. Also, there are several levels of the signal change, for example by using two blue-filters as in Fig. 8, or by using a grey filter together with a blue-filter as in Fig. 11. Such reproducible changes are not due to experimental faults.

One possibility for the pulses observed is the generation of some kind of high-energy penetrating particle from some other equipment in the chemistry research building where the experiments have been done. Particles have been tested for by a GM detector (alpha, beta and gamma), by a CsI(Tl) detector (gamma) and several neutron bubble meters (thermal and high-energy neutrons). Only normal background signals are observed in these instruments during the experiments. The operation of the gamma and beta detectors have been checked by background measurements and also by using a $^{137}$Cs source (gamma, beta). Thus there is no indication of any source outside the laboratory. Besides, it is not understood which type of external source would be able to produce the particles detected.

The final point to discuss is apparently the relation of the present results to proposed spontaneous energy-releasing processes like low-energy nuclear reactions (LENR) [23,24]. It is important to realize that the emission of particles that form particles in the detector does not necessarily indicate nuclear fusion. A conclusion about the existence of nuclear fusion requires a measurement of the total energy released in the process, which is not given here, or at least a measurement of the particle energies [3,6]. The alternative process which has been neglected in almost all previous work on energy release in similar systems (with one important exception [45]) is the condensation and reorganization of the ultra-dense deuterium phase to a lower energy level. This type of process is however not yet known to be spontaneous.

Conclusions

It is shown that high-energy penetrating particle radiation is formed spontaneously in ultra-dense deuterium D(0). Both sharp mono-energetic peaks and broad, beta-decay type distributions are observed in energy spectra from the photomultiplier detector. Such spectra are observed both coupled to the D(0) generating apparatus, and at a distance up to 3 m from this apparatus. The signal variation from changes (or removal) of the glass converter in the detector is large. This broad signal which gives linear Kurie-like plots can be understood as due to reactions of nuclear particles like muons. It is pointed out that the generation of such high-energy particles may be inherent in LENR and so called cold fusion.

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