

European Patent Office

Our ref. 160854EP

27 May 2020

**European Patent Application No. 17870991.1 in the name of: Norront Fusion Energy AS**

Dear Sirs,

The applicant hereby submits the following statement in reply to the Invitation pursuant to Rule 63(1) EPC dated 6 April 2020 (the Invitation).

**1. Main request**

***1.1 Statement indicating subject-matter to be searched***

As a main request (as provided for by the guidelines B-VIII, 3.2.2), the applicant requests the search division to search the subject-matter defined by the claims as filed, with the following guidance taken from the description as filed:

The claim term "*ultra-dense hydrogen*" should be interpreted, based on the passage on page 2, lines 20-28 of the application as filed, as hydrogen in the form of a quantum material (quantum fluid) in which adjacent nuclei are within much less than one Bohr radius of each other. In other words, the nucleus-nucleus distance in the ultra-dense state is considerably less than 50 pm.

The field source should be arranged to provide a perturbing electromagnetic field to the accumulation portion of the accumulating member.

***1.2 Clarity (Art. 84 EPC)***

The statement under item 1.1 specifies the term "*ultra-dense hydrogen*", corresponding to point I on page 1 of the Invitation, and the "*field source*", corresponding to points III and IV on page 1 of the Invitation.

Regarding the feature listed as point II on page 1 of the Invitation, it is respectfully submitted that this feature does not contravene Art. 84 EPC, for the following reason.

In the claims as filed, the hydrogen transfer catalyst is defined as *"having a material composition being selected to cause a transition of hydrogen from the gaseous state to an ultra-dense state"*. In the present case, the hydrogen transfer catalyst cannot be defined more precisely without unduly restricting the scope of the claims. Furthermore, the result – the transition to the ultra-dense state – can be directly and positively verified by tests or procedures known to the person skilled in the art, without undue experimentation. This feature is therefore not prohibited by Art. 84 EPC (see the guidelines F-IV, 4.10).

For this invention, the skilled person is a scientist or a team of scientists including an experimental physicist. Scientists are used to searching and consulting scientific publications and skilled in applying techniques described in relevant publications.

The skilled person (or persons) would be aware of, for example, the enclosed publication "Ultradense protium  $p(0)$  and deuterium  $D(0)$  and their relation to ordinary Rydberg matter: a review" by Leif Holmlid and Sindre Zeiner-Gundersen, Phys. Scr. 94 (2019) 075005 (26pp), in the following referred to as E1.

E1 describes (section 2) three different methods of detecting and characterizing ultra-dense hydrogen. Using one of these methods, the skilled person or persons can directly and positively verify the transition of hydrogen to the ultra-dense state.

### **1.3 Sufficiency of disclosure (Art. 83 EPC)**

On page 2 of the Invitation, it is asserted that the application is not sufficiently disclosed (contravening Art. 83 EPC) to such a degree that it is impossible to carry out a meaningful search regarding the state of the art for all the subject-matter claimed.

The applicant respectfully disagrees with this assertion, for at least the reasons set out below.

#### *1.3.1 The existence of ultra-dense hydrogen*

It is acknowledged that most of the work involving ultra-dense hydrogen has been carried out by a limited number of groups, notably in Sweden, Iceland, and Norway. This cannot, however, be considered to be an indication that ultra-dense hydrogen does not exist. There are numerous scientific publications that describe theory, detection, and characterization of ultra-dense hydrogen. For simplicity, E1 is referred to. E1, in turn, cites numerous additional references.

#### *1.3.2 Experimental evidence for accumulation of ultra-dense hydrogen in the apparatus according to the invention*

On page 2 of the Invitation, it is asserted that the application does not provide any experimental evidence for the actual obtainment and accumulation of ultra-dense hydrogen in the apparatus according to the invention. This assertion is not correct. As is stated on page 3, lines 19-23, it can be determined that ultra-dense hydrogen has actually been formed by irradiating the result of the catalytic reaction with a laser and then measuring the time of flight or velocity of the emitted particles. An example of such determination is described in detail under the heading "Experimental results" of the application as filed. The experimental evidence provided in the application as filed indirectly proves that ultra-dense hydrogen was obtained and accumulated.

Furthermore, as was mentioned above under item 1.2, different methods of detecting and characterizing ultra-dense hydrogen are described in the art (for

example E1) and can be applied by the skilled person or persons without undue experimentation.

### *1.3.3 Detailed step-by-step method*

On page 2 of the Invitation, it is asserted that the application does not include any detailed method of how to operate the apparatus according to the invention. This assertion is not correct. For an example configuration, the application specifies the gas and pressure used (D<sub>2</sub> gas pressure in a vacuum chamber around 1 mbar with constant pumping – page 14, lines 15-16), the temperature (heating the apparatus to transition the ultra-dense hydrogen from a super fluid to a normal fluid, which is known to be approximately 525 K for ultra-dense deuterium – see for example Figure 21 of E1), and the field source (pulsed laser with pulse length in the few nanosecond range. Both visible and infrared laser light give similar behavior. The pulse energy used for the typical experiments is of the order of 200 - 400 mJ – page 14, lines 17-21). The only non-trivial step or parameter that is not given in the application is the flow rate of the D<sub>2</sub> gas. The flow rate is, however, not a critical parameter. A wide range of flow rates will result in production of muons, and the determination of a suitable flow rate will therefore not require undue experimentation.

## **1.4 Summary**

Concerning the main request, it is thus submitted that the claimed subject-matter, with the indications given under item 1.1, is sufficiently clear (Art. 84 EPC) and sufficiently disclosed by the application (Art. 83 EPC) for a meaningful search to be possible.

## **2. First auxiliary request**

As a first auxiliary request (as provided for by the guidelines B-VIII, 3.2.2), the applicant requests the search division to search the subject-matter defined by the statement provided below.

As is correctly noted on page 1 of the Invitation, the present invention aims at providing a cheaper and more energy-efficient way of producing muons. According to the invention, this is achieved by an apparatus by which gaseous hydrogen passes a hydrogen transfer catalyst and is, following passage through the hydrogen transfer catalyst, subjected to a field provided by a field source. The essential features for achieving this aim are defined by the claims as filed using references to ultra-dense hydrogen. It is, however, possible to define the essential features without references to ultra-dense hydrogen, using the following statement according to the first auxiliary request:

1. An apparatus for generating muons, comprising:
  - a hydrogen accumulator including:
    - an inlet for receiving hydrogen in a gaseous state;
    - an outlet separated from said inlet by a flow path;
    - a styrene catalyst arranged along the flow path between said inlet and said outlet; and
  - an accumulating member for receiving hydrogen from said outlet at a receiving portion of the accumulating member and accumulating said hydrogen at an accumulation portion of the accumulating member, the accumulating member being configured to provide a downward sloping surface from said receiving portion to said accumulation portion; and
  - a field source arranged to provide, to the accumulation portion of said accumulating member, a field adapted to stimulate or induce emission of negative muons from the hydrogen in the accumulation portion.

This definition is clear, and the application as filed contains experimental evidence of the production of muons using a thus defined apparatus.

Concerning this first auxiliary request, it is thus submitted that the subject-matter defined by the statement is sufficiently clear (Art. 84 EPC) and sufficiently disclosed by the application (Art. 83 EPC) for a meaningful search to be possible.



### **3. Second auxiliary request**

As a second auxiliary request (as provided for by the guidelines B-VIII, 3.2.2), the applicant requests the search division to search the subject-matter defined by the claims as filed, with the following guidance taken from the description as filed:

The claim term "*ultra-dense hydrogen*" should be interpreted, based on the passage on page 2, lines 20-28 of the application as filed, as hydrogen in the form of a quantum material (quantum fluid) in which adjacent nuclei are within much less than one Bohr radius of each other. In other words, the nucleus-nucleus distance in the ultra-dense state is considerably less than 50 pm.

The hydrogen transfer catalyst should be understood to be either a styrene catalyst, or metallic catalysts such as iridium or platinum.


The field source should be understood to be a pulsed laser.

#### **4. Concluding remarks**

In view of the statements according to the main request and first and second auxiliary requests set out above, it is respectfully submitted that a meaningful search is indeed possible. In this context, the applicant would like take the opportunity to remind the search division that the guidelines (B-VIII, 3) state that the word "meaningful" must be construed reasonably. It is not to be construed in such a way that Rule 63 is invoked simply because a search is difficult or does not provide results that are significant for subsequent examination proceedings.

Yours faithfully,

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