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Editorial from the Editor in Chief

Where and whither fusion

Whither Fusion was the title of a talk given by J.D. Lawson that I had the pleasure to listen to more than 10 years ago. He used this occasion to publicly contemplate about the route fusion research had to take. Today fusion is at crossroads again. With great interest and enthusiasm the international scientific community has followed the development of the world's most powerful laser facility, the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) in the United States. This initiated similar large scale laser programs in other countries as well, like France, Japan, China, and others. At the same time we saw an unprecedented development in laser technology worldwide to provide high laser power. Today a peta-watt class laser is affordable even for an average university laser laboratory. The NIF-laser has its share in sparking this development. Now that the NIF laser is completed, it is fair to view it as one of the technical miracles of our time. As far as we know this laser works exactly to the design values like a Swiss clock. One scientific aim of this laser was to ignite a fusion target under controlled conditions in the laboratory. To this aim the most advanced simulation models were applied and the experiments were set-up according to the simulation requirements. The National Ignition Campaign was designed to achieve ignition last year. However, it did not work out. Nature has found a trick to circumvent the predictions of one of the most sophisticated simulation programs. Whether it is a lack of proper physics input to describe the hydrodynamics of fuel compression and mix, or insufficient control of the initial conditions, we do not know yet.

The scientific community now feels it to be very important that science programs continue to further our general understanding of high energy density matter. This requires advanced diagnostic methods to study the compression dynamics of a fusion target. High energy proton radiography is one of these options and is already pursued at a number of Institutes. Among them Los Alamos National Laboratory, where they have developed the method and apply it regularly with great success and the ITEP Institute (Institute of Theoretical and Experimental Physics) in Moscow and the Institute of Modern Physics in Lanzhou, China and finally the heavy ion Laboratory GSI/FAIR at Darmstadt where this method is just about to be implemented. At the upcoming IFSA Conference (Inertial Fusion Science and Application) in September 2013 in Nara, Japan the scientific community will discuss which route inertial fusion science will take in the future.

Not only "big science" will significantly contribute to fusion science, but also dedicated laboratory work in university laboratories. Some time ago we received a manuscript titled:

Direct observation of particles with energy >10 MeV/u from laser-induced processes with energy gain in ultra-dense deuterium. The manuscript was submitted by Professor Holmlid from the Gothenburg (Holmlid, 2013) University in Sweden. His claim was to have initiated fusion reactions in super high density deuterium by means of Nd:Yag laser with a power density of only 3×1012 Watt on target. The manuscript was reviewed with by the editorial board. One reviewer suggested outright rejection the other reviewer suggested having an immediate press release. Of course we were aware of previous claims with table-top fusion experiments. Nevertheless, the editor of this journal decided to visit the laboratory in Sweden to get a personal point of view of the experiment and the team as well. I made sure that this was a serious experiment. Professor Holmlid himself performed the experiment in my presence and I could see all the signals that are reported in the manuscript. Then we had approximately a full day of discussion. A major revision of the paper was suggested, with emphasis on the experimental results and an interpretation of the results by the author as conclusion.

A proof of fusion reactions requires the measurement of the respective neutron and proton spectrum. Here, however, a rather crude time-of-flight method was applied. A particle spectrum measured with Thomson parabola is viewed as standard in many of these measurements. High energy protons of 10 MeV are well above the Coulomb barrier and should induce pn and p2n reactions leaving radioactive Cu nuclei that could be detected in minute quantities. None of this is reported in this experiment. The super-dense Deuterium phase has been published in different journals, where I assume more expertise on this topic is available and here we rely on the peer reviewed publications of other journals.

After two revisions we decided the result of the experiment is interesting for the community to be discussed and be repeated in a different laboratory where the neutron and proton spectra may be measured simultaneously.

If we look for progress in fusion we cannot entirely rely on big programs like ITER and NIF. These two "big science" projects showed that they deal with difficult technological problems as well with physics issues that are not fully understood. Therefore serious research on all levels involving new ideas and university lab research must continue.

REFERENCE

HOLMLID, L. (2013). Direct observation of particles with energy >10 MeV/u from laser-induced processes with energy gain in ultra-dense deuterium. Laser Part. Beams **31**, 715–722.

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