Introduction to Ion Beam Experiments

The previous section dealt with measurements of particles, namely neutrons and light ions, which are emitted from LENR experiments. It is also possible and instructive to use ion beams to impact materials to probe what is happening before, during or after a LENR experiment. In these experiments, the measured particles are either scattered incident ions or particles that have been ejected from the target by impacts. There are three motivations for such beam experiments, which generally use protons or deuterons as the energetic probing ions.

First, the interactions, scattering and effects stimulated by the impact of beams of low mass ions can reveal much about the character of the target. This is true independent of LENR. A wide variety of experimental methods employing ion beams is available for material analysis. The methods often yield information on the composition, that is, the distribution of elements, as a function of depth into the target. These methods can be used for measurements of the results of transmutations in LENR experiments. For example, the paper by Yamaguchi et al in the section of these proceedings on transmutations used four ion beam technologies for their study of transmutations.

The second reason to fire ions at a target is to determine the conditions and dynamics of deuterons (D) within the target material. A few studies have shown that impacting deuteron beams with energies of about 100 keV onto D rich targets (such as TiD_2) yields evidence of three body (D-D-D) reactions. The count rates are very low. It is possible that modeling of such experiments will give information on the probabilities of two deuterons in the target materials being very close to each other at the time of impact of the incident deuteron. The billiard ball metaphor that is used in these experiments has been very convenient analytically but it depends for its appropriateness on the existence of the strong binding force that holds nuclei together. This permits the treatment of the weaker electromagnetic force as a perturbation. LENR experiments may be probing a part of phase space where little is known. Astrophysical observations have prompted investigations in the “low energy” realms.

Finally and importantly, ion beams with relatively low energies have been used to measure interaction cross sections (probabilities) that are much greater than expected on the basis of the cross sections for ordinary two-body collisions at higher energies. In such experiments, the beam energies are relatively low (a few keV) by usual beam standards. As a result, the count rates are also low. But, the quantitative data show that the cross sections are as much as an order of magnitude greater than expected. The data are interpreted in terms of the screening potential energy that would be required in the normal two-body collision theory to yield such enhanced cross sections. It remains to be seen if such interesting experiments are directly relevant to LENR. On one hand, they may be the high energy beginning (as the beam energy is decreased) of the greatly enhanced nuclear reaction probabilities seen in ordinary LENR experiments. On the other hand, energies near 1 keV are still over 10,000 times greater than the energy equivalent of room temperature (1/40 eV), where most LENR experiments are run.

The number of papers at ICCF-14 on beam experiments was small. They all had to do with the third of the above reasons for incident-ion experiments.

Kasagi heads one of the three groups that have measured enhanced nuclear reaction cross sections at low beam energies during the past decade. He presented an invited overview of low energy D-D reactions, and new data on the effects of H and D ions collisions on both solid and liquid targets. It was found that the liquid Li has a screening potential substantially higher (by 300 eV) than the solid Li target. That difference was interpreted as due to differences in ion screening, which was said to be much stronger than ordinary electronic screening.

One of the two German groups measuring enhanced low energy cross sections presented two papers at the conference. However, the results were already available in the literature, so they were not provided for inclusion in these proceedings. Drs Huke and Czerski presented the experimental and theoretical work they and their collaborators have been doing. Reports of what they did and found are available in three publications:

F. Raiola et al., Eur. Phys. J. A13 (2002) 377.
K. Czerski et al., Eur. Phys. J. A 27 (2006) 83.
A. Huke et al., Phys Rev. C78 (2008) 015803