Introduction to Photon Measurements

As with energetic particles, there are two kinds of LENR experiments involving photons. The first are emission experiments, in which the LENR cause electromagnetic radiation of some wavelengths to be generated. The second category of experiments involves irradiating part or all of a LENR experiment with photons for some purpose. The reasons for such illumination include (a) diagnosing what is happening in an experiment or else (b) controlling the output of an experiment.

It should be noted that most of the electromagnetic spectrum has been employed, one way or the other, in LENR experiments. That is, measurements and stimulation have ranged from gamma ray spectroscopy to the use of tera-Hz (THz) radiation to the employment of radio frequency radiation. X-ray measurements and probes have been used. The emission of light and infrared radiation has been measured. Scattering of optical radiation is a useful *in situ* probe of kinetics within an operating experiment. Laser light has been used to turn on and turn up the production of excess power in electrochemical cells. Two laser beams with difference frequencies of 1-25 THz have also been used to stimulate and control excess power production.

At ICCF-14, there were several papers on optical and x-ray measurements. Two of them involved the use of lasers to control experiments. One of those papers and another involved interactions of light with optical phonons in Pd. Another paper reported soft-x-ray emission during and after the operation of a glow discharge LENR experiment.

Tian and his collaborators used a 532 nm laser to trigger a D and Pd gas loading experiment. Even though they did not have high loading (D/Pd ratio), the authors report 2.6 kJ within half an hour, that is about 1.5 W average power. Remarkably, the wire used in the experiment, when irradiated with a 25 mW laser over 1 cm length spot, achieved a power density exceeding 10^4 W per cm^3 of Pd.

Letts and Hagelstein employed dual lasers to produce tunable difference frequencies in the Thz range. It was used to irradiate the Pd cathode in an electrochemical experiment. It is not known if the illuminated Pd is acting as a non-linear material and mixing the laser beams or some other phenomenon is occurring. Sharp peaks in excess power were found at laser frequency differences of 8, 15 and 20 THz. The first two frequencies are consistent with optical phonon frequencies in PdD. This indicates that such phonon modes are relevant to the mechanism for LENR in Pd.

Tsuchiya and his colleagues observed optical phonons in PdH and PdD using Raman spectroscopy. Raman peaks were found at 56 meV in PdH and both 57 meV and 59 meV in PdD. Note that 56 meV corresponds to 13.5 THz. Large effects, indicative of nuclear reactions, were not found in these experiments.

Swartz and his colleagues measured the spatial distributions and time histories of near infrared emissions from operating electrochemical cells. The observed infrared radiation was judged to be non-thermal because it appeared to be linked to an active cell’s excess heat production and not its physical temperature. It was asserted that the observations might confirm the Bremsstrahlung-shift hypothesis. The idea is that a temperature-controlled shift from penetrating ionizing radiation to infrared radiation from the surface of a cathode (within the skin depth) might accompany low-temperature nuclear reactions.

X-ray emissions from LENR experiments are frequently measured. Three papers found in other sections of these Proceedings include measured x-ray data. They are the paper by Karabut and Karabut in the section on Heat Measurements, the paper by Storms and Scanlon in the section on Particle Measurements and the paper by Kornilova in the section on Cavitation Experiments.

In this section, we include a paper reporting remarkable x-ray results. Karabut and Karabut measured x-ray emission in the photon energy range of 0.6 to 10.0 keV in glow discharge experiments. A wide variety of gases and cathode materials was used. The authors report the measurement of laser microbeams with 10^{-4} radian beam divergence, sub-picosecond emission times and x-ray powers of 10^7 to 10^8 W. Further, they state such emissions occurred within about 100 msec after turning off the discharge current.

More LENR electromagnetic emission and probe experiments are needed. There are many interesting reports that will influence (constrain) theories for the mechanism(s) active in these experiments. However, most of the experiments have not been adequately reproduced by other investigators, and many of them would benefit from the use of available modern apparatus for more sophisticated measurements.