The Satellite Symposium of the 20th International Conference on Condensed Matter Nuclear Science

A Report on the LENR Symposium in China Prior to ICCF20 in Japan

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Over the decades since Fleischmann and Pons announced their ability to produce heat energy from some unknown reactions, the International Conferences on Condensed Matter Nuclear Science have been a primary global forum for the field. The meetings were initially known as the International Conferences on Cold Fusion, with the abbreviation of ICCF, which has been retained. The primary topic of the field came to be called Low Energy Nuclear Reactions (LENR), although there are about 20 other names for the subject. The first 19 of the ICCFs had generally similar formats, with a few of them having one-day short courses at their beginning. A new arrangement was introduced for ICCF20, thanks to the initiative of Professors Zhong-Qun (ZQ) Tian of Xiamen University in Xiamen and Xing-Zhong Li of Tsinghua University in Beijing. The basic thrust was to have a meeting on LENR in China immediately prior to ICCF20 in Sendai, Japan. It turned out to be a very good idea.

The Satellite Symposium was held at Xiamen University in the coastal city of Xiamen, which is in southeast China, across the Strait from Taiwan, as shown in Figure 1.[1-3] The city of Xiamen has about 3.5 million people, and a pleasant climate that attracts many tourists. Xiamen University is 95 years old, and has about 38,000 students in 20 schools with many research institutes. It has a large and beautiful campus. Figure 1 shows the location of Xiamen, the complex geography of the region, and an image of part of the university campus. A super typhoon named Meranti struck Xiamen less than two weeks before the start of the Satellite Symposium, with wind gusts to 175 miles per hour. Extensive damage to trees on campus was evident at the time of the meeting. The damage caused no problems for the Symposium, because most of it was cleaned up before the meeting started.

Registration was held on September 28, and the sessions took all of September 29-30. The Symposium was very well organized and executed by Professors Tian and Li, a Local Organizing Committee with eight members, and an on-site team of seven very helpful young people. The two organizers of the Symposium were the Collaborative Innovation Center of Chemistry for Energy Materials (iCHEM) and the State Key Laboratory of Physical Chemistry of Solid Surfaces, both entities being part of Xiamen University (XMU). The three sponsors were the National Natural Science Foundation of China, the Huai'An Thinkre Membrane Material Co. Ltd. and XMU National University Science Park Development and Construction Co., Ltd. It is noteworthy that one national organization and two companies provided sponsorship of the Satellite Symposium.

About 50 scientists and others from five countries participated in the symposium. Most of us stayed at the Yifu Hotel on campus, a very pleasant place with excellent indigenous food. There were 23 presentations, three or four at one sitting, for the two full days. A poster session occurred at the end of the first day, with a marvelous banquet in a nearby Buddhist Temple after the second day. The organizers have already provided almost all of the graphics used by Symposium presenters on their website: http://ssiccf-20.xmu.edu.cn/download.asp. The conference photo in Figure 2 is from that site.

Figure 1. Maps showing the location of Xiamen in relation to Taiwan, and the location of Xiamen University just south of the heart of Xiamen City. A photograph of part of the large and scenic campus of Xiamen University.

Figure 2. The attendees and some staff of the Satellite Symposium.

This report might have been organized by topic. However, it will be presented by country and ordered by the number of presentations from each country. Hence, the following sections cover work from China, the U.S., France, Japan and India, after a summary of the Keynote Presentation by Professor Peter Hagelstein. His talk was entitled "A Perspective on Condensed Matter Nuclear Science." It was a selective overview of experimental results, mainly on excess heat, but including information on helium and tritium production, transmutations, and collimated X-ray and γ-ray emission.

The excess heat data exhibited by Hagelstein included early results from Fleischmann and Pons, which had a power gain of 20 at times during a long run. He also cited, and showed, data from six other laboratories. Hagelstein analyzed 217 papers from the Dieter Britz bibliography,[4] all of which had reported early negative results. Hagelstein found that only three had achieved conditions later known to be required for production of excess heat. So, he concluded that the "case for lack of reproducibility was oversold." Hagelstein went on to display many other instances of heat production. He emphasized the favorable roles of high temperature and the input of heater pulses during a run, both of which tend to increase LENR power output. The roles of nanomaterials and cathodes other than Pd were also discussed.

Hagelstein presented a great deal of data on helium production and its correlation with heat generation, and on the production of tritium, some data on neutron and proton emissions, and a few graphics on collimated emission of high energy photons and on transmutations. Hagelstein's overview of the field is a very good resource for those interested in evidence for the occurrence of LENR and the characteristics of such reactions. All of his graphics are available at the Symposium website given above.

LENR Research in China

The Symposium had a mutually-beneficial reciprocity. Chinese researchers involved or interested in LENR got to hear and interact with about one dozen foreign researchers, who came for the meeting. And, those of us from abroad enjoyed getting a wide and deep view of the many and diverse current LENR activities in China. They are summarized in the following paragraphs. Figure 3 shows the locations of Chinese organizations with LENR activities, which were presented at the Symposium.[5] It is not known by this author if there are other LENR research or commercialization activities in China.

There were nine oral presentations and four poster papers on experiments and theories by Chinese researchers at the

Figure 3. The cities and organizations performing LENR research in China, which were represented at this Satellite Symposium.

symposium. The first presentation from a Chinese laboratory was not directly on LENR. The organizers recognized the existing scientific and potential practical overlap between LENR and the storage of hydrogen in materials. Hence, they invited Dr. Ping Chen, from the Division of Hydrogen Energy and Advanced Materials at the Dalian Institute of Chemical Physics, to present on "Materials Development for Hydrogen Storage." She gave an excellent overview of hydrogen storage in inorganic materials including transition metal alloys, hydrides of light elements and systems containing metals, nitrogen and hydrogen. Strategies for materials design and development were presented, including adding metals to compounds, forming composites and making complexes of materials. Many examples of these processes were presented. Other applications of the processes were briefly considered. This paper had seven co-authors. Photos of 14 colleagues were shown, and collaborations with eight organizations were noted, including institutes in the U.K., Sweden and U.S. Funding from three agencies in China was cited. Dr. Chen stated privately that there are 35 hydrogen storage research groups in China.

There were two papers on high temperature Ni-H experiments. Such experiments have been pursued since the earliest days of the field. The work was initiated by Piantelli, and followed in succession by Focardi, Rossi, Parkhomov, Jiang and many others, including the Martin Fleischmann Memorial Project. Ni-H reactors are the most likely LENR sources to result in the initial commercial products.

Professor Hang Zhang is in the Qiuran Laboratory in Xi'an, China. His presentation was "Anomalous Heat Effects in Ni-H ($LiAlH_4$) Systems." He started by showing a schematic of the apparatus used by Professor Jiang, and gave results obtained with it. The time history of the pressure in the reaction vessel showed an initial rise because of the decomposition of the $LiAlH_4$, and then a decrease to a partial vacuum, followed by several increases due to provision of hydrogen gas from a bottle. The results included an excess power of "about 600 W," and a self-sustaining operation for over two days after power to the experiment was terminated. Next, Zhang described an improved apparatus, in which 34.1 g of Ni powder and 2.7 g of $LiAlH_4$ were heated to 1200°C. Anomalous power obtained over 31 hours was estimated to be 14 W. The results were repeatable in five consecutive runs in the two different reaction vessels. No radiation was detected above background levels in these high temperature Ni-H experiments.

The second paper on hot Ni-H experiments was a poster by Chongen Huang and five colleagues from Xiamen University. Their title was "A Pilot Study of the Ni-H High Temperature Systems." Their reaction tube was connected to a pump, hydrogen bottle and pressure gauge. Temperature was measured with a type K thermocouple and contact thermography. No excess heat was observed to date. However, inductively-coupled mass spectrometry indicated an isotope shift in Li in some experiments, without any change in the isotopic distribution of Ni. ^{6}Li increased by 5%, with a corresponding decrease in ^{7}Li. This group acknowledged support from the National Natural Science Foundation of China.

There were two other elevated temperature experiments reported at the symposium. The first was by Chang-Lin Liang and five colleagues from Tsinghua University, namely "Anomalous Heat Effect in Gas-Discharge Tube with Pd and D/H." A gas discharge was employed for 600 hours to co-deposit Pd with D or H in a thin film, which exhibited a metallic luster, on Pd wires inside of a glass tube 3-4 mm in diameter. The tube was then driven with DC power within a dewar. The approach involved *in situ* co-deposition, permeation and storage, all without contamination. During periods of glow discharging, temperatures suddenly rose, when they reached 115°C. The temperature jumps "occurred many times" with temperature increases of 2 to 20°C. Excess heat was generated more than 13 times, with the best power gain being of 86% average and 327% peak. The authors ended by stating, "Significantly, repeatable and very outstanding excess heat effect was obviously observed." Optical spectroscopy was employed to monitor the composition of the glow discharge plasma. The authors reported "no evidence for new elements such as He, etc. was observed." This research had multiple sponsors, including the Chinese Association of Science and Technology, the Ministry of Education, the Ministry of Science and Technology (Fundamental Research Division), the Natural Science Foundation of China and the Tsinghua University Basic Research Fund.

Gas discharge experiments were also reported in two posters by researchers from the College of Chemistry and Chemical Engineering of Xiamen University. In one of them, Chongen Huang and four collaborators discussed "A Preliminary Study on Ni-H Gas Discharge Systems." Following work at the company Defkalion Green Technologies, they constructed two Ni-H gas discharge systems. In a cell with a spark plug, they did not observe any excess heat. However, in a high voltage cell, 20 W of excess power was recorded, when the cell contained H_2 at a pressure of 0.2 MPa. That value was about 14% of the input power. With D_2, the Heat After Death (HAD) phenomenon was observed. But, the authors state "we cannot reproduce these phenomena."

The second poster on the gas discharge experiments at Xiamen University was by Miaohong He and Wei Hang with the title "The First Exploration of the Discharge Reaction between Ni-Foam and H_2 via Mass Spectrometry and Optical Spectrometry." These researchers used both DC (19.5 mA) and pulsed high-voltage (5 keV) discharges between nickel foam and a counter electrode in an atmosphere of H_2. Optical Spectrometry showed that hydrogen was excited to Rydberg States. Electro Spray Ionization Time-of-Flight Mass Spectrometry (called EI TOF MS by the authors) and Residual Gas Analysis (RGA) were used to monitor the gas in the experiment. No new species were found during the runs. The EI TOR MS was also used to measure the nickel foam before and after the experiments, and no differences were noted. The authors plan to reduce the surface oxide of the nickel foam before future runs.

The other presentations by Chinese researchers did not fit into categories. They ranged from an overview of work done at one university to consideration of applications of energy from LENR. Each is reviewed in the following paragraphs.

Jian Tian gave a review of "CMNS (Cold Fusion) Research in CUST," which is the Changchun University of Science and Technology. He covered three eras: 1990 to 2010, 2011 to 2016 and 2017 to 2021. Tian cited two important Chinese articles on LENR. The first was by Tian-hong Lu, "Research Situation and Controversy of Cold Fusion," which was published in the *Chinese Journal of Nature* in 1990. The second was published in the same journal in 1995 by Xing-Zhong Li, the Co-Chairman of this Symposium, with the title "Abnormal Nuclear Phenomena in Solids Containing Deuterium." During his presentation, Tian showed numerous photographs of complex experimental setups in well-equipped laboratories at CUST, in addition to excess heat results obtained with them. The review of the second era showed the Chinese response at Xiamen University, Tsinghua University, the Chemical Institute and CUST to Andrea Rossi's announcements in 2011. Funding was obtained by the group from the National Natural Science Foundation of China to perform hot Ni-H experiments. CUST measured 7.5 MJ/day, compared to 3.0 MJ/day reported earlier by Focardi. Those runs used temperature triggering. A new apparatus made at CUST employed current triggering. Excess power ranging from 1.04 W to 10.28 W was measured. Planned work at CUST will "try every other possible *attempt* to find 'excess heat.'"

A paper entitled "Excess Heat Measurements in $Pd|D_2O+D_2SO_4$ Electrolytic Cells and $Ni|H_2$ Systems" was presented by Professor Wu-Shou Zhang in memory of Professor John Dash. He showed electrochemical loading data indicating that pre-electrolysis in an open cell is an effective way to activate a cathode. Data he presented at ICCF15, obtained by using that procedure, gave excess power values of 120 and 220 mW. Interestingly, Zhang showed data for a "stable" excess power of 96 mW over 5 to 7 hours with a relatively small loading ratio of D/Pd = 0.62. In another run, he got excess power of 120 mW for 8 to 10.5 hours with a loading ratio of 0.58. A very useful summary of the success rates with four different pre-run treatments was provided. For those four processes, excess heat was obtained as follows (success/attempts): 5/21, 11/22, 21/37 and 3/6. The large number of runs (86) is noteworthy. Post-run analyses of cathodes with an Energy Dispersive Analysis X-ray (EDAX) detector in a Scanning Electron Microscope (SEM) indicated some appearance of silver. In summary, Zhang noted that temperature and surface roughness are significant for excess heat production, but there is "no clear correlation with D/Pd or current density." Zhang then showed the activities and results obtained in many hot Ni-H experiments. Calorimetric results for 15 runs were shown. The excess heat values scattered about zero, ranging from -0.23 % to 0.45%. The breadth and depth of the LENR research being done by Zhang's group are significant.

A poster paper by X.Y. Wang and six colleagues from two institutes of the Changchun University of Science and Technology was titled "Excess Heat Triggering by 514 nm Laser in a D-Pd Gas-Loading System at Low Apparent Loading Ratio." Almost all of the earlier laser triggering work in the field was done in electrolytic loading systems. This paper is noteworthy because laser triggering was done in a gas loading system. The laser power was 40 mW and the excess heat 63 mW, even though the loading ratio was low. EDAX measurements in a SEM indicated the appearance of Ag and Sn after the experiments.

Dr. Farong Wan from the University of Science and Technology in Beijing dealt with "Response of Gas Bubbles to Electron Irradiation in Aluminum." He began by reviewing the bubbles produced in sonoluminescence experiments. But, his paper was on the bubbles produced inside of metals that are bombarded with high fluxes of H or D ions. The work was initiated in 1989 by Kinoshita *et al*. Dr. Wan and his colleagues prepared thin Al films for Transmission Electron Microscope (TEM) analyses. The foils were next ion implanted to high doses of either H or D, and then examined in the TEM. It was seen that both the H and D implanted samples exhibited electron diffraction patterns indicative of polycrystalline Al. Earlier data were interpreted as an energy release due to D-D fusion causing melting and recrystallization of a small region of the Al sample. But, the present results, which included evidence of recrystallization in H-containing samples, ruled out D-D fusion. The author attributed the melting to "plasmatization" of gas in the trapped bubbles due to electron beam irradiation in the TEM.

A poster paper by Professor Lin Xishi of the Guangzhou Tonghe Cold Fusion Energy Laboratory was titled "The Principles and Applications of Cold Fusion." It was published in the third issue of *Modern Sciences* in 2014. The posting on the Symposium web page is 33 pages long. It gives background on the journal and this author. That paper states: "In 1995, he found in an experiment that seawater of a certain concentration can produce heat when irradiated in a high-frequency electric field at a certain frequency, so he seized the physical phenomenon discovered by chance, and made further research. After 10 years of painstaking research and communication, he finally summed up a set of special theory, established power generation technology belonging to cold fusion technology..." The paper has a section on design of a 150 W cold fusion generator. It, and the abstract for this paper, discuss applications for the propulsion of ships, cars and even small aircraft.

There were three theoretical presentations by Chinese researchers. For one, eight scientists from two departments of Tsinghua University gave a paper "Hydrogen-Lithium Low Energy Resonant Electron-Capture and Bethe's Solar Energy Model." The lead author was Professor Xing-Zhong Li, and Gui S. Huang presented the paper. The paper had three parts: (1) What atoms participate in LENR (the three-parameter formula), (2) How do LENR happen (selective resonance tunneling) and (3) What is the reaction probability (Bethe's solar model). The first section was a review of Professor Li's three-parameter formula for the fusion cross section of light nuclei. In the second section, selective resonant tunneling was invoked to rule out one reaction ($^6Li + p \rightarrow {}^3He + {}^4He$) and argue for another ($^6Li + p + e \rightarrow {}^7Li$ + neutrino). Finally, a method in Bethe's solar energy model was employed to obtain an equation for the reaction probability and its temperature dependence. The final reactions and their energies were given as $^6Li + p + e \rightarrow {}^7Li^*$ + neutrino + 6.468MeV and $^7Li^* \rightarrow T + {}^4He$ + 4.001MeV. These ideas ought to be testable by varying the concentration of Li in LENR experiments.

Song-Yuan Ding and two other authors from Xiamen University offered a theoretical paper "A Hypothesis of Stimulated Surface Phonon Emission Contributed to Low-Energy Nuclear Reactions." It dealt with these topics: (1) Insight from optical properties of nanoparticles, (2) Insight from phenomena far-away-from equilibrium, (3) A new physical model, (4) Atomic vibrations of Pd-D atomic chains, and (5) Predictions. The first topic considered the question "How to prepare an emission state (with input unit energy ~70 meV) outside Coulomb barrier and resonantly coupled with a well in nucleus reaction region?" A gold nano-particle in a microcavity was offered as the means of answering that question. Coherent excited phonon states with localized anharmonic vibrations were touted for preparation of coherent excited vibrational states. The harmonic and anharmonic characteristics of various linear chains of Pd and D atoms were considered. The authors envisioned three mechanisms: (1) a coherently excited local anharmoic phonon state, (2) resonant coupling of the coherent phonon state with a nucleus reaction state in a nucleus well, and (3) heat released by lattice vibrations. The authors suggested an experiment containing nanomaterials supporting mid-infrared localized surface plasmons for H-Ni or D-Pd. A specific design was noted, namely Al:ZnO, Ga:ZnO, n-GaAs, n-InP and n-Si nanoparticles embedded in or directly on the Ni or Pd foam film, with the whole system encapsulated with a metal cover in order to form an infrared cavity.

Professor T.S. Wang of Lanzhou University gave the third theory paper from China. It was entitled "Experimental Study of Sub-Coulomb Barrier Fusion Reaction of Light Nuclei in Various Environment." He noted various factors that affect the Coulomb barrier, including the materials employed and their phases and density, plus temperature. Much of his presentation dealt with electron screening and its effects on nuclear reaction cross sections.

Near the end of the Symposium the Co-Chairman Professor Tian and ten colleagues from Xiamen University offered "Some Preliminary Thoughts on Abnormal Phenomena of Condensed Matter Loaded with D/H." The paper began by noting the very high threshold for performing research on Condensed Matter Nuclear Science. One problem is the production and characterization of LENR active sites within bulk materials. The team then went on to consider experimental reproducibility, including (a) the positive and negative roles of impurities, and (b) required actions, including sample preparation, pretreatment, loading and characterization. Many options for the several actions were listed. The irreversible character of loading materials with H or D was noted, and the point made that nano-structures are easier to regenerate between experiments by dissolution of the old nano-materials and their re-synthesis. Examples of shape-controlled production of Pd and bimetallic nano-crystals were shown. Nickel nano-crystals were also considered. The last part of the paper considered how to trigger LENR synergistically, including new coupling in a non-equilibrium state, the subsurface region and nanostructures, and a combination with inertial confinement fusion. Triggering was judged to be "underestimated." At the end of the presentation, the authors listed the six approaches to LENR research that have been pursued at Xiamen University since 2011: (1) Fleischmann-Pons electrolysis systems, (2) laser pulse triggering, (3) Ni-H high temperature systems, (4) metal nanoparticles related to ICF, (5) mass spectroscopic analysis and (6) theoretical exploration.

LENR Research in the United States

Seven scientists from the U.S. gave talks at the Symposium. Five of the papers were either on theory or experiments motivated by theory. They are reviewed first.

Professor Peter Hagelstein presented a paper with Irfan U. Chaudhary entitled "Thoughts about New Basic Physics Experiments in Condensed Matter Nuclear Science." This paper was a continuation of their theoretical research on the interconversion between one large (keV to MeV) nuclear quantum and many small (meV) vibrational quanta in solids (phonons). The authors provided a relativistic formulation for phonon-nuclear coupling, and applied it to a homonuclear diatomic molecule of two atoms of ^{181}Ta. That isotope was chosen because it has a very low energy nuclear level at 6.24 keV with an electronic (E1) multipolarity. Reasons for this choice were provided. A potential experiment was described. It involves a radioactive ^{181}W source on a vibrating beam made of ^{181}Ta. That W isotope would decay to ^{181}Ta. To quote the authors, "Stimulation by vibrations has the potential to cause excitation transfer," meaning that they "would expect less emission at the location of the source." Emission of 6.24 keV photons at the location of the ^{181}W and along the beam without and with vibration could indicate excitation transfer due to phonon (vibrational) coupling to the nuclei.

The possible experiment just described is not the first experiment to be designed by Professor Hagelstein to test the coupling between vibrational and nuclear levels. An earlier such proposal is already being tested in an MIT laboratory by Florian Metzler, Hagelstein and Suyuan Lu. Metzler is a Ph.D. student in the business school at MIT, who works with Hagelstein on that experiment. He presented a paper with the title "Experimental Effort at MIT to Study Phonon-Nuclear Coupling," with the sub-title of "Seeking X-ray Emission from Ultrasound-Induced Nuclear Vibrations." That experiment aims to measure energetic radiation from the up-conversion of many small vibrational quanta. Metzler reviewed four earlier LENR experiments that gave evidence, which might be due to such up-conversion, and reviewed Hagelstein's theory relevant to that process. The experiment seeks to measure X-rays with energy of 1.5 keV due to decay of an excited nuclear state in ^{201}Hg that is pumped by the phononic up-conversion. Work to date has included the design of vibrating plates, computation of their modes of vibration and associated frequencies, development of a system to measure frequencies, and matching of the plate resonances to the resonant frequency of the ultrasound transducer. The necessary overlap between the frequencies of plate vibrations and the transducer frequency has been achieved, and the efficiency for coupling of transducer energy into the plate vibrations was measured. The MIT group built and tested an energy-dispersive X-ray detector that is responsive from 1 to 20 keV. The system will be used in coming weeks to seek correlations between mechanical vibrations and emission of energetic radiation.

Professor Hagelstein also had a poster on "Statistical Mechanics Models for PdH_x and PdD_x." It dealt with the occupancy of the octahedral (O) and tetrahedral (T) sites within Pd. He produced a generalized Lacher-type model for O-site and T-site occupation, and found that it is not possible to account for alpha-phase solubility data without T-site occupation. This approach enables modeling of H/Pd and D/Pd above unity loading. It showed that the phase diagram is not physically reasonable without T-site occupation. The model is consistent with neutron diffraction data. The O-site to T-site excitation energy at low loading was obtained.

Another theoretical presentation was by Daniel Szumski, an independent scholar from Davis, California, entitled "So

You Want to Design a Cold Fusion Electrode." He envisions interactions and energy exchanges between nuclear levels, similar to those between molecules within solids, and treats them as an "imperfect" thermodynamic process. Szumski applied this approach to analysis of the transmutation data published by Miley and his colleagues. Five classes of nuclear reactions are considered. Electrode designs were offered, for which addition of particular isotopes during excess heat runs would have predictable effects. Those results were obtained with a computer program based on the "Least Action" principle. That dictates each step of the multi-step reaction process involve the smallest mass or energy change. Applications for excess heat production, isotope production and stabilization of radioactive waste were noted by Szumski. There are two concerns with this line of research. The relatively minor one is the lack of computed rates of postulated reaction sequences, when such rates are central to any of the three applications. The major concern is the assumption that multi-body nuclear reactions can occur at low temperatures, for example $^{61}Ni + ^{107}Ag + 2\ ^{2}H$ to give ^{172}Yb. There is no experimental evidence for such reactions, and they are highly unlikely theoretically.

The last theoretical presentation from the U.S. was by Dr Melvin Miles of the University of LaVerne in California. It was entitled "The Eyring Rate Theory Applied to Cold Fusion." He started by noting that thermodynamics shows that fusion reactions are possible at room temperature, and have large, negative Gibbs energy. Going beyond thermodynamics to kinetics, the Eyring theory applies to rates of processes, including ordinary chemistry, electrochemistry, diffusion and viscosity. Miles determined numerical values for the kinetics of two deuterons reacting to form ^{4}He, including the Gibbs energy change, the change in enthalpy and the activation energy. The last of these is similar to the activation energy for diffusion of deuterons in Pd. That led Miles to postulate that "the D + D fusion reaction in palladium may be controlled by the diffusion of D atoms (or D+ ions) into some fusion reaction zone." He went on to note that the potential fusion reaction zones include two near-surface possibilities, the primary double layer in the electrolyte near the surface of the cathode, which might be rich in Li+ ions, and a secondary layer immediately within the cathode materials, which has high concentrations of both electrons and deuterons.

There were also four experimental presentations at this Symposium by researchers from the U.S.

Dr. Miles gave another paper entitled "The Fleischmann-Pons Calorimetric Methods and Equations." He started by noting that the methods used by the originators of the field are still important today. They were part of the early controversy, and are still poorly understood by most scientists. When correctly applied, the methods are very accurate, and they have potential applications to other electrochemical studies. Miles emphasized that temperature measurements limit the accuracy of calorimetry, which is part of the reason CalTech, MIT and Harwell did such poor measurements in their early, publicized and damaging studies. He detailed the terms in the equations needed to understand the performance of an isoperibolic calorimeter, and gave many graphics with data showing their variations. Miles went on to describe the setup and results of a recent 13 day run he made with a Pd cathode in a 0.1 M KNO_3 electrolyte. The experiment produced excess heat after four days, which later peaked at about 72 mW. Cooling rates were obtained after the experiment was terminated. At the end of his presentation, Miles listed 11 factors that are important in attaining calorimetric accuracy with Fleischmann-Pons methods. He asserted that calorimetric errors as low as 0.01% (0.1 mW) can be achieved.

Professor George Miley has been a central actor in the LENR field for a long time in several roles. Now, he is pursuing commercialization of LENR in the company LENUCO, which is funded in part by Industrial Heat LLC. His paper was titled "LENR Reactions Using Clusters." His presentation covered four topics. First, he reviewed earlier work on thin-film electrolytic experiments. That part included secondary ion mass spectra taken before and after electrolysis. Then, Miley went on to discuss pressure loading of composite nano-particles of Pd in a ZrO_2 matrix. He showed time histories of temperature differences due to first pressuring the 47 g samples and then pumping out the D_2 gas. Results from about 200 runs were shown. Data on characterization of the samples was also given. The third part of this presentation dealt with hydrogen clusters produced by plasma treatment of materials. The idea is to produce large numbers of lattice defects that can trap hydrogen to form clusters. Finally, Professor Miley provided a concept for a LENR-based reactor. A group photo showed seven members of the LENUCO team.

Michael Halem is an investor in Brillouin Energy Corporation. According to their website, Brillouin has two technologies:

1. A low temperature system operating at up to 150ºC based on an electrolytic (wet) process. Brillouin Energy's WET™ Boiler systems can supply low temperature thermal energy for space and water heating, and other common low temperature industrial purposes such as for food processing or healthcare applications.
2. A high temperature system operating at 500ºC to 700ºC based on applying high-pressure hydrogen gas to the core. Brillouin Energy's HYDROGEN HOT TUBE (HHT™) Boiler systems can supply high temperature process heat and can also be used to generate electricity in much the same way as fossil or nuclear fuels generate electricity.

Halem is also a very capable technologist, who has been making measurements on the Brillouin HHT™ system at both the company's location in Berkeley, California and the SRI International laboratory in Palo Alto, California, and then analyzing the resulting data. His presentation, "Validation of Brillouin Energy Corporation Hydrogen Hot Tube Experiments," provided the results of his on-going assessment of the high temperature system. Halem's abstract stated that the "results show with very high confidence excess energy output above chemical" reactions. He stated that nuclear reactions yielded "12 to 20 watts over an 18 to 20 hour period several times during the spring and summer of 2015." The power input was stated in his presentation to be 80 W.

This reviewer presented a paper entitled "Another Approach to Reproducing Reported LENR Excess Heat." The essence of that methodology is to repeat experiments that have reportedly resulted in significant excess heat with a substantially improved suite of measurement equipment.

The author and student colleagues are performing electrolytic experiments with nickel cathodes in light water electrolytes. Such experiments were done in the early 1990s, some with very strong excess heat results. In addition to thermometry and planned calorimetric methods, this group is using several diagnostics, not common to LENR experiments. They include Impedance, Optical, Radio-Frequency, Acoustic and Electrical Noise Spectroscopies, each over broad frequency ranges. The last of these methods is very sensitive. It might be able to detect the occurrence of LENR at levels far below what can be measured with a calorimeter. The Lattice Enabled Nuclear Reaction (LENR) Energy and Spectroscopy Laboratory in The George Washington University in Washington, DC has been in operation for only six months.

LENR Research in France

There were two presentations by French scientists, each very different from the other, one theoretical and the second experimental.

Dr. Jean-Francois Geneste is the Chief Scientist of AirBus, the large international defense and aerospace manufacturer in Europe. He is relatively new to the LENR field, and has introduced a completely novel theoretical approach to explaining such reactions, "Symmetry, Entropy and Order." His first presentation on LENR was described in his Symposium presentation in China as follows: "In the Toulouse conference of the ISCMNS in October 2015, we have presented a theory of LENR which is based on combinatorial games theory." The current paper, with Dr. Jenny D. Venko of the Hydrogen Energy Research Agency, focused on the differences between symmetric views of matter from within a material system and dissymmetric views of the same system from outside of the system. Dr. Geneste described the existence of a problem in the material world, which he proposed to solve by "introducing in physics non-Archimedean geometry." That is an unfamiliar mathematical concept. The complexity of this approach is compounded by Geneste then invoking something called the Banach-Tarski paradox, another mathematical idea, which is called a "paradox" only because it is counter-intuitive. It is proven mathematically that the surface of a sphere can be broken up in such a manner that it can then be put back together in a different way to yield two identical, but smaller copies of the original. The authors of this paper then stated, "Now, if we consider an isolated system we can write the Boltzmann equation. Applying the Banach-Tarski paradox to this equation in the space of phases implies that we have infinite energy!" The ideas underlying this paper have been published in a book by Dr. Geneste.

Jean-Paul Biberian retired as a Professor at Marseilles University. But, he remains active in the field by doing experiments in his home laboratory, and by serving as the Editor of the *Journal of Condensed Matter Nuclear Science*. In his presentation at the Symposium in Xiamen, he gave status reports on six different experiments in his private laboratory. A brief summary of each of them follows.

1. Nickel powder and alloys in hydrogen or deuterium gas. Four materials, two powders and two foils have been tested, but no excess heat has been measured.
2. Diffusion of deuterium gas through the walls of a palladium tube with a mass flow calorimeter. Here, again, Biberian has no evidence of heat production.
3. Microwave excitation of carbon powder. A reactor designed and built by Dr. George Egely of Hungary is used to process carbon powder. The goal is to detect transmutations. Biberian is looking for a laboratory to perform quantitative analyses on the processed carbon.
4. Plasma electrolysis with tungsten cathode or anode at high voltage and high current. This is a replication of experiments performed and reported on by three researchers. Dr. Tadahiko Mizuno (Japan) measured both excess heat and production of hydrogen by using a tungsten cathode in a K_2CO_3 light water electrolyte. Dr. Yuri Bazhutov (Russia) also reported large excess heat production, with an energy gain of six, with a tungsten anode in a NaOH light water electrolyte. And, Dr. Pierre Clauzon (France) got an energy gain of two, also with the NaOH electrolyte. To date, Biberian has measured only 10% excess energy with a DC system. He will soon use a pulsed system. However, he has already measured "large quantities" of Ca in the powder in the bottom of the cell after a run.
5. Electrochemistry in an ICARUS-9 type calorimeter with palladium cathode in D_2O+LiOD electrolyte up to boiling temperature. In this experiment, the goal is to measure excess heat using a Fleischmann-Pons type calorimeter. The first 60 day run at 200 mA did not exhibit excess heat. Another run is in progress.
6. Solid-state electrolytes using $LaAlO_3$ as electrolyte in deuterium gas. In this experiment, the material conducts protons or deuterons, with vacancies playing an important role. Excess heat up to 45% was observed in deuterium experiments, but not with hydrogen. The experiments are "totally reproducible." Biberian has been using large crystals of the $LaAlO_3$. He is about to perform such experiments with powders of the material.

LENR Research in Japan

There is a great deal of work on LENR in Japan, with an active Japanese Cold Fusion Research Society. But, there was only one presentation by a Japanese scientist at this Symposium. That was probably due largely to ICCF20 occurring in Japan the following week. That one presentation ("Anomalous Heat Generation and Nuclear Transmutation Experiments at Condensed Matter Nuclear Reaction Division of Tohoku University") was by Professor Yasuhiro Iwamura of Tohoku University in Sendai, the co-chairman of ICCF20. It contained four parts, and involved several organizations and many researchers. Figure 4 shows both the organization of the Condensed Matter Nuclear Reaction Division of Tohoku University and the research plan of the Division.[6] The vertical dotted line marks the present time. That is, the two-pronged energy and transmutation program is nearing the midway point of the four year effort.

Iwamura is well known in the field for transmutation results in deuterium permeation experiments. Now, he is performing energy generation experiments in addition to continuing transmutation studies. The first excess heat experiment is based on successful experiments by Dr. Tadahiko Mizuno of the company HEAD. It is a collaboration with Clean Planet, Inc., which is headed by Hideki

Yoshino. The experiments involve exposure of Pd and Ni nanoparticles to deuterium gas at temperatures of a few hundred degrees centigrade. Excess powers near 6 W were obtained for a 7 W input, or a power gain near 80%. The results were taken as a confirmation of Mizuno's earlier data.

The second excess heat experiment is another replication, this one involving both D_2 and H_2 gas exposure of Ni-based binary nanocomposites. The work is a collaboration with Technova, Inc., Kobe University, Nissan Motors, Kyushu University and Nagoya University. This line of research was pioneered by Professor Akito Takahashi of Technova and Professor Akira Kitamura of Kobe University. Oil flow calorimetry was employed to measure excess heat from $Pd_{0.04}Ni_{0.31}Zr_{0.65}$ materials prepared by melt spinning, followed by oxidation of the Zr to coat the Pd-Ni nanoparticles. Excess power near 6 W was obtained with these procedures. Results from Tohoku University (0.57 eV/D) were very near those gotten at Kobe University (0.56 eV/D) with materials from the same batch. These parallel experiments and their good agreement are noteworthy. In addition, coincident increases in the pressure and temperature in the gas within the reaction chamber were measured in the experiments in Sendai.

The third part of Professor Iwamura's presentation sought confirmation of the presence of ^{141}Pr by use of Rutherford Back Scattering (RBS). That element was reported in earlier work to be a transmutation product from the operation of LENR on Cs. In the current work, ^{40}Ar was used for RBS measurements of ^{141}Pr. The existence of the Pr isotope was reported with a small statistical significance. This research is being done at Tohoku University.

The last part of the paper from Japan involved transmutation experiments on stable isotopes of Pd, Zr and Se. These experiments are precursors to later experiments on LENR involving radioactive isotopes found in fission reactor waste. As in earlier transmutation experiments, thin films of Pd containing layers of CaO were used. An anomalous increase in mass 114 was found, which "could suggest transmutation of Pd" due to D_2 gas permeation. These transmutation experiments are being done with Mitsubishi Heavy Industries, Ltd.

Overall, the excess heat experiments by the Condensed Matter Nuclear Reaction Division of Tohoku University are going well, but the transmutation experiments there have yet to attain the strong results reported by Mitsubishi Heavy Industries, when Iwamura was a scientist there.

LENR Research in India

Early in the field, there was a great deal of research on LENR (then "cold fusion") in India. Over 50 scientists worked on the topic at the Bhabha Atomic Research Center (BARC) in the months following the Fleischmann-Pons announcement in 1989. One of the leaders of that effort was Dr. Mahadeva Srinivasan. He has continued to contribute to the field over the years, even though the BARC program was terminated in 1990. This year, Srinivasan organized a meeting on LENR of a dozen Indian laboratories. A few have actually begun experiments.

At this Symposium, Dr. Srinivasan gave evidence of an extraordinary possibility, namely the daily production of tons of transmutation products by LENR. His presentation was entitled "Observation of Anomalous Production of Si and Fe in an Arc Furnace Driven Ferro Silicon Smelting Plant at Levels of Tons per Day." It was authored by C.R. Narayanaswamy, former owner and Managing Director of Silcal Metallurgic Ltd. in Tamil Nadu, India. The plant run by the author produced about 25 tons of Fe-Si steel daily by use of a very large electric arc furnace operating at 12 kVA and 30-60 kA to melt steel scrap, wood charcoal and quartz. Srinivasan reminded the Symposium attendees of past reports of transmutations induced by arc experiments. An accounting of the masses of input and output materials at the Silcal Metallurgic Ltd. plant indicated that the operation produced about three tons of excess Si and one ton of excess Fe daily. Such production would have been accompanied by release of massive amounts of energy, which was not observed. That obviously casts doubt on the reported transmutation rates.

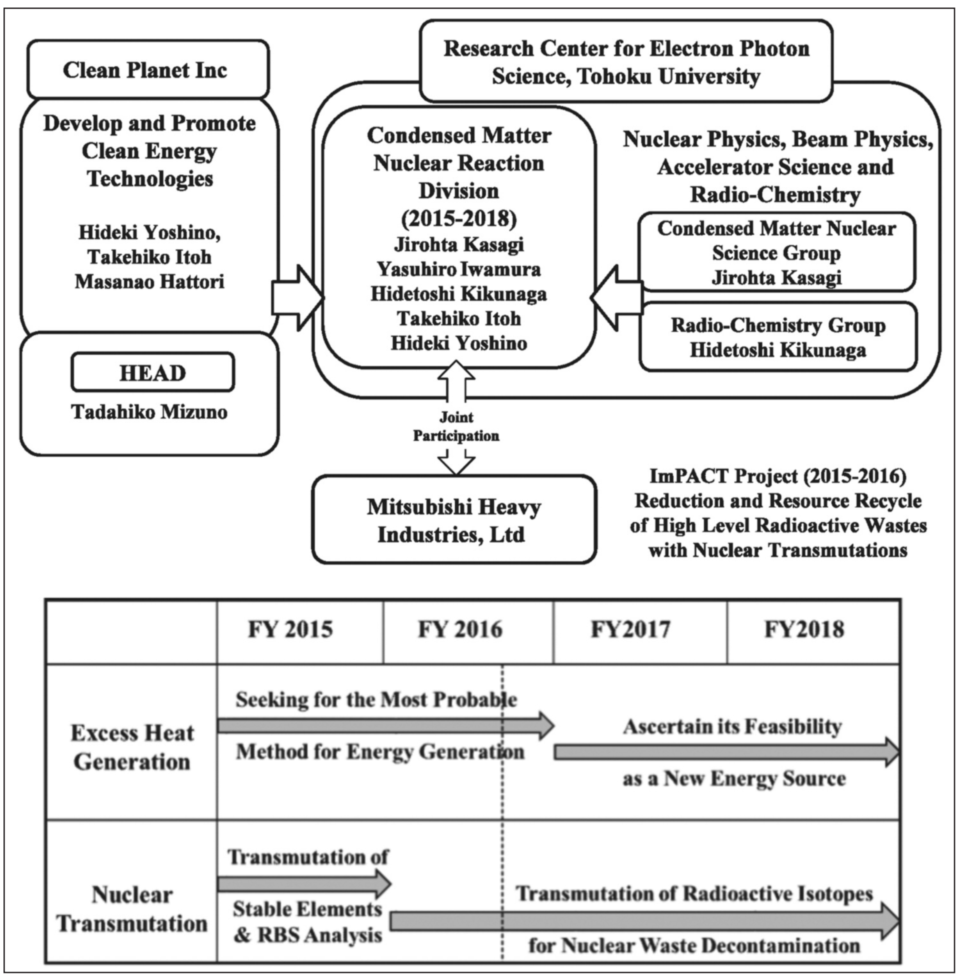

Figure 4. The relationships and schedule for the Condensed Matter Nuclear Reaction Division.

The plant no longer operates. Unfortunately, the author of this paper did not retain samples for isotopic analysis. Srinivasan expressed interest in contacting operators of any other Ferro Silicon plants to obtain samples for testing, and to do detailed accounting of their materials and energy flows.

Conclusion

This outstanding Symposium was organized by two individuals with deep roots in the field. Professor Tian did his Ph.D. studies with Martin Fleischmann. His topic was Surface Enhanced Raman Spectroscopy, another discovery attributed to Professor Fleischmann. Professor Tian has been involved in LENR research for more than a quarter of a century. Professor Li participated in most of the ICCF conferences, and made many contributions to the field. About the only negative aspect of this Symposium was the fact that his health prevented Professor Li from participating in the meeting. The many colleagues who admire and respect him wish him a fast and full recovery.

Numerous Chinese organizations are working on LENR, including institutes, which have not been noted so far. For example, the paper on laser triggering was done by scientists from the Laboratory of Clean Energy Technology and the School of Life Science and Technology within Changchun University of Science and Technology. The reader is referred to the Symposium website, which has almost all of the presented graphics, for more examples of institutional work on LENR.

The breadth and depth of the research on LENR in China made this reviewer wonder about a Chinese equivalent of the very successful Japan Cold Fusion Research Society, which meets annually [http://jcfrs.org/indexe.html]. Such a society in China might promote more rapid understanding and applications of LENR.

The fact that most of the presentations at this Symposium were from either China or the U.S. brought to mind another idea, namely Sino-American collaboration on LENR. Both countries use immense amounts of energy and are in great need of sources of clean energy. Further, it is clear that speeding the development of LENR in both countries would promote global welfare. The Symposium showed that government and other support of LENR research in China is diverse and has a relatively long history. When similar acceptance of LENR as a legitimate topic for scientific research is achieved in the U.S., it might be possible to make LENR an example of cooperation between China and the U.S. This has precedence, for example, in the cooperation between the Soviet Union and the U.S. for operations in space. The possibility of such a bilateral collaboration takes nothing away from important LENR research in other countries.

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References

1. http://www.globalsecurity.org/military/ops/taiwan_strait.htm
2. http://isecs.xmu.edu.cn/venue.jsp
3. http://english.xmuoec.com/shownews.ashx?news_id=107
4. http://www.dieterbritz.dk/fusweb/papers.pdf
5. https://www.travelchinaguide.com/map/
6. Y. Iwamura presentation at the Satellite Symposium

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