This page describes the Arata experiment, in order to facilitate understanding, replication and/or criticism. If you edit it, please add your source and date. This information may be made public-domain at some point (unless someone offers a rationale for not doing it).

Previous Work

Y Arata and Y. Zhang, “The Establishment of Solid Nuclear Fusion Reactor,” Kouatsu Gakkai (high temperature society) 2008. He provided a partial translation of that paper in English. (Rothwell, May 24)

Papers in J. High Temp. Soc. Jpn (in Japanese: Kouongakkai), Febr. And March issues 2008. (Arata, May 22, Takahashi, May 25)

Full list of Arata's work extracted by Lietz from Britz' full CF bibliography

Experiment

Arata and Zhang demonstrated very successfully the generation of continuous excess energy (heat) and generation of helium-4. They used ZrO2-nano-Pd sample powders under D2 gas charging. Demonstrated live data looked just similar to the data they reported in papers of J. High Temp. Soc. Jpn, Febr. And March issues 2008. This showed the method highly reproducible. (Arata, May 22)

The new experiment uses a steel cell about 20 cm tall and 3 cm in diameter. (I do not have the dimensions in writing but I saw the cell.) A sample of zirconium oxide with palladium nanoparticles in (ZrO2*Pd) it is placed at the bottom of the cell. In some tests, an alloy of Zr*Ni*Pd is used. The cell is initially evacuated, and at room temperature. (Rothwell, May 24)

Pd nano-particles (about 5 nm diameter) are distributed inside about 50-100 micron ZrO2 particles. (Takahashi, May 25)

In my understanding of their paper, Arata used a Pd tube regulating D2 gas flow from 100 atom D2 source to remove any He-4 in the source D2 gas
and to control flow rate. They believed there remained “no” He-4 in D2 flow after filtering through the Pd tube which was set before the cell inlet. For the blank run with H2 gas, no He-4 particles were detected. (Takahashi, June 1)

Highly purified deuterium gas is pressurized in an external tank to about 100 atm, and then injected into the cell in a high powered jet stream of gas, for about 10 minutes. The gas is in the jet stream is ionized and much of it is instantly absorbed by the material. The gas is not absorbed by the steel vessel walls. Much of the gas is absorbed by the Zr-Pd target. Gas pressure rises gradually after the flow is DISPUTEDLY cut of, as the sample degasses.(Rothwell, May 24)(No cut-off, says Takahashi, May 25, and again, May 29)

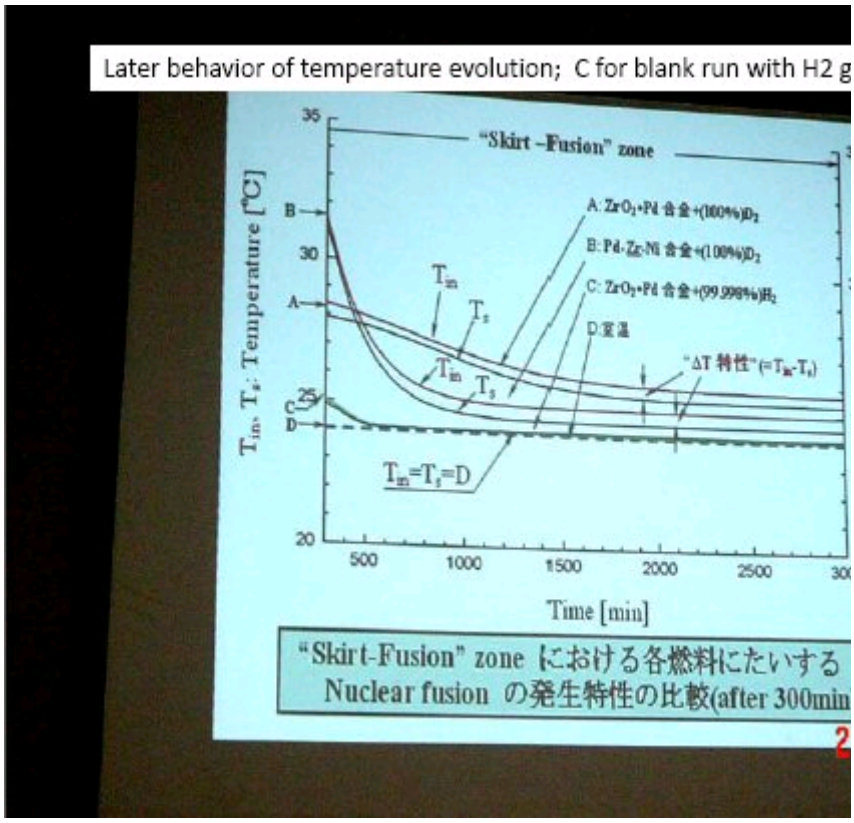
Zhang said, "they used D2 flow rate 20 cc per min", at the occasion of demonstration. (Cited by Rothwell, May 29)

Heat generation

Heat production begins immediately. Heat production begins with a large burst lasting as long as the gas stream is injected. The temperature rises to about 70°C. Arata says this is caused by a combination of chemical and nuclear reactions. After the gas flow is shut off, the cell remains warm for 50 hours, gradually cooling. It would probably remain significantly warm for 100 hours, although they have not continued the experiment this long yet. During the second phase, the temperature in the center of the cell remains significantly warmer than at the outer cell wall, typically about a half-degree Celsius. This half-degree temperature difference remains about the same during the 50 hours of the run.(Rothwell, May 24)

Arata thinks that the heat from the second phase is entirely from a nuclear

reaction. In one example, the first phase produced 4.4 kJ (at a rate of 18 kJ/hour, or ~5 W), and the second phase produced ~250 kJ (at ~4 kJ/hour, ~1 W). (Rothwell, May 24)



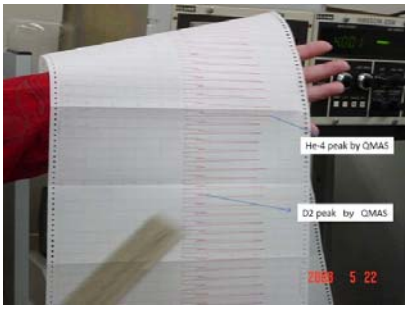
Room temperature is 24°C. A ZrO2*Pd sample with D2 begins phase 2 at 28°C and over 3000 minutes (50 hours) falls to ~26°C. A Zr*Ni*Pd with D2 begins phase 2 at a higher temperature, 32°C, but the temperature declines more rapidly at first, to ~26°C after 700 minutes, and thereafter to 25°C at 3000 minutes. A ZrO2*Pd sample with H2 begins phase 2 at 25°C (just above room temperature) and falls to room temperature after ~200 minutes, with no changes thereafter. (Rothwell, May 24)

With the D2 samples, there is a persistent half-degree temperature difference between the center of the cell and cell wall, but no difference with the H2 sample. From this, I surmise that a 1 W heat flow produces a ~2°C temperature difference between ambient and the center of the cell, which is reasonable. There is no input power, so the signal to noise ratio is very high. (That is to say, laboratory grade equipment can measure a 2°C temperature difference with high confidence.) The cell is wrapped in insulation, as shown in the photo at LENR-CANR news. The graphs show that ambient temperature is controlled to within ~0.1°C. The facility is modern with laboratory grade HVAC, and first-class equipment, much better than most other Japanese national university labs I have visited. (Rothwell, May 24)

Helium generation

DISPUTED: Helium is produced in the same ratio to the heat as with plasma fusion (No, says Takahashi, May 25 !). However, the Zr-Pd sample has to be baked out after the run, to recover all of the helium. (Rothwell, May 24)

Amount of helium-4 factorx10~17 corresponds to 0.5 to 1 Mega Joules, by 23.8MeV/He-4. (Takahashi, May 25)



Control experiments

* Hydrogen with the Zr-Pd target. The cell heats up in the first phase. After the gas stream is turned off, it cools down. There is no significant difference between the cell center and outer cell wall. Arata think the heat comes entirely from a chemical reaction. Helium is not produced.
* Deuterium with no Zr-Pd. No heating effect or helium is observed. Gas pressure rises immediately in a straight line, and stops rising as soon as the gas flow is cut off.
* Hydrogen with no Zr-Pd. The same result as with deuterium. (Rothwell, May 24)

Discussion of the experiment

Deuterium is trapped in regular PdD lattice (x=1.0) by Arachi et al paper with microscopic analysis with SPring8 X-ray beam, and D/Pd ratio in average is about 2 by macroscopic (total absorption) analysis by Yamaura et al paper (they thought deuterons are trapped in interfaces). This sample nano-composite and D trapping (maybe dynamic) states seem to be of key for continuous He-4 producing reactions. (Takahashi, May 25)

Arata has calculated the amount of heat (~250 kJ), so he must have done some sort of calibration. Note that even without a calibration the comparison control experiments prove there is heat. (Rothwell, May 24)

Arata believes that highly pure deuterium is the key to success, and also, by the way, that helium contaminates the surface and must be removed in order to keep the reaction going. (Rothwell, May 24)

In this configuration, Arata uses pre-purified deuterium so that the cell can be operated starting at room temperature, without an auxiliary heater.In previous work, he used the DS-cathode configuration outer shell as a hydrogen purifier. The disadvantage was that it had to be heated to ~200°C with an auxiliary heater to allow the hydrogen to pass through the shell. The other advantage of the new configuration, not mentioned by Arata in this lecture, is that the nanoparticles of palladium do not sinter together as they did with Pd-black. The zirconium, which is 90% of the material, keeps them apart. (Rothwell, May 24) The underlying physics for producing heat and He-4 is considered to be same between the former method and the new method. Biberian-Armanet could replicate partially

heat generation, without observing (not tried) He-4, using Pd-black powders which had much larger averaged particle size (about 100 nm) to be speculated that the CMNS effect was much less than ZrO2-Pd-nano-composite which Arata used for the former method also. (Takahashi, May 26)

Other comments

A small electric motor is placed next to the cell, and powered by a thermoelectric generator that when there is a large temperature difference between the cell and ambient. Arata neglected to describe it during the lecture, although it was shown in a diagram. Apparently it is a proof of principle device. As far as I could tell, he neglected to mention several other details, such as the method of calibration, and the nature of the chemical reaction in the first phase. (Rothwell, May 24)

The high operating temperature, instant response and reliability of this device make it the most practical form of cold fusion yet developed. The small amount of palladium is also a major advantage. As far as I know, all of the tests with Zr-Pd targets and D2 have produced heat immediately and predictably. It may not be possible to turn off the reaction instantly, but this is no impediment to practical applications; it is not possible to turn off the heat from burning coal or uranium fission either. The reaction stops gradually as the sample degasses. It might be possible to force it to degas more rapidly, by raising the temperature and pumping out the cell.(Rothwell, May 24)

The key result of Arata this time is the long lasting heat generation without input power associating helium-4 generation. This is essential to making R&D further for energy source application. (Takahashi, May 25)

Criticism, open issues

On the face of it, the graph above proves nothing. It only shows that Pd-Zr-Ni reacts more rapidly with D2 than does ZrO2-Pd. The behavior of H2 is anomalous and makes no sense. The only important evidence would be a graph of He generation superimposed on this graph. Without this comparison, the figure means nothing. (Storms, May 27)

It seems that both H and D give a "chemical" heat generation at the first of each experiment. And Arata uses the long term heat generation of the D for the argument that nuclear events are happening. However one would expect that even the generation of chemical heat from D may be slower than H due to the mass differences. Was there any attempt to integrate the total energy out H and D and compare the total heat including the initial chemical heat? It looks like the initial chemical heat was just ignored. The real question is the total integrate heat generation. (Cravens, May 28)

Looking at Arata's mass spectrometer plots, it's hard to tell what is happening. Was there convincing production of He4 at the demo? Where do we get with Arata's 'belief' that nuclear processed were involved in certain phases of the process, without supporting analysis? His graph from the mass spectrometer provides no evidence at all, possibly because only a brief time interval is represented. Obviously the He concentration from background sources can't actually be ZERO, and a proper presentation would give an upper bound, taking into account all potential sources of He, which is after all present in the atmosphere in significant quantity. Even if He4 can't enter _with_ the D, could the observed amount of He4 have been stored up somewhere in the apparatus and released by some mechanism or another during the expt.? And even then, we need to know what 'no' He actually means. (Josephson, May 31)

Other

The group includes: Arata, Zhang and Wang with two technicians. (Takahashi, June 1)

There came about 60 people from universities and companies in Japan and few foreign people (including Jed Rothwell). 6 major newspapers and two TVs (Asahi, Nikkei, Mainichi, NHK, et al.) were there. Mr. N. Yabuuchi took video of lecture and demonstration experiment. (Source: Arata, May 22)

In contrast to the substantial number of mass media persons attending, very few [Japanese] newspaper has actually published in this morning the article on the event. Among several newspapers found in my University Library, I have noticed the article only in Nikkan Kogyo Shimbun (The Business and Technology Daily News).(Kitawura, May 23)

A video recording Arata's lecture and some feature of demonstration may be uploaded in the JCF web-site. (Takahashi, May 25)

Arata said that he would be ready to speak (in English) the same at ICCF14, if invited. (Takahashi, May 25)

DISPUTED: His lecture was difficult to follow, even for native speakers. (Rothwell, May 24) (No, says Takahashi, May 25)

There is an entry on PhysicsWorld blog. Physorg.com, on Gizmodo and on SlashDot, IndiaPR, Azonano .

There's been an amazing response to the PhysicsWorld blog: nearly 80,000 people have looked at the article, and over 60 have made comments (a new record for Physics World). (Cartwright, May 30, cited by Josephson, May 30) Jed had to buy more GB from his service provider to cover the download bytes from lenr.org. (cited by Josephson, May 30)

The day of this lecture, May 22, was Arata's 85th birthday. There is no doubt that Arata is a genius, even though his lectures are, to put it politely, not well organized, and he is a character. As he often does, he passed out a book in Japanese listing his many honors and accomplishments, which include 70 patents, the first plasma fusion reactor in Japan, several major breakthroughs in welding and other high temperature industrial processes (essential to the Shinkansen and other major technology), dozens of awards including an international award in his name, a building named in his honor at Osaka National University, and the highest national award bestowed by the Emperor. (Rothwell, May 24)

I believe his collaborator Chang (sometimes transcribed Zhang) did the hands-on work in this experiment. She is assisted by three grad students from China. They seem highly competent but regrettably I did not have much time to speak with them or observe the experiment first-hand. (Rothwell, May 24)