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Cold Fusion: “You have to embrace this”

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”You just have to embrace a new technology that might solve the energy problems of mankind, at least until it can be rejected,” Swedish professor Sven Kullander said in a scientific discussion on the Italian ‘energy catalyzer’.

(Swedish version here. Italian translation here. An English transcript of the video above can be found below this article).

Ny Teknik invited Professor Emeritus at Uppsala University Sven Kullander, chairman of the National Academy of Sciences Energy Committee, and Hanno Essén, associate professor of theoretical physics and a lecturer at the Swedish Royal Institute of Technology and chairman of the Swedish Skeptics Society to participate in a scientific discussion on the Italian engineer Andrea Rossi’s so-called ‘energy catalyzer’.

(The ‘energy catalyzer’, demonstrated to invited scientific observers in January, is producing heat by an unknown reaction. The device’s reactor is loaded with nickel powder in the presence of secret catalysts, and pressurized with hydrogen. When the device is ‘ignited’ by the application of heat through an electrical resitance, a reaction emitting about 10 kilowatts of heat output starts. Rossi’s hypothesis is that the energy derives from a nuclear reaction in which a nickel nucleus captures a proton (the hydrogen nucleus of) to form copper. This could be regarded as”cold fusion”.)

NyT: What was your first thought when you read about this?

Essén: What struck me were the differences compared with the past. There have been many failures in the context of fusion. It started with Pons and Fleischmann *(a famous experiment in 1989 which could not be repeated)* and more recently we’ve had bubble fusion, which also was connected with irregularities (in the scientific methods).

So this area is very affected by such events. But what appeared to be different this time was that another physicist, Giuseppe Levi, was allowed to test the process independently, measuring input and output power.

And it seems repeatable. And there is a device. And now it has been tested for a longer time. That’s a big difference that seems crucial.

(NyT: On 10-11 February 2011 Giuseppe Levi performed a new unofficial test of Rossi’s device. The test lasted for 18 hours. Read about the test here).

Kullander: Many people have believed and argued that it is not possible to get energy out of the Bologna-experiment *(a fusion between a nickel nucleus and a proton)*, but since I at the beginning of my research career measured the separation of protons, and the binding energies of the outer shells, and matching of the protons’ momentum in nuclei up to nickel, it was easy to see that the process is quite feasible kinematically *(i.e, a reaction that emits energy, if it occurs)*.

It is easy to calculate this, but we have gotten so used to schemes of how to make energy from fission and fusion that perhaps we may have difficulty accepting an energy yield from strongly bound nuclei.

NyT: Kullander here is referring to the fact that nuclear reactions that provide energy lead to iron in the periodic table because nuclear particles of iron are most heavily bound -- the binding energy per nuclear particle of iron is highest among all the elements. In nuclear reactions it is the binding energy that is extracted: When particles are bound more heavily, binding energy is released. Therefore, energy is released when you split large nuclei down to iron -- this is called fission and is used in nuclear power plants. Similarly, energy is released when you fuse small nuclei up to iron -- this is called fusion. This rule, however, is only valid for nuclei of about the same size. In this case there is a nucleus of nickel with heavily bound particles, and a lone proton – the nucleus of the hydrogen atom -- which is completely unbound. If the proton can be captured by the nickel nucleus it will be heavily bound (whereby nickel is converted to copper) and the binding energy is released. This is what is meant by the reaction’s being kinematically possible -- if it really occurs energy will be released.

Kullander: The second thought was that it is impossible -- and so it seems to nearly everyone who has worked with dynamics of nuclear reactions -- that the reaction occur between a free proton and a nickel nucleus with 28 positive charges, and therefore it must have been something else. But we need not exclude a priori that a nuclear reaction actually take place supported by any suitable catalyst.

NyT: Kullander refers here to the fact that both the proton and the nickel nucleus are positively charged and therefore repel each other by electrostatic forces. This is called the Coulomb barrier. According to most physicists temperatures of millions of degrees are required to give the proton and nickel enough kinetic energy to overcome the Coulomb barrier. He then mentions some physical phenomena and theories, including muon-catalyzed fusion, in which the Coulumb barrier has a decreased importance.

Kullander: I think we have to consider the experimental facts and not indulge too much in speculation about what could happen in theory. We must be sure that they make

measurements and observations as accurately as possible, and that the experiment is able to be repeated by independent researchers -- that's not possible in this case *(the catalysts in the device are secret)* -- but you have to rely on Rossi that he is true to what he conveys, and through discussions with him we may try to conclude how reliable the measurements are.

If this is true, it’s big, and one might have acted similarly (keeping some parts secret as Rossi has).

But the patent must be approved and there must be enough data -- all data must be published so that independent researchers can repeat the experiment. Then we can begin to sift through theoretical speculation and proceed to seek explanations.

Essén: Then it will become science. When this comes out it there will be a lot of research done, and then I think we’ll understand it too, within a year or so.

NyT: How credible do you consider the information presented is?

Essén: It’s very hard to guard against someone who is lying in this context. It’s almost impossible for us to know. You try to evaluate the physics and then you assume that the data is presented as honestly as possible.

As a physicist you do this. Then as a human you can always have all sorts of sociological and psychological reflections on what lies behind it all.

But if Rossi’s information is valid, it is sensational.

Kullander: Well, I think they used a fairly scientific approach. But above all that they have heated a building and have done so for one year (according to Rossi), and have run the experiment for ten hours without any electricity other than 80 watts to power the instruments *(the most recent experiment in Bologna on 10-11 February)*.

Previously, all problems of cold fusion have been that it was intermittent, it worked for a while and then stopped. But this time it seems that they have continuous (power), and have attained consistent results in repeated tests. That also makes it interesting.

NyT: You have both had the opportunity to send questions directly to Rossi via email, and have received replies. What impression have you got from this dialogue?

Kullander: Well, it has reinforced my impression that he is serious. I find that he is an interesting person to talk to, and I find it hard to imagine that he has indeed created a scam.

Essén: I get the same impression. It seems very unlikely that it is a pure fraud.

NyT: What are the main uncertainties you see in the material?

Essén: A nuclear physicist at Lund’s University whom I have been talking with, Peter Ekström, thinks that there are far too little gamma quanta. (The process) doesn’t match normal nuclear physics. It would not be enough with a few centimeters of lead shielding, it would take 80 cm of lead to shield from the radiation, if it were a normal nuclear physics.

Kullander: Peter Ekström is right in this objection, that the absence of gamma quanta is one thing that you want clarified. The conservation of energy and momentum requires a high-energy photon.

NyT: In a subsequent conversation Kullander notes that the energy generated, if a proton is captured by the nickel nucleus, should be of the magnitude of 3.5 megaelectronvolts and sent out as a high-energy gamma photon. This should result in strong gamma radiation and no heat.

Rossi says instead that the emitted radiation is weak, resulting from particle decay linked to so-called weak interactions.

NyT: Then what could the physical explanation be?

Essén: A plasma of only electrons and protons could be formed in some way close to the metal surface. I’ve been doing a lot of theoretical studies of plasmas and their thermal statistical mechanics when taking in account magnetism, which very few others have done. And some very strange things happen there.

Firstly, it looks as though, when approaching thermal equilibrium, you get strong currents and strong magnetic fields. And maybe then you get very high speeds and possibly some relativistic effects.

And when approaching the speed of light the Coulomb barrier is not so interesting because magnetism and Coulomb are of about the same order of magnitude. Thus it lowers the Coulomb barrier.

It is my speculation, it is the only thing I can guess that it is relevant here.

NyT: But don’t you still have the problem with absence of gamma rays?

Essén: Well, basically you do. There’s a lot to take into account --quantum mechanics, statistical mechanics, electrodynamics... It is easy to get lost somewhere. So I hardly believe that someone can calculate it.

NyT: It sounds like there is a very large area of uncertainty here, in which the explanation could be found?

Essén: Yes, definitely. Plasmas have never been well understood. The theories are still very weak.

Kullander: Rossi and Focardi speak about an extension of the nucleus -- that is where the forces from the nucleus act -- of two fermi (femtometer), but it can be much more. The outer shells can reach up to maybe ten fermi.

My explanation could be that extremes in both atomic physics, molecular physics and nuclear physics interact, plus that Rossi has chosen an element with high affinity, high ability to bind (hydrogen), and that he has been adept at maximizing the nickel surface.

One should also keep in mind that the nickel nucleus which has a positive charge of 28 units, is extended. And far out, maybe 20 fermi from its center, a single proton arrives which can be bound by nuclear forces, whereby energy is released.

NyT: What is the reaction to this work of Rossi’s among people you have talked to?

Essén: It’s about 50-50. Many who are skeptical present the same argument that all fusion researchers do -- the Coulomb barrier cannot be overcome. It is a bit oversimplified, I think.

Kullander: I have spoken with physics colleagues. Most are quite critical and do not believe in the experiment, but I have also heard statements such that it could involve a molecular resonance.

But being a researcher and encountering such a great new development that might help solve the energy problems of mankind I just have to seriously analyze the realism

of the proposal, at least until it can be rejected.

NyT: Do the skeptics believe that it is pure fraud and fake?

Essén: Yes, they mention, for example a man called Randell Mills, who has been working a long time with something he tried to get funded. I do not believe in it at all. His website doesn't convince me. And hydrino would be that the hydrogen atom would collapse and release energy whereby the electron should get closer to the nucleus. It completely contradicts the uncertainty principle. So I don't believe in that at all.

NyT: What is the difference between such a phenomenon that you don't believe in, and Rossi's invention?

Essén: Well, I know of no independent reports of energy production, such as the study Levi did, and I don't know that he sells any devices. That's the difference.

Kullander: Hydrino sounds like a very unlikely process and conflicts with quantum theory. Proton capture in nickel nucleus, however, I accept, but at a low level of probability. It's kinematically possible, but dynamically hopeless.

The first criterion, that it can occur kinematically -- meaning that it's an exothermic reaction (which produce energy), and not endothermic (requiring energy) -- is in any case satisfied.

NyT: Would you see any natural environment where this process could occur?

Kullander: Yes, the universe. What is interesting is that all elements in the universe initially were built up by fusion. There was only hydrogen and helium from the beginning. And then there were successive fusions, hydrogen became helium, helium became bohr, and a sequence of fusion processes with formation of carbon, magnesium, silicon, sulfur and so on up to iron.

But when the elements arrived to form iron, there could not be more fusion (between roughly equal-sized nuclei) because the elements around iron (and nickel) are the most heavily bound of all elements. To form heavier elements a new mechanism took place of neutron capture and successive beta decay. And in that way all the heavy elements in the universe up to uranium were created.

So the reaction of the Bologna researchers ought to be called a cosmic reaction. For they start with the most heavily bound of all elements. They cannot reach higher elements with conventional fusion, instead proton capture with subsequent beta decay is involved – it's proton capture and not neutron capture as when heavy elements are formed in stars.

And something that I found thought-provoking in an earlier publication of Rossi and Focardi from 2008 was their hypothesis about what might happen in the nickel-hydrogen case, the nickel-58 isotope captures a proton, becoming copper-59, transferred to a nickel-59 through beta decay, then the chain continues on to nickel-60, nickel-61 to nickel-64.

Thus nickel is not consumed; according to Focardi and Rossi it passes on during the processes to heavier isotopes. Nickel produces energy with hydrogen, but only binding energy is used.

This explanation shocked me as completely unreasonable, but it also gave me a vibe. It is a process that happened (and happens) during element formation in stars, but then neutrons were captured in a chain that led to creation of all elements heavier than iron, up to uranium. And at very different temperatures than in Bologna!

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READ MORE: *Our complete coverage on Rossi's E-cat can be found here.*

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Transcript of the video above:

Mats Lewan: *We're sitting here at the Ny Teknik's newsroom and have had a conversation about the 'energy catalyzer' that is invented by the Italian engineer Andrea Rossi, and is a device that produces energy with something that appears to be a kind of fusion reaction, but maybe we should not call it that.*

With me I have Professor Sven Kullander and Associate Professor Hanno Essen who we've been talking with, and I'd like to ask you Sven to try to summarize what you think ... what are your considerations on this invention, what do you think about it and how you think we should look upon it at this moment.

(The transcript is edited by Kullander):

Kullander: In this case, you have to believe in the inventor Rossi, who says he has been producing heat without any input of energy except for what you have inside the device. Thus, 100 kWh in ten hours.

And in addition, he has heated a building in Bologna for a year.

And then, the reaction itself, namely the proton capture of nickel, is something completely new in the cold-fusion context, and it should therefore not be dismissed without further investigation.

But the problem is that Rossi, and to some extent Focardi, won't release any details. It is unknown what the reactor looks like inside, what substances it contains, the patent is not approved, so therefore the experiment cannot be repeated. And therefore the process cannot be scientifically grounded.

The question now is the reliability of the information we have been supplied. But I think we need to continue to monitor the development, because if the experiment would turn out to be true, it gives mankind new ways to gain an additional energy source.

Mats Lewan: What is it that makes you think it may be credible despite the lack of some essential pieces of information?

Kullander: Well, partly because he says it, partly because it is a process that is kinematically perfectly possible *(a reaction that produces energy if it really occurs)* and partly because he has optimized (the process) in different ways. In the case of nickel powder, for example, he has maximized the surface to optimize the adhesion of hydrogen. On point after point, he has behaved rationally in order to optimize the experimental conditions. On the other hand we cannot from molecular physics and nuclear physics find an acceptable explanation. We need to get more data from the experiment before we can start thinking about explanations.

Essén: What I think is important in this context is that for the first time, so to speak, there is a device which is made in many units and which is being sold, and has been tested by independent people -- input, output -- how much energy that comes in and how much that comes out, in circumstances which these people have controlled.

And that has not happened before in this context. So the physicist Levi believes in this, and the physicist Focardi believes in this, and I believe (their credibility) is above all doubts. It is of course difficult to assess the inventor Andrea Rossi, but there are enough people involved, and enough good data and reports to make it look very seriously at this stage.

Mats Lewan: You have both had the opportunity to send questions directly to Rossi via email, and have received replies. What impression have you got from this dialogue?

Kullander: Well, it has reinforced my impression that he is serious. I find that he is an interesting person to talk to, and I find it hard to imagine that he has indeed created a scam.

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