Experiments at the TU Einhoven and other places have created a plasma and UV radiation of as yet unknown origin. A dissident quantum theory predicts 'hydrinos', an exotic form of hydrogen atoms which tap into a new source of energy. Nasa and the ESA have already conducted studies on hydrino-based rocket propulsion. According to experimentalist Gerrit Kroesen "We are not on a mission to confirm the theory: we continue to search for alternative explanations."

Enst van Eijk

"I hope I don't get into trouble for giving this interview", laughed experimental physicist Dr Gerrit Kroesen during my visit to him at the Technical University of Eindhoven (TU/e). The experiments which he carried out and which he intends to continue with, appear, in fact, to support a very controversial and wholly new theory of physics, developed by Dr Randell Mills, who claims that hydrogen, in the form of 'hydrinos', can form an exotic, large-scale energy source.

Kroesen remembers the crucial moment well: "It took a long time for the glowing filament to reach the right temperature, but, at at certain point, we clearly saw plasma forming. It gave off a bright white light, visible to the naked eye. We observed phenomena for which we had no ready explanation."

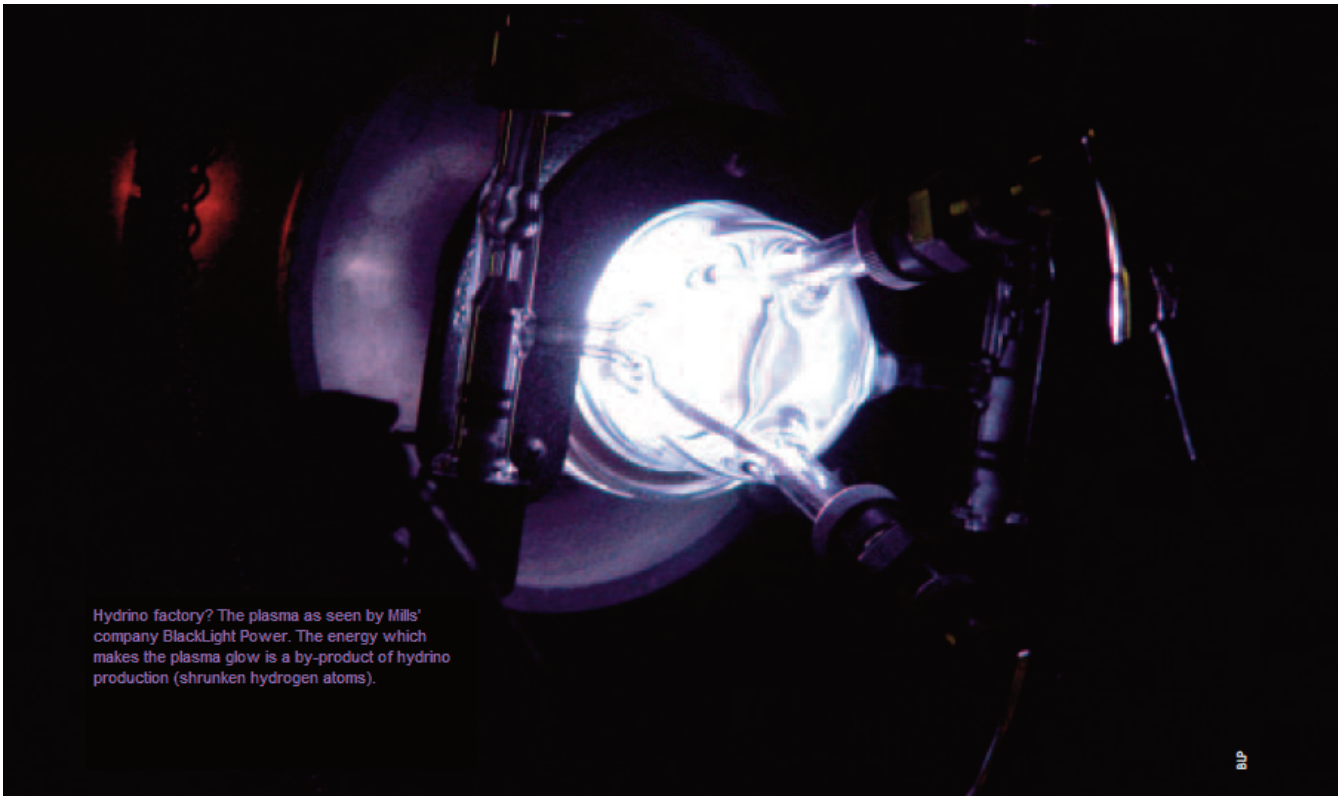
Kroesen is naturally concerned about any hype of the sort associated with 'cold fusion' towards the end of the eighties. At that time it was not Mills, but the German physicist Dr Johannes Conrads who took the question seriously. Conrads was one of the first outsiders who, albeit after his retirement, began experiments into this subject from a laboratory in Bochum.

Contrary to all expectations, Conrads quickly obtained very promising results. Given the right catalyst (a substance that facilitates a chemical reaction without itself being consumed), such as kalium or strontium, the reaction yielded an unusual amount of energy from hydrogen - exactly as predicted by Mills' provocative atomic theory. Kroesen said: "Hans Conrads was director at two of the largest German research institutes and one of the most respected plasma physicists in the world; thus, if he said that anomalous effects occurred, you can be sure there was no nonsense involved. During my conversations with Conrads, it became clear that something was going on, and that it was worth further investigation."

Voltage "We duplicated Hans Conrads' setup here at the university", explains Kroesen, "We conducted the first session with him." The setup consists of a transparent cylinder containing hydrogen gas at approximately one thousandth of atmospheric pressure and a gauze fitted with a layer composed of a Kalium compound. The gauze is folded in a cylindrical shape around a wolfram heating coil. Applying a current to the heating coil quickly made it glow red like a toaster, but not hotter than about 1100 degrees Celsius. This causes the kalium to vaporize and mix with the hydrogen gas. Moreover, it is known that hydrogen molecules which collide with the wolfram surface of the heating coil can split into two free hydrogen atoms. Up until this point energy has been fed into the cylinder and, according to conventional theory, nothing odd should be happening; but according to the hydrino hypothesis, a plasma should indeed form. A plasma is the most energetic form that matter can assume. Any substance into which sufficient energy is fed, through heating for example, goes through the stages of solid, liquid, gas and, finally, plasma. In the plasma state some of the atoms split into a positively charged remnant of the atom (ion) and a negatively charged electron, which can move freely through the plasma. A thunderbolt consists of plasma, as does the sun and all the other stars in the universe.

"Conrads increased the current in the coil", continued Kroesen, "but nothing happened at first. He asked if we could apply more heat. Unfortunately we weren't able to. 'Then we shall just have to wait', said Conrads. Then, at some point, we actually saw a bright white plasma that seemed to form by means of an unknown chemical reaction between kalium and atomic hydrogen. In a control experiment using natrium, which strongly resembles kalium chemically, but should not react catalytically according to hydrino theory, no plasma was formed. Strontium however, which is a catalyst according to the theory, did produce a plasma. Plasma is normally formed electrically by the application of a high voltage of several thousand volts to a gas rather than by chemical means." A fluorescent light, for example, works on the same principle of applying high voltage to a gas. "But our heating coil only had a voltage of at most fifty volts across it", continued Kroesen, "which is much lower than the discharge voltage of the gas mixture at the given pressure. So, it is unlikely that the weak electric field of the heating coil was the cause of the plasma."

This conclusion was also strengthened via another line of argument: "After we had switched off the heating coil, the plasma continued to glow for one or two seconds after that. If the plasma had been caused by the electric field around the heating coil, then the plasma should have vanished within milliseconds of it having been switched off. The two seconds during which the plasma continued to glow cannot be reconciled with the duration in which an electric field of this sort vanishes – but is understandable in terms of the timeframe during which the coil cools off to the extent where it can no longer split hydrogen molecules. It is therefore not the electric field, but rather the presence of atomic hydrogen, together with the catalyst, which



Hydrino factory? The plasma as seen by Mills' company BlackLight Power. The energy which makes the plasma glow is a by-product of hydrino production (shrunken hydrogen atoms).

explains the formation of a plasma", concluded Kroesen. "But no chemical reaction is known to exist between kalium or strontium and hydrogen which could produce enough energy to create a plasma under the stated conditions of the experiment."

That it was, moreover, a high energy plasma, follows from measurements of the visible part of the light emitted. By splitting the emitted light into its separate wavelengths, one obtains a spectrum with all kinds of very clearly defined spikes in light intensity, these being the spectral lines which are the signature of specific atoms in the plasma. Kroesen said: "We clearly recognized spectral lines which indicate that hydrogen atoms are emitting light with energies about twice that released during the most energetic kind of reaction in the cylinder, namely, the recombination of hydrogen atoms to form hydrogen molecules." These results lead Kroesen to the tentative conclusion that "all in all, the first steps have been taken towards a new area of energy research involving the hydrogen atom."

Catalyst The foundation for the theory was already laid at the beginning of the nineties in the United States. The company BlackLight Power, Inc. (BLP) based in Cranbury, New Jersey, and comprising presently 25 employees has, according to its own statements, tapped into an almost limitless source of energy. During a convention at the Center for Plasma Physics and Radiation Technology at Lunteren in March of this year, president and founder Randell Mills explained how his company is making a clean fuel based on pure water. This is accomplished using virtually the same experimental setup as with the TU/e. As Mills explained: "First of all, water molecules are split into hydrogen and oxygen using electrolysis. We remove the oxygen and split each hydrogen molecule into two hydrogen atoms." A small amount of energy based on conventional physics is added to this. "Following that, we allow the hydrogen atoms to react with a catalyst such as, for example, helium. A resonant reaction between the helium ion and the hydrogen atom ensures that the helium ion becomes doubly ionized and that the hydrogen atom collapses to a hydrino." Energy is released by the collapsed hydrogen atom, either in the form of heat or extreme ultraviolet light (EUV) with an extremely short wavelength which is even shorter than that emitted by the sun, and which is responsible for tanning the skin.

Mills claims that this BlackLight Power could, in the foreseeable future, be a great source of energy: "Using only pure water as a fuel, the energy yield is greater than that put in externally. Moreover, useful hydrinos are left over which, together with other elements, can form completely novel compounds. We are working right now on a method for directly converting the heat energy produced into electricity."

"In America, they are measuring net energy production from water in tens of percentage points", explains Kroesen, who has made a personal visit to the premises. "They are putting twenty watts in and getting thirty watts out. I was standing right there, and, as far as I could tell, they were not doing anything wrong. But calorimetry – the measurement of heat flow – is a difficult subject. In my opinion BLP doesn't have enough expertise in that area. For that reason, we wanted to repeat their heat measurements with complete independence at the TU/e. We are now trying to get funding for that."

"I was also present during the measurements made on the UV light," continued Kroesen, "I could

see that there was no nonsense going on. When you held your hand between the light beam and the spectrometer, the spectrum disappeared -- the spectrum really was being measured." A cheap source of EUV light is, in any case, of interest for the semiconductor industry. Firms such as ASML require very accurately focused light beams in order to etch light-sensitive microscopic chips, with the rule being, the shorter the wavelength, the greater the detail possible.

"We have had various discussions with ASML", says Kroesen, "the firm was involved in the measurements. But measuring spectra is time-consuming, which indicates that the source intensity falls far short of that needed for the purposes of the semiconductor industry. Other applications are however possible, given the fact that the source is much more compact and economical than standard EUV sources."

But Kroesen doesn't want to jump to any hasty conclusions: "We did some measurements in collaboration with BlackLight Power in the US because we couldn't set up any connections to Dutch research groups quickly enough – but, naturally, these readings need to be independently verified. We intend to carry out the EUV measurements using equipment which is more advanced than that used in the US. For that reason I will be working together with the Laser Center at the Vrije Universiteit(VU) of Amsterdam (VU=Free University). Wim Ubachs, Professor of Spectroscopy at the VU, who attended the Lunteren convention especially to see Mills, said he would be interested. His area of expertise is in the analysis of atomic and molecular spectra. Thus, even if we ourselves don't have the expertise, we can engage others who do."

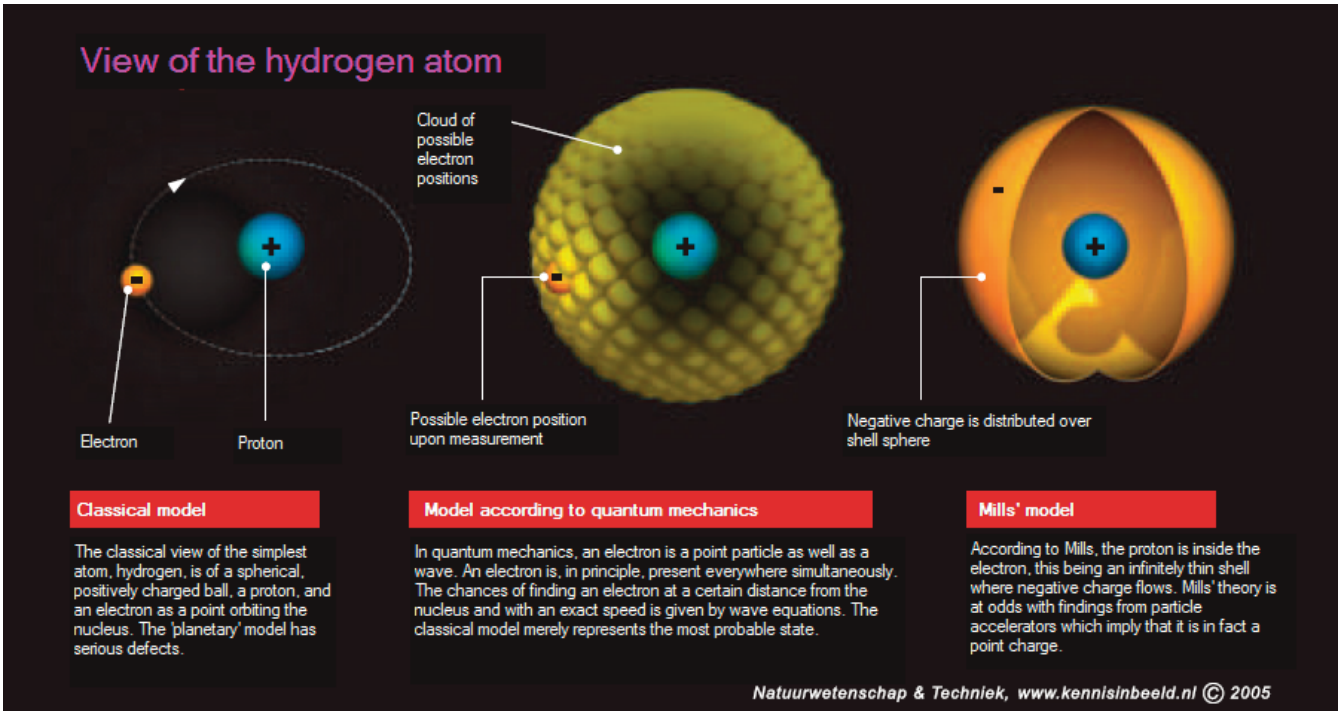
Impact Dr Wim Ubachs said: "If we assume the spectrum isn't *faked*, then it is certainly odd that spectral lines are found in the extreme ultraviolet region, and that none of the elements present in the plasma are radiating at that wavelength. Even a spectral line of a 30nm wavelength is clearly emitted by an impacted helium ion. Noteworthy in regard to the line is that the process can only take place in very high energy plasma."

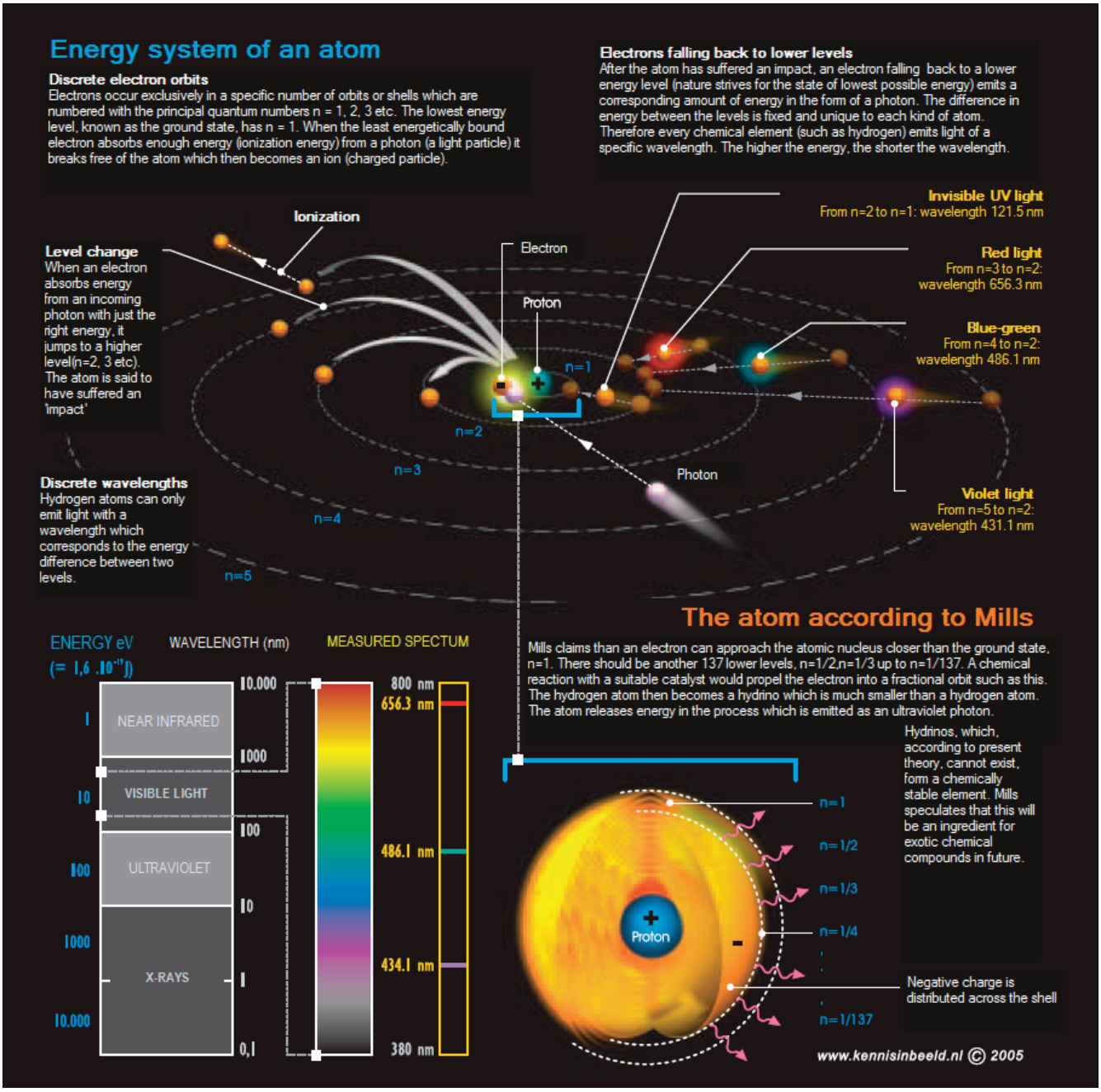
But, as Ubachs suspects, a mistake has crept in somewhere during measurement. If a grating spectrometer is used, then spectral lines always pop up which don't belong, a kind of shadow image which is produced by the apparatus itself. These so-called 'second-order spectral lines' are a recognized phenomenon in spectroscopy. "But you wouldn't expect someone who is published in the scientific literature to make such an elementary mistake", said Ubachs.

"On the other hand," concedes Ubachs, "Mills does publish a lot, but, up until about two years ago, only in fairly obscure journals. I have even refereed one of his papers prior to publication. I rejected it, but it turned up again somewhere else. In that particular article Mills claimed that hydrinos could explain the formation of 'diffuse interstellar bands' (DIBs). An interesting problem in itself and one on which I myself worked."

The name DIBs is connected with large clouds of interstellar gas which partly obscure the light from stars behind them. The spectrum of absorption clouds of this sort shows all kinds of sharp downward peaks--the absorption bands--the opposite, in fact, of the spectral lines produced by a source producing only light. A few of the absorption bands can be ascribed to familiar molecules present in the cloud, such as carbon monoxide or water. But despite the fact that they have been known since the 1920s, no one knows what mysterious substance, or substances, gives rise to the DIBs.

"It cannot be any kind of matter we are familiar with here on earth, but we are detecting unknown





spectral lines which point to something novel. I, and many others, think that we are dealing with the molecules of substances which are known to us, but in a form which is unknown on earth. That is exciting enough in itself. In Mills' view this material is in fact hydrinos. By this means, he can explain certain spectral lines, but, according to his own theory, other lines should be present which we just don't see. At that point, I think: what am I to do with this?" says Ubachs.

"The very fact that Mills' book not only does away with current atomic physics, but that a formula for the mass of the electron and muons pops out, that dark matter is explained, or that a value for Hubble Constant is churned out, all of that gives the theory the flavour of crackpot physics."

"I don't see any reason to toss modern physics overboard", says Ubachs. "A research group is working presently in Munich which is making measurements accurate down to fourteen figures, and these agree exactly with theoretical predictions. Mills' underlying hypothesis that electrons are relatively extended currents of electric charge rather than points is not in agreement with the experiments. Collisions in particle accelerators assume that electrons are, for all intents and purposes, point particles."

Ubachs sees the emergence of parallels to the controversy surrounding cold fusion. In 1989 the electrochemists Martin Fleischmann and Stanley Pons claimed that nuclear fusion could occur at room temperature, ie without the use of fusion reactors which swallow billions of dollars and continue, even now, to consume more energy than they deliver. In Fleishmann and Pons' simple experimental setup, a small electric voltage was applied to the noble metal palladium, which caused water molecules to split into their component atoms, which then (owing to a supposed side-effect of the reaction) caused their nuclei to approach so closely that they fused. Alas, no one was

"My theory is actually quite simple. Once you have figured out what an electon is, the rest follows automatically."

able to duplicate the marvel.

In stark contrast to this, a stream of researchers was able to replicate Mills' results and produce plasma inside a so-called resonant transfer cell (the name refers to the supposed resonant reaction between hydrogen and the catalyst). Moreover, net energy production was measured. This was the conclusion of Dr Jonathan Phillips, Professor of Physics at the University of New Mexico, USA after conducting his own experiments: "A plasma with a volume of only a few cubic centimeters was already yielding thirty watts net." That is enough to power two small energy-saving light bulbs.

In May, following a request by Greenpeace and other environmental groups, a team led by Dr Richard Maas, an environmental scientist at the University of North Carolina, conducted a week-long study at the BlackLight Power laboratory. They published their report this month. According to Maas they were given complete freedom to inspect Mills' experiments as well as carry out their own. Maas claims that his calorimetric data is sufficiently accurate to justify the conclusion that the plasma reactions yielded hundreds, or even thousands of times the amount of energy released under conventional hydrogen combustion. It should be borne in mind the the actual net energy yield from every experiment was only a few percent. This is because the alleged hydrino reaction cannot yet be sustained as a continuous process. This is because only small quantities of hydrogen enter into the vacuum tube and a relatively large amount of energy is required to restart the process each time. According to Maas, the efficiency was considerably increased to achieve 40% yield by applying a pulsed voltage across the heating coil. Calorimetric experiments designed to determine the amount of energy released by a process are notorious for the number of practical pitfalls which can lead to inaccuracies. Despite this, the authors are not hesitating to summarize their provisional conclusions as proof of the existence of hydrino reactions, and to describe the energy yield as 'overwhelming' as well as concluding that Mills' theory is 'undeniable'.

Hydrino Rockets However promising the experiments may be, the 'Theory of Everything' (which indeed promises a lot) behind BlackLight Power technology is, for the majority of scientists, unpalatable. Energy is said to be released following the collapse of hydrogen atoms to the point where they are many times smaller than normal – which is a complete impossibility for conventional thinking. 'Classical Quantum Mechanics' as Mills confusingly titles his theory, has little to do with quantum mechanics as it has been taught at universities for the last eighty years. "Mills' theory is the sort of caliber of work that I don't want to invest much time in", was the reaction of Dr Gerard 't Hooft, professor of theoretical physics at the University of Utrecht. The American author might well not want to include the following quote on the back cover of his book *The Grand Unified Theory of Classical Quantum Mechanics* which stems from Holland's famous Nobel Prize winner: "In his introduction, Mills demonstrates for all to see, that he has understood nothing of quantum mechanics. That is not a good position from which to launch a new theory."

A theoretical physicist who did however invest some time in Mills' theory, for which a few days was sufficient, was Andreas Rathke, working at the Advanced Concepts Team in Noordwijk for the European Space Agency ESA. He was approached by the Italian aeronautics firm Alinea with a request to take a look at Mills' theory. Rathke explained the aeronautics and space industries' interest in hydrinos: "The Institute for Advanced Concepts at the American space agency NASA has been investigating BlackLight Power technology for years as a possible means of propulsion for space craft." Following an initial investigation in 2002, NASA wanted to carry out further studies on how the energy released from atomic hydrogen could be converted into a means of propulsion. "But before the ESA would invest money in the study", says Rathke, "I was commissioned to study the theory."

According to Rathke he was the first to do this: "The hydrino model did indeed receive a lot of public attention, because some respectable scientific journals published the results of recent experiments which the authors interpreted as proof that hydrinos exist. However, the discussion around the underlying theory was limited chiefly to the fact that Classical Quantum Mechanics was at odds with current quantum theory and therefore suspect. In attempting to study the hydrino theory effectively, I tried to bridge the gap between theory and experiment."

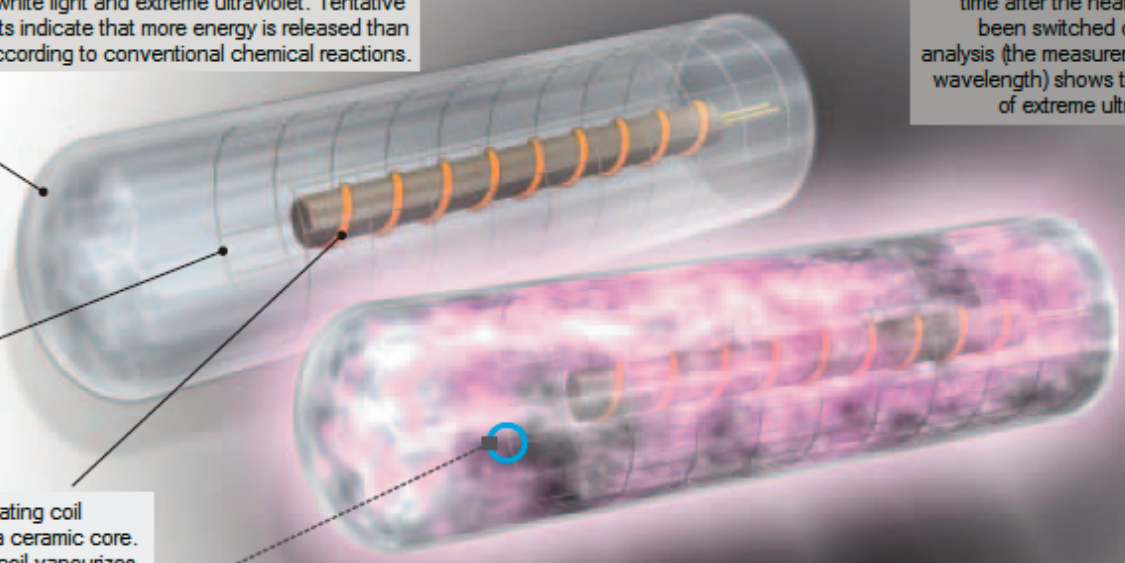
Minus sign At the end of May, Rathke published an article in the *New Journal of Physics* where he made short shrift of the hydrino. "In contrast to what Mills claims", said Rathke, "his theory is in conflict with special relativity because his equations are not the same for two observers moving with respect to each other. But a physical argument is not even necessary in order to refute Mills' theory, since the theory contradicts itself. I simply checked a few of Mills' formulas, but these did not appear to be correct. This means that Classical Quantum Mechanics does not describe all the physics of the hydrogen atom, whereas conventional

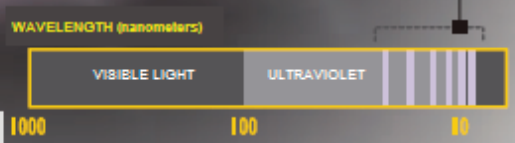
A puzzling experiment

Hydrogen gas and kalium vapour generate a plasma which emits white light and extreme ultraviolet. Tentative measurements indicate that more energy is released than is possible according to conventional chemical reactions.

Observations

A light-emitting plasma forms some time after the heating coil has been switched on. Spectral analysis (the measurement of light wavelength) shows the emission of extreme ultraviolet light





Mills' claims - step 1

The H2 molecules in the hydrogen gas first have to be split into free hydrogen atoms. This step requires energy.

Mills' claims - step 2

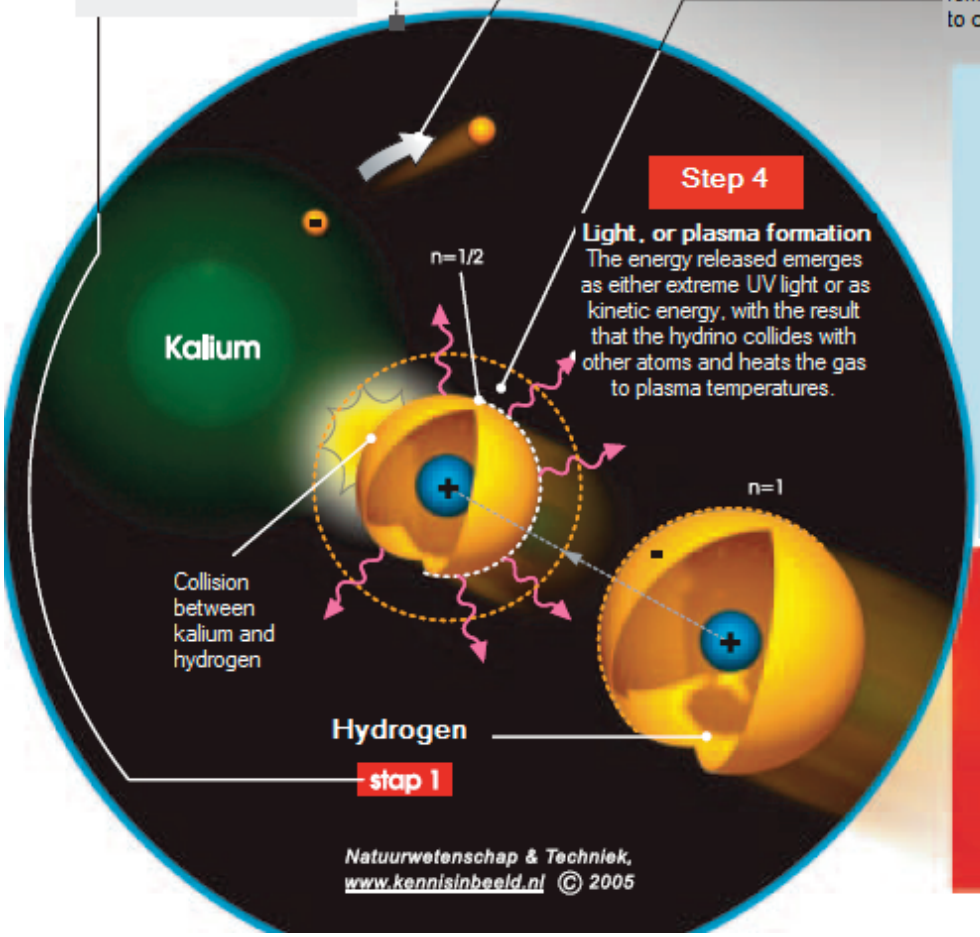
Kalium is ionized

When the hydrogen atom receives an impact, it gives up energy to the catalyst. A suitable catalyst is a chemical element where the ionization energy exactly matches the energy difference between the fractional states of hydrogen, kalium being an example of such. The kalium atoms ionize and transform into a plasma consisting of positive ions and unbound electrons.

Mills' claims - step 3

Hydrogen atom collapses

Because the catalyst receives precisely the energy difference between the fractional states, a resonant effect occurs whereby a catalyzed hydrogen atom collapses to form a 'hydrino', a smaller hydrogen atom which, according to conventional quantum mechanics, does not exist.



The Puzzles

How does the plasma come about?

It normally takes thousands of volts or a very high temperature to create a plasma. In the experimental setup, the heating coil had only 50V across it and did not get hotter than 1100°C. According to current theory no plasma should be formed.

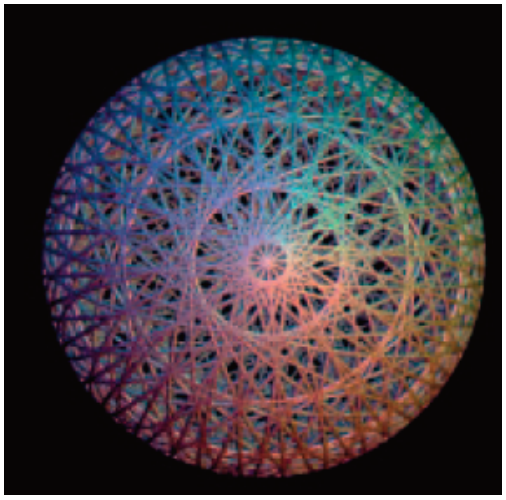
Where does the extreme ultraviolet light come from?

Hydrogen, along with other components of the plasma, have an emission spectrum in the extreme ultraviolet range (wavelength 10-50 nanometer). A plasma of this sort should only be emitting visible light (380-800 nm) and ordinary ultraviolet (380-100 nanometer)

Mills' claims

A plasma forms which generates hundreds of times more energy than is necessary to free up the hydrogen used (from water for example). Hydrogen reacts in the gas to form hydrinos, smaller atomic versions with an energy much lower than the usual ground-state of hydrogen. If this is true, then a completely new source of energy has been discovered. This would also mean that quantum mechanics, the foundation of modern science, would have to be thrown overboard in its entirety.

Mills' theory of everything – according to Mills



"My new model of the atom demonstrates that the entire edifice of quantum mechanics is superfluous", said Dr Randell Mills. His presentation at the congress, held at the Center for Plasma Physics and Radiation Technology, has just finished; but in the hotel lounge in Lunteren he continued talking to me about his orbitsphere model, supported by artistic model renderings on his laptop.

"Quantum mechanics arose", explained Mills, "because classical physics was unable to explain why atoms are stable." At the beginning of the previous century, Ernest Rutherford showed that atoms consisted of a positively charged nucleus with electrons circling around like satellites. But, according to Maxwell's theory of electromagnetism, any charged particle will emit radiation – or, in modern terms, photons - when its velocity changes in magnitude or direction. Electrons circling around a nucleus should thefore, within fractions of a second, emit so much energy that they crash into the nucleus like kamikaze pilots. "Niels Bohr assumed that Maxwell's laws simply did not apply within the atom", said Mills, "Electrons should only be allowed to occupy a specific number of fixed orbits around the nucleus. Quantum mechanics arose from these notions, and, in my opinion they are incorrect. Instead of abandoning the laws of Maxwell, one could have assumed that they were still valid at the atomic scale, but that elementary particles such as electrons are not point particles. My theory is actually very simple. As soon as you have figured out what an electron is, the rest follows automatically."

Mills' model of the atom

Mills reveals a model of the atom whereby the nucleus is *inside* the electron, that is to say, at the center of a spherical shell composed of smoothed-out currents of negative charge. In contrast to quantum mechanics, Mills' classical quantum mechanics is a fully deterministic theory. "My theory describes the whole of nature, from quarks to cosmos", asserted Mills. With a view to convincing the skeptics he presents tables which show comparisons between his computed values and well-known atomic measurements. He even claims to be able to derive the masses of elementary particles – something which is definitely beyond the reach of current quantum mechanics. "All my calculations agree with experimental data down the last decimal place", stated Mills.

Into the wee small hours (he was still on US time) Mills expounded on his approach to virtualy all the big questions in modern science. What is dark matter made of? How does dark energy work on small scales? The Grand Unified Theory of Classical Quantum Mechanics has an answer to all of these questions. Mills does not think there was ever a Big Bang, but rather that the radius of the universe oscillates slowly between nine hundred billion and two thousand billion light years. At a certain point, the hotel personnel politely ask us to leave the lounge. Mills cannot get his 'theory of everything' published in the specialist journals, but the book comprising several thousand pages is available on the internet in its entirety.

theory does. I looked in particular at the manner in which Mills infers the existence of hydrinos. However, the formula Mills uses to describe hydrinos is not a solution of equations he used earlier, although he may claim the contrary. Classical Quantum Mechanics does not therefore predict hydrinos!"

Moreover, hydrinos, says Rathke, cannot be reconciled in any manner with conventional quantum mechanics. But upon taking a closer look, these mathematical solutions do not seem capable of describing any physical states because they are not subject to normalization. In other words they cannot be cast in a form where they can make predictions about the world, which is, by contrast, the case with other solutions." Thus Rathke implacably consigns the hydrino to the realm of fantasy. "It's not a question of belief", he says, "but rather just a question of writing down the formulas."

"Rathke's article is full of misunderstandings," countered Mills when asked. "I immediately wrote a rejoinder and sent it to the *New Journal of Physics*. My theory does not conflict with special relativity because I make relativistic corrections following the solutions to my equations. In contrast to Rathke's allegation that Classical Quantum Physics does not describe all the physical characteristics of the hydrogen atom, the theory in fact yields exact solutions of all states from the hydrogen atom and the helium atom, expressed exclusively in terms of the fundamental constants. The theory predicts, moreover, the existence of hydrinos. Rathke copied one of my equations incorrectly in which he got an extra minus sign. His following claims

are therefore invalidated by this negligence."

Unsolved Mysteries Kroesen follows these heated arguments from a distance: "The theory is interesting, but it is not my specialist area. I specialize in experimentation, and our experiments are showing results which cannot easily be explained. Our subsequent investigations are not intended to confirm Mills' theory: we continue to search for alternative explanations. For example, I want to measure electric field strength in the plasma. Perhaps we are missing something, and there is, after all, an electric field of sufficient intensity to explain the plasma formation. I would also like to see what happens when we don't raise the temperature by means of a heating coil, but, instead, put the whole setup inside an oven without applying an electric field. I do of course want to replicate the BLP results by examining the spectroscopy of the extreme ultraviolet, as well as heat measurements, so that we can be confident about the integrity of the experiments. We have a sizable group with plenty of experience in diagnostics, which will allow us to make precise measurements of field strength and temperature."

Before making measurements of this sort, we need to have advanced measuring equipment which is difficult to move. But, if the mountain will not come to Mohammed…"."Ideally I would like to ignite the plasma in a mobile setup", said Kroesen. "What I mean is, say, a service trolley."

Kroesen is readying himself for a long-term project: "Experiments cannot, generally speaking, provide incontestable confirmation of a theory, but can merely invalidate it. But if our results refute, once and for all, explanations based on conventional physics, then it will be more difficult to keep Mills' theory at a distance. Experiments don't lie."

Criticism from his colleagues notwithstanding, the initial results, according to Kroesen, should be justification enough to get some funding freed up so that his plans can be implemented. "You are left with the plain fact that a plasma is forming under conditions where you wouldn't expect one to form. As a physicist, that gets you thinking. I'm just curious: what in God's name is going on here?"

Information
The Grand Unified Theory of Classical Quantum Mechanics
www.blacklightpower.com/theory/book.shtml
Mill's workshop at the Technical University of Eindhoven
www.blacklightpower.com/theory/TheoryPresentation030905.pdf