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Warming Up to Cold Fusion

Peter Hagelstein is trying to revive hope for a future of clean, inexhaustible, inexpensive energy. Fifteen years after the scientific embarrassment of the century, is this the beginning of something

By Sharon Weinberger

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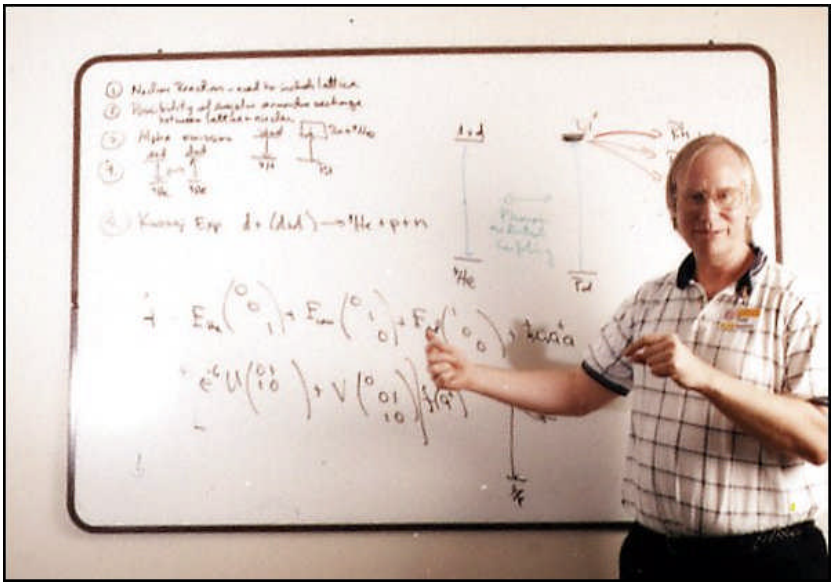
On a quiet Monday in late August -- a time of year when much of the Washington bureaucracy has gone to the beach -- a panel of scientists gathered at a Doubletree Hotel set between the Congressional Plaza strip mall and a drab concrete office building on Rockville Pike. They sat around a U-shaped table decked with laptops, with three government officials at the front, ready to hear about an idea that, if it worked, could change the world.

The panel's charge was simple: to determine whether that idea had even a prayer of a chance at working.

The Department of Energy went to great lengths to cloak the meeting from public view. No announcement, no reporters. None of the names of the people attending that day was disclosed. The DOE made sure to inform the panel's members that they were to provide their conclusions individually rather than as a group, which under a loophole in federal law allowed the agency to close the meeting to the public.

At 9:30 a.m., six presenters were invited in and instructed to sit in a row of chairs along the wall. The group included a prominent MIT physicist, a Navy researcher and four other scientists from Russia, Italy and the United States. They had waited a long time for this opportunity and, one by one, stood up to speak about a scientific idea they had been pursuing for more than a decade.

All the secrecy likely had little to do with national security and more to do with avoiding possible embarrassment to the agency. To some, the meeting would seem no less outrageous than if the DOE honchos had convened for a seance to raise the dead -- and in a way, they had: Fifteen years ago, the DOE held a very similar review of the very same idea.



MIT researcher Peter Hagelstein works on new models to describe cold fusion reactions. (Photograph by Sarah Ross Wauters)

It was front-page news back in 1989. The subject was cold fusion, the claim that nuclear energy could be released at room temperature, using little more than a high school chemistry set. In one of the most infamous episodes of modern science, two chemists at the University of Utah announced at a news conference that they had harnessed the power of the sun in a test tube. It was, if true, the holy grail of energy: pollution-free, cheap and virtually unlimited.

If it worked, cold fusion could supply the country's energy needs, with no more smog, no more nuclear waste, no more depending on other countries for oil. For a brief moment, an energy revolution seemed on the horizon.

But when many laboratories tried and failed to reproduce the Utah results, scientists began to line up against cold fusion. Less than a year after the announcement, a DOE review found that none of the experiments had demonstrated convincing evidence of cold fusion. Almost as quickly as they had become famous, the scientists involved became the butt of comedians' jokes; they were even lampooned in a Canadian production called "Cold Fusion: The Musical." A Time magazine millennium poll ranked cold fusion among the "worst ideas" of the century.

But now, at the Doubletree in Rockville, it seemed all that could change. For the scientists who had risked ostracism to persist in studying cold fusion, the very fact that the Energy Department was reviewing their work this summer seemed like a breakthrough. True, according to two of the presenters who were there, the meeting began with harsh questions. But at 5 p.m., the presenters were ordered to leave the room, and when they returned, the mood had visibly lifted. At the end, the scientists presenting the idea and those reviewing it all shook hands. The reviewers stayed on to discuss the material. The cold fusionists went to a barbecue, feeling celebratory. No one had told them if the presentation had convinced anyone that cold fusion was real. But it was nice, they said, after so many years, just to be treated with respect.

"WHERE'S PETER?"

It was noon and the sun was shining in California's Bay Area. It was the week before the DOE meeting in Rockville, and at SRI International, a nonprofit research center in Menlo Park, chemist Michael McKubre was gearing up for what he hoped would be cold fusion's big break. He believed that after 15 years, the new DOE review could give him and others a chance to build an energy source that had the potential to revolutionize society.

But first he needed to find Peter Hagelstein for a meeting with a reporter. McKubre's secretary poked her head in the office and said she'd ask Jessica, the summer intern. A minute later the secretary was back. No Peter.

"Can you call Peter?" he asked. "Tell him to comb his hair and stuff," he added, shaking his head. McKubre checked the time and settled back in his chair. Peter Hagelstein, his longtime friend and colleague in cold fusion, who was spending the summer with McKubre at SRI, works at night and rarely makes it to the lab before noon. "He works himself into a state where he's physically ill," McKubre said.

McKubre, on the other hand, was a vision of health. A native New Zealander, McKubre has worked on fuel cells and energy sources for 27 years at SRI, and nearly three decades in the lab haven't faded his tan. At 55, he is bronzed and handsome. An engaging speaker, McKubre loves to talk, and most of what he talks about is cold fusion.

March 23, 1989 -- the day Martin Fleischmann and Stanley Pons announced their miraculous discovery -- was a day that McKubre says changed his life. He knew and respected Fleischmann, then one of the world's leading electrochemists, and shortly after the news conference, one of the funders of McKubre's research approached McKubre about performing a small experiment to test cold fusion. When McKubre's initial work showed promise, he says, he began a more ambitious project. Fifteen years later, he's still hooked.

McKubre and Hagelstein met in 1990 at the first international cold fusion conference and quickly hit it off. While hundreds of scientists still plow away at cold fusion worldwide, the two of them have emerged as perhaps the most prominent, particularly in the United States. Hagelstein, an applied physicist at MIT, works on theory, while McKubre is a practiced experimentalist.

McKubre's staff is well below its all-time high of 12 people -- today, it's just he and a part-time assistant -- but the lab is still well equipped. For years the experiments took place behind bulletproof glass, the result of a 1992 accident that killed one of his colleagues. McKubre still has bits of glass embedded in his side from the cold fusion experiment that exploded that day in his lab (the blast had nothing to do with fusion; hydrogen mixed with oxygen, creating the equivalent of rocket fuel).

Normally, nuclear fusion occurs in the sun or in thermonuclear weapons, where intense heat and pressure allow the nuclei of atoms to overcome their natural repulsion and fuse, producing an astounding amount of energy. But fusion takes place at temperatures equivalent to those of the sun -- millions of degrees. So imagine the staggering advance cold fusion would represent, if

real. It would mean that fusion could occur at room temperature, potentially making energy production cheap and easy. But even among cold fusion proponents, there is no accepted theory of how this could happen -- one reason why mainstream science has never taken cold fusion seriously.

The experiments McKubre ran for 15 years consisted of immersing a metal, palladium, in a bath of heavy water (water where heavier deuterium atoms have replaced lighter hydrogen). Running an electric current through the setup causes the metal to soak up the deuterium, and eventually the deuterium nuclei fuse -- at least according to cold fusionists. McKubre claims that when an experiment works, scientists can measure fleeting bursts of excess heat released in the process -- at times, up to 30 percent more energy comes out than went in. In some experiments, McKubre has detected byproducts, such as helium and tritium, that often accompany nuclear reactions. He says both phenomena are clear proof that fusion has occurred.

Since 1989, hundreds of scientists working in dozens of labs around the world have claimed similar results. Supporters point to the written literature -- more than 3,000 papers -- as proof of the effect. But the most credible cold fusion advocates concede that the vast majority of those papers are of poor quality; one *supporter* called the collection "mixed toxic waste."

And even the best research is plagued by cold fusion's most nagging problem: a long history of failing to reproduce experimental results. McKubre is one of the more respected people in the field, and in more than 50,000 hours of experiments, he says, he has recorded 50 times when the setup "unmistakably" produced excess heat. That is a far cry from the scientific standard for reproducibility. Erratic results such as those, coupled with the theoretical unlikelihood of the whole idea, long ago drove most mainstream scientists to dismiss cold fusion; they say that any indication of heat or nuclear byproducts is the result of an error in the experiment. Now few of them take the trouble to review the new results or attend the annual cold fusion conferences.

Research money has dried up. The U.S. Patent and Trademark Office has refused to grant a patent on any invention claiming cold fusion. According to Esther Kepplinger, the deputy commissioner of patents, this is for the same reason it wouldn't give one for a perpetual motion machine: It doesn't work.

These problems, Hagelstein and McKubre argue, are all tied to the 1989 DOE review. While the report's language was measured, pointing out the lack of experimental evidence, "it was absolutely the intention of most of the framers of that document to kill cold fusion," McKubre says.

Pons, who gave up his U.S. citizenship, now lives in France and no longer works on cold fusion, and Fleischmann is retired. Scientists still looking at cold fusion work in a kind of underground. Edmund Storms, a former scientist at the renowned Los Alamos National Laboratory, has set up a cold fusion lab next to his home in Santa Fe, N.M. John Dash, a physicist at Portland State University in Oregon, conducts cold fusion research, but among his academic colleagues, he says, "I'm an outcast, a pariah."

According to McKubre, the reason cold fusion experiments can't be reproduced on demand is a materials issue: It's a matter of developing a form of palladium, or another metal, with the right mix of impurities. With help on that issue and more funding, he suggests, a small cold-fusion-powered heater or generator could be ready in as little as two years. If it proved reliable and affordable (a big if: McKubre acknowledges that palladium is too expensive to be used commercially), the applications could expand. He's not afraid to make big claims. "Cold fusion," he writes in an e-mail, "has the potential to replace all sources of energy and power, indefinitely."

Yet some cold fusionists have been making the same claims since 1989. The new DOE review could help answer the question of whether they're really any closer now -- and, once again, if there's any validity at all to the idea of cold fusion.

PETER HAGELSTEIN FINALLY SHOWED UP AT MCKUBRE'S OFFICE A LITTLE BEFORE 1 P.M., hovering wordless at the back of the room. When he does speak, it's so softly that his Southern California accent is barely audible. With a boyish grin and oversized glasses, he looks like the grownup version of a high school valedictorian.

"Brilliant," "genius" and "reclusive" were words used to describe Hagelstein 20 years ago, when he rose to prominence as one of the young scientists behind President Ronald Reagan's plans to build a missile shield in outer space. He made his mark designing the X-ray laser that was to be the centerpiece of Reagan's "Star Wars" anti-ballistic missile system.

A protege of Edward Teller, father of the hydrogen bomb, Hagelstein by 1989, at age 35, had a prestigious position at MIT and had been selected as a member of the Jasons, an elite group of scientific advisers to the Defense Department. He was on his way to great things.

He was flying out to visit the Lawrence Livermore National Laboratory in California when the news of cold fusion hit in 1989, and he met with Teller and Lowell Wood, another prominent Livermore scientist, the next day. Both men encouraged him to work on cold fusion. (Teller died last year, but Wood continues to support cold fusion and attends the conferences.) Hagelstein did what his mentors suggested, and his career has suffered.

"If I had spat on cold fusion back in March 1989, along with everyone else," Hagelstein says, "then I would have funding, I would have had papers published, I would have been successful. Lots of good things would have happened."

But he didn't. Why?

"Because it wouldn't have been the right thing to do," he says.

McKubre and Hagelstein come off as the consummate odd couple of science. McKubre, the optimist; Hagelstein, the pessimist. The charismatic New Zealander, the geeky physicist. McKubre talks about late nights at cold fusion meetings, drinking whiskey with colleagues. Hagelstein doesn't touch anything stronger than lemonade. It's a friendship forged in 15 years of scientific warfare. Hagelstein describes the mainstream scientific community as "mafias" that

promote and publish their friends' work, unwilling to accept new ideas. "From time to time there will be wild claims that will be wrong," he says. "Let's accept that, instead of destroying the careers of the folks who either say such things or work on such things. This is a normal part of the process, too."

As Hagelstein explains it, leading physicists came out swiftly and prematurely against cold fusion. A prominent physicist at Caltech said Pons and Fleischmann were "suffering from delusions." William Happer, a Princeton professor, called them "incompetent boobs."

Just days after the infamous Utah announcement, Hagelstein presented possible theories for cold fusion, and MIT applied for patents on his behalf. Some scientists openly ridiculed his theories. And cold fusion, despite his support, was attacked the next month at a Jasons meeting he attended. Hagelstein remembers Happer, then chairman of the Jasons, telling him to choose between cold fusion and his membership in the group. Hagelstein resigned.

Happer says he never told Hagelstein he had to leave the Jasons. "I do remember telling him: 'Look, Peter, why get messed up with this field? It's going to be nothing but a tar baby. You could make a great career in physics.' He didn't want to hear it.

"I feel bad about it . . . Peter . . . had a tremendous future ahead of him, I thought," Happer says. "He's still well known, but he could have been a greater man than he is."

Hagelstein says his acceptance of cold fusion was by no means immediate. "Sometimes I was pretty sure that it was real, and sometimes I was convinced that it was all junk," he writes in an e-mail. It took several years before he was convinced. "At this point, there are far too many results, of many different types, that constitute an argument that is very strong. There is no going back."

Cold fusion has, if nothing else, taught Hagelstein to be flexible. As new experiments emerged, his theories evolved. For almost every strange result, he came up with a new theory for how cold fusion worked. But he has tossed aside almost as many theories as there have been experiments.

As cold fusion research limped forward, Hagelstein faced a series of personal reverses. He has tenure at MIT, but he never made full professor. When his funding ran out, he eventually lost his lab space, his secretary, even his office. He has suffered from depression, which he attributes to his experience with cold fusion, but also downplays it. "What's more important," he asks, "me taking a little grief or if, by my actions, I could make a difference in the world?"

The SRI summer intern, Jessica, provides her own take on Hagelstein's experience. Jessica, it turns out, is his daughter, a 20-year-old chemistry student at MIT. She was 5 when Pons and Fleischmann hit the covers of Newsweek and Time, and she literally grew up with cold fusion. She describes her father as a gifted pedagogue, popular among his students at MIT and also dedicated to his cold fusion work. She recalls visiting colleges with her father, who would sit down in the library, open his laptop and work on theories, while she toured the campus alone. This consuming passion has left its mark. "My whole life growing up," she says, her father "was always really sad about everything."

Hagelstein today remains the best-known name in the cold fusion community. And that's why in April 2003, he wrote directly to Energy Secretary Spencer Abraham to request a new review. By November, the DOE had decided to do it, agreeing that after 15 years it was reasonable to review the progress of work in the field. The August review was limited to a single question, according to McKubre: Is the work surrounding cold fusion legitimate science? A positive answer -- even short of a ringing endorsement -- would finally lift the stigma, McKubre has said. It would also "loosen the purse strings" among potential funders. As of last month, the Department of Energy was saying that the review would be released by the end of the year.

THE OFFICES OF THE AMERICAN PHYSICAL SOCIETY, a bastion of mainstream science, take up a corner of the National Press Building in downtown Washington. Amid the myriad foreign news agencies on the 10th floor, Bob Park, director of APS public information, and enemy of cold fusion, writes his weekly column, "What's New."

Park's office, not unlike his writing, is filled with strange things. Magazines about aliens lie next to physics textbooks, and next to those, books on electromagnetic healing. Park uses his savage wit to ridicule everything from the international space station and missile defense to alien abduction and cold fusion. His weekly column is distributed, by his rough estimate, to 40,000 subscribers.

When the August 2004 issue of Popular Mechanics, the magazine for hobbyists and car enthusiasts, ran a cover story claiming cold fusion could allow terrorists to build homemade hydrogen bombs, Park derided the magazine and the science. "A nuke? The cold fusion guys can't brew a cup of tea," the column teased.

Park's reference to tea was a throwback to another cold fusion critic with a humorous edge. Douglas Morrison, a Scottish physicist, was for years the lone critic to attend the annual cold fusion conferences. Every year he would ask the group, "Please can I have a cup of tea?" -- a sardonic way of pointing out that cold fusion had yet to produce even the simplest heating device capable of boiling water. Morrison died in 2001, still without his cup of tea.

Park, on the other hand, does not go to the conferences or read the cold fusion literature -- a waste of time, he says.

When Park considers a wild idea, his blue eyes focus on some faraway horizon, as if wondering: Could space aliens exist, does Bigfoot roam the forests, could cold fusion be real? When he refocuses, the answer is always no. What unites these things, Park contends, is people who wish to believe the world is some other way than what it is.

That, for him, is the essence of cold fusion. "Some of the people who are attached to it are attracted to it because it's under some sort of a cloud," Park says. "I don't want to be unfair to them, but I think that's part of what's going on in their own mind." Another problem, he says, is that the people involved aren't that good. "It gets a lot of people that are marginal," Park says. "There aren't any scientists that are deeply involved in this that I would rank among the upper echelon. . . That's going to sound awful to you, but what the heck."

Park corresponds with some cold fusion supporters, including Scott Chubb, a physicist at the Naval Research Laboratory in Washington. Chubb calls Park "a good friend." Park calls Chubb "competent."

Park says Hagelstein is an "unusual case," but points to the connection to Teller, who made positive statements about cold fusion early on. "When the master says it's right, it must just be a matter of showing it."

And some cold fusion advocates, says Park, are flat-out crazy, undermining whatever respect the field may have.

But he did not oppose the DOE review. "I would say they're reviewing it because these guys are now playing by the rules," Park says, citing Chubb and others, who have started to give papers at American Physical Society conferences.

The review might even be a good thing, he suggests. "Maybe there is something there, some funny reaction going on." Park pauses, staring off for a moment. "If there is, I'll make another prediction. If there is, it may solve some puzzles, but it won't be important."

"Or it may be bad science," he adds.

Most nuclear physicists are even more pessimistic about cold fusion. Richard Garwin, 76, is a fellow emeritus at IBM's Watson Research Center and a member of the Jasons. He was on the original DOE review panel, and as a young man did critical design work for Teller's hydrogen bomb. His annoyance with cold fusion is based on visits to various labs. What he finds, in some, are basic mistakes, and in others, the potential for mistakes. "People who can't do a good sophomore experiment are suddenly free to suggest that the discrepancies in their results come from unexplained, basic, earth-shaking, heat-producing phenomena," Garwin gripes in an e-mail about one French lab he visited in 2002.

After a 1993 visit to McKubre's lab, Garwin and a fellow scientist wrote a report to the Pentagon, complimenting SRI on its serious and competent work. While Garwin found no huge blunder in McKubre's experiments, he saw a host of possible problems, ranging from false signals in the equipment to simple measurement errors. Asked to summarize his technical report, Garwin replies with a characteristically brief e-mail: "Did not support any finding of 'excess heat.' "

As for Hagelstein, Garwin says he isn't interested in reviewing the MIT scientist's theories. A smart theorist can explain anything, even mistakes, Garwin says. And why bother? "There is no sense having a theory if there is nothing to explain."

HAGELSTEIN AND MCKUBRE ACKNOWLEDGE THAT COLD FUSION HAS ATTRACTED ITS SHARE OF ODDBALLS. "There are a bunch of people who attend the conferences and have otherwise excellent reputations, who have bought into this so heavily that they've lost their sense of reason or sense of judgment," McKubre says.

McKubre often speaks about a company in Israel, Energetics Technologies, that has received a couple of million dollars a year in private support to research cold fusion and has achieved "startling results," producing much higher levels of power and heat than his own experiments. McKubre has visited the lab. "It's the first clear indication that something practical might come out of all this effort," he says.

But the scientist behind the Israeli group is Irving Dardik, a former surgeon, who secured funding from Sidney Kimmel, the billionaire head of Jones Apparel Group Inc. Dardik's state medical license was revoked by New York in the mid-1990s after several patients testified to a review committee that he had promised to cure them of multiple sclerosis using "waveform therapy." The review committee found that Dardik had charged ailing patients as much $100,000 for treatment involving little more than exercise and sports watches.

Dardik, according to a patent application he submitted, believes that "all things in the universe are composed of" waves, and that those waves are part of larger waves, in what he calls "superlooping." This "superlooping gives rise to and is matter in motion." He has pursued research tying that theory to treating AIDS, Parkinson's disease and depression. The medical board questioned his use of made-up words such as superlooping and speculated openly about his mental health, describing him as "manic." According to the public records of the proceedings, the board ultimately concluded that he was mentally fit but found him guilty of "fraud and exploitation."

Dardik says the medical establishment was simply intolerant of alternative science. No longer able to practice medicine, he is now applying his waves theory to cold fusion. Dardik would like, at some point, to get his medical license back in New York, but not now, he says; he's too busy with cold fusion. "I don't even have the time."

McKubre and Hagelstein have consulted for Dardik; McKubre has cited Dardik's research to the DOE, now works closely with him and has repeatedly touted the work of Dardik's group.

McKubre seems acutely aware of the strangeness that pervades the field, and he handles challenging questions calmly, seeming at times weary of -- and amused by -- some of his more fervent colleagues. But, in this case, it's easy to wonder if his optimism has gotten the better of him. Although he has acknowledged in an e-mail that "Dardik's ideas must sound mad, and . . . adherence to them is not science based," McKubre has continued to talk up the results of the Israeli research; he argues that the experiments themselves work. Yet endorsing the physics experiments of a medical doctor found to have defrauded sick patients is a serious threat to McKubre's reputation. Asked about Dardik's waveforms, McKubre traces waves along the wall with his hand and begins to talk about Dardik's theories of biological rhythms. He pauses, looking a little embarrassed. He acknowledges that, even to a cold fusion supporter such as himself, the theory requires a certain "leap of faith."

ALONG WITH THE POSSIBILITY OF FINANCIAL AND SCIENTIFIC REWARDS, the DOE review offers cold fusion scientists the hope of one final prize: moral redemption.

While the review was of cold fusion in general, the primary focus was on Hagelstein and McKubre. They chose the material, wrote the review paper and even selected the presenters. Reproducibility remains a nagging issue. While cold fusion proponents now claim better success in re-creating their results from one experiment to the next, Hagelstein acknowledges that their consistency is far from perfect, and some experimental results have never been reproduced. Like McKubre, he holds out the hope that better materials will produce more consistent results down the road. Yet he argues that already there have been enough positive results, from experimentalists he trusts, that at least some of them must be accurate. "I think that things are well past the point that experimental error is a likely possibility," he writes in an e-mail. The scientific method, however, doesn't work that way, Garwin says. As he puts it, it's absurd to claim that experiments that seem to support cold fusion are valid, while those that don't are flawed.

Regardless, Hagelstein says, he has seen enough cold fusion data to convince him that the science is clearly real. The field's acceptance, he maintains, will be simply a matter of the scientific community's looking at the improved experimental results in the future and coming to understand them.

To McKubre, the main reason cold fusion has been belittled all these years is that the mainstream scientists who dug in their heels long ago can't change their minds now: "If it turns out these people are wrong, they're dead. They're scientifically dead."

So, let's say he's right, and the majority of scientists are wrong, and cold fusion does work. What will it take for the critics to accept it? McKubre quotes Max Planck, the father of quantum theory: "Science advances one funeral at a time."

Eternally the optimist, McKubre walked out of the SRI building that August day bouncing like a teenager. He was excited about the review: Maybe it would herald a new era, when the DOE would break its stodgy habits and fund alternative energy. With Hagelstein's help, he said, cold fusion had a chance at redemption.

In fact, he observed, the stigma around cold fusion was already disappearing. "Cold fusion shows up everywhere," he said. "In comic books, in movies and in songs. It is the standard power generator technology of some cartoon characters. It is a fact."

But aren't "facts" like that nothing more than fantasy?

"It's a fantasy fact," he said. "That's nearly as good as reality."

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