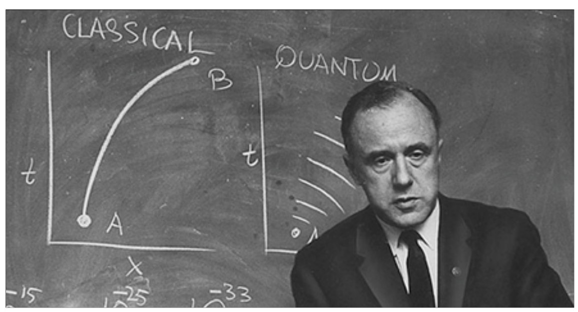
BREAKING THROUGH EDITORIAL

In Praise of: Old Nassau, John Archibald Wheeler and the Grand Identity Crisis

Scott Chubb

My dad, Charles F. Chubb Jr., loved physics. He also loved knowledge and learning. He passed these traits along to me. It is obvious that Princeton University had a big impact in making this happen. Dad was devoted to Princeton, to his experience there, and to something greater that he received there: a love and reverence for curiosity and tenacity, and the truly wonderful things that can result from both. During the 1960s, every Saturday afternoon in the fall we would listen to a distant, barely audible AM radio station (WVNJ, Newark, New Jersey) that broadcasted Princeton football games. Regardless of whether or not Princeton won, at the end of each game Dad would stand up and slowly move his right arm backward and forward, in time with the Princeton marching band, and sing as they played the chorus of the Princeton Anthem ("In Praise of Old Nassau"). At the time, I found this somewhat odd but got used to it. (I also sensed that the gesture of moving his arm was a sort of "prayer," but later learned that it was intended to simulate raising a drinking glass in good cheer!)



John Archibald Wheeler (1911 - 2008)

After I had also graduated from Princeton and experienced the impact of my Princeton education on my life, I began to sense a deeper appreciation of why my Dad had shown such "school spirit" long after he had left Princeton. The football game and the ritual were symbolic.

The game itself and the emotion tied to it create a sort of spiritual event that captures aspects of the human spirit that have tremendous importance, I think, in how we should view life. Winning or losing the football game did not matter (as, in life, whether or not we meet a particular expectation or not should not be all that matters). The experience of rooting and caring about the outcome (caring about our expectations in life) are what count. The ritual Dad performed each Saturday was his affirmation that his Princeton experience counted.

In any case, the point is that erudite Princeton University is actually a very human place; basic human traits presented in the context of profoundly important ideas by creative teachers there have had far-reaching consequences. John Archibald Wheeler, who passed away at the age of 96 on April 13, not only typified the kind of creative individual who inspired this kind of thing, he did this in the kind of scientific discipline (physics) where most teachers never exhibit these kinds of traits. His creativity and open-minded boldness led to truly wonderful ideas that have profoundly affected the physicists he taught and, in more general terms, what he said and how he said it affected the world of science. He did this throughout his career through his tenacious spirit of hard work, creativity, and willingness to be curious. These traits not only are necessary in science, when science is done correctly, they also are necessary in life when life is most fulfilling and meaningful. John Wheeler brought a human face to science and physics and to what goes on in science and physics, and his love for this was passed along to me through my father. It is an honor to acknowledge and celebrate this and to remember the genius, caring nature, and basic humanity of Professor John Archibald Wheeler.

"Quantum foam," "Wheeler's wormhole" and "black holes"—these seemingly "delusionally-imagined" words are actually the creation of this remarkably creative and ingenious scientist. Professor Wheeler did much more. In fact, he was almost always concerned with curiosity and the most curious aspects of science, which, at heart, involve the boundaries of science. His genius about this was passed along to his students: some of them potentially becoming some of the more extraordinary physicists/philosophers who have ever lived. One student was Hugh Everett, who in his Ph.D. thesis on quantum mechanics under Professor Wheeler envisioned parallel, alternative universes endlessly branching and splitting apart. Bryce DeWitt of the University of Texas in Austin called this the "Many Worlds" hypothesis.

Although this picture sounds like a form of science fiction, which for most physicists is too bizarre to be believed, it may potentially play a role in helping to resolve questions related to the beginning and end of the universe. In particular, beginning from a potential phenomenon (Wheeler's wormhole) and by including the possibility that the universe may repetitively expand and contract, a colleague of Professor Wheeler, Princeton Professor Paul J. Steinhardt, (www.actionbioscience.org/newfrontiers/steinhardt.html) has suggested a theory involving cyclically occurring forms of the Big Bang that, in principle, is consistent with this "Many Worlds" hypothesis. Somewhat remarkably, through this "cyclic 'Big Bang' theory," Professor Steinhardt has been able to suggest a way to explain one of the more bizarre astronomically observed paradoxes, involving "hidden" or "dark" matter, which involves a phenomenon (hidden mass) that has dumbfounded cosmologists and astronomers for more than 20 years. He has done this by accounting for the missing mass as arising from gravitational forces that are not generated by our own universe. Instead, he makes use of the assumption (which is consistent with the predicted topology of space and time, based on General Relativity) that an infinite number of universes already exist and that each universe can project a gravitational force into a second universe through a gateway—referred to as "Wheeler's Wormhole"—that joins the two universes at the center of a Black Hole.

Richard Feynman, who won the Nobel Prize in 1965 for a truly remarkable tour-de-force approach for understanding the most basic forms of physics involving re-interpreting quantum mechanics and its relationship to electricity and magnetism, was inspired in his work by the rare opportunity of working on a problem, suggested by Professor Wheeler, in which future events could alter the past at the microscopic (atomic/electronic) dimension, while also involving a completely novel idea that in the limit of nothing taking place, changes in reality involving motion would not involve changes in the external environment. Quite literally, as a potential research project Professor Wheeler suggested to the young graduate student Feynman that he investigate the idea that in situations involving the very smallest and finely-resolved levels of possible forms of measurement, the limiting idea that "a tree falling in a forest not making a sound when no one was there to listen" was quite a genuine possibility.

In fact, since in this picture there is "nothing around," it is quite impossible to preclude this possibility. The combination of this possibility and the seemingly impossible idea that the future could affect the past actually helped to inspire the approach that Feynman used in the work that led to his Nobel Prize. Feynman recalled in his Nobel Laureate address the remarkable concepts through an exchange that he had with Wheeler shortly after this work occurred, during the creative events that followed. A considerably simplified paraphrase of the phone conversation that he had with Wheeler is the following: "Feynman, I have figured out why all electrons and positrons have the same mass. This is because there is only one electron in the universe. When it moves forward in time, it behaves as an electron; when it moves backward in time, it behaves as a positron."

This conversation involved a detailed series of questions about how classical physics might be related to quantum physics. Because new science was involved, Professor Wheeler stated the ideas in a more complicated way, but the essential idea was there. He said, "Feynman, I know why all electrons have the same charge and the same mass." "[Feynman said] Why?" "Because, they are all the same electron!" Then, he used classical physics language, based on special relativity, to suggest the idea in a complicated mathematical way that the masses of electrons and positrons would be the same if they moved forward and backward in time in a symmetrical way, in a manner that did not account for the fact that there are many more electrons than positrons in the universe. Because of this apparent deficiency, Feynman asked, "Why Professor Wheeler, aren't there as many positrons as electrons?" "Well, maybe they are hidden in the protons or something," Wheeler said. Feynman points out in his lecture that he did "not take the idea that all the electrons were the same one from [Wheeler] as seriously. . .as the observation that positrons could simply be represented as electrons going from the future to the past." This idea, he pointedly stated, "I stole!"

These insights capture the flavor of the many additional ideas and the wonderful physics that followed (involving, for example, the possibility that the "one electron" would move along infinitely many, different paths and the extraordinary possibility that "particles" moving forward or backward in time would be required to exchange places with other particles that are moving in time in the same way, from one moment to the next, over arbitrarily large distances). These are examples of the essence of great science that can occur when truly creative people are involved. John Wheeler and Richard Feynman certainly were such people. Dr. Wheeler was an advocate of curiosity; he was a mentor to my father and I appreciate that he passed this love on to my father.

Beyond inspiring his students, Dr. Wheeler made great contributions, not only by creating terms such as "black hole," "quantum foam" and "Wheeler's wormhole," but through his learned books and theoretical contributions. When my father had John Wheeler as his teacher of Modern Physics during the spring of 1939, Professor Wheeler told my father about something truly extraordinary that had occurred in Germany several months earlier: a new, miraculous form of energy had been created, involving a revolutionary process called "nuclear fission." Not only did John Wheeler know about the importance of this discovery, but while he collaborated with the father of quantum mechanics, Neils Bohr, he helped to explain nuclear fission in a way that could be used to design the atomic bomb and nuclear reactors. John Wheeler and Neils Bohr could have won the Nobel Prize for this. John Wheeler certainly could have won the Nobel Prize for many other things.

"If there's one thing in physics I feel more responsible for than any other, it's this perception of how everything fits together," Professor Wheeler said. "I like to think of myself as having a sense of judgment. I'm willing to go anywhere, talk to anybody, ask any question that will make headway." Richard Feynman presented a more dramatic picture. He said about Professor Wheeler, "Some people think Wheeler's gotten crazy in his later years, but he's always been crazy." I met John Wheeler only once in person, but I have known him well through his books and his impact on my father. I have learned since about his legacy, which included not only his love for science and all people who love science (which are loves that transcend time) but also his contributions, including his work on nuclear fission. He is gone, but his legacy continues. "He's always been crazy." This is an essential description, sometimes literally true, of truly great scientists.

If John Wheeler had been younger or had received more accurate information about cold fusion, I am quite confident that he would have been an advocate about changing the dialogue (or lack of dialogue) about the subject. John Wheeler's involvement with "fringe" elements of reality is related to an important theme associated with truly creative science which involves language, thought, and when language and thought come into conflict (which certainly has been the case with the terminology "cold fusion" as it has been applied to the Pons-Fleischmann effect). Dr. Wheeler was truly a genius and inspirer, someone who could have made a difference in the cold fusion debacle if he had been involved. Why this did not happen is an open question.

The classical picture that formed the basis of Dr. Wheeler's idea that a positron can be viewed as an electron moving backward in time is fundamentally entirely consistent with what is known about electricity and magnetism. The quantum mechanical and quantum field theory implications of this classical theory are at the heart of what I refer to as "The Grand Identity Crisis." In particular, in the fall of 1989, I met and confronted Edward Teller—another "giant" of twentieth century physics—at a meeting about cold fusion that was held at (although only indirectly sanctioned by) the National Science Foundation, in a private (behind closed doors) meeting. At the time of this meeting, I had no idea how contentious the cold fusion debate and lack of debate would become. Teller at this late stage in his life (he was well over 80 at the time) was open-minded about the subject, albeit in an environment (behind closed doors) where his ideas about it were not widely circulated. Behind closed doors, he suggested that a "crazy particle" could explain cold fusion. Teller called this particle a "meshuganon," which is derived from the Yiddish word for crazy, "meshuga," and the commonly-used language construction that physicists practice of adding the suffix "non" to a particular word in order to create a word for describing a new form of particle.

I interrupted Edward Teller when he started to talk about this. At the time, I had no idea about the protocol for scheduling talks (which I realize now did not really exist) or the degree of formality that should be associated with the ongoing discussion. I simply held up my hand and said, "Excuse me. There is no reason to invent new physics to explain cold fusion. It can be explained through the known laws of physics. I have prepared a talk that I can present now about this, or we can go to dinner." We went to dinner.

During the dinner conversation, I began to sense considerable confusion about what constituted the relevant physical situation associated with what Pons and Fleischmann had observed. In particular, given the low, average energy and momentum per unit volume that is potentially available associated with the Pons and Fleischmann effect—as opposed to envisioning that a particular single "particle" collision process could be responsible for the effect—intuitively one might suspect an alternative kind of effect might be responsible involving a phenomenon that is similar to electronic (or potentially deuteronic) charge conduction in solids or the formation of a Bose Einstein Condensate, in which many particles are allowed to interact coherently, effectively, without colliding with each other.

Later, Talbot Chubb and I wrote a paper for the Proceedings of this workshop, titled "Fusion in a Solid Through Solid State Effects: The Grand Identity Crisis." An interesting connection between the positron-electron ideas developed by John Wheeler and Richard Feynman and the underlying physics associated with what Talbot Chubb and I suggested in this paper involves the haunting idea that when we really do not know where things are (which can occur in periodically ordered solids when the situation involves low momentum and energy, or when single electrons move forward and backward in time), a seemingly impossible phenomenon can occur in which many particles can "lose" their identities.

In the case of periodically ordered solids involving deuterons interacting with the solid and with each other with low energy and momentum, this loss of identity can occur because the deuterons can begin to act together as a single entity (similar to the way bosons behave in a Bose Einstein Condensate). In the case of electrons in solids, a similar, counter-intuitive form of interaction can occur in which individual electron identities are also lost, but instead of a situation in which each particle (in this case an electron) begins to interact with the others in a way that resembles a single entity, the electrons can be required, effectively, to "pay attention" to the remaining electrons (and holes that are left behind at locations where electrons are not present), preferentially in a manner that also results in a "loss of identity"— similar to the situation in free space, when electrons and positrons are involved, where the identity of each electron or positron becomes lost through a complicated process involving effective forms of motion. In both situations, in more general terms, the identities of individual particles are lost because it is impossible to distinguish one identical particle from another.

When this happens, the resulting effect is what we referred to as "The Grand Identity Crisis." In more general terms, being open to the possibility of unexpected, wonderful, new science occurring through a form of "Grand Identity Crisis" is a theme that requires confidence that by embracing change and unexpected results, it is possible to find truly great ideas and effects. In this sense, loss of identity can be viewed as being good and, in fact, by being willing to explore completely new and novel ideas, John Wheeler embraced the concept of a "Grand Identity Crisis."

An interesting thought is that potentially a much larger "Grand Identity Crisis" has taken place associated not only with the scientific issues related to cold fusion and how cold fusion has been portrayed and misrepresented but also with deeper issues involving the ability of our own country and the existing scientific establishment to identify truly great science and to implement change. John Archibald Wheeler would have been shocked at this. "The Grand Identity Crisis" is a metaphor for so many things that should and will occur, provided we have confidence that by embracing new ideas and change, a better world will become possible.

"In Praise of Old Nassau" is a phrase that seems to mimic something shallow: a drinking song. But it represents, at heart, the best aspects of "The Grand Identity Crisis": perseverance regardless of the outcome, intensity, tenacity, and confidence that through change, new, wonderful things will become possible. It is both profound and terribly human to be able to accept and embrace the unknown without reservation, and doing this really counts.