

A NEW PERSPECTIVE ON TIME

Interview with Professor Richard Muller

BY CATRIN BAILEY, DANIEL YOON, JORDAN WONG,
SASINAN SANGTEERASINTOP, YU LUO
LAUREN ZHU, VIDYUN BAIS, GEORGIA KIRN

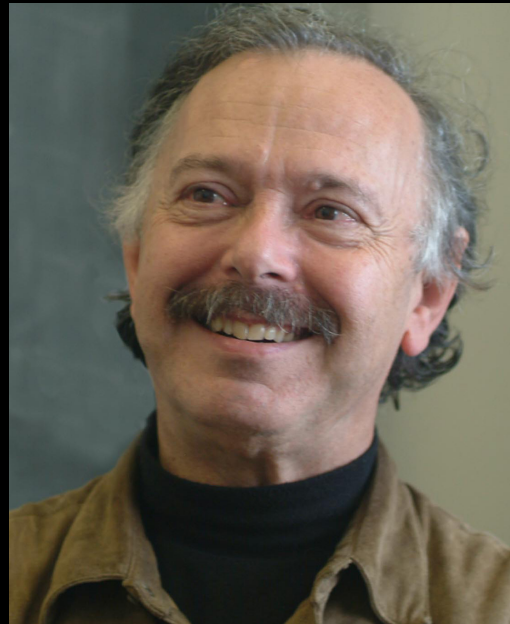
Dr. Richard Muller is a Professor of Physics at the University of California, Berkeley. His many interests include particle physics, geophysics, and astrophysics. He has studied the extinction of the dinosaurs, the affect of the planets on ice ages, the beginning and end of the universe, and the nature of time. He teaches the class Physics for Future Presidents.

BSJ: How did you get involved in physics, specifically astrophysics?

DM: My interest in physics dated back to high school; I loved all sciences and I found biology to be too difficult, I didn't really get excited by chemistry, all the things I loved in science turned out to be physics....Now, I consider myself to be an engineer as well as a physicist, but back then, it was the physics that looked like the field that held the answers to the most interesting questions.

BSJ: You've done a lot of research in glacial cycles. If you were first a physicist, how did you come to correlate the two?

DM: In a very backwards way, it came about because my closest associate, my mentor, Louie Alvarez, had gotten involved in geology through his son Walter. They had addressed the question of "what killed the dinosaurs?" I got involved in that too to some extent; I wrote some papers on the subject, and at the end of their work,



my thought was "what a surprise this was, that something from space, astronomy, could cause such a big impact on things on the Earth, what else could there be?"

I started thinking about the Ice Ages, and if those could be caused by astronomy, maybe by the impacts of asteroids and comets? I looked into it and discovered it was an astronomical theory that explained the cycles of the Ice Ages in terms of the changes of the planetary positions. It was a widely accepted theory, but as I read into it, I realized this theory must be wrong. Typically when I read something new, if it makes a lot of sense that's great, but if you looked at it critically rather than accept authority, as scientists are taught, I found severe flaws in the theory. That's when I started playing with the theory, trying some alternatives, finding an approach that worked much better than the

standard theory, and publishing papers on that. That's what led me into geomagnetic reversals.

Louie Alvarez died in 1988 after he had done this fantastic work; he had a Nobel prize for working in elementary particles in physics, but I think the piece of work that he will be most remembered for will be the discovery of the cause of the extinction of the dinosaurs.

BSJ: You heavily studied glacial cycles that have shifted from 21,000 year cycles to 100,000 year cycles; what are the environmental implications of this shift?

RM: We know that for the last million years we've had an Ice Age every hundred thousand years, an Ice Age typically lasts 80-90,000 years, so we've mostly been in Ice Age, for the last 15,000 years we've been in an interglacial, the warm period in between, and that's when all of civilization was developed, not surpris-

ingly. These short periods of good weather are when we developed civilization. There was no civilization before 15,000 years ago. It warmed up suddenly, we developed farming, farming led to the ability of people being able to create more food, not everybody had to be working all the time, which meant they could have physics professors and things which would normally be considered a waste of time because they didn't produce food. And a new Ice age is due any millennia now. That got me into global warming.

BSJ: You've argued that phase stability of glacial cycles has no relation to quantum mechanics, so it has to be due to astronomical forces.

RM: It has such a regular 100,000 year cycle; the only thing in our environment that has that kind of regularity is astronomy, not perfectly regular, but extremely regular: there's no other mechanism that anyone has ever proposed

other than astronomical that could lead to such regularity. But I would say that the astronomical cause of the previous ice ages is firmly established. Exactly how astronomy does that is still not on firm ground in my mind. A lot of people say it is, but their theory, the Milankovitch theory, is demonstrably wrong.

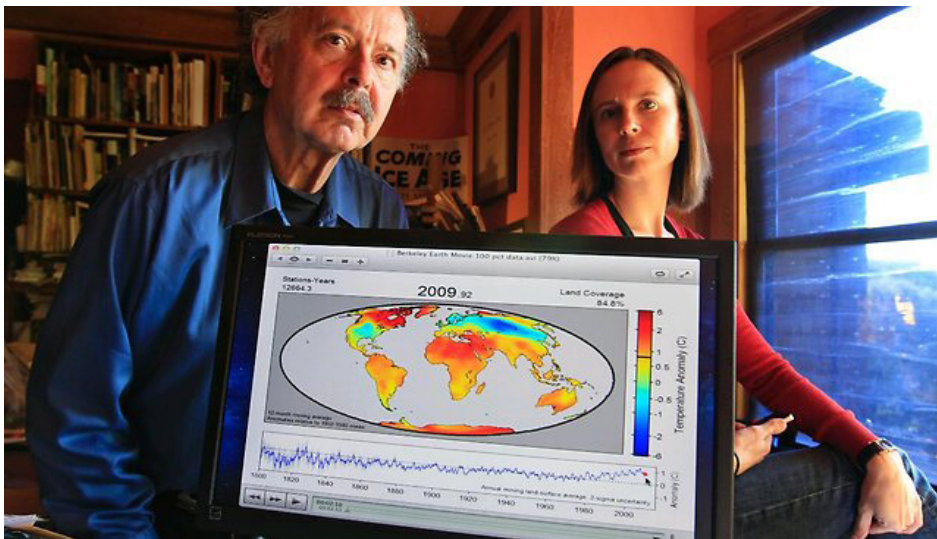
Some people in this field say 'ok well what's your alternative' well none of the alternatives work either and they say 'therefore we accept the Milankovitch theory' well that's crazy, if something is wrong it is wrong. We do know it's related to cycles of the Earth but how we don't fully understand.

BSJ: Explain how you researched cycles of fossil diversity and related glacial activity with the fossil diversity, theorizing that there are (periodic passages) of our solar system that pass through the milky way every 62 million years which leads to the extinction of these species on Earth.

RM: The 62-million year cycle in my mind is not explained. There have been several proposed explanations including passing through the milky way... We postulate that there might be a dust region but that theory doesn't really work either...

BSJ: Recently you published the book 'Now: Physics of Time', did any of your prior research lead you to study the creation of time or was it just purely personal interest?

RM: I had been involved in two major projects studying the big bang. The first one was a study of microwaves of the big bang in which I had proposed we measure the microwaves from different directions and I had a much more sensitive way of doing it than anybody had done before and I thought we would be able to



Muller is the director of the Berkeley Earth Surface Temperature Project which he founded alongside his daughter Elizabeth Muller

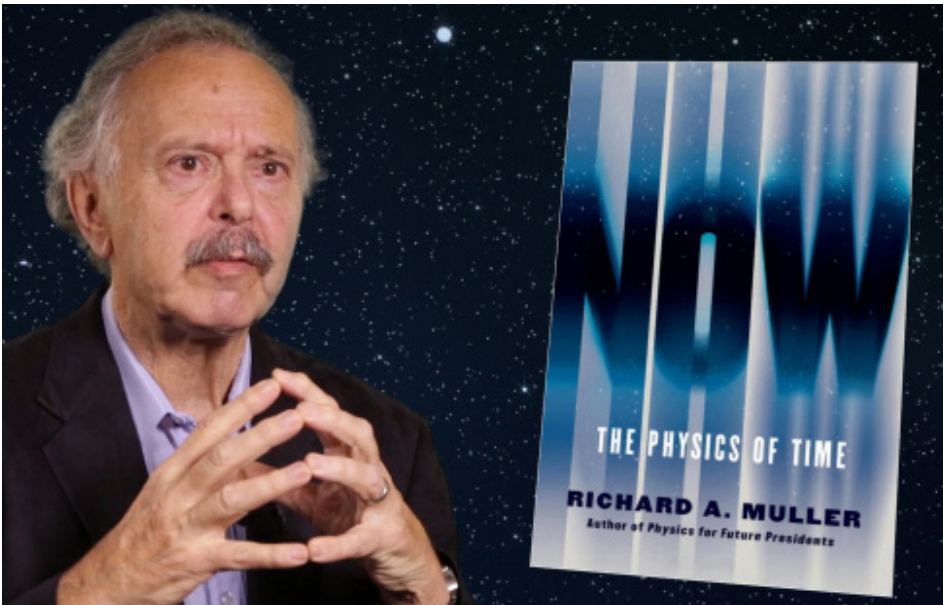
see that variation and in fact we did and thanks to that experiment I became a professor at Berkeley and my student who was working on that experiment got a Nobel prize. That project was very successful and had to do with what was going on at the very early moments of the big bang, what can we tell by looking at these microwaves. There are a bunch of interesting theories there and they all relate to the big bang being a unique event in which space and possibly time was created...My best guess, pure speculation, is that time did not exist before the big bang was created and space did not exist before the big bang, that matter did not exist before the big bang and there was literally nothing, not even empty space. My the next experiment had to do with whether the universe would expand forever. Having worked on the big bang I wanted to look at the other end. I worked on that project for 15 years, my student took over and he won a Nobel prize. That had to do with the end of time. I had to tell my class that now with Saul working on that project I believe that within three or four years he would know the answer with whether time would go on forever or whether we would eventually stop with a big crunch. Then two years later I had told my class I can tell you now time is going to go on forever. The discovery made by Saul and the people working in that group was that the universe would expand forever. So yes my own research led me into two projects that led to a study of the two most interesting aspects of time, the very very beginning and the possible end.

BSJ: You theorize that time is expanding because space is expanding, therefore time travel is not possible because the future doesn't exist yet. Are there proactive ways to experimentally test this or do you have to wait for certain events such black-holes colliding?

RM: If you look at the previous theories of time, and I've looked at them all, it has a very bad history of failure to propose tests. Of all the theories I've looked at, nobody has ever proposed a test. This goes back to 1928, when Eddington said that the arrow of time depends on entropy and he didn't propose a test. All sorts of other people have adopted his theory, they have all elaborated on it, nobody has ever proposed a test. When I first came up with this idea, I actually came up with it while writing the book. When I came up with this idea that time was due to the creation of new space, I knew I had to find a test or else it wasn't up to my standards of science – standards that I wish everybody else shared but not everybody does these days. I came up with two tests. One is the study of gravity waves that would be produced by the Big Band that would indicate whether or not new time was being created. The second thing I came up with was as the universe is expanding, the dark energy that accelerates that expansion should also accelerate time. And the trouble with those tests is I couldn't think of any way that we would be able to do those measurements within my own lifetime, which is not very satisfying. After the book finished, along came this discovery in LIGO of two black holes colliding. Suddenly I got very excited because based on my understanding of general relativity, I realized that this might actually be a test and I quickly worked out the numbers and it turned out that it was testable. So I looked at the LIGO

“It has such a regular 100,000 year cycle; the only thing in our environment that has that kind of regularity is astronomy”

experiment and I found they just barely didn't have enough accuracy. So I got a hold of the LIGO data and I reanalyzed it – if I could only squeeze out a little more accuracy out of their data, then I could see if my theory is right or wrong. And I could not, it turned out that the analysis had been done in the best possible way. I'm very good at data analysis – it's one of the skills I have and I know how to take data and analyze it in a way that is optimum – and to my disappointment they had already done that. So that experiment barely misses being able to test the theory, but I realized that they turned on and within six months they saw this event. Odds are they'll see another event in the next year or two that will be just as big, and if it's closer, pretty good odds that'll happen, then we'll be able to test the theory because the signal will be stronger. So when you say “Is there something we can do?”, yeah we can watch what happens on LIGO. I've talked to all the people on LIGO, they're going to look for this, and I expect to get a phone call one day and it'll probably go something like this, “Hi Rich! Guess what? We have a new event and it's 10 times stronger than the old one!” And I'll say, “Wow, that's just what I wanted! So, what about my theory?” Then they'll say, “The bad news is that your theory is wrong.” And I'll go, “Oh darn!” or maybe I'll use a stronger word. But I will be proud that at least I had a theory that is falsifiable! And nobody else has done that! Now people will argue against me, they say “Well I think your theory is this.” How do you test it? You can't. Gah, that's not a theory! We should not accept theories in science that are not testable – just because they feel good. And maybe he'll say, “Well, you were exactly right.” And then what an accomplishment that would be. To come



Dr. Muller discusses his new book “Now: The Physics of Time” which details his theory on the flow of time [Source: UC Berkeley News]

up with a theory of time, brand new, one of the most fundamental things in human experience, time, and with this theory make a prediction that turns out to be right. Wow, that’ll be a great achievement! And I’m optimistic in the next few years, I’ll find out one way or the other. I’ll see which way it turns out to be.

BSJ: In regards to the experimental methods, how has the measurement of cosmic microwave uniformity, and the discovery of dark energy facilitated your new theory and understanding of time?

RM: Well it hasn’t facilitated it yet. What it does is it allowed me two predictions, neither of which I know how to test. So the dark energy, for example, says that the universe is not only expanding, but it’s expanding faster and faster. In my theory, if the universe is expanding faster and faster then time is accelerating too. So can we tell if the time in the past is going slower in the past than it is now? We can do this by looking at distant galaxies and seeing how rapidly things are happening. For example spectral lines which are oscillating atoms, you look at the line, it should have a lower frequency – it should be redshifted. So we could observe it that way. The problem is it is redshifted and we attribute that to the fact that it is moving away from us. Well maybe it’s not moving away from us as fast, maybe part of that

redshift is actually due to this new effect, how do you separate those two ideas? And right now I don’t have any good way of separating it. So that test is a good test in principle but not one that I know how to implement until we find an independent way to measure the recession of velocity. I’ve thought of some ways to measure that but none of those are practical. So maybe twenty years from now they will be. The other is the Big Bang, when we believe (it’s not yet definitely proven) that during the early Big Bang was a thing called inflation, when the universe was expanding much much more than now. If that’s true then there should’ve been a great deal of acceleration of time during that period. If that’s the case then the calculations people have done for gravity wave emissions during that time were wrong. So we have to redo those calculations taking into account the acceleration of time. I haven’t done those calculations yet. I don’t know whether I’ll do it or someone else will but it needs to be done. Then there is some hope that the gravity waves in that inflation error will be observed with current experiments. There was a report that they had been observed a few years ago and that report turned out to be false. They had to retract their observations a year later because what they had been seeing was background interference from a layer of dust. So they had not seen it. But with better experiments we can see it and we can better compare the two theories to see which one turns out to be right. But the cleanest, simplest test is this LIGO test with two colliding black holes. That’s what I’m most excited about. But I emphasize, theories are worthless in my mind if they don’t make predictions that allow you to prove them right or wrong. Usually they’re proven wrong. If you survive a lot of tests where people are trying to prove you wrong and they fail, then the theory becomes part of our understanding.

BSJ: If your idea is that space and time are so intertwined that one cannot create one without the other, why is it that we can go back in space but we can’t go back in time?

RM: You can move in any direction in space, yet time moves forward in a way that affects our lives over which we

have no control. That really is the question, and why is that? So in addressing that question I have to address another principle of physics, which is the Principle of Causality...

I have to think about another principle of physics, which is, the principle of causality, that we think that one thing causes another. When I decide I am going to drop this pen on the table, it hits the table, but I have to drop it; I had free will. I could decide to do that or I could decide to not to. Now casualty in physics is a separate principle from relativity. It's something that stands outside of the other laws, from conservation of energy- we have many laws in physics- but causality is yet another law. Some people deny it. Some people say I have no choice but to drop it the first time and not the second time. And the reason is, all these molecules are hitting me and I am just responding to the past. And I have no choice over what I do. I cannot do things except what the past gets me to do. I remembered when I named my daughter Elizabeth. I learned years later that was the most popular name of the year. And so maybe so I don't really have free will. It turns out that casualty- which claims that the past determines the future- is no longer a law of physics. That has been innovation of the 20th century and it's often not stated that way and it is something I spent a lot of time in the book explaining because it is absolutely true and yet not widely appreciated. The old philosophers like Schopenhauer and Nietzsche who argued that free will is only illusion, but that is repeated today by scientists who should know better by major physicists who should know better; they repeated the same thing! When Schopenhauer said that people widely believe that physics was completely deterministic, that the past completely determines the future, we know now that is not the case, at least that is not the current theory of quantum physics. Quantum physics says that identical things will explode at different times, even though they are identical. That means the past doesn't determine the future. That is the substantial part of quantum physics as it is today.

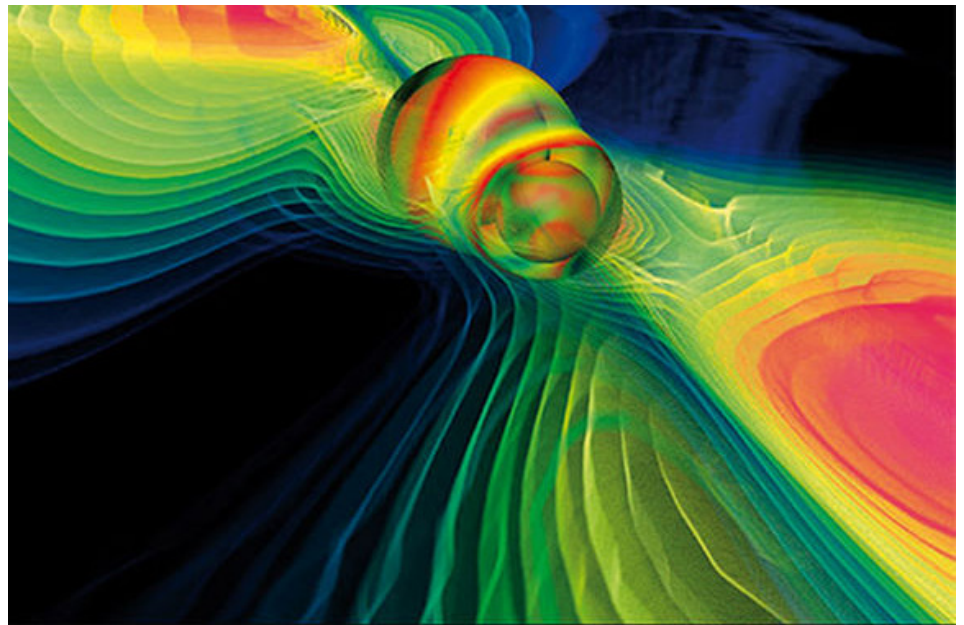
So given that, the argument that so many otherwise smart people had made that logically, we know that we don't have free

will-- Dawkins had made a career out of this, Richard Dawkins, he writes wonderful books but then he writes this nonsense as if he doesn't understand quantum physics, and maybe he doesn't. But it's nonsense.

The argument against free will is just not scientifically valid and they are all based on assumptions that we know aren't true. So here's a way of thinking about the answer to your question.

We do exist in time, we existed in the past. The past has all been determined later and you could sort of go back in time- it's called memory- but what you can't do is change things back in time. You can't go back and say, "Oh I wish I hadn't said that", and not say it again because all that has been determined. The only time when things are not determined is when we get to exercise our free will. What I am saying, in a sense, is drifting away from physics.

The physics is the causality, but the question I am addressing is, "Why is the moment now- the title of my book- why is "now" so important to us as humans?" And the answer is, because it is the only time we can exercise our free will. So here I am drifting away, some people wish I just stayed with physics in the book and yet, I think, in opening up this question of free will, I think for the first time in over hundred years that this has deep philoso-



Gravitational waves may be able to provide new perspectives on the concept of time

phy and religious implications that we can make decisions that are not based on the history of what came before. We can based them on something nonphysical- I like to term “empathy”— that we care about other people. There’s nothing in the past that makes us care about other people. Dawkins would say, oh we don’t really have a choice, it’s our genes that are telling us— I really like Richard Dawkins, his book “The Selfish Gene” which everything we do, even the things that look altruistic, are being done because we are saving someone who are sharing the genes we have and we want the genes to survive. Okay, that’s a nice theory, he never proposes it for test of course, and we are all supposed to be persuaded by the fact that it sounds so plausible, but yet it doesn’t sound plausible to me. He proclaims that atheism is self-evident and logical, which is another one of these things that I go, “Where did you get that?” He just come out and makes it up and says, “This is science”. No, this is not science! So the reason we can’t go back time, we can go back in time, it’s called memory, but what we can’t do is change things in the past because we cannot exercise our free will in the past. We can only exercise our free will right now.

BSJ: To you, what is the greatest importance of understanding the creation of time, and why did you choose to direct your study toward it?

RM: I don’t think we choose the science what to direct our study towards. I think we choose things because they are fascinating; because they are of fundamental importance to our own understanding of ourselves. Why did Louis Alvarez, the physicist decide to work in geology for the first time in his life? Because the question of why did the dinosaurs die, he felt, was a really fundamental issue. And it is. It changed our view of evolution. No, we used to think before Alvarez were. That evolution was simply survival of the fittest competing with each other and that’s it. And may the best creature with. With his discovery, we now know is we’re not just fighting each other, we’re fighting survival against catastrophe. And so there is great advantage to flexibil-

ity, to being able to be more complex, to be able to survive in new circumstances. It gives a whole different meaning to what we are, why we are here, why we’re surviving, how we will survive in the future. So I think ultimately what drives science and scientists is to get a better understanding of the reality and meaning of life. And there’s nothing more fundamental life than time. And the thought that I knew enough about time, enough about relativity theory, enough about what other people were saying that I could contribute the key in all of the work I’ve done for which I have made. Contribution has always been as with the language there, and we look at it very close and say wait a minute, this does not make sense; there is something wrong here. Actually everything I’ve done has turned out to be important has only started. With I looking at what came first in saying: “No, this doesn’t make sense. There’s something fundamentally mistaken in the prior work.” And that’s where I was when I started recently thinking about time. There are things that bothered me for years. And I thought recent I just gonna write a book about that. And as I wrote about the book, I started thinking fundamentally really in putting together the arguments why the old xxx a picture of time was no good. I got much more depth and I start thinking of things from cosmology that also proves the theory was wrong. And as I put all the stuff together and then quantum physics bringing that in putting in blackhole operation. As I put all these things together, I began to see the larger picture. That it did make sense. If xxx the time was created at the Big Bang along with space. And all these other things fit together with that insult. When I start reading the book, I didn’t claim to have any powerful conclusions in the book. And it wound up that what I really needed to do was to put together everything that I knew, to address all of the quandaries, to figure out where everybody else was wrong. And then realized there was something that explained everything. Truly out came about.

BSJ: What are the future directions of your research and in the field?

RM: Well I would like to improve the theory. Right now I’ll give an example when Einstein first predicted the light was deflected by the sun. He did this in a paper which he calculated using some equivalence principle that like should be deflected by the sun. Couple years later he worked out a complete theory with the complete equations. This equation showed indeed that light was reflected by the sun, produced afflicting twice as much as in the original theory show. So I feel that we’re at the stage that original theory. We will come up with the fact that when space is created, time is created, but I haven’t yet modify the equations of relativity to take that into account to come up with a full theory. That’s something I would like to do. I like to come up with other predictions. I could be tested in other realms, ideally would be a laboratory experiment. When Einstein did his original work, on relativity theory one of the things he predicted was that gravity would cause the frequency of a light beam to change. And he didn’t know of anywhere that could be tested. But a few decades later, there were two ways to be tested both with verified. One was by looking at light coming from the white dwarf star which had such intense gravity at the frequency of the atoms was actually changed by the time I’d like to work start being slowed down by the intense gravity that could actually observe. The other was in a laboratory experiment which was signed his crowning Ripka actually took gamma ray photons from a tower, and had them fall down, then measure the frequency very precisely when they reach the ground they could see the Einstein condition clear too. So there there may be things lurking that could be done, I’d like to find more of those.