



SECOND LOOK

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Beyond Einstein

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The Myth of Einstein's Brain

Interview: Multiple Universes

Can Time Run Backwards?

Technology is the Universe

Radical Physics of Twistors

An Einstein Commemorative Issue

MULTIPLE UNIVERSES

Dr. David Deutsch
Interviewed by Robert K.G. Temple

Atomic physics is called "quantum theory." The word *quantum* is German, meaning "quantity, share, portion." It was chosen by the physicist Max Planck at the beginning of this century to describe the fact that energy, in atomic physics, had to come in bundles. These "portions" or "quantities" of energy are therefore known as *quanta* of energy. It is unfortunate that the non-scientist sometimes finds the word "quantum" frightening, and as soon as he hears it becomes immediately convinced that it means something like "calculus"—synonymous with "incomprehensible."

There are different interpretations of quantum theory. The most extraordinary is known as the "many worlds interpretation," which postulates an infinite number of simultaneous universes. No reliable popular account of it has ever been published to our knowledge. We therefore thought *SECOND LOOK* should be a pioneer and attempt to bring this theory to the attention of its readers. You may well wonder why nobody has ever done this before. One reason is that only a small number of scientists are aware of it at all, and many of those who are either don't understand it, don't want to, or are frankly frightened of it.

Dr. Max Jammer, one of this century's leading philosophers of science, in his scholarly and rather technical book *The Philosophy of Quantum Mechanics* (1974), has near the end of his book a section on the many-worlds theory. Jammer quite accurately says: "The multiuniverse theory is undoubtedly one of the most daring and most ambitious theories ever constructed in the history of science. . . . it is virtually unique." (p. 517)

The theory was first proposed by Hugh Everett in 1956 in a Ph.D. thesis at Princeton University. The next year he published an article in *The Physical Review* announcing the theory, which was accompanied by a commentary from his Ph.D. supervisor, Professor John A. Wheeler, who had himself earlier laid the theoretical foundations for the hydrogen bomb. Since that time few physicists have had the courage to come to grips with the theory. But this is like the situation mentioned elsewhere in this issue of *SECOND LOOK*, in an article by Dr. Paul Murdin where he describes de Sitter's discovery in 1917 that the Universe was expanding, which went largely unnoticed for 12 years until Hubble found evidence to substantiate de Sitter's idea. Everett's theory has now been lying around for 23 years and been studiously ignored by most atomic physicists. The leading proponent of the theory today is Professor Bryce DeWitt of the University of Texas, co-editor of and contributor to the only book on the subject in existence, *The Many-Worlds Interpretation of Quantum Mechanics* (Princeton University Press, 1973).

Professor DeWitt recommended to *SECOND LOOK* a former student of his, Dr. David Deutsch, of the Department of Astrophysics at Oxford University, as someone well qualified to explain the ideas of this most startling of all the theories of modern physics. Dr. Deutsch kindly consented to the following interview.

ROBERT TEMPLE: You have written that you "can make the most staggering assertion in the history of Science: there is more than one Universe."



DAVID DEUTSCH: Yes.

RT: You are not just saying this because you want it to be true?

DD: Well there are many ways in which I certainly don't want it to be true.

RT: You mean it really makes you quite uncomfortable?

DD: It makes me quite uncomfortable, yes. There are many senses in which I enjoy it because I enjoy paradox and so forth. There are other senses in which it makes me very uncomfortable.

RT: So one of the reasons why you are exploring it so hard and so fast is that you hope that you can maybe get rid of it that way?

DD: Either get rid of it or see that it really ought to be so and become more comfortable with it; see other reasons why it should be so, perhaps.

RT: In other words if this is the way things must be, let me learn how to live with it?

DD: Right. Or else try to find a new way of looking at quantum theory that solves the problems that the many worlds interpretation solves, but doesn't have the unacceptable consequences.

RT: Basically what you are maintaining is that we live in the universe but there are, simultaneously, countless numbers of other universes occupying in some incredible way the same space?

DD: That's right. The notion of space, of course, only has a meaning within a universe and the same point, as it were, the same location, has a representation in each of the universes rather than saying that each of the universes is at the same point.

RT: But if somebody else were walking in this location which to us is a room but which to him would be a desert, he wouldn't run into us, he would go through us in some way? That sounds like spirits.

DD: What it means is that the "observable" corresponding to, say, the number of people in this room does not have a definite value. It may look to us quite obvious that that number is two. In fact if we were to work it out from quantum mechanics, if we only knew the state of this room, which in practice is impossible, but in principle if we knew the state of this room, we might very well find that the number of people in this room did not have a definite value, that this value was, as it were, shared between the value zero, one, two, three and four, let us say.

RT: So we, whether we like it or not, are really far more ephemeral than we fancy ourselves to be?

DD: Yes, that's inescapable.

RT: That's one certain conclusion from your . . .

DD: From the many worlds interpretation, yes.

RT: Well this has a lot of implications.

DD: Unfortunately, yes.

RT: It means, first of all, that we shouldn't be quite so arrogant because we are not as substantial as we think. We may, some of us, exist in several different universes and be different ages in each of them. You say there is no way we can know how many of the other universes there are?

DD: In practice we can't, because this would involve knowing exactly what the state of the universe is.

RT: Could there be an infinite number?

DD: There are certainly an infinite number, yes.

RT: I know a lot of physicists don't go along with the many universes interpretation because they maintain that it's, well,

When we speak about the different universes interacting at the microscopic level, it is a shorthand way of saying that the real entity which comprises all the universes together is evolving.

as John Taylor said to me only yesterday, that it's rubbish, that it's a great big mistake and . . .

DD: I don't see really how one can say it's rubbish, in the sense that the many universes interpretation as far as physics goes, is quantum theory. The other interpretations add on to that. So—well of course one can't tell *a priori* whether it is true or false.

RT: John Taylor maintains that the so-called ensemble interpretation of quantum mechanics completely gets round this business which is the big problem that the people who have fallen into the many universes interpretation are worried about.

DD: I believe this isn't so and I think that the ensemble interpretation and the attempted solution of the interpretation problem through statistical mechanics is a mistake. Let me counter attack. I believe it's a mistake which attempts to solve the problem by defining it away. But again if you look at the construct that appears, this ensemble, for example, and ask whether it is supposed to be really there or whether it is a mathematical construct, or when it appears or when it disappears, you are back to exactly the same problems as with the "Copenhagen interpretation."

RT: The "Copenhagen interpretation," named that because of a Danish physicist, is the conventional interpretation?

DD: Yes.

RT: Of quantum theory?

DD: Yes. It's strange, though, that it's the conventional interpretation.

RT: It's in fact only our bias against there being so many universes that leads us to think that your theory is weirder than their theory?

DD: Absolutely.

RT: We've got these other universes and some other fellow may be walking through green pasture and pass through this very location in another universe, unaware of us. What's the difference, I ask you, between that and the theories of dead spirits?

DD: The difference is this—or I would rather compare it with, for example, Leibniz's theory of all possible worlds where there is again a proliferation of universes all with different properties. The difference is primarily this, that the

many universes—the properties of the many universes described in the many universes interpretation—are defined by quantum theory. They tell you that there are a certain number of universes with this property and a certain number with that property and for some properties there are no, or essentially no, universes. So the first difference from Leibniz's many worlds is that there are many more of Leibniz's worlds than there are of Everett's.

RT: Well this is a way of saying that Everett founded this theory of the many universes interpretation of quantum mechanics. That there are fewer universes than some people might think; this is not meant to make us feel more at our ease.

DD: Well the infinity, in fact, is very controllable compared with, for example, Leibniz's one. There is a stupendous class of possibility.

RT: Well this wasn't based on any scientific point, it was pure speculation. But I still want to find out . . .

DD: The difference from supernatural phenomena is that a supernatural phenomenon is precisely one which has two properties which the many worlds don't. First it impinges on gross features of our world; in other words, if there were such a thing as a ghost and it were in this room then we would see it or something like that.

RT: Well, not necessarily.

DD: Oh well if it were of a kind that could necessarily not be seen . . .

RT: If it were a seen ghost, you mean. Seen ghosts are very naughty and not allowed in your theory, but if it is an invisible ghost it's alright.

DD: Yes, if you are willing to call, for example, the copies of us who exist in other universes ghosts, then they are ghosts.

RT: But they are nothing to do with dead spirits?

DD: No.

RT: You can't die in this universe and be born in the one next door?

DD: Certainly not, that's one of the possibilities that doesn't happen.

RT: So that's absolutely ruled out? If you are going to be born again anywhere it is going to be back in this one or it is going to be up in Heaven or whatever that may be?

DD: Well that's outside the domain of physics.

RT: You mean you are not yet in—not yet entering into the field of theology?

DD: Right. And from the point of view of the other worlds, in that sense, re. other ghosts, they regard themselves as being real and all the other universes including us as being less real.

RT: It's like the ancient Aztecs who might have been told about the Europeans in 1400 AD and we would have appeared to have been ghosts to them because they had never seen us.

DD: Yes and they might have been told these people do exist, have a civilization, it is just that you can never reach them. The difference is, of course, one of degree. The reason they couldn't reach them was because of the width of the Atlantic. We can't reach them because of the laws of physics, which is a stronger barrier.

RT: And when will the Christopher Columbus of Physics appear?

DD: When quantum theory is proved false.

RT: Ah. Well I want to ask you now about the many universes interacting with each other. Apparently they can but also apparently they can't?

DD: Yes, we have just been talking about how they can't interfere with each other. Now let's talk about how they can.

RT: They cannot observe each other or detect each other?

DD: They cannot detect each other.

RT: But they can still interact? How? This is a crucial point which made John Taylor say that your theory was rubbish. He said they can't detect each other, therefore what is Deutsch talking about when he said the things interact with each other?

DD: Well it is a crucial point and obviously if he didn't understand it, then I didn't explain it well enough. It is rather crucial and it is a subtle point but one which I believe I understand.

RT: Well I am dying to hear the answer.

DD: The crucial thing is interference phenomena. That is, the class of experiments which we can perform which demonstrate the effect of the other worlds on us.

RT: Now the other worlds, the other universes do have effects on us?

DD: Yes.

RT: As we sit here, they are effecting us?

DD: Yes.

RT: Against our wills?

DD: Well our will insofar as it is describable by physics, is itself a physical phenomenon and exists throughout the many universes.

RT: Well the fellow walking through green pasture which is in this very location, we might say in our terms in this room, and the other fellow walking across the desert which is also in this room are effecting us now?

DD: They are effecting us, yes. First of all the way in which quantum theory views the world through the many worlds theory. And I must say, of course, that what I am saying now is the many worlds interpretation, is that the true nature of reality as viewed by God, as it were, or as viewed by the laws of physics does not make specific reference to this room and us sitting in it and so on. It makes reference to a composite object one of whose aspects can roughly be described by two people sitting in a room and another of whose aspects can roughly be described by someone walking through the room. But if you look in sufficient microscopic detail at the true nature of reality, you would see first of all that it doesn't in the last resort make sense to talk about these things being separate.

RT: You mean the fact that we are sitting here and that they are walking through the pasture and desert respectively is only

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just an approximate description of what is really happening?

DD: Yes, and the true description is of an entity that contains all these things at once.

RT: So really talking about individual universes is . . .

DD: . . . an approximation.

RT: The greater reality is all of them at once.

DD: Yes.

RT: And so we are at a lower order of definition and distinction when we talk about individual universes?

DD: Yes, or a lower order of approximation as it were. When we talk about individual universes, we are already using an approximation, something that if you looked at the ultra-fine level wouldn't really make sense.

RT: Just like if you have a glass of vinegar in front of you, it looks like just an ordinary liquid. You put it under the microscope, you look and you see little live worms wriggling about in it. So that when you get down to the lower levels, the finer details of things, you discover they are really very different from what you had blithely assumed they were.

DD: Absolutely, that is a good example with the vinegar. For most practical purposes you assume it is a liquid, it will flow and so on. But for some purposes if you put it through the microscopic gauze then you would find it didn't flow like a liquid because the worms get stuck in the holes.

RT: So this is what it is like with the universes?

DD: Exactly.

RT: And this is what it means to say that we can't detect them, because detection would be on a gross level.

DD: Exactly.

RT: But it also is true to say that they are effecting us because that is at the smaller level of the—say vinegar worms which we can't detect because we don't have microscopes quite that powerful for this problem and yet this is still very much the case?

DD: And yet to pursue the analogy further, it is like it was in the days before they had microscopes that could detect bacteria but they knew that if they passed an infecting solution through microscopic pores it would become non-infecting and therefore they had indirect evidence of the existence of these unobservable things. And so supposing that microscopes had never been invented, one would say alright, we will never see bacteria, we will never weigh them or see them or directly interact with one, yet we have indirect evidence of their existence. We can perform an experiment which we can say with hindsight would have happened differently had there been no bacteria.

RT: And we can perform such experiments with regard to the universes which means that although we can't detect them, we can infer their existence from certain effects which we can detect from experiments which we can set up.

DD: Yes, that's right.

RT: So we really have proof that these other universes do exist?

DD: It's not proof, one can never prove anything in science. What it is, is corroboration of the theory.

RT: So that if it's not indicating that there are other universes, it is really very important to indicate something else extremely important which we haven't yet thought of?

DD: Oh absolutely, yes.

RT: So either your theory is true, or something, as I believe you said earlier on, even more amazing is probably true?

DD: Yes.

RT: Must be true.

DD: Yes, yes.

RT: So even if you are not right, what you are talking about is sufficiently important for everybody really to be paying a lot of attention to?

DD: I think so, yes. It could be, for example, that the "Copenhagen interpretation" is true. Now if that were true it would be orders of magnitude more remarkable, in my opinion, than if the many worlds interpretation were true. It would mean that there was something special about, for example, consciousness. It would mean that conscious beings are treated differently in physics from other things. That if you use the laws of physics to predict the evolution of my brain, you would get the wrong answer.

RT: In other words if the conventional interpretation of quantum mechanics is true and yours is not, consciousness has to be an entirely different phenomenon from anything physical?

DD: Yes. That is one representation of the "Copenhagen interpretation." Some people say it is not consciousness, it's a degree of complexity, or—from my point of view they all suffer from the same defect that there is no precise criterion possible.

RT: Any person, and we are no exception, knows what we are talking about when they say the word consciousness?

DD: No, certainly not.

RT: So what we really come down to is we've got our noses up against this incredible difficulty that nobody knows what consciousness is and nobody knows what a universe is.

DD: Yes, if you like.

RT: You say the many universes are interacting. What about them interacting at the sub-microscopic level? How can anything at that ridiculously small level mean anything?

DD: First of all it is noticed that when we speak about the different universes interacting at the microscopic level, that is again only an approximate way of talking. It is a shorthand way of saying that the real entity which comprises all the universes together, is evolving, is undergoing a self interaction.

RT: Do you think it is growing up?

DD: Well the sense in which it is changing into something new is a philosophical matter.

RT: Outside the domain of physics, to use a very good expression.

DD: Outside the present domain of physics, although I think that is one of the things that we may begin to be able to elucidate.

RT: What would you call the totality of all the universes?

DD: The state.

RT: The state of the world, or Universe Aleph.

DD: Well that sounds like just one. It is the set of all universes.

RT: But you told me earlier on that you didn't believe that the set of anything was distinct from the things in it by degree or kind. But now you are maintaining it is.

DD: No, no, no, it is just a manner of speaking. This true reality you can either call it "set of all universes" or actually "all the universes."

RT: Do you believe that the totality, the state of the world is greater than the sum of its parts?

DD: With a naive definition of "sum" of or "parts," it is, of course, greater because it consists also of the configurations of its parts, and in quantum mechanical terms the state of its parts. But anyway, perhaps that is getting off the subject.

When you talk about universes splitting, branches splitting into smaller branches, you must always have in your mind that you are referring to gross aspects of them.

RT: Well that's interesting. If this man walking across the green pasture had to pass through this room, walked through us and obviously wasn't aware of it, what difference does it make, then, to say that the universes are interacting with each other at a microscopic level because he doesn't feel anything and we don't feel anything? How is he effecting us if he doesn't know we are here?

DD: The reason is that although that is an example of an experiment where the effect of the universes on each other is exceedingly small, one can set up experiments where the effect of the universes on each other is amplified. That was, of course, an experiment, that's what it is, an amplification of something, some effect into a larger effect, to try to detect it.

RT: But you said we couldn't detect the other universes.

DD: We cannot directly detect them. We can detect indirect evidence of their effects.

RT: You could get many, many universes interfering with each other then, in producing microscopic phenomena?

DD: Yes, yes.

RT: Which means that you could suddenly have an earthquake in the middle of London because something like 9,282 different universes happened to get jumbled up at that location?

DD: Oh absolutely, yes. A more familiar example is, perhaps, the ERNIE, you know the Electronic Random Number Indicator Equipment that does the premium bonds. The number that it chooses is produced by quantum interference effects and the randomness there is essentially, from the point of view of quantum mechanics, dividing the world into millions of proportions in each one of which there is a different number and the effects of this can be stupendous. If you win, for example, it can change your entire trajectory, your macroscopic trajectory through the world.

RT: Which can give you a big house, to say the least.

DD: Yes.

RT: And can make you retire from your job and buy a Rolls Royce.

DD: Yes, whereas in some other world, somebody else won. But the thing is that this proliferation into different possibilities if you were to look at it at too fine a level, then

you would get to the point where it didn't make sense to talk about two different universes. So when you talk about universes splitting, branches splitting into smaller branches, you must always have in your mind that you are referring to gross aspects of them.

RT: Do you mean to say that I am drinking my tea in this universe but in the next one I am not? In one universe I am dead but in this universe I am alive? But they are all me in them?

DD: Yes.

RT: So in fact, I really exist in an infinite number of universes, even those in which I do not exist?

DD: Well no, you don't exist in the ones in which you don't exist.

RT: What about the ones in which I am already dead?

DD: Oh then you have existed, yes, you exist in a previous time.

RT: So it is kind of across time as well as space, in a sense?

DD: Yes.

RT: So I should feel that I am really everywhere, just as you are everywhere doing everything?

DD: Yes.

RT: I am doing everything at once?

DD: Yes.

RT: Do you think that this is really true that we are all of us, everywhere, doing everything, at once?

DD: Well, . . .

RT: Of course I must say I realize that the words "at once" are meaningless because there is no "at once" even on Mars, it is minutes different from here, much less any other world.

DD: But we are the suitable definition of "at once," yes. Well when you are asking do I really believe this is true, there are two levels at which one can interpret that. First of all do I believe the many worlds interpretation is true? I've already given you the sense in which I believe it is true. And in fact I can tell you that the more I look at it, the less outrageous it seems to me.

RT: The other sense?

DD: The other sense is whether I believe that the state of the universe is such as to make all these worlds happen. And I believe, again, yes, because it would have to be a contrived state that didn't have that property.

RT: Well now I want to go back to all of us being everywhere and doing everything. This really makes, first of all it makes everybody fantastically more important than they would appear to be just living in a single universe, it transcends mortality because even if we die in this universe we are still alive in hundreds more.

DD: Yes, well I said that, absolutely, and indeed one could argue that there will always, no matter how likely it is that you'll die, there will always be a few universes scraping by and of course there is an infinity . . .

RT: In which you are still surviving.

DD: In which you are still surviving.

RT: So that we are always around and doing everything that you can think of?

DD: Yes, although is this of any use? For example, there are universes in which we were around a hundred years ago, but they are of no use to us.

RT: If they were able to effect us at the sub-microscopic level, let's assume there is something in your brain and my brain at the sub-microscopic size which is susceptible to this kind of influence.

DD: Oh yes, but the kind of influence—the degree to which universes effect each other, as I have said, is greatest when they resemble each other most closely. The closer two universes are in resemblance to each other, the more they effect each other. As soon as they have some gross feature different, the percent of their interacting becomes negligibly small, it goes down—I was going to say exponentially, but probably very much more sharply than exponentially with the degree of correlation between the two universes.

RT: Well in what sense does it mean anything to say that we are all immortal and everywhere and doing everything? Is the fellow who's walking along in the other universe, who is also called Robert Temple, anything really to do with me? Because I don't know what he's looking at through his eyes, even though he looks like me.

DD: Yes, you don't because the chances of an observable in your mind being affected by one in his, are incredibly small.

RT: But would it be true to say, then, that he and I are part of a greater entity?

DD: Yes.

RT: And that I am only an infinitely small part of a huge immortal entity called Robert Temple which . . .

DD: . . . which is itself only part of a greater entity called the state of the world, yes.

RT: And that indeed the Robert Temple who speaks to you now is just like a little finger of the greater Robert Temple who lives everywhere and everywhen?

DD: Yes. But what I am really interested in is not the universes that exist at the moment. What I am really interested in is the branches that are going to branch off from this universe, creating further ones, creating further branches. Those are the only things that are in my future.

RT: So the number of universes is constantly growing?

DD: Well it depends what you mean by the number.

RT: Do they ever wither away and cease?

DD: No, all that happens is that they subdivide themselves. But each division is really the same size as the whole lot.

RT: But when you say that they all interfere with each other at the sub-microscopic level, could one take that to mean that at that level of size, they cease to be many and become one?

DD: They become one but it is not really a universe, it is a much larger object than the thing we are accustomed to describing as the universe.

RT: A huge amorphous blob?

DD: An amorphous system of stuff of possibilities, as it were, although they are actualities.

RT: So all these universes are like so many branches sticking out of a single root?

DD: Yes. But there is nothing in quantum theory that says that the branches can't come together again and form one possibility out of many.

RT: You mean universes can become one?

DD: Yes.

RT: Even though they may be individual? What happens if another universe tomorrow joins up with us?

DD: It would produce experimental effects that would be outrageous. Such as interference experiments ceasing to work, for example.

RT: But what if somebody really bizarre, little green men, started walking down the street? They would be from another universe which had combined with ours?

DD: . . . well it could be that the effect in our universe could be produced by the previous recombination of two universes into one.

RT: I am in quite good health at the moment, but if I wake

The things that prevent us gathering the required data to predict the evolution of the state of the world are the laws of physics.

up tomorrow desperately ill, it could be as a result of the fact that my other self in another universe combined with me during the night who was extremely ill, on the verge of death, and the two of us have come together and as a kind of a compromise I am not feeling well at all. And if this happened, everybody else would have to have it happen too?

DD: Not necessarily, but I repeat that the probability of such a thing happening on a macroscopic scale is negligible. Essentially the state would have to conspire, God would have had to set up this space especially at the beginning of the world, especially to make that happen.

RT: You are talking a bit like the philosopher Laplace; if you know the position and the momentum of any given universe at a certain moment you can predict all the future states.

DD: Almost, yes.

RT: But do you believe that?

DD: Well I believe it on the level of the determinism of the many worlds interpretation, yes. The combined conglomerate of all the universes is an object that evolves deterministically.

RT: A kind of a monstrous hyper-Laplace.

DD: Yes, although one difference with Laplace is that the thing that prevented him from gathering the required data was, as it were, simple experimental difficulties. The things that prevent us gathering the required data to predict the evolution of the state of the world are the laws of physics. The world is constructed so huge—in such a way that we could never, by the laws of physics, gather the appropriate data.

RT: Does the fact that you think you exist in many universes, many times, give you personal comfort?

DD: No.

RT: So it doesn't assuage your existential anguish in any degree?

DD: No, and as I said before, there are senses in which it makes it worse.

RT: But you do have existential anguish?

DD: Well I certainly wouldn't put it that way. I believe there are philosophical problems and certain philosophical problems that I think are important are exacerbated by the many worlds interpretation. But I regard myself as a physicist first and philosophical conclusions derived from physics take priority in my mind, regardless of how I regard them for other reasons. And I think this is a fairly good point of view to take simply because physics, in my opinion, is the most advanced of forms of human knowledge and if I can't, at the moment, conceive of a more general philosophical basis which the many worlds interpretation would fit, maybe it is just because philosophy isn't as advanced as physics yet. □