THE MEANING OF QUANTUM THEORY

All natural laws are therefore claimed to be, 'in principle,' of the statistical variety and our imperfect observation practices alone have cheated us into a belief in strict causality.

Albert Einstein (1928)

Nobody knows any machinery. Nobody can give you any deeper explanation of [the two-slit experiment] than I have given; that is, a description of it.

Richard Feynman (1965)

Einstein never ceased to ponder the meaning of the quantum theory.

Abraham Pais (1982)

It seems premature to embark on a study of the Universe conceived as a single quantum-mechanical entity when, even in the restricted realm of mechanical phenomena, quantum mechanics does not provide a universal description.

Peter Holland (1995)

The unpredictable, random element [of quantum theory] comes in only when we try to interpret the wave in terms of positions and velocities of particles. But maybe that is our mistake: maybe there are no positions and velocities, but only waves.

Stephen Hawking (2005)

The task of understanding quantum mechanics has become all the more urgent.

Vlatko Vedral (2011)

"So do you see?"

He's still with me. Or at least not gone; he sounds supercilious. Swift relief is damped by slower anger. Of course I see. Without me what would *he* see?

"You see space and time do not exist?"

Has he lost his marbles? He's just showed how time and space begin and now he says they don't exist?

"The space and time you see aren't really *there*."

Well okay, maybe now I do see what he means. What we think of as space and time, what we mean by those words, what we experience or think we do, *that* space and time are pure statistical abstractions. What's real, what's actually there, is very different. We've seen that. So, yes, I see it. Can *he* see?

"And all its consequences?"

I haven't thought of consequences and there may be many. Starting with Gödel. Well, not exactly *starting*, but he leaps to mind. His proof that time does not exist has a strong influence on physics. Though now I see that he is wrong about this too. The two times that he proves do not exist do *not* exist; he may be right to that extent. But that's not what he's after and it isn't what he thinks he gets. He thinks his two times *are* time or at least they cover all the bases. They do not. He's trying to abolish time before he understands it.

Meantime physics is increasingly uptight about all times. It shows up as a *t* in most equations but the thing about the faith in math in physics is that in the end the math must all come back to wordy definitions. The *t* in those equations doesn't stand for time, it stands for an *idea* of time and this must be conveyed to minds with words. Einstein's equations do not tell of time, indeed tell naught of time, but rather tell—his *words* explain quite clearly—about *clocks*. Clocks keep a pseudo-time in terms of arbitrary seconds. It's no wonder physicists are having a rough ride. They're trying to describe reality in terms of things that don't exist—a list of crucial cosmologic oxymorons. This might be okay or even useful *if* they knew what they were doing. But doing *and* not knowing, that is bound to be confusing. What they need is Tocks. A simple quantal number says it all. And, being real, it is a one-way ticket. Even if that egg unscrambles it's a local aberration; they can count on the UC to keep things Tocking on. Its *t*, unlike eggs's, helps make physics better. Just for starters it could change the way that physics figures things before the universe's temperature falls to ten trillion degrees and physics as we know it now begins to happen.

"How?"

He is still with me! And I don't know how. That is the physicists' dilemma as they try to rewind time. Doesn't he recall? As it gets hotter with time in reverse, things should get simpler. This is what the LHC is all about: It's reaching back into that hotter, simpler world. It's archeology, an excavation into time. The calculating in reverse can only go so far. When the calculation's hotter than the hottest measurement then physics needs another dig. A bigger particle collider is the standard tool. Exotic particles—unstable pieces of the puzzle—flash into existence in huge instruments and almost instantly disintegrate. As things get hotter, the three forces become two. Then maybe one—but no collider ever gets that hot.

In his Beginning there is no such thing as temperature, though something like it will arise as time Tocks on: One million and one, one million and two, one million and three—my fast-forwarding is effortless so no collider's needed. Governed by some simple quantum Rules, the first one being: Fizzion! Wouldn't it be cool to bandy numbers where the physics is too hot to handle? The idea is the first Rules will give birth to rules that we call physics as the hot stuff settles down. The first Rules stay the same but as the Tocks go by the physics rules will come to be a good approximation. This is why he asks me: How?

Well, the answer should turn out to go like this: At a scale involving very many Flecks—such as an atom—over time involving very many Moves—such as a picosecond—QM describes events approximately. Very many means a number larger than I can imagine. And 'approximately' means a very good approximation. Suppose the Rule was: Flip a coin. I want to know what's going on in coin flips but it is impossible to see a coin. All I can see is a report on a gazillion or more flips. The report might say:

Flips	10,000,000,000 gazillion
Heads	5,000,000,000 gazillion
Odds	5,000,000,000/10,000,000,000 = 0.5000000000

Every time the flips are tested the report is just the same. I have no way to know the Heads count may well be a tenth of a gazillion off. So now suppose that I don't know about the Rule. I don't know about coins. I don't know anything of Flips or Odds. I get reports of measurements and instead of Heads the label's 'distance' and the unit is not counts but meters. This report says:

Distance 0.5000000000 m

What would I say? This is a random process? He says nothing and I'm pleased. He could have said the flipping thing's simplistic. It is but hopefully he sees the point. It doesn't appear random. It looks like a measurement, repeatable and accurate to physics' limits, roughly one in some ten billion. There is nothing to reveal that it's a random flipping process. Nor to show that it is not. Of which dilemma Einstein says, 'All natural laws are therefore claimed to be, "in principle," of the statistical variety and our imperfect observation practices alone have cheated us into a belief in strict causality.' He does not buy this claim: 'Even the great initial success of the quantum theory does not make me believe in the fundamental dice game, although I am well aware that our younger colleagues interpret this as a consequence of senility.' Loss of strict causality's anathema to him. Now the Beginning writes a *finis* to his long defense. Yet it should show too how practical causality emerges. Cause and effect are real. They look strict until one looks too closely.

Looking closer, Frank finds meaning in QM. Or should I say behind it?

Space is quantized.
So is time. To which he adds the meaning of non-local:
Each space quantum's ribbon-linked to every other.

And the quantum meaning behind matter is:

Kinks in Links make all we see.

And last the quantum meaning behind motion is:

Kinks may move one space quantum per time quantum.

These five facts unveil the meaning hidden in QM. They are only sunshine. Making hay will need new physics, of which B-T's twists may be only a taste. Looking back I see why physics is hung up on measurement. It's incredible that physicists succeed so well while they are so deprived. They literally don't know *what* they're measuring and they know they don't. They've got a lot of measurements but measurement is all they've got. Yet measurement can't tell them what is going on. They measure things like distance that lack real existence. They can't say what is real or what real is. They can only talk of what they *know* about the way that things behave and all they know is average behaviors. No wonder they have more doctrinal disagreements than a bar-room full of bishops. With the albatross of averages around their necks it is remarkable that they have figured out so much. As in, the sole distinction between witchcraft and QM is: Witchcraft doesn't work.

QM lives downstream of a digital-to-analog conversion. People do this all the time. The message in an iTunes download's digital. What's listened to is analog—a speaker making waves. They are statistical—air molecules do dances. They're so distantly directed by the digits there's no way for music buffs to reconstruct the message. There's not even any way to tell it was once digital. This is what baffles physics: Beneath its integer disguise QM's intrinsically analog! Even more surprising is that it's a model of the large rather than, as often stated, of the very small. I find, online and later in a book, Rovelli saying, 'QM is not the theory of micro-objects. It is our best form of mechanics.' Except for, I can almost hear Frank saying, the mechanics of the universe. He says nothing.

He has no need because I know what his R_x is: digital mechanics. His Beginning points the way. It is about the truly small; there's nothing smaller. And the truly large; there's nothing larger. It's simple; it rests on the Manifold and on the Rules. They are both primitive in that they don't derive from something else. And they are digital. Has QM found a home?

"You are still missing it."

He's agitated, almost angry. What more does he want?

"Unification! Bilson-Thompson, Markopoulou, Smolin did the work five years ago."

I remember that they wrote on quantum gravity. Unification? We just concluded it's impossible. Gravity just isn't like the other forces. It isn't really like a force at all.

"You read it twice and now you have forgotten."

He knows exactly what I do? It's instantly embarrassing. And if I read their paper I forgot it long ago.

"They said a theory of this kind may be already unified."

It all comes back. It's true. It was their main conclusion. They showed how particles made out of twists could travel through the kind of not-quite-space and not-quite-time he says we have. I check it out again; they even have *already unified* italicized. How is it unified? Maybe he can do this in his head but my head doesn't go there. Yet, as I must remind myself, he's doing it in my head. When I think about the pieces they seem simple. When I try to track the twists and braids, the Flecks, the Windows and the six dimensions threading through them two by two, all jerking Tock to Tock, it gets so convoluted I get nauseated. Could this be why B-T wraps his thoughts in math?

There is another consequence I bet he thinks I'm missing. A real quantum theory, one that will describe the universe, *can't* be concerned with measurement. It's not only that there *was* nobody there in the Beginning to make measurements. Tougher yet is how to meet the need that Gilder neatly summarizes—the need for the experiment and the experimenter to be *outside* the quantum system. It's hard for me to even think about.

Instead I think about the meaning of a real quantum theory. What can be said about this without having it in hand? Well, surely something. I tick off ten points:

It starts with a single 6-D quantum

It tunnels into two

It makes 1-D, 2-D, 3-D

This leads to quantized time and volume

All volume quanta are connected

They lead to quantized area and twist

There is a finite number of each kind of quantum

There is not even nothing else

Its math is natural

All physics—QM and GR—must flow from this

An answer to a larger question comes unsought: The true QT must be a theory from outside. I'm grappling with this thought lest it elude me when another hits me. *This* is the divide! GR describes the universe from inside. That's where its observers ride. QM's view's confused. Its observers are inside the universe but are outside the quantum system. Echoes of Bell saying: ‘When the “system” in question is the whole world where is the “measurer” to be found? Inside, rather than outside, presumably.’

But the true QT *must* be an outside view! That’s the thought that caught me first. It is that way from the Beginning. No observer is inside. But one can be imagined, like his fool Pooharticle. After Move 1 it sees two Windows, nothing more. Maybe a Flatland 2-D viewer could slip through a Window and check out the other side. It would see nothing new. Indeed as he took pains to show it cannot tell that it is on the other side. After Move 2, each Fleck has four Windows. Nothing else is changed. And so it goes; that’s it, that’s all, that is the inside story. Only from the non-existent outside can a thought-observer see how many Flecks there are, and that they have the property of volume, and that they are linked so that the universe must be non-local. Only an outside observer sees the building blocks for quantum theory. Only when he went outside could he bring back a way for time to start and for space to emerge. Is this enough to say he’s conquered the Observer Problem? And, too, rejigged the Measurement Problem? I load the score sheet, think a bit, and add two checks.

Both these observers are unphysical. The one cannot in fact invade the Fleck; the other can’t escape the universe. But his unphysics solves QM’s confusion. QT needs observers in and out. Only by comparing notes on thought experiments can they perceive what’s real. The delicious bit is this: What’s real is illusion. *How* can they perceive what’s real? Why, we imagine them and they imagine it!