

DE BROGLIE AND BOHM

Ridicule is the tribute paid to the genius by the mediocrities.

Oscar Wilde (ca. 1898)

The ... scientific view has for long oscillated between a mechanical and an undulatory conception of light; however, these two views are perhaps less opposed to one another than was previously thought.

Louis de Broglie (1924)

[I]f anyone can do it, then it will be Bohm.

Albert Einstein (ca. 1950)

But in 1952 I saw the impossible done. It was in papers by David Bohm.

John Bell (1987)

We do think it very likely that if the ultimate theory is a quantum theory it will in fact be a Bohmian theory.

Detlef Dürr et. al (1995)

Without Bohm's challenge, we would not have Bell's results.

Mara Beller (1999)

Bohm's work, like de Broglie's, failed to attract much support, because it could not be distinguished experimentally from conventional quantum mechanics.

Tim Folger (2009)

Especially I like the human-interest stuff. The dramas and the tragedies, the odd comic-opera bit. I feed him some of it from time to time. It's not clear that she approves. The only time I mention it she just says nothing. Instead I get an I-thought-you-were-for-real look before she switches subjects to Bohm's physics. Whatever. *I'm* not about to switch the subject. De Broglie tries to make sense of this senseless story. He takes what Reichenbach calls 'the decisive step'. He says matter too is like a wave. Bohm picks up where this leaves off.

She may not like it but he needs to witness what they did to Bohm. He shows an unexpected interest in Bohm's approach. What *is* the interest that he is taking? Well it could be, or it should be, that he sees Bohm's work could set him free from QM's rigid grip. No chance. He doesn't get it. He's tuning in to what he sees as *her* interest. He's sucking up to his employer. But I have trouble understanding what *she* sees in this. Not the tragedy for sure; it leaves her cold. And her interest

in matter so far seems to focus mainly on black holes. Bohm wouldn't know a black hole if he fell in it.

Bohm begins in Princeton. It's where Einstein spends his latter years. Bohm is his colleague. Bohm sets out to find a way around QM. When he says 'if anyone can do it' Einstein is speaking of this very venture, of devising a new quantum theory to blaze a trail beyond the QM quandaries. And, as Cushing and his colleagues later say, Bohm does just that:

We are often told ... that no physical theory describing well-defined objects ... can account for [quantum] phenomena. The great majority of physicists continue to subscribe to this view, despite the fact that just such a deterministic theory, accounting for all of the phenomena of nonrelativistic quantum mechanics, was proposed by David Bohm more than four decades ago.

Is his the right trail? Well, that's another matter altogether. No doubt it falls short of Einstein's expectations. But the thing is, he shows it can be done, and he does it without all that weird stuff about observers.

Here's how it happens. Bohm has a solid grasp of quantum theory and especially the Copenhagen Interpretation. He literally writes the book on it—*Quantum Theory*—in 1951. When they first meet Einstein tells him he enjoyed the book. He asks Bohm to visit. Over coffee or maybe out walking as was his wont he explains to Bohm that QM's incomplete. Bohm is soon persuaded. It sets him to thinking.

He comes up with a radical idea. Well, actually he comes up with a new take on an idea that de Broglie first proposed in 1924. The radical idea is simply this: The Wave Function is real. Copenhagen disagrees. It says the Wave Function describes not what *is*, but only what we know. It's like the difference between a real red billiard ball and the statement 'there is a billiard ball and it is red.' The theory Bohm builds on this idea gives the same results as QM. But it has a different interpretation—one that makes sense!

Bohm says the Wave Function is 'the mathematical representation of an objectively real field.' He compares the action of this field on a particle with the action of an electromagnetic field on a charge—a subject that's much-studied and well-understood. It's the way an old TV set gets electrons to the right place on its screen. He is saying, in effect: This is nothing strange; the field directs the particle. His story's in stark contrast with the Copenhagen tale: He needs no collapsing wave function, no quantum weirdness, and he *explains*.

Thus in a single stroke Bohm brings causality to quantum theory. What's worse, what his theory adds to QM seems to eliminate its quirks. Why worse? Well, Copenhagen claims this is impossible. Indeed, Heisenberg makes the impossibility of improvement QM's main line of defense. Bohm isn't just

attacking it. His theory may be fatal to the orthodoxy.

So why is Copenhagen still the only show in town? The short story is: Bohm's work is ridiculed; then he is accused of un-American activities. He is charged with contempt of Congress. He is acquitted. Princeton terminates his contract. He is run out of the country. He tries to bear the torch from exile in Brazil. He dies in England. Some say he was the best quantum physicist of all time. No one steps forth to take up the torch. It is in any case too late for a new theory—or even worse an old one—to replace Copenhagen if it has no better reason than that it makes sense. Decades pass before conferences and learned papers begin to explore issues raised by Bohm.

Looking back I see that in the end it's the beginning of the universe that takes him down. I wonder: Is there a message here? It starts when Einstein first persuades Bohm that QM is incomplete. Bohm understands the underlying issue. After his death his friend the Dalai Lama recounts that:

In our conversation Bohm also gave me a glimpse of the long-standing debate between Bohr and Einstein ... ; at the heart of the debate is the issue of whether reality at the fundamental level is indeterminate, unpredictable and probabilistic.

Bohm has a burning interest in this issue. As his biographer records, 'His lifelong search had been for order.' By the 1980s, now in Britain, he is in the final throes of working on his magnum opus. It will demolish Copenhagen. It will vindicate his theory. He turns his mind to implications for the way the universe begins. This turns out to be a stubborn problem. As he delves into it his theory seems to destroy order and create chaos. He sinks into a depression; then he crashes and he burns. Again I wonder: What's the message here?

The big picture is no less disturbing. Conventional QM with its inanities is now entrenched in the establishment. Of late, one measure of how deeply comes to light. A philosopher of physics, Guido Bacciagaluppi, and a physicist, Antony Valentini, comb through records of that fateful Solvay meeting. *Quantum Theory at the Crossroads* they call their report. With fresh translations they reveal 'the extensive discussions of de Broglie's pilot-wave theory [and] on Born and Heisenberg's presentation of a "quantum mechanics" apparently lacking in Wave Function collapse or fundamental time evolution.' Born and Heisenberg? A Wave Function that won't collapse? The shock waves then should surely shatter many myths. And should now too. But I mutter to myself before I head for home: Don't hold your breath.

The sun has set. I sit, back to a wooden post. Waves work on their fifth billion years of pitiless attack. There is a song stuck in my head:

Bohm Bohm Bohm Bohm. Just a lonely bell was ringing....

Not quite what Jim Brown intended. Nor Manning when he wrote the words. I shake my head. What are we to make of this mess?

De Broglie's and Bohm's inspirations are still out there. But it isn't clear that they are right. So what can Frank take home? From his perspective they provide two things: They show he'll have to go beyond conventional QM to get to the Beginning; and they maybe show it can be done.

It's getting chilly on the shore. Something plashes in a lazy wave. An otter? In the western sky's reflection I can't make it out. But some things are coming clear: He doesn't have a clue what I am on about. She's not stupid so she can't imagine that he does. And so whatever it may be that she is after, it's not *really* the Beginning.