THE COPENHAGEN HEGEMONY

The truth of the thoughts that are here communicated seems to me unassailable and definitive. I therefore believe myself to have found, on all essential points, the final solution of the problems.

Ludwig Wittgenstein (1919)

Physics, as we know it, will be over in six months.

Max Born (1929)

We are still, in Newton's words, like children playing with pebbles on the sea-shore, while the great ocean of truth rolls, unexplored, beyond our reach.

James Jeans (1943)

I'm so sorry because most of that was wrong.

Niels Bohr (1962)

This Copenhagen interpretation, as it came to be called, eventually became orthodoxy among the physics community.

David Peat (1997)

There seem to be as many different Copenhagen interpretations as people who use that term, probably there are more.

Asher Peres (2002)

I'm thinking as I climb the stairs this morning, needing exercise. Frank has handicaps. Not only that he's real. Politically he's naive. So it may be doubly difficult for me to tell him physics has its politics. Actually, it's riddled with it, rooted in arcane intrigues of academe while sometimes reaching—in Europe in the early 1900s—for the dizzy heights of national destiny. He won't get far in this milieu as a naïf. Whatever. Fingers walking through the Web I build an outline, hoping he will check it out.

In the 1990s a physicist named Sokal writes a parody of postmodern science dressed up as a paper on QG. Later Beller writes about reaction to the hoax. Well, that's how she begins. She soon turns *her* guns on the Copenhagen gang—Bohr, Heisenberg, Pauli, Born and Jordan—stopping short, but not much short, of calling them conspirators. She trashes their key arguments. My take on her conclusion: Selling Copenhagen was self-interest; it's not physics; much of it is fiction; but it sells.

Beller's not the only critic to reach such conclusions but she's blunt. That helps. I begin to get the picture: In an ambitious move, five physicists set out to

protect their vested interest. The big guy is in their way. They have to take him down. Well, that's one version of another fiction.

In the beginning it is all collegial. For example, in 1916, Einstein pens a letter to Max Born. Thus begins a lifelong correspondence. Unlike Einstein, Born is part of the establishment. By 1919 Einstein has them using the familiar *du*. It's linguistically equivalent to thou. It's intimate. It's like *tutoyer*ing in French but it's fast forward for a German whom he met just once before 1915. They become dear friends, close colleagues, a mutual admiration society of two. This relationship will last a lifetime. But on physics they will strongly disagree.

Even after weeks of reading I still have a problem keeping track of the four-letter names beginning 'Bo'. So I make a mini-list:

> Born—born in 1882; German physicist; works in Göttingen
>
> Bohr—born in 1885; Danish physicist; works in Copenhagen
>
> Bohm—born in 1917; American physicist; works in Princeton

Nineteen twenty-four's a fateful year for physics and so fateful for the planet. In October, the clash between Einstein and Niels Bohr, recent Nobel laureates, over the foundations of QM comes to a head. Their differences are said to have become 'irreconcilable.' It is all triggered by a paper co-authored by Bohr. The paper is of little consequence; it leads to no advance. It is so far from the mark that it rejects photons, which will soon be sexy. But Einstein's reaction paralyzes, and soon polarizes, the community of physics.

Decades later Pais describes the circumstance:

> Einstein and Bohr, the two leading authorities of the day, were locked in *conflict* (the word *conflict* was used by Einstein himself). To take sides meant choosing between the two most revered physicists.

At root, their difference is this: Bohr says Complementarity's a fundamental law of physics. Einstein begs to disagree. Greene describes Bohr's position: 'Before one measures the electron's position there is no sense in asking where it is. It does not have a definite position.' That is, Bohr says, objectively there's no reality. He is not alone. Even Born, by now close friend of Einstein and respected elder, is a member of the group. So is Heisenberg, who works with Bohr in Copenhagen. Another Born assistant, Jordan, is in on it too. And Pauli, who also had worked with Bohr in Copenhagen, is a leading light in the cabal. In a coordinated campaign unlike any ever seen in the high halls of academe, they defend their common interest in preserving the integrity of QM. Whatever that is.

The defense they mount is mostly nonsense. Cushing says, 'Bohr's pronouncements on the interpretation of quantum mechanics are often difficult to understand and at times just plain opaque.'

More sweepingly Frayn says that 'Bohr … was fluent in various languages, but I have heard it said that the problem was to know which language he was being fluent in.'

It is so nonsensical that one must wonder why nobody says the obvious: The emperors are not well-dressed! Is it the Aryan stereotype of respect for authority? This is too facile.

Yet Beller bluntly tells me, 'Bohr was notorious for the obscurity of his writing. … But Bohr's obscurity is attributed, time and again, to a "depth and subtlety" that mere mortals are not equipped to comprehend.'

The record shows that even Born speaks rubbish. It shows that his peers admit, in private, they don't understand him. Perhaps the larger national context plays a role. In the aftermath of World War I, Germany's supremacy in physics wanes. Its journals are no longer *the* place to publish. English-language journals soon usurp their role. In part this is a spillover of post-war poverty. In part too, other science communities pull back from one that tried to blackball all of them.

By 1926 the intellectual die is set. But not clearly. Heisenberg records that:

> An intensive study of all questions concerning the interpretation of quantum theory in Copenhagen finally led to a complete and, as many physicists believe, satisfactory clarification of the situation. But it was not a solution which one could easily accept. I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair; and when at the end of the discussion I went alone for a walk in the neighboring park I repeated to myself again and again the question: Can nature possibly be as absurd as it seemed to us … ?

There was and is no 'satisfactory clarification of the situation.' To this day a coterie continues to parse the differences among the Copenhagen five. Beller says 'the Copenhagen interpretation is in fact a compilation of various philosophical strands, given a public presentation that often hid shifting disagreements between its main architects.'

As orthodoxy takes its shape, Einstein knows what is at stake. In an essay that he sends to Born he says that a particle does have a definite position and velocity, and, he says, 'According to this point of view, the [wave] function represents an incomplete description of the real state of affairs.' He goes on to note, matter-of-factly, 'The theoretical framework of quantum mechanics would then be exploded.'

The defense against this threat is a two-pronged attack. *Á la* Wittgenstein, the Copenhagen version is proclaimed to be inevitable—a pitch that still has currency today. Of this, Beller, blunt as ever, says that 'all the Copenhagen arguments of "inevitability" are in fact fallacious—they rely either on circular reasoning or on highly appealing but misleading metaphorical imagery.' But the inevitability line is under-

pinned by sharp attacks on those few who refuse to toe it. Beller says, 'The founders of quantum physics -- Bohr, Born, Pauli and Heisenberg -- misrepresented and ridiculed Einstein's "naive" belief in an objective, observer-independent reality.' The success of QM, which mere mortals cannot hope to grasp, props the pulpit from which these mental giants preach. Though secular they are the priesthood of their day.

But is this what is really going on? Is the target Einstein? Well, Beller writes a careful book that says it's Schrödinger they want to tame. He is a cat of a different color. He has his own take on QM. It features waves and is called wave mechanics. In his book about the great debate Kumar says, 'Schrödinger told physicists they no longer needed to suppress intuition and to operate only with abstract concepts such as transition probabilities, energy levels, and the like. It was hardly surprising that they greeted wave mechanics with enthusiasm and quickly rushed to embrace it.'

The gang of five assails them with, as Beller says, 'intense hostility.' Jordan admits later that they see these waves as possibly extinguishing their own approach, matrix mechanics. How? Well, simply put, the waves are easier to market. So: Who gets the most attention? Schrödinger.

Among themselves the five agree on little. One thing they do agree on is: Get Schrödinger. They need a story that will sell. Heisenberg admits their vision is ambitious. They want to 'influence the research of the following century.'

So Born and Pauli come up with a story: Schrödinger's waves aren't real; they are only probabilities! It's ironic. And it's *blitzkrieg*. It's Walmart v. Mom and Pop. Beller calls it 'the huge project of legitimization of the Göttingen-Copenhagen program.' It's PR versus physics and it works.

But reading on I see that in the end it's *not* a battle of the models. Though the two look different it turns out that they are the same; the math of either one can be transformed into the other. So the final battleground is how to *think* about them. It's all about the brand. It's Coke and Pepsi.

In October 1927, Heisenberg and Born announce to the fifth Solvay Conference and to the world: 'We regard quantum mechanics as a complete theory for which the fundamental physical and mathematical hypotheses are no longer susceptible of modification.' Born's stamp of approval on this appalling declaration may have been decisive in what was to come. The Copenhagen way of thinking becomes orthodoxy. Trouble is, it turns out it's a lousy way to think.

Frank Herbert understands such episodes: 'It was the interpretations that mattered. Which was why a High Priest must be the final interpreter.'

In 1935 Einstein and two colleagues try a comeback. They publish what becomes the most-often-cited physics paper ever. It's so famous Google hits it when I search on 'EPR', the initials of its authors' names. It says that QM's incomplete or

else the universe must be non-local. It's brilliant but it doesn't make a dent. Copenhagen PR bashes it. EPR will wait three decades before Bell revisits it and takes it to its logical conclusion.

Exactly how it happens we may never know. But in defense of their position five men of genius—one a Nobel laureate, three soon to be, and one who joins the Nazi party and so never is—shunt physics in a siding. As I read more I begin to see that this is where it sits today. It is—in spy-speak—a shut-ended situation.

The politics of physics like all politics gets personal. Einstein endures years of attacks before he leaves for Princeton. In 1929 he says (to the Sorbonne):

> If my theory of relativity is proven correct, Germany will claim me as a German and France will declare that I am a citizen of the world. Should my theory prove untrue, France will say that I am a German and Germany will declare that I am a Jew.

By now few think it is untrue. But already he is more concerned with quantum theory and especially his favorite cause: causality.

I tell Frank that it's a cause close to the heart of any quest for the Beginning. After all, isn't *it* the cause of everything?