BRIDGING ONE DIVIDE

Einstein believes that the modern development in quantum theory … will be replaced by a theory built along different lines.

Leopold Infeld (1950)

The aim of scientific explanation throughout the ages has been … the comprehending of a maximum of facts and regularities in terms of a minimum of theoretical concepts and assumptions.

Herbert Feigl (1970)

CRASH. Why do you get to choose? Why don't I get to choose?

ANNIE. Actually none of us on this planet ever really choose each other. It's all Quantum Physics and molecular attraction. There are laws we don't understand that bring us together and break us apart.

Ron Shelton (1988)

At the foundations of physics there is today confusion and incoherence. … GR and QM have opened a revolution. The revolution is not yet complete.

Carlo Rovelli (2004)

Ramona Nowitzki: That would change the way we view the entire physical universe.

Sheldon Cooper: That's what I do.

Chuck Lorre (2008)

This morning we have visitors. They're here, *inside*, when I unlock the door. Two men in their thirties, well dressed, studiedly inoffensive, steely-eyed. They don't stand as I enter, don't ask who I am. They offer me no names. They decline my offer to make coffee. I sit down.

They have, one of them says, some questions. They seem official in a quiet way. They are polite but not the least bit friendly. Can I refuse to answer? I don't even try. We talk. They ask me about Axiam. What can I say? It's just a job, I tell them. They refer to her as Dr. Eisenlich; it's not a name I know. I try not to reveal this but I'd say they don't miss much. They want to talk, not with her but about her. In less than half an hour they know most of the little that I *know* about her and I hope not much of what I might imagine. As to where she is I say that she's abroad, in Europe I suppose and I'm not sure when she'll return. Somehow I feel that they know more.

Do they know what she's up to? If they do they do not say. They ask about

her travel. I name cities: Berlin, Paris, Genève. Not locations. Not my guesses. Not P.I. Not CERN. Not LHC. But as they're talking this is all I'm thinking of: Black holes. I'm thinking terrorism's about terror, the herd instinct, panic in collective mode. More are killed by traffic daily than by terrorism in a year. Few think this as they drive yet many fret about the terror level. Reading tells me CERN is right: A small black hole will simply fizzle but all a terror plot would need would be a solid *story* of a black hole that's gone missing. What CERN says about it will not be believed. In fact whatever CERN says will just push the panic button. All a terror group would need is for the media to buy—half-buy will do—a story that they have a black hole from the LHC. Count on governments to do their bit. Forget Keep Calm and Carry On. The target's the economy and it will tank. I say no word of them but I think of black holes.

Before they leave they mention in a pointed way a few things from my former life, things that I thought no one could know. It's cool, one says, as if to blunt the heavy-handed hint. The other calmly checks the hall. They go; no handshakes but they're still polite. They close the door.

I'm sweating. They have searched the place. They made no effort to conceal the fact. It wouldn't take them long—one room, three desks, a little annex with some shelves that would be our supply room if we had supplies. They even pulled the plants out of their pots and mashed them back.

The parting hint is clear: They were not here. But one of them has left a card. No name. No logo. Just a number. Country code 972 I recognize. The city code is 2; I have to look it up. It is Jerusalem. Another hint. They didn't have to tell me this. It only adds to my uncertainties. What should I do—get out? But why? They're gone. So indecision is the easier decision.

QM's all about uncertainty. Of course QM's no help to me, but thinking of this gets me back on track. Paraphrasing Heisenberg, the prophet of uncertainty: If we know where a thing is then we don't know what it's doing; if we do know what it's doing then we don't know where it is. This is embodied in Planck's constant. It's that tiny number that's the reason QM seems to speak of tiny systems. Heisenberg in the post-Solvay fray is ever ready with the Copenhagen explanation why uncertainty's inevitable at this scale. His pet example sets up an electron that has well-defined velocity: To measure where it is he zaps it with a gamma photon. But the photon's energy gives it a jolt and changes its velocity, which thus becomes uncertain. With this, Heisenberg discloses his devotion to the Copenhagen story. His example's simply wrong; QM can compute the change in the velocity so there is no uncertainty. Several colleagues point this error out. He goes ahead and publishes it anyway. Physics students learn his wrong example to this day.

By contrast, the Beginning's quantum theory *cannot* deal with measurement. One reason's simple: All its action happens at a scale of size and time that's far too small for measurement by any means. A second reason's even simpler: There is nothing there to measure with. A third: There's nothing there to measure. But then I think: Would Einstein be deterred? In an age when Verne is the authority on flight in space, Einstein's out in space with clocks and rods to measure others passing at high speed. So let me think: What would I see if I could check reality down at the scale of Flecks and Tocks?

Well, I can bring no measuring device. A gamma ray is off limits or, more precisely, out of sight: I am inside a gamma photon like a fish is in an ocean. It is six wide-ranging Tweedles herding loosely on their way to their appointment in Samarra. I am up close to a single Tweedle. I can see that it's a twist between two Flecks. A half-twist, though I have no way to prove it. I am working on the same two questions: Where it is and what it's doing. While I watch with my mind's eye the CC ticks a Tock. Does it move or does it not? This may seem to be a brand-new question but in fact I'm at the intersection of two century-old trails.

In the early 1900s the emergence of two fundamental constants signifies the new divide in physics. The enormous speed of light and Planck's miniscule constant speak of scales so far apart that physicists regard them as two different worlds. One seems to speak of certainty, the other of uncertainty, and this embellishes their dissonance. In years that follow physicists must pack their bags and pick their paths. The signposts seem to say: Go large! Go small! Can the Beginning bring them back together? Well, maybe it can. Here at the scale of Flecks and Tocks it gets them back on common ground.

So this time I imagine I'm accompanied by tiny quasi-Einstein. He can see the Tweedle's speed is set by the UC—one Fleck per Tock. To quantify it he divides one by the other. In fundamental units, then, the cosmic speed limit is one. Not one point zero. One. Not as convenient convention but as a statement of the way it is, c equals 1.

And what of Heisenberg? Well as I watch my Tweedle its uncertainty is not about position and velocity. In my Moving realm where neither of these measures has a meaning, tiny quasi-Heisenberg might track my Tweedle to its Fleckish region. And, as he seeks to pin it down, he finds that it's not measurement but meaning that constrains him. Each Tock, the UC jerks not just his quarry but his only Frame of Reference, the Flecks in whose embrace his quarry lies. At this scale he has no energy, he has no *hither* and can't even think of *yon*. Just jerks, one jerk per Tock. If his mental quantum camera captures two sequential Tock frames, when he compares he'll be uncertain between which two Flecks my Tweedle was. If he takes more frames he'll wonder which Tock is the one he's looking at. He only knows

that nothing Moves more than one Fleck per Tock. This is the selfsame information that enables quasi-Einstein to divide them, getting *c*. But, being quasi-Heisenberg, he'll want to multiply them so he knows how much he is uncertain: never less than one flecktock. Not one point zero. One. Last waltz with Spacetime; it's all over now. One Planckish unit, cubed, multiplied by another; Max to the power four; so *really* small. It's the uncertain brick from which Frank builds his universe. Truly trekking down to Tweedleworld would be tough travel but I have no need to go there. Thanks to Frank I know this—all that ever can be known about that Tweedle—without stirring from my chair.

Here then is his bridge across the New Divide. Two fundamental constants—one huge and the other miniscule—shake hands in the Beginning. The quanta of space and time combine to limit cosmic speed and set the ultimate uncertainty. Two fundamental constants stand revealed as Yin and Yang, as two sides of one universal coin.

It's more elegant than Einstein, it's more orderly than Heisenberg. No need for arbitrary numbers, and no call to make things small. They are small already. Thus the Problem of Small Numbers was a surplusage of signposts. When the signposts disappear you have arrived.