THE ZEROS AND INFINITIES

There are many difficulties in the quantum mechanics of fields. In particular, infinite quantities always arise.

Sin-Itiro Tomonaga (1966)

If you calculated something roughly, it would give a reasonable answer. But if you tried to compute it more accurately, you would find that the correction you thought was going to be small … was in fact very large—in fact, it was *infinity*!

Richard Feynman (1985)

I suspect that infinity has been a prime cause of insanity among mathematicians.

Leonard Susskind (2008)

Previous theories of fundamental physics regarded [the particle] as an infinitely small, zero-dimensional point—an object that … the mathematics of today is still ill-equipped to handle.

Shing-Tung Yau (2010)

Every morning now when I awake, if I sleep that is, he's present in the first awareness of my mind. He's there, I know he's there, although of course I know he's really not. His presence makes a difference. Now my research is for *him*, it seems to me. Today, by the time my hard drive's booting, Flatfoot Frank has morphed into an afterthought. He is sitting there. But in my mind my guy and I are now the team. Which leads me to wonder: I hear him; does he hear me? Does he hear the tale my thoughts can tell? This too is not quite Lightfoot.

Like right now I see he needs to know about the interplay between infinity and zero. Unless he knows already. But how could he know? I do a quick review for him; it is a whole new feeling. Division's just a shorthand method of subtraction. Let's say I divide six by two. The answer's three of course. But what's the question? Well, if I have six apples—why apples?—how many times can he take two of them? First take, four are left. Second take I'm down to two. Third take and they're gone. Answer three. Likewise multiplying is shorthand addition.

Why babble about apples? Well, what if I divide by zero? Here again are my six apples. Take none. Keep on taking none until all six are gone. The number of my apples doesn't matter; the taking never ends and so the answer's infinite.

Physics deals with points. Funny things can happen just because their size is zero. Take a particle such as an electron or a quark, the basic building blocks of

all we see. Given chalk and blackboard, any physicist can find one. Physics says it's pointy. If its size gets written on the wrong side—to the right—of a divide-by sign, the hand that holds the chalk is taking zero from the number on the left.

Thus, for example, QM calculates the mass of an electron to be infinite. It's the sort of answer Susskind says drives physicists insane. QM calculations often lead to silly answers. So physicists devise a way to fudge. Sometimes it works; sometimes it doesn't. But it's ugly, always ugly. So they tag it with an ugly name: *Regularization and Renormalization*. Feynman has his own description of this process. He makes his rep by speaking physics in plain language. Of R and R he is dismissive. A shell game, he calls it, and hocus pocus. Hawking's more restrained. He says, 'This renormalization procedure has never been put on a very firm conceptual or mathematical basis.'

A theory that needs fudge like this is said to be not well-defined, a weighty accusation. To be respectable—to be a *real* theory—well-defined is what a theory needs to be. Even to the uninitiated it seems something's wrong with theories that lead to answers that need cuts and pastes to make them meaningful. Hocus pocus? There's a clue here, I can feel it.

A while ago he slipped away; I doubt he will be back today. I didn't think infinities would turn his crank. Or even zeros. *My* Frank would focus on one zero. It's the one that GR says was there in its beginning. The one that it says *is* the universe—a mash of time and space and galaxies and physicists and even their ideas. GR says they once were squeezed into a point. Or, for those who like their movies to run forward, like Evelyn Nesbit, they burst out of the pointy cake. Either way, it has no size. Infinite density. Is there a difference between this first infinity and any other? They are all inscrutable. Is this the word I want? *Encarta* says it means 'mysterious: not expressing anything clearly and thus hard to interpret.' Which shows I got it right; *and* shows it is a self-descriptive adjective.

I wonder why my thoughts would wander hither. Whither will they wend?

"It is the infinite regress."

It's him! I mean it's he. The Frankish contrast clutches me. A moment passes, then I pick up on his words. He's right. A regress. Is this where my thoughts were heading?

Early in my studies I learned Russell studied sets. A set is just some *Somethings*. Like clues or dictionaries. Or, says Russell, adjectives. He finds in them a paradox. Some adjectives, like English or polysyllabic, are self-descriptive. Some, like German or monosyllabic, aren't. So what about the adjective 'non-self-descriptive'? Is it self-descriptive? If it is, it isn't. And if it isn't, then it is. My Frank must think I'm crazy. If he's following my thoughts, that is.

But it all fits together. Russell says the way to solve the paradox is that a set

cannot contain itself. This is where my head was heading. It's the observer QM wants to watch the universe. To do the job he sits outside. But then the universe plus the observer *is* the universe. So *it* needs an observer. Etcetera. It's called an infinite regress. Russell's cure is not as easy as it looks.

I have a feeling that this too must be some kind of clue. But what kind? What would *he* do with it?