EINSTEIN'S UNIVERSE

The physicist cannot simply surrender to the philosopher the critical contemplation of theoretical foundations; for he himself knows best and feels more surely where the shoe pinches.

Albert Einstein (1936)

Today an individual galaxy is considered as a local disturbance of a distribution which is indeed isotropic and homogeneous, to a degree which itself demands explanation. Einstein had no such physical grounds for assuming these two properties.

Abraham Pais (1982)

As we try to reconstruct the past history of these cosmologies, we encounter a striking feature. If matter and radiation continue to behave as they do today, and Einstein's theory continues to hold, then there will be a past time when the expansion must have encountered a state of infinite density and temperature.

John Barrow (2000)

Even a child can ask: If there is an edge to space, what's beyond it?

Dana Backman (2013)

Late in the day she's back from Europe. Straight from the airport, she announces, confirmed shortly by her carry-on hot on her heels. Berlin and Genève as well as Paris she explains, without explaining anything. The weather's turning mean, it's wet and blustery, but as always she looks like she stepped out of a salon. As she looks at what we're doing I wonder if she wonders why we have not much to show. In a shifty spasm, I blurt that we can't rush this stuff; then feel foolish as she's never said we should. And who would've thunk that there would be so much? I wade through a hundred or more pages sifting out a single page of notes.

As she samples the slim pickings I tell Frank that physicists have trouble with this stuff. Even Einstein. I've lost track of all the times he changed his mind. He admits it, writing to a colleague with wry humor, 'That fellow Einstein suits his convenience. Every year he retracts what he wrote the year before.' So it's not just *what* he says we have to track, I tell her, it's also *when* he says it.

They leave soon after. Separately. There's this sense of something being staged—contrived may be the word I'm fishing for—on the few occasions when the two of them are here. Why so? The only audience is me. Is *I*? Why do I have this pronoun problem? Perhaps because the way to say it is: *I* am the only audience. Anyway, should I be worried? Is something going on? Not sex, or I don't

think so. I mean, she's early thirties and good looking. He's late fifties, looks ten years more than that, wears too much weight, a klutz. So she's young, he's old, and their vibes aren't right. But I keep track of eyes. They don't look much at each other. It's not quite avoidance, but when they do it's just a glance-and-look-away or change of focus. Whatever. I park my vague suspicions and I plug away.

Einstein is the guiding light in the evolution of the new ideas that drive twentieth-century physics. His role is complex and at times eccentric. His influence pervades a century of science. His long shadow leans across our landscape. Few now see how he transforms all lives. For this reason if no other, Frank will need to take a fresh look at Einstein's theories or, rather, a look behind. He needs too to understand the view of the universe embedded in them. Why? Because he needs to eschew it. Which he won't. But a fictional Frank might. Suppose *he* were to take a run at this. Like any fictional detective first thing *he* would want to know is: Who is this guy?

Though mostly thought of as a physicist he's foremost a philosopher. He rejects the notion physicists should stay clear of philosophy. This notion was the fashion then and now it is the norm. No fashionista, Einstein cultivates a philosophical approach and so reshapes the future of the world.

His work is based on deep ideas about reality and how we see it. In this he has a nineteenth-century view. He accepts implicitly the concept of a universe that doesn't change. Thus he sees the idea of the universe *beginning* as unphysical. Of course he doesn't have the benefit of measurements cosmology will yield in sixty years or so. A satellite? A picture of the universe from thirteen billion years ago? He can't imagine, he can't even *dream* of this.

My version of a super sleuth, the fiction, he would dig this stuff. From *his* perspective Einstein's clueless, out of touch, yet he goes on to paint a picture of the universe that dominates cosmology for a hundred years. How does this happen? Super Sleuth would want to know.

From his teens Einstein has his own version of the world. In what at twenty he conceives to be a love letter to his wife-to-be he writes, 'I'm convinced more and more that the electrodynamics of moving bodies as it is presented today doesn't correspond to reality.' His single-minded search for reality as he sees it makes him a rebel. For more than a decade he is the sole champion of the idea light behaves like particles called quanta. He embarrasses his friends. Four famous physicists who nominate him for a signal honor eight years after his paper launching quantum physics write:

> That he may have missed the target in his speculations, as, for example, in his hypothesis of light quanta, cannot really be held too much against him, for it is not possible to introduce really new ideas even in the most exact science without

sometimes taking a risk.

Eight years later he'll receive the Nobel Prize for the discovery for which his friends so anxiously apologize. His 'light quanta' will be labeled photons. They are particles of light. As to his taking risks? In 1905 he is a young patent clerk. Newly-wed he has a new-born child. He's seeking a career in physics. So he takes on its establishment?

He does not yet think much about the universe. He is well-read on astronomy but it is in its infancy. He knows about the orbits of the planets. He knows about fixed stars; he knows too that they move. He knows nothing of galactic movements but then no one does. He imagines space as infinite. Like his peers he views the universe as something that's just there. Almost nobody (well, no physicist) is thinking much about the way the universe began. This question is not seen as *scientific*.

He moves to Berlin. He takes two top positions. He gets divorced. He survives near-fatal illness. He publishes his famous paper on GR. He thinks of it as saying how some piece of space behaves. At first he seems to have no interest in what GR may say about the whole. But then, in 1917, he turns his GR dog loose like he sics it on the cosmos. But all he's after is to take it for a run. First he simplifies the picture; he assumes things that he knows he doesn't know. One is his *Cosmological Principle*. It says the universe is everywhere the same. In other words, any observer (if there were an observer) looking any which way anywhere in the universe will see the same sort of thing as an observer somewhere else. It's not just simplified; it's off the wall—pardon me my Michael Jackson. For anyone whose eye is on the universe this is a problem. His eye is on the dog.

As Pais will later say with great restraint: His is a bold assumption. A glance at the night sky would say it's wrong. He hopes it could be nearly true 'over enormous spaces.' But the point is it makes his equations take a form that he can solve.

GR has odd problems when it's used on pieces of the cosmos. The one thing that it surely should be good at is the whole of it. Soon it becomes *the* theory for physical cosmology. That's a fact that Frank should keep in mind. Why? Well, GR is by now embedded in most everything that's said or thought about the universe.

It takes a GR problem to get Einstein thinking of the universe at all. His paper on cosmology is not about cosmology itself. He's looking for a GR tune-up. He finds it by reflecting on the universe's contents at infinity. This leads him to a contradiction so he says it can't be infinite. With a bit more thought he figures that it has no edges and no ends, no boundary in space. Where it came from's not a question that engages him. He still thinks it has been around forever and so has no boundary in time. But GR says this is a problem. Its picture is a universe that

may expand or may contract. To keep it balanced he throws in a number he calls the *Cosmological Constant*. It seems he doesn't really see this as a fix. It's just his tune-up. He thinks it is—wants it to be, insists it must be—true. Until astronomy shows that it's not.

Using GR, physicists explore the universe in the ensuing ninety years. Their works define cosmology today. They depict a cataclysmic struggle on a cosmic scale. Einstein's universe is trying to contract and rushing to expand. These two tendencies war over time. Expansion wins the early battle but the long-term outcome is unclear. It is, as Frank will learn but I don't say today, a universe that's so unlikely as to seem impossible.

Einstein has what may be the most important quality for physicists—a bit of luck. Next to impossible, his universe withstands the test of time along with relativities he builds it on. Most published works on physical cosmology depend upon his thoughts. It's hard to keep some kind of track of which is based on what. The shadow of the king looms large across our mad investigation. It's a challenge that *my* Frank would take. Even in fiction he would be Einstein's inferior. But Einstein never looks for the Beginning. *He does not believe in it*. If he was here today he'd be the first to reconsider his own thoughts in light of the new facts, the evidence that's stacking up. His basic tenet is that 'the justification for a physical concept lies exclusively in its clear and unambiguous relation to facts that can be experienced.'

World War I drags to an end. Times are tough. The media madness comes and goes. Einstein settles in Berlin. Though he dabbles disastrously in politics and becomes a target of racist attacks, his scientific life and work seem poised to move toward a new and more secure, an almost tranquil, phase. But his other brainchild, quantum theory, is entering its teenage years. It is at odds with his deepest beliefs. Like teens the world around, it sets out to wreck his tranquility. It is as if he is a victim of that allegedly-ancient, said-to-be-Chinese curse: May you live in interesting times.