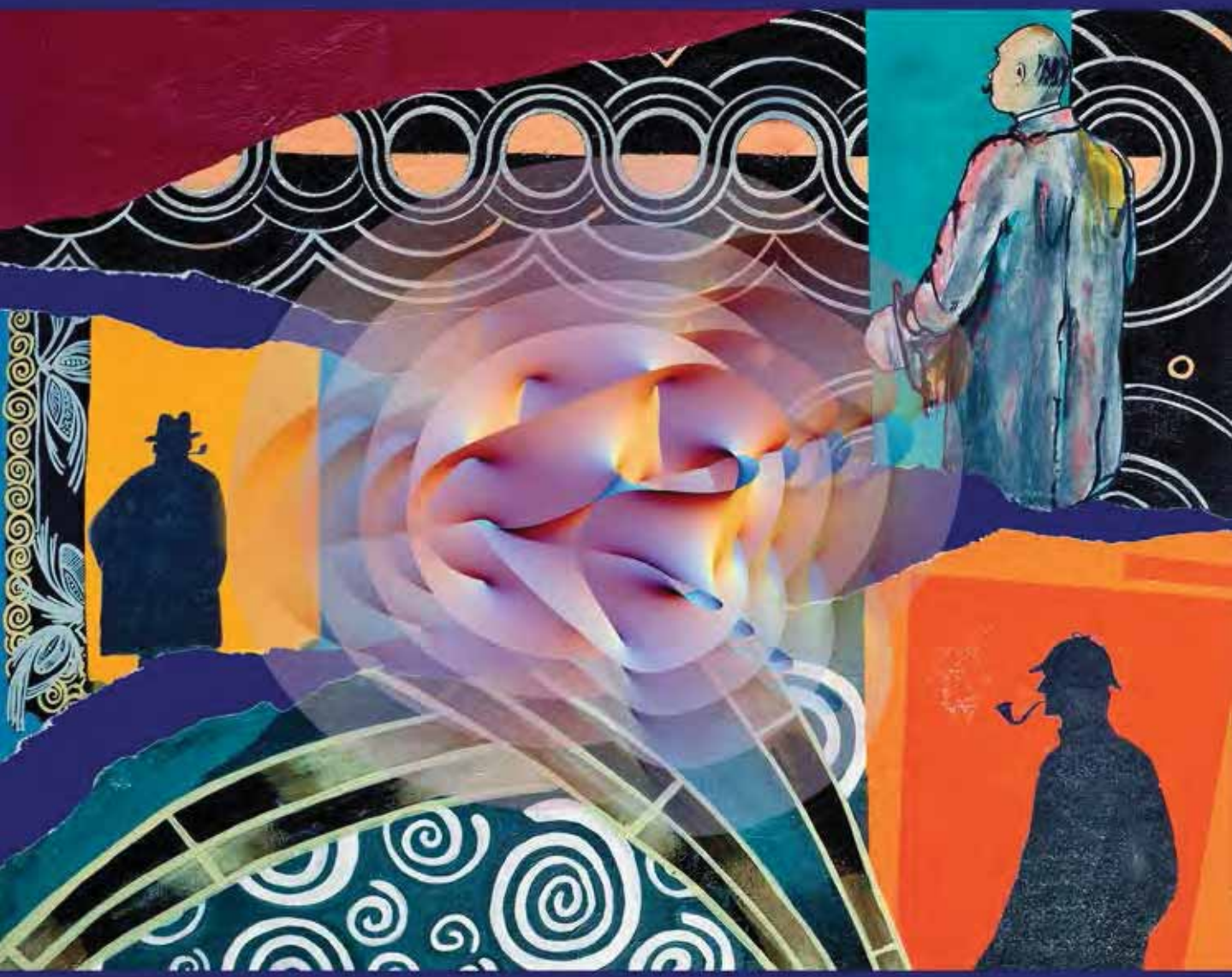
DISCOVER HOW THE UNIVERSE BEGAN

TIMEONE

COLIN GILLESPIE



From the author of

THIS CHANGES EVERYTHING

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Colin Gillespie

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BOOK ONE OF THREE

Theme of the Work

Science is the study of emergence
Religion is reflection on all else
The beginning brings them both together

For those without whom this work would not be

Joan, Don, Brian, Carolyn and all who wrought

And the many more who thought and taught

I am asking a question which has to be asked at the beginning of an enquiry about anything—was the world, I say, always in existence and without beginning? or created, and had it a beginning?

Plato (360 BCE)

In imagination there exists the perfect mystery story. Such a story presents all the essential clews, and compels us to form our own theory of the case.

Albert Einstein & Leopold Infeld (1938)

Where and when it all began still remains the most intractable problem of modern cosmology.

Andrei Linde (1994)

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PREFACE

"In the beginning," he said, "exactly fifteen point two billion years ago, there was a Big Bang and the Universe--"
I had stopped writing. "Fifteen billion years ago?"
I said incredulously.
"Absolutely," he said. "I'm inspired."

Isaac Asimov (1979)

We are all, each in our own way, seekers of the truth and we each long for an answer to why we are here.

Brian Greene (1999)

I wanted to understand how the universe began.

Stephen Hawking (2001)

For the first time in the history of science, we have at least a chance of putting together a sensible theory of time and the evolution of the universe.

Sean Carroll (2010)

The Big Bang model … says nothing about what banged, why it banged or what happened before it banged.

Manjit Kumar (2012)

It is the ultimate mystery. Humankind has long sought the answer, maybe since the dawn of thought.

Is an answer within reach? Some say there was no beginning. In 1927, Bertrand Russell says, 'There is no reason to suppose that the world had a beginning at all. The idea that things must have a beginning is really due to the poverty of our imagination.' Really? When he says this, concepts of the cosmos are a speculative sinkhole. But soon science says he's wrong: There *was* some sort of a beginning. How can science say so? It unleashes a tsunami of new evidence, a picture from a moment nearly 14 billion years ago. Suddenly we can see that far back in time! The picture shows the *Big Flash*, light let loose as space becomes transparent. It shows the universe when it's an infant, less than 400,000 years old. Before the Big Flash, space was as opaque as thick lead bricks so the beginning is forever hidden from our view.

The fact that the universe began with a Big Bang is widely known. It's also wrong. The Big Bang model describes how the early universe's dense, hot matter expands and cools. That is, it shows what happened *after* the beginning. It predicts things that we see today. Most physicists think something like it happened. But whatever happened, they know that the Big Bang's *not* how it began. Why not? Because it doesn't say how it *got* to be dense and hot. Thanks mostly to this model, cosmologists believe they know how the whole universe evolved through all the

years that followed its first fraction of a second. But this makes it all the more surprising that they don't know how it began. It's not that they have *no* idea—they have lots; but so far none that hang together.

This book takes a new approach: It follows a fictional detective and his sidekick. Their job is to untangle clues and work out what went on. They're not always a happy team. But as they struggle on they find there's lots of evidence.

Every fictional detective knows that he or she is to make sense of *all* the clues. But scientists, says Edward Wilson, do not look at the big picture; they must focus on their bit of it or they get left behind. This book is all big picture. It aims to discover how the universe began and cast new light upon the mystery of our existence. The fiction's aimed at being helpful in discovering what's real. Through ancient puzzles and more recent revelations there are many twists and turns. The key to keeping track is this: Just follow the detective. He defies the odds and finds a simple answer. How will readers know it's true? Well, as in all detective stories, it explains so many things that once seemed inexplicable.

Here, dear reader, please be warned. You are entering a world that needs novel ways of thinking. It may change your view of what is real. Few of its elements are new and many of them netted Nobel prizes but here they coalesce into a radical new vision, a universe that's beautiful (a word with special meaning for philosophy and physics) and singularly simple. Readers can acquire what Infeld calls the greatest pleasure—understanding.

The book has many quotes, some before each chapter, others in the text. They are integral to the story. And on the website there's a Cast of Characters (the players in this drama of the Modern Age), a Glossary of Terms (shown in *Italics* upon first use in the text and with a Capital thereafter), and much more information. Links (and of course Web searches) lead to other aspects so the reader is invited: Check it out.

INTRODUCTION

Some power there is that draws men's eyes and hearts up and outward, beyond the heavy clay that fastens them to earth.

Mary Stewart (1979)

The … results have given physicists confidence that we understand the origin of the universe to within a fraction of a second after the Big Bang. However, we are still left with the embarrassing questions of what preceded the Big Bang and why it occurred.

Michio Kaku (1994)

Extrapolating all the way [back] to "the beginning," the universe would appear to have begun as a point … in which all matter and energy is squeezed together to unimaginable density and temperature.

Brian Greene (2003)

Cosmology is the scientific attempt to answer fundamental questions of mythical proportion: How did the universe come to be? How did it evolve? How will it end?

Charley Lineweaver (2003)

Tracking the history of the Universe from the instant after the Big Bang is a stellar achievement—but it leaves unanswered the fundamental question of how the Big Bang started in the first place.

Patricia Fara (2009)

Finding how the universe began turns out to need two new approaches. One is simply to begin at the beginning. The reader may think it odd that anything so obvious is new. These days it is. But trying it has fallen out of fashion. Experience suggests it's risky. And, too, the physics that should help turns out to stray amid a maze of problems. To the detective all these problems help to crack the case; they are the clues. So the other new approach is this embrace of many problems. A famous case may illustrate the way this works.

In 1687 Newton's apple shows him how to calculate the motions of the planets. Astronomers soon find his method works. Some two hundred years later a faint new planet, Uranus, is found. Its orbit doesn't fit the calculations. Le Verrier takes a big leap. He proposes yet another planet—one that nobody has ever seen—could, if *it* is in a certain orbit, make Uranus move the way it does. When telescopes are pointed where he calculates his planet needs to be, it's there! Uranus's problem is the clue that leads to Neptune.

Another case may show how extra clues can help. The year is 2009. The scene is tropical Pacific islands. The puzzle is their peoples: Where did they come from?

There are many theories. Genetic studies lead to mixed results. Old pottery is inconclusive too. The origin of Austronesian peoples seems lost in the mists of time. Enter the detectives. They are scientists. The island languages, a thousand of them, yield more clues. Studies of the stomach-ulcer bugs in islanders add more. Taking all the clues together gives a clear and simple answer: They all—peoples, pots, tongues and bugs—came from Taiwan 5,000 years ago. Of course it isn't quite that simple. But the concept's simple and it's central to the art of the detective: Lots of clues say much more than a few.

By the 1980s, cosmology is an experimental science. It soon discovers many strange new clues. They make it possible for a detective—when a good one can be found to take the case—to ask and answer: What happened? It's a five-part story.

First, the detective will need a briefing on how cosmology's ideas—good and bad ones—came to be. Part I is *The Case History*, though no detective ever had one with a history like this.

Figuring out how the universe began is of course much messier than turning a math problem inside out to find a planet. But cosmology has lots of problems—well known among the in-crowd—that a detective could put to use. Focused more on problems than accomplishments, Part II is *The Cosmic Clues*. Part III is *The Apprehensions* in which any way to solve some problems could become a starting point to deduce—or more precisely, induce—the Beginning. The detective finds how space and time begin. Then, in Part IV, *The Way of It All*, the detective sets out to unravel how the universe emerges. But he isn't finished when this task is done: What can the Beginning say about the end? Part V is *From Here To Eternity*.

The book thus sets the scene; reviews the clues; discovers how the universe begins; sets out some of how it works; and follows up its future. Is it really this well organized? Well, it does get messy. After all, it's a detective story.

THE SINECURE

There are some subjects, however, to which dialogue-writing is peculiarly adapted, and where it is still preferable to the direct and simple method of composition.

David Hume (1776)

Life's a piece of cake.

Ogden Nash (1935)

Fact and fiction are so intermingled in my work that now, looking back on it, I can hardly distinguish one from the other.

Somerset Maugham (1938)

Deciding on a book's beginning is a matter as complex as determining the origins of the universe.

Amos Oz (1999)

The machine, the Large Hadron Collider (LHC), aims to recreate the conditions of the Big Bang, when the universe is thought to have exploded into existence about 14 billion years ago.

Jonathan Leake (2007)

***

The elevator comes to rest about 400 feet below Commune de Crozet. A man steps out. Having left the car in a lot just off the road from Crozet to Saint-Genis he has passed Security at Point 3—PZ-33, building 2395 to be precise. It's just after 3 a.m. He's known to all the night shift so his presence troubles no one. He walks south through Sector 2-3, carrying an item like a lidded thermos. Its jacket might be stainless steel. The Sector, ever-bending slightly left, is two miles long. Behind him lies the sector where a big explosion shut the whole thing down. Now it's back on line.

He is on the French side of the border. Ahead of him near Point 1 the well-lit tunnel with its fat vacuum pipe passes into Switzerland. He has no need to go that far. He has a rendezvous with ALICE at the next collision point. She's one of the smaller, special-purpose particle detectors. Smaller meaning only 50 feet in height and some 10,000 tons. Her special purpose is to study what went on in the Big Bang. *She will serve his purpose too. The thing in his hand is a magnetic bottle. Its special purpose is to capture a black hole. Three kilometers to go. He glances at his watch but there's no need to hurry. Even in the tunnel it's a pleasant evening for a walk.*

***

It's just a job. It isn't clear how come I got it as I'm not exactly qualified. A hacker with creds bumming round the surfing world. A lost philosopher, you might say, of the ocean road. It's even less clear why I took it. Not for money, though the money's very good.

There was a short ad for an assistant in the *Daily News* under Science/Research, a short interview with *her*, a mention of 'sponsors' whom she never says a word about again. I've come to think that she—she gives no name at first and afterwards I cannot ask—must be some sort of physicist but doesn't say. Accent is northeast but not New England. Direct about her wants but saying almost nothing about why.

Next day, a tad sarcastic, she mentions just in passing, like, a Word. The Establishment is what I think I hear—an *attitude*. Or, thinking later, maybe not? Maybe the innuendo's in my head. She's moved to a hotel out by the airport. I am looking for an office for her firm.

She calls my job research. Upmarket label. Mostly lots of reading, which is fine because I read a lot. Making notes. And Web stuff; fine too as the Web is where I live. General gofer. Answering the phone. Then there's briefing the detective. Hiring him is her plan from the get-go.

But within days she's like: Let's not bring him on board just yet. So already the detective is a 'him.' Does she have someone in mind?

A *very* big bank draft. She hands it to me! It's made out to Axiam Associates. This is, she says, the business name.

Set up an account, she says. Oh, and make a list.

Three desks, two Dell desktops—she has an old MacBook—a file server and a local intranet. A printer. High-speed hookup for the Dells. No email; she says it is insecure. Cellphones and a landline. A budget for 'research' including books. Her travel. And some salaries, she says. And business cards, low key, with a slogan—'cutting-edge cosmology'—all lower case. She signs the checks. She needs receipts for everything. Though I'm not irresponsible I've never had responsibility.

My title is 'executive director.' Like the janitor is a custodian. This is embarrassing. Truth is, I am, like Holden was, a corny kind of guy.

But . . . she does seem to have money. Maybe it *is* the money? Anyway, this is how it all began.

PART I

THE CASE HISTORY

The eternal mystery of the world is its comprehensibility.

Albert Einstein (1936)

In Hollywood anything can happen, anything at all.

Raymond Chandler (1953)

Since the discovery of general relativity we no longer are sure of what spacetime is, and since the discovery of quantum mechanics we no longer are sure of what matter is.

Carlo Rovelli (1997)

En route to explanation … theorists must tread with considered step through the jungle of bewilderment, guided mostly by hunches, inklings, clues, and calculations.

Brian Greene (2004)

To continue the progress of science, we have to again confront deep questions about space and time, quantum theory, and cosmology.

Lee Smolin (2006)

WISHING WELL

No man will be a sailor who has contrivance enough to get himself into a jail; for being in a ship is being in a jail, with the chance of being drowned.

Samuel Johnson (ca. 1760)

If you look at the results which science has brought in its train, you will find them to consist almost wholly in elements of mischief.

Thomas Peacock (1875)

In this world there are only two tragedies. One is not getting what one wants, and the other is getting it. The last is much the worst, the last is a real tragedy!

Oscar Wilde (1892)

It is only to be expected that the recent revolutionary advances of physics are bound to have the most profound effect on our worldview and on our philosophical outlook.

Jan Smuts (1931)

I think that the responsibility for the search for the new synthesis is not for physicists alone.

Carlo Rovelli (1997)

People often have strong emotional responses to questions of the origin of the universe.

Roger Penrose (2004)

Be careful what you wish for.

Anonymous

It's weeks before she actually hires him, or should I say before she tells me that he's hired. Much later I find out *she* is the one who decides his name is Frank. He's likely never thought about the world beginning. Never heard of Dr. Johnson either. Even before he's hired I start to ask myself a Johnson question: Have I got myself into a ship? Every aspect of this job seems odd. Nothing like the research projects I latched onto in the past to keep me surfing. The biggest puzzle is the crazy task she says we're taking on. So from day one a question dangles: What about existing theories? I didn't dare to ask it in the interview. And she didn't ask *me* anything along these lines, which seems a little strange. First day in the office, chairs unpacked and desks assembled, I sit down for the first time and I ask.

Oh, but there *are* none, she says, smiling. None worth mentioning, she goes on, turning to her empty desk, but check it out.

Check it out, I'm soon to find, is her way of sidelining awkward questions. She has others, such as, when she says she is 'affiliated with the Institute' and I ask which one, she switches subjects. She must know I see through this. She's what in my day kids called square, signing L7 with their fingers behind someone's back. Yet she exudes determination, which is something I admire.

In time my job description is a little clearer. I make coffee. I pick up the phone—if it should ever ring. I water the two potted plants and do the research. The first few days are easy, trolling websites, building background. Then she steers me into reading physics, which is heavy going. And history, which is just fine. My research report, which she checks daily. And she wants lists. A strange assortment. Lists of books and lists of problems. Apt and wise quotations and their sources. Shopping lists. Physicists. Philosophers. Poems and poets too. Name dropping—who's who's what she calls it—is encouraged. She also wants a briefing book for this detective. I'm to write it. A case history, she says.

Another affectation, I would say. Of course I don't. Later, she says, when she finds the right detective I can write up his investigation. All this will become some kind of record of the quest. It's daft. Shades of the Red-Headed League? But I'm like Jabez Wilson; it's okay by me. I like writing. No one ever paid me for it, not till now. And having rattled off her list she lets me follow my own train of thought. That's Thomas Hobbes not Mother Mother. I never got to do this since the salad days of college. Liberal Arts—history and literature. A minor in math and computing. Then post-grad philosophy, the 'thesis incomplete,' the surging surf and hip-shot chicks on the unending beaches in the many lands that round off the next decades of my education . . .

So I go along. I pick up the metaphoric pen. The *Oxford Dictionary of National Biography* says Dr. Johnson is 'arguably the most distinguished man of letters in English history.' He does have a way with words. Maybe he exaggerates a bit about ships of his day but then he isn't really writing about ships, he's writing about *choices*. He has a pessimistic view of human philosophic aspirations. In the flowery fashion of his day he says this too:

> O'erspread with Snares the clouded Maze of Fate,
> Where Wav'ring Man, betray'd by vent'rous Pride,
> Then say how Hope and Fear, Desire and Hate,
> To tread the dreary Paths without a Guide;
> As treach'rous Phantoms in the Mist delude,
> Shuns fancied Ills, or chases airy Good.

A warning one might think amid the salad days—two salads in one page, it's Will—of the apostrophe. And yet our forebears and his too *did* choose to sail in ships in search of rumored lands. They chose and we still choose to tread the dreary paths without a guide. E'er seduced by curiosity, chasing airy Good or driven by the vision of a buck. We too have aspirations. With them we find choices of our own.

So *her* choice is she wants to know: How did it all begin?! Securing this small starting scrap of knowledge is the highest purpose of the human mind. And she

chooses *this* to take on with a computer-savvy beach bum and an out-of-work detective trailing in her wake? The sheer effrontery is dazzling. Of course the odds that she can pull it off are zip. Not even!

And now, first task, I am to ask: What if she pulls it off? Then what hopes or hazards might that landfall bring? It's Dr. Johnson: Amidst this foolishness he brings out my didactic style. But, I soon see, she doesn't seem to mind.

What damage, though, I wonder, could we do? Of course at this point I haven't yet met the detective. I don't yet know how truly hopeless it will be. Later she admits she wants this in a book. A real book for publication. About, as she calls it, The Beginning. She says it that way, with capitals. I don't know why she thinks some P.I. hack can do the job. Or anybody else. But if he can, if he actually does, I'd have to rank it in the class of dangerous ideas. Like fertilizer mixed with diesel, only worse. Why? Well, they didn't call it the Big Bang for nothing.

So I set out trolling, armed with Google, Johnson's ship in mind, and find that Victor Hugo says, disarmingly, 'Life is a voyage.' Just when and why he says it isn't clear. Nor would I make note of it but trolling further it appears he doesn't stop when that site says he did. He continues (so say several other sites), 'Life is a voyage; the idea is the itinerary.' This brings me back on track because he means we need ideas. But history should teach us that ideas may be perilous. I remember Gruber has his character Wazir explain, 'Ideas cause events.' Indeed they shape the world. No doubt some work to general advantage. Without ideas we would live in caves and even that was an idea. But ideas have a nasty tendency to work to the advantage of a few and disadvantage of the many. Think witches; think slaves; think Pakistan. Think *jihad* or think *perestroika*. Think any bloody idea that has staying power.

The book, she tells me, is to be about philosophy and its pursuit of physics. Two downbeats and for no reason that I can discern she says it's *not* about religion.

Who is she kidding? Whom? Her objective, her Beginning, was a pawn of more than one religion long before the early days of Western science. Let's suppose that she succeeds. We succeed, I should say. So we stumble on it. She'd have to be naive to think that no religious sect will use it to advance its own agenda. She may be a bit dippy but I don't think she's naive. In fact the spillover wouldn't be restricted to religion. The one thing that's certain is the consequences could not be contained. The world would change. Are we ready for this? Rhetorical question. We will never be ready.

She likes this. Watching while she looks it over, I can tell. Not the message; she seems oblivious to content. The style, the tone, of history should teach us that ideas may be perilous. Her demeanor's serious so I don't let her see my snippy bits; Word keeps them under cover. An exposé, she remarks with a big smile as she's leaving, should start off low-key but classy.

So what's with the exposé? Is this a new spin on the project? Digging on the Web I must admit that there may be some sort of story here. At least it's not the now-hear-this they fed us when I was in school. Maybe I could've gotten better grades. This is more like what we *don't* know. I'm madly making lists. Philosophies checklist. Cosmologists checklist. Theories list. Physicists list. Unsolved problems of physics list. Lists of sources of all sorts for everything. Already there are lists of lists of lists. I download LISP which makes it effortless to track them. Especially the

problems. Clues she calls them. And then there's this summary, a *CliffsNotes* kind of outline. She says she needs me to feed it to our soon-to-be detective. What can he do with it anyway? Well, that's her problem. It may all be pointless, but classy's something that I can arrange.

A century ago, as sole author of relativity and *agent provocateur* of quantum theory, Einstein artlessly unleashes on an unsuspecting world two scientific revolutions. Mentioning as a mere by-product of his first theory the equivalence of mass and energy, he thinks little of the fact that this will usher in the age of atom bombs. At the time maybe he doesn't think of this at all. The bomb is just one of an open-ended string of consequences he (and others) don't expect and can't control. A half century later Heisenberg, in his 'popular' book on quantum theory, is at pains to ponder its impact on 'the religious and philosophical foundations' of human cultures. Blandly, it is true, but he does ponder it. No more than Einstein though does he foresee its impact. Anyroad, which is the way that some say anyway in Britland, by the time he stops to ponder it his quantum horse is long gone from its stable door.

Anyone can turn the world upon its head without a license. No one does impact assessments on ideas. Curiously, of those who put their thoughts on record at the time, it may be Smuts, speaking to the British Association for the Advancement of Science in the interregnum between his two terms as Prime Minister of South Africa, who best apprehends the weight of what's afoot. So what now should we, knowing if not full well then at least much better what *was* afoot, say of it? That it sparked a renaissance of scientific progress? That it founded a new world economy? That it spawned weapons of mass destruction? That it underwrote the cost of recognizing fundamental human rights? These and a dozen more perspectives voice mere slivers of its impact up to now. Can we cast a better augury than Heisenberg's?

Well, what are we dealing with? Articles I'm reading say the scientific revolution is on pause. Watching her eyes later I see that she reads this simple sentence slowly, twice. Odd. Mostly she just skims. This must matter to her. Why? To me it sounds more than a bit pompous. No, portentous is the word I'm looking for. But she seems to lap it up. Behind all its bountiful activity its (sorry; my own interjection threw me off the thread) the scientific revolution's intellectual engine's parked—they say—in a back alley. Not an unproductive alley. Its very fruitfulness is an attraction for many of the best minds in science. But apparently it's like a fruitful garden that grows mostly mushrooms.

Soon I'm reading physics and it's way beyond my pay scale. Though I have a bit of background it takes half my time to learn the lingo.

The twin theories that drove the revolution now enliven countless kinds of human enterprise. They're enormously successful. But from the perspective of future physics they suffer from a pair of ultimately fatal defects: there are two of them; and they aren't right. It's worse than that. There is a sense afoot that in the grip of these two too-successful, unexplanatory theories, physics may have lost its way.

The Problem of Two Theories is already on my clues list. I don't need a detective to know that it belongs. That there *are* two theories shows that at least one of them must be wrong. In a hundred years neither of them has ripened into *the*

theory. Hope fades that either of them ever will. The reason's simple: *The* theory must include and so must be built on the foundation of the way the universe began. Almost everybody says so. If our present enterprise (that is, finding that beginning; who knows what we're really up to) doesn't wholly fail, it might help physics finish off its hundred-year-long revolution. To what ends? Knowing something of the consequences of the start-up of the revolution, should we look for less from its completion?

With no Smuts we can't foreshadow even as generally (no pun; just the right word) as he did the impact of such change. At best perhaps we could expect more of both triumph and disaster. The hopeful calculation is that by being better stewards humankind could tilt the trade-off in the triumph direction.

Actually, I think that's true. Maybe *I'm* naive. But *she's* a snag short of a barbie; she won't discover anything. It's just a job. Don't worry, be happy: McFerrin says it all.

But the impacts could be huge. The choices will be thrust into the hands of future generations. Should we then embark upon the voyage? Well, the truth is that we have no choice. We never really did. We are the ever-ready victims of our curiosity. Ideas have lives of their own.

Of course it *could* work for the better. In 1965, Arthur C. Clarke says, 'With the expansion of the world's mental horizons may come one of the greatest outbursts of creative activity ever known.'

I say truth is it is a crapshoot. It's all in the way it comes together. A ballet dancer propositions Shaw:

> Think of the children (she says). With my beauty and your brains …
> Yes Madam (replies GBS). But what if they have *my* beauty … ?

This is supposedly my notes. Of course I keep my *own* notes in the markup. She seems to like the stuff she gets to see. More the style than the substance. It's not that she doesn't follow what I'm saying. It's more that she doesn't seem to care. But she seems serious about the writing, about it getting done. I can see it's not just notes. I reckon that she wants this for her book.

Closing up the shop I see a small plaque on her desk:

IF YOU AIN'T THE LEAD DOG
THE VIEW WILL NEVER CHANGE

Sounds like something Sarah Palin might have said. But nothing that she's said so far is in the least political. What does this saying say of her?

ENTER THE DETECTIVE

In Hollywood, if you look hard enough, underneath the false tinsel is the real tinsel.

Bob Schiller (1947)

The fictional detective is a catalyst.

Raymond Chandler (1950)

Can I call you "Frank"?

John Cleese (1971)

Philosophers' search for truth resembles a detective story.

Jostein Gaarder (1991)

In science, detective movies, love or any other area of life, when one is confronted with a situation in which the old assumptions are no longer working as they used to, it is perhaps time to look for new questions to ask.

Lee Smolin (1997)

Considered in this milieu, the detective—in his role of disentangler of enigmas—becomes an investigator into the mysteries of the cosmos.

Lawrence Frank (2003)

What we will do first, she says with a straight face when I ask how we're going to approach our quest, is gather up the wisdom of the ages.

It turns out that by we she means me. And the wisdom of the ages? What exactly does she mean by that? I must have missed the course in college. So tongue in cheek I check it out. Only about 500,000 hits or so says Google. Of course when I click my way through the first hundred or so the estimate is down to 216,000. And hit 689 turns out to be the last of 'the most relevant results'. The Wisdom of the Ages For Now Anyway jumps off the first page. It's from the *New York Times*. Journalist McKinley quotes a Kansas bookseller as telling him, 'You don't have to read 20 books to get this wisdom. I'll give it to you in a $14 paperback.' Then I see this wisdom was in Fashion & Style. Back to Google, I can soon see I *will* need to read 20 books. Maybe more. And write too. *My* job, she says more than once, is: Write. She doesn't mention who will do the other jobs, the hard work, I assume.

Next I check out who else set out on the same quest. She was close to the mark. Digging deep I find a few. And they found glimpses, so my searching of their searches says, but no one claims the grail.

So what *is* this stuff that I'm to write? I mean, it would be grouse—as some may say in Strine, the slangy dialect of Brit they use in Oz to keep the Brits at bay—to know. Not least because to do it well I need to pitch the lingo apropos. I

put this to her, more politely, and she fesses up. It's like, it seems, not tea but text for two. But maybe this, she says, will turn into the book. *Be* the book more likely I imagine. It's okay by me, but why not say so?

Even now, she doesn't lay it on what *kind* of writing she expects to buy. But watching her look at my notes I soon think I can tell. She's okay with snappy and sarcastic is no problem. But she likes, she almost *oozes* happy feelings over, eloquence. Saying great things in a simple style. Oliver Goldsmith, I believe. Excuse me and whatever. She is paying; I am writing. My words are my own but my styles are for sale. I can do eloquence. With good material I like it, and I'm tapping heavy writers here. They have heavy things to say. *Big* questions and deep thinking.

Breaking into my musings she up and says now we need an investigator—her latest label—who will help us find our way. She says it's about evidence; an experienced detective will bring the right perspective to the file. I could say: Not. I don't. And so it's back to work. First order of the day: Detectives.

According to her there are analogies between a crime scene and the universe today. They could help us finger what we want. The analogies, she says, are simple: Something happened. An event. We want to find out what. So, she says, as if it follows, we need a detective. Maybe, I think, a *fictional* detective.

This Beginning she and I have, so she says, set out to understand is nothing like a crime. But then detective fiction's never really about crime. It's about detecting.

The puzzle posed for the detective—or the reader—hinges on the simple fact there is no witness to the murder. Once the body is discovered, experts clamber all around the scene. They have their views about the clues. The clues are central to the story. The detective has to reconstruct the crime from clues that seemingly are unconnected. Poe establishes these rules with the world's first detective-fiction story. And—is this coincidence?—it is written with a backdrop of debates about the way the universe begins.

The same rules—event, no witness, puzzle, experts, clues and reconstruction—could apply to the Beginning. But the detective on *this* case faces a much tougher task: He (I soon see that he's a he) is on the trail of an event that is unique. There is no body of experience to help him to intuit how the universe began. How then can he do it?

The hallmark of the fictional detective is a distinct investigative strategy. This is odd as each is cast in others' molds. Doyle bases Holmes on Poe's detective, Auguste Dupin. Indeed Watson on first meeting says to Holmes, 'You remind me of Edgar Allan Poe's Dupin.' The which intended compliment Holmes turns aside. He says Dupin is an inferior fellow. With this he subtly shows he knows that he himself is just another fiction. In fact, in fiction Holmes is *the* acute observer; but like Dupin he reasons from effect to cause. And like Dupin he has a penchant for prosopographia—deducing people's lives and occupations from a brief inspection of some kind.

Christie creates Poirot in the Holmes tradition. At first Poirot mirrors Holmes' approach—he sees detection as an exercise of the trained and focused mind. He changes over time. To his author he becomes 'a detestable, bombastic, tiresome, ego-centric little creep.' His focus moves from concrete clues to interpersonal

relationships. But his technique remains the same. He gets people to talk and 'in the long run, either through a lie, or through truth, people were bound to give themselves away.'

At the far end of the spectrum from Doyle's cerebral Holmes, Simenon creates the rural-French-become-Parisian Maigret. His may be the best-developed character of the detective genre. Maigret's investigative strategy is simple and *enchanteur*. He sets out to understand the perp. He gets to know the neighborhood. He soaks up its atmosphere. He hangs round; he's moody. He makes pit stops in the bars. It's an old-world approach. He chats up the locals. Anything unusual or out of character may be a clue. In the end the clues fuse in a single picture. Mentally he replicates the perpetrator's point of view. In that insightful instant he 'commits' the crime and so identifies the criminal.

A real-life murder mystery turns on a mundane item—a surveillance camera shot, a fingerprint, a hair with DNA. Solving it may take a lot of time but often not a lot of brain. In fiction the investigative strategy of each detective's suited to his clue-milieu. And there's not just one; there's a whole *book* of clues. Each is subtle, baffling, even esoteric; they are a confounding mess. Solving mysteries in fiction is all brain. The detective susses out an insight that makes sense of the whole mess.

The clincher is: To have a chance to pull this caper off she needs what Hauser calls 'a capacity for the promiscuous combination of ideas.' Well, the best bet for promiscuous combination of ideas is the fictional detective. The ideas that get combined in any of their cases are bizarre. I can fashion her a fictive *flic* who'll flit from physics to philosophy with ease. Surely she will see that this is so!

So she has me fashion a 'Professional Help Wanted' ad to run in local papers. I've laid it on her heavy yet she's unpersuaded. Does she think I'm kidding? Later it will seem to me that this, right here, is the beginning of the schism. Wanted, my mind says to me, a composite detective. Of course she won't let me say that, but she easily agrees we need one who can take tips from the top role models. That'd be so easy if she'd go for fiction. Detective fiction is an imitative business.

So with my ideas in mind, she says, she up and hires a cop. He's ex-LAPD. Thirty years in homicide, he tells her, so she tells me. I try to look impressed. Retired several years ago. His wife died. The pension isn't bad but every day he wants to go to work. Not wants to work; he wants to *go* to work. His rates are easy. Tad too easy, I say to myself. Why would she discount-shop for a detective? His name, she tells me, is Frank. Just like, I think, a movie character. Frank from *Blue Velvet* is the image in my mind. He doesn't want his last name on the file. Maybe, I think, he has *his* doubts about this business? Well, I'm not about to ask. Besides, down by the beach I could say, as Chandler has his P.I., Marlowe, say: 'The cops don't like me too well, but I know a couple that I get along with.' I can get along with this one too. I make a simple plan: He reads the file. He starts to set up insights and to knock them down. He *haunts* the scene, inhales it, takes in every aspect, until somehow something starts to coalesce. No need for him to look for evidence. We are the perfect team. My job is to find the clues; his is to comprehend them. Maybe he needs expert help; she gets the help he needs. He asks probing questions and assumes the answers are untrue. He's looking at the biggest picture. It's the coldest

case that ever was but there are new clues he might use. He's perfectly positioned to rethink it. Maybe she is right.

He stops by next day just to say hello. A little too much weight for five eleven. Slightly crummy-looking. In a trench coat on a warm and sunny day? Does he know that Marlowe says that every well-dressed toughie has one? But then that isn't Chandler's Marlowe speaking.

He seems friendly, though—perhaps from force of habit—he's a tad high-handed. Interesting work, he says. And then tells me to screen him from the limelight. What limelight does he have in mind?

So, she tells me later, here's the deal. He will head up the investigation. I will feed him leads. Of course I'll have to make my own sense of them first, to choose them. He'll provide the private-eye's-eye view, insider story, open window into his investigation. There's that word again. I'll write it up. He is Frank No-name, with no word on why. She tosses off an airy line: He understands the part that he's to play. What am *I* supposed to understand? What part? Or part of what? Whatever. I suppose she'll tell me anything I need to know. No future in my asking nosy questions. Shut up, write on. And so, I write.

He reminds me of Chandler's saying: 'He was a guy who talked with commas, like a heavy novel.' It is just his manner. He is like a character who's searching for an author. He seems like a blank—or blanked out?—page. And though he's been around the block he doesn't know enough to be uneasy—as he ought to be—about this job.

She sits at her empty desk and checks my notes. A daily ritual. But just a glance; no more. Without the markup where I keep my private comments, they are thin. She doesn't seem to mind. She asks no questions, offers no remarks. And so I dip my toe into the murky water, asking what's expected. Right away she's like: They are my notes—so I should write them as I want. This would be easy if I knew what it's about.

In the morning our detective drops in for a chat. He must have walked a ways; his forehead shows a slick of sweat. He speaks as though he's on a secret mission. Between the lines it seems he means that strategy is central to his work. Maybe he's telling me he reads the notes. So notes is what I feed him.

The investigator of the universe, cast as a detective, will encounter strange events set in dramatic scenes. The challenge to make sense of them could overwhelm. But one thing's for sure: her Beginning won't be found by ordinary reason. Why not? Well, if it could be, someone would have bagged it long ago. This investigator must be different. Einstein, himself no mean investigator of the universe, suggests, 'No logical path leads to construction of a theory, only a groping design with meticulous consideration of objective facts.'

When Frank sees these words he tells me they look like his own approach. He's surprised, he says, to find he has so much in common with a physicist, especially *this* physicist. If he has *anything* in common with the maestro I'm a bender of bananas. Or did he just yank my chain?

At some other level, a detective and a physicist have deeply different strategies. Could this offer him a chance where many physicists have failed? A detective looks for the kind of holistic realization that looms into view full-formed—the kind

where, as MacDonald has Harry Max Scorf advise: 'When you know enough, all of a sudden you know it all.' This is what the combination of ideas is about. And he has ignorance, another odd advantage. As Eisenstaedt says: 'Sometimes ignorance is a good thing.' Maxwell, long before Eisenstaedt, wrote of the 'conscious ignorance that is a prelude to every real advance in knowledge.'

So what he says next stops me dead. *He* tells *me* that for much of the last hundred years, physicists have tended to move incrementally, in small steps. Hawking, he says, likes this. Yes, it's guru Stephen Hawking's name he's dropping. Next he tells me that he disagrees with him! He says the stepwise strategy has not hit on the Beginning. It's like searching with a thick lens in the outfield as a way to find home base, is how he sees it. The physicists may think they're in the ballpark but it just makes them frustrated.

From him it's a speech. I must admit that he makes sense. I check his take on Hawking and it's true. What kind of ex-cop would know this? Who is he?

Well who he is is easy. He brings out some well-worn pictures. Younger him with his young wife. His dad in LAPD uniform. His badge. He kept his dad's badge number, 235. His dad was killed on duty, shot, he says. I say I'm sorry. With this info he's an open book. But his book, it seems when he is gone, is fiction. Three of Google's top four hits are *fictional* detectives; all of them are called Columbo. Another search says that Columbo's name *is* Frank! Could he be kidding? Does she know about his little bit of fun, if fun is what it is? For no good reason suddenly my heart is pounding panic and the only thing that I can think is that I'm dying. Ten adrenalin half-lives go by before my reason reasserts its lazy grip. He's only fooling. The attack is gone and I move on.

Can Flatfoot play a useful role? He *is* my *raison d'être* but he is not about to figure how the universe began. So I wonder. Does she see him as her Marlowe, as a scientific Don Quixote in a private-eye disguise?

THE OLD DIVIDE

In the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture, in different times or different cultural environments or different religious traditions.

Werner Heisenberg (1958)

The principle of science, the definition almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth.'

Richard Feynman (1963)

Focus on … crime … took the American detective story off the path marked by Poe—for the time being at least.

Leroy Panek (2006)

There is a belief in a creator who existed before the Big Bang and set the universe in motion, which is something that cannot be proved or disproved by science.

Peter Raven (2008)

In the beginning, it was science vs. religion.

The Globe and Mail (2009)

Edgar Allan Poe was obsessed with the medieval theology of sin.

Aidan Johnson (2012)

By the second week I settle in. She isn't here. I realize this place is mine. The Office, she calls it. It's not much. Her choice of location is a bit bizarre. Mostly she spends like a drunken sailor; not on this. North Hollywood may sound upscale. If you're from some other town that is. Paradise Incorporated, sneers Chandler in an Age before the acronym. It's a short spit or two from Universal City. I think about that while the elevator grinds me up to three. At least there is an elevator. Two connecting rooms. North-facing view. Dirty windows overlook the freeway. I guess they need no blinds. White noise from the air-vent blends with freeway drone. At least the air is cool.

Mostly, I'm the only one who's here to notice. Her consulting cop, perhaps not knowing he's supposed to haunt the scene, stops by from time to time. He rarely sits for long at his desk; he gets up and paces or he parks on mine. I don't suppose he wants to chat about religion but there really is no choice. He's supposedly consulting about things that were conceived in a religious context long before physics

came along and took them on. How can I ease him into this? It is one wall of the world he's walking into. It is stuff he needs to know.

But in the end I tell him Brel—another Belgian—says it all in song: 'Les Flamandes dansent sans rien dire…'

This poses a dilemma that he cannot duck. Simply: Anything worthwhile in any language doesn't truly translate to another. The genius of English builds upon this fact, embracing foreign words that come its way. I could tell him, Flemish women dance in silence … except this would miss my point. Listen to Jacques Brel, I tell him, look him up on Wikio, use your own computer, look and listen and inhale his cadence, Brel is legendary, check him out.

He listens. I sit back and think. What am I doing? What I'm writing's not about a book that may not happen. Not about word games with her that she won't read. Right now, it seems he is my sole consumer. What can I offer him? I wonder, feeling phony. I don't know this stuff; I just know how to find it. It's like FitzRoy taking Darwin to the Galapagos willy-nilly on the *Beagle*—except he's no Darwin. Lewis following Sacagawea? Except he's no Lewis. But like Lewis all that he will get to see will be the views from paths I'm choosing and my choosing's idiosyncratic. Maybe my task like Sacagawea's or FitzRoy's is to pretend I know the way. A thought that haunts me is I'm likely to be wrong.

Now I've got religion. To me Brel is timeless. What will Brel turn out to be to him? Will he go below the surface? Will he see what can't be written with a heavy hand? Will he find religion's roots in human thinking? Will he take a true long view of time? Will he, far from city lights, see what his ancestors once saw on each clear night? Will he feel the awe with which they watched the roving planets and the stately panoply of stars, their fear of deviant events like comets and eclipses? The quest to understand the sky may be as old as humankind. Was this what Healy calls the first unspoken word? *The First Idea*? One can imagine how such sights might light a long candle of questions before there were words with which to ask them. Religion owned these questions long before the dawn of physics.

In the early 1600s there's the celebrated standoff when the church asserts control of science. Galileo Galilei and the Roman Inquisition is a benchmark confrontation. It adds fuel to the fiery co-evolution of science and religion. They come to be seen as opposed or at least unreconciled. Today, of course, their institutions have in practice largely made their peace. But most still see them as mutually exclusive if not hostile pillars of society. It wasn't always so.

In early times, religions underpin the study of the reasoned argument. They build foundations for it—philosophic, economic, social and academic—and so for its brain-child science. Thinkers of the Islamic Golden Age (say from 800 to 1200 CE) initiate developments in philosophical and scientific thought. Islamic philosopher and theologian Abu ibn al-Haytham can be seen as the first scientist. Around 1000 CE he invents experimental testing of ideas. He bases his novation on the Qur'an. A thousand or more years ago religion and science are practically indistinguishable.

It's little recognized these days that, like religion, science is a system of belief. Every such system has its definition of truth. The divide between religion and science can be traced to their definitions and to the objectives that underpin

them. Religions seek power through doctrinal definitions of truths: Is it written? Science seeks knowledge through a pragmatic definition of truth: Does it work? So religions like species tend to be conservative and multiple and to diverge. Science by contrast tends to be avant-garde and unitary and to converge. Or so it should.

The last millennium saw power shifting from religions to kings and from kings to peoples. It was not given; it was taken. Science played its role in bloody struggles of which many tell the tale. Part of the sagas they depict is the deep schism that the struggles drove between the two.

Given this, it might seem that their discourse would have long since dwindled into silence. Not. They hold strained conversations. Isaac Newton bases his theories of mechanics and of time on his theology. Even now the dialog's alive, it's civil and it's keeping up to date, each side a source at least of provocation for the other. A careful listener might hear echoes of an old turf war. Civil, yes. But elbows are still up.

The line between science and religion is tightly defined. A proposition lies on the science side if it is disprovable—at least in principle. If not, then it's on the religion side. This distinction we inherit from al-Haytham. But the line is not as clear-cut as it sounds. A hundred years ago most of the tools now used to test such propositions were unimaginable—even in principle. Who knows what will be or seem to be disprovable to future generations?

He glazes over as I give him this. He doesn't see why he should know this border. I tell him it's as if he has to work near Shisidaogouzhen. He's in China; he's on 303 Provincial Road. He's admiring the meanders of the frozen river. I show it to him using Google Earth. He can see on-screen where Google says the border is but it's what locals say that matters. If some xenophobic North Korean sergeant thinks he's crossed the line he's looking at a long road home.

Of course this is hyperbolic. The penalties for trespass into physics are much less severe. But he needs must know and so should study physics' border. Like most borders it's a relic from a war. He has a philosophic passport with a metaphysics visa. Using the same language Jeans issues a friendly warning: 'In whatever ways we define science and philosophy, their territories are contiguous; wherever science leaves off—and in many places its boundary is ill-defined—there philosophy begins.'

He disappoints me. Having not showed up till after lunch, he now leaves early. To do what, he doesn't deign to say. She gets here from the airport twenty minutes later. Quick trip to Toronto, so she says. It's news to me. Actually, Waterloo, she says and turns to other topics. Another disappointment. What, I wonder, is in Waterloo? I don't ask her and she doesn't tell, but Google does: What's physics in Waterloo? scores five million hits. Top of the hit parade is the Perimeter Institute for Theoretical Physics, aka—a new coincidence—P.I. So as she likes to say I check it out. Interesting stuff: If I had infra-physics goggles I'd see P.I. as the hot spot on the globe. A meander through its website has me caught up in a lecture for an hour or more. Roger Penrose, a Brit physicist, gives me his ideas about the universe beginning. It's a talk he gave at P.I. a few years ago. Another hit's a headline: Hawking has a date with Waterloo. He stops by P.I. for a lengthy visit. Yes, the one who wrote *A Brief History of Time*. Better known for writing though he can't write

and for speaking which he can't do too. Checking further I see that in Waterloo he may be best known for his studies of black holes. It seems Hawking is to black holes what Einstein is to relativity. He and Penrose wrote the book.

So is P.I. where she was? Where else would she be in Waterloo? Google says the second star attraction is the station. Then it says *that's* in the London in the south of England. So I'm thinking that she *did* go to P.I. Why? I mean, if it's about *our* business, as seems likely, why not say so? What's afoot here and where is he when I need a *real* detective?

TROUBLE IN PARADISE

There is nothing new to be discovered in physics now. All that remains is more and more precise measurement.

William Thomson, Lord Kelvin (1900)

Convincing evidence that the automobile of today is as far perfected as the materials of construction and mechanical ingenuity will allow, is afforded by the fact that the cars shown in the two annual exhibitions this year exhibit no novelties of a radical character as compared with the cars of the preceding year.

Scientific American (1910)

The most elegant theories could be shattered by a single inconvenient fact.

Tom Clancy (1993)

Once again, physicists believe the physical world has been explained, and that no further revolutions lie ahead.

Michael Crichton (1999)

NICOLA: You need to write something new. Something real.

DAN: Like what?

NICOLA: Like this, like everything that's happening right now. Not a silly detective story. Something real.

Dennis Potter (2003)

It seems strange at first, working in an office. It's in a gritty neighborhood, on the third floor of a clean but slightly grotty building with respectable pretensions. But within a week or two it feels like home. Soon strange new habits coalesce into a new routine. Already there are one or two panhandlers I flip change to when nobody's watching. Been there, done that, is my motto. Now *I've* got the job and the clean shirt. Now the pretensions are mine. And best of all I get to write all kinds of stuff and say I did it my way. Most people wouldn't know that that's Paul Anka. For him maybe it was nothing more than a hack writing job—though for Sinatra it became *his* song. But for me the writing's always therapeutic. Long evenings on a beach some like to take a toke or sing songs to the surf. On any beach, on any night, I'd sooner sit near light and read and write. Today I'm in an office and alone. Why does this feel even better? Kerouac's tip for what's right for writing comes to mind: 'Scribbled secret notebooks, and wild typewritten pages, for your own joy….'

As the 19th century gives way to the 20th, the popular as well as the inside take on science is self-congratulatory. In many lands that follow the Julian calendar the century has brought the best of worlds. At its epicenter the British Empire is the leading power. Peace breaks out, prices fall and populations grow. Cities come of

age. A new level of prosperity looms into view, built on the success of science. Little wonder that the book of knowledge is now widely seen as written, all but closed. Kelvin speaks for a consensus. By 1900 physics in particular is seen as finished. Mankind knows everything worth knowing of it, it is thought (and said) by many, but for perhaps a few details. The universe is understood.

No doubt, some say, a few discrepancies remain and could be ironed out, but for physics there is nothing earth-shaking left to be done. There is in all the world no hint of the new revolution in thought and action that will soon overthrow most of its accomplishments and raise entirely new ones in their place, giving birth to almost everything that by 2000 will comprise the engine of the world. It is the calm before an intellectual storm. In this calm the idea that Newton's mechanics (on the movement of mass) and Lorentz's electrodynamics (on the movement of charge)—the pillars of three hundred years' achievement in physics—are about to become chapters in *history* is widely unthinkable and universally unthought.

Little noticed, three harbingers of storm are in the air. The first relates to Scottish physicist James Maxwell's wave theory of light. A detail, a mere fragment of this consummately successful theory predicts that light shining on a surface should make it give off electrons and that higher-frequency (that is, higher-energy) light waves should make *more* electrons, whose energy should stay the same. But that's *not* what is found: higher frequency light produces the same number of electrons, not more of them, and their energy is higher, not the same.

The second one also has ties to light. Theory says the speed of light depends on motions of observers. Experiments find no change in its speed.

As the calendar shows double zero few brows frown at these two technicalities.

But there is a third harbinger of storm: A 21-year-old stateless Ashkenazi-Jewish immigrant in Switzerland is about to graduate from the Federal Polytechnic Institute in Zürich and, having failed to find work as a teacher, take a job evaluating patent applications. It is a job that will allow him time to think. The world is about to change forever.

THE NEW DIVIDE

We seem to be making for a real clash between the relativity and the quantum concepts.

General Jan Smuts (1931)

No one has been able to construct a theory which is completely satisfactory as a unification of quantum mechanics and relativity. It is still not even clear whether this can be accomplished without a radical change in the basic principles of either, or both, theories.

Lee Smolin (1997)

General relativity and quantum mechanics appear to be fully inconsistent with one another.

Carlo Rovelli (1997)

[General relativity] recognizes that spacetime is curved but neglects the uncertainty principle, while [quantum mechanics] takes the uncertainty principle into account but pretends that spacetime is flat. Both theories have been spectacularly successful in their own domain, but neither can be anything more than an approximation to the truth.

John Baez (2001)

She walks in near noon. After a few inconsequential words about the weather and the furniture she holds out her hand.

By the way, call me Birgit Kapelhoff, she says, looking straight at me.

She spells it out and has me write it down. I need it for her cards. Her title, she says, should be principal. Everything, she says again, to be in lower case.

It is an awkward moment. It's not just that of course she is tacitly acknowledging she didn't give me her name in that interview at her hotel suite a few weeks ago. It's more the feeling that her manner gives me, an odd feeling that it's *not* her name.

As it happens Kapelhoff's a name I know. It's what is known as a location name; it means church square. It's an uncommon name. The way she spells it is now little used. How do I know? Well, I recall it as the name that Doris Day was born with. Way back when, I was a fan. Her real name *is* Doris von Kapelhoff and it is really rare, or so I think the cognoscenti said. As she likes to say and I like to do I do as soon as she is gone: I check it out. Just for a change I swing with Bing. Bing goes bingo!—my recollection checks.

Why would she lie about her name? It leaves me with second thoughts about this work. I haven't given it a lot of worry up to now. In most respects it looks like easy street. But maybe it's too easy. As the saying goes, if it *seems* to be too good to be true.... My spidey sense is all atingle. It's warning that this may be Barney

Rubble. It fails the sniff test—nothing I can quite pin down. What to do? My best bet is: Take to the beach again before I find I'm in a jam. But on the other hand my motto's always been what I don't know can't hurt me so the easy way would be to let it slide. I've always had a soft spot for the easy way. And it's not just the money. Something about this work has got me on the hook. It's like self-study on the Net; if what I read were less confusing I'd be having fun. And so I do, I let it slide.

And I too slide—into a chasm that splits physics to its roots. On the surface it seems simple: quantum theory versus relativity. Even before I figure out what they are it is clear that their divergence isn't simple. It infiltrates the fabric, ideas, structure, mathematics, practice, teaching, organization, politics and financing of fundamental physics. In a vague way I already knew about it. But nothing has prepared me for the depth, the breadth, the mind-bending bewilderment I find.

The two compete for money, students and prestige. Relativity takes an early lead it loses soon after the race begins. It runs for a hundred years. It is still running. God knows how I'll get this mess across to him.

Meanwhile he haunts the office. His work ethic's pretty ordinary, seems to me. He pretends to read. He paces. Mostly though he chatters up a storm. He makes it hard to concentrate. He tells a dirty joke or two. I gather I'm supposed to fake that this is fine. Maybe I could even like him someplace else. Or not. But certainly not here. My desk is piled with books and sundry paper stuff already. It's stacked to keep his fat butt off my desk without quite cutting off my freeway view.

So I sit him on his chair and say he needs to know the rift. He needs to follow how it comes to be. Which means I need to understand it too. Which means lots of digging, lots of physics, lots of history from lots of websites. There's lots of info out there. But teasing out its meaning turns out to be tough.

It begins in the early 1900s. For the first time physics enters realms that are outside our experience. One is far too large; the other is too small. Relativity is about space and time. It's tied up with the speed of light, far faster than the fastest rocket. Quantum mechanics is about the way things work—or seem to—at scales smaller than an atom. Einstein plays creative roles in both. Indeed Einstein more than any other drives the rift in physics. It persists to this day. Most people think his thing is relativity. But his Nobel is for his role in starting quantum theory.

It's soon clear that these two theories are at odds. They are two solitudes. When MacLennan uses these two words as the title of his book he speaks of cultures—English and French. Rilke, speaking of relations between the sexes, calls them *zwei Einsamkeiten*. It's much the same idea; but *zweimalig* Rilke's better.

When next he sits I tell him that it seems a civil discourse on the surface, but he shouldn't be deceived. In a sense it is a battle to the bitter end. When the outcome is decided we may witness a reprise, a revolution no less sweeping than a century ago. Hoping he won't catch the catachresis, I say it will be an earthquake that will reshape physics. Once more, say the auguries and I, the world will change.

In his heyday Einstein comes up with two theories that define the field of relativity: special relativity in 1905; and general relativity a decade later. Both deal with how things move in space and time. Someday soon, I warn him, we will take a look at both. Meantime I'm doing lesson planning, surfing, sussing out who has

the story right, who tells it well, and generally getting bearings of my own. He may as well stay home, I say. To my surprise he doesn't go.

SR deals with things moving steadily. It is spelled out in equations; real physics is invariably written up as math. It shows how measurements of time and space depend on how the one who does the measuring moves relative to what he measures. Einstein ties his new equations to the speed of light; they work even when things move very fast. It's out of these equations about space and time and motion that he pulls the emm-cee-squared one. There's no way that Frank will understand this. Surely she can see he doesn't have a clue. She still has, or says she has, this foolish notion—though she doesn't say it's foolish—that he can pull a cosmogonic rabbit from my 'research' hat.

What he needs to know is *this* equation isn't only an equation. It's an insight into how the world is made. It says that mass and energy are two forms of the same thing. Like, I plan to tell him, ice and steam. Though they don't look the same they are both water by another name. So how can I get this across? 'Mass-energy' might keep the SR concept in his face. Whatever term I use I doubt he'll get it. *GR's* next and GR gets much worse.

Einstein's passion drives him to it. GR too's about how objects and observers move through space. With GR they move any which way. Finding its equations takes him years of work. He's pursuing an idea to its logical conclusion: Laws of nature can't depend upon the dipsy-doodles of observers. So, as Eisenstaedt explains, Einstein sets off with 'an inspired imagination [to] reach some unknown and improbable land.' Eight years later he arrives. His great revelation is that gravity is *not* a pull exerted at a distance between bodies like the Earth and Moon. He shows that a mass like Earth affects the curvature of space. A second mass—such as the Moon or, say, a showman shooting from a circus cannon—just goes with the curve; it takes the shortest path that it can find. So does the Sun. So does a galaxy. This path is called a geodesic. It may look curved depending on one's point of view. Headwinds and alternate landing strips aside, a flight from New York to Hong Kong will take the shortest path. It won't head west. It heads near-north to eastern Hudson Bay, the Arctic Ocean and Siberia. Its course makes a wide loop on almost any map. But seen from overhead this line looks straight. It's the line a piece of string makes on a globe when stretched from New York to Hong Kong.

Actually GR starts out being about motion but in the end it's about gravity. Not just the gravity all know and love—like astronauts soon sick if they're deprived. GR embraces gravity from faintest traces between galaxies to fiercest tempests in black holes. Newton treats gravity as action at a distance—a concept that he never likes. GR gets rid of his problem. It shows that gravity is *local*. This is a deep idea. What we like to think of as Earth's pull on, let's say, a four-seam fastball several feet above the ground is in fact the curve of space between the batter and the mound.

An equation is a way to ask a question. Solving the equation gives an answer. After Einstein comes up with GR's equations, he and others search for answerable questions. In the 1920s Friedmann finds an answer for a version of the universe. It ruins Einstein's day. It leads to rafts of problems. Though the best minds on the

planet try to fix them they don't go away. So Einstein's fingerprints and Friedmann's are on many of the clues.

He'll find Einstein's prints on quantum theory too. Quantum theory's a loose term. Its meaning has evolved. It begins a hundred years ago as the idea of energy that comes in tiny pieces known as quanta. Quanta do strange things. One might say *QT* calculates the ways small things are strange.

Actually, having started small, these days QT applies at least in principle to things of almost any size. Of course given all the talk of how the early universe was tiny even he can see the question: Can QT calculate the universe? Well, I plan to tell him, that's the question. Many toil as we speak to find the answer. But to ask the question they must first define that universe exactly. They can't. It's called GIGO: putting Garbage In, it says, gets Garbage Out.

Quantum mechanics is a term he'll need to know. It too is not precise. It means one or all of several different quantum theories. At first he may think it sounds mysterious. And it is. But I bet that he will soon detest it. These days QT usually means *QM*. Not that this will make it any simpler or less detested.

Unlike GR, QM's not concerned with curving space. It works with geometry kids learn in school. While it deals with things that are very small it also deals with bigger things. Big things are made of atoms. So QM deals with everything; though for big things its equations can get messy.

Reading further I discover QM doesn't really deal with things at all. It just gives the *odds* of finding this or that. Well, that's not quite right either. Turns out it's difficult to say anything quite right about it using words. For now I'll just tell him QM is a term for strange things happening with particles of light and atoms. He doesn't know it yet but soon he will eat QM three meals a day.

First I must break the news to him about *Complementarity*. It's an idea I am slowly getting used to. Some see it as the bedrock of quantum theory. Like many others, I see it as strange. Most science sets out what we know—or think we know. QM starts with what we *don't* know. Not as in we don't know yet; but as in we can't know ever. Why not? Well, that's just the way it is. I'm thinking this is not a friendly message for your average detective when, having gone for lunch, he walks in bearing Starbucks coffee. Two Guatemala blacks for him and me and a cup marked C for cappuccino. Does he expect her? I don't ask and he doesn't say. He just puts the cappuccino on her desk.

Maybe it's time to try him out. I tell him to take a look at something, any kind of thing that's moving. He looks out the window. It could use a wash. A steady stream of cars is heading north to the I-5. Okay, I say, pick one and watch it closely. I ask: At any given instant do you know precisely where it is? He nods in a skeptical, not-buying-this-shit kind of way. And, I ask him: Radar gun in hand, could you at that instant know its exact speed? Another nod. Actually, I tell him, QM says it can't be done. This earns me a look of pure disdain.

Okay, it is a lousy demonstration. But the concept that it *can't* be done is basic to QM. The more we know about where something is the less we know about how fast it's moving. With something big—a car—the wiggle room's so tiny no one gives a damn. But with something small—an atom—the wiggle room is big. If he could measure where an atom is exactly he'd know nothing about where it's going—or

if it moves at all. And he'd have no way to find out without letting go of what he knows of where it is. Science seems to be a search for certainty. But uncertainty is what QM is all about. And, I tell him, this is just a taste, a teaser, of its weird ways.

I'm careful not to say that they are right but GR and QM are both incredibly successful. Each in its own domain predicts things more precisely than experiments can check them out. Each says something too about what went on in the early universe but neither gives a credible description of how it all began. Between them they split physics into two broad streams no one can reconcile. For his benefit I label this the New Divide. It derails the nascent scientific revolution. Physics reels in disarray.

For some reason he's still punching keys on his computer. I try a dozen different searches, combing through the differences between the theories. They stem from different philosophic roots. Relativity is kin to a philosophy called scientific realism. It says reality exists even if it's not observed. Nineteenth-century philosopher George Berkeley asks, 'If there are trees, and no one to perceive them, do they exist?' Well, actually, he is said to say it but he didn't. Confronted with this question, a realist will answer simply: Yes. It's the philosophy that Einstein will embrace.

QM, on the other hand, seems to say that only probabilities are real. All else—if there *is* an else—depends on if and how we choose to observe. In this QM tends to *Positivism*. It's a philosophy that Comte composes in the 1800s. It springs to life three generations later in the Café Central in Vienna. It deeply influences physics.

The positivist says to Berkeley: If there's no observer then the question has no meaning. To me this sounds like a sloppy way of saying: No. Worse; it's like saying that no crime has been committed if no witness can attest the facts. But then I realize: Is this not in practice if not principle the law?

After founding quantum theory Einstein soon abandons it. He says that it does not describe the real world. To his friend Max Born he writes:

> Quantum mechanics is very impressive. But an inner voice tells me that it is not yet the real thing. The theory produces a good deal but hardly brings us closer to the secret of the Old One. I am at all events convinced that He does not play dice.

The quantum anti-realists reject Einstein's ideas as not just wrong but meaningless. The rift deepens. Its final plunge begins with money. Yet another Belgian, Ernest Solvay, funds physics meetings. Attendance is by invitation. In October 1927, the invitees include proponents of QM and critics. The topic is electrons and photons, QM in thin disguise. Proponents arrive well prepared, critics maybe less so. There is—as they would say in a press conference today—a vigorous discussion. When it's over the consensus is that Einstein lost the battle. And perhaps the war.

In 1935 Einstein and some colleagues try to launch a comeback. By now they don't need a hit; they need a homer. They assail the standard version of QM. It says: Until it's measured, the state of any quantum system is a mix of all the states it *might* be in. It's called *Superposition*.

Schrödinger's a physicist who preaches his own version of QM. In support of Einstein he dreams up a zany problem. He means it to lampoon the standard version. He creates a cat that is *both* dead and alive—until someone checks it. He sets out how to craft this quantum mess:

> A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference by the cat): in a Geiger counter there is a tiny bit of radioactive substance, so small, that perhaps in the course of the hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives if meanwhile no atom has decayed. The wave [or probability] function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts.

He calls it quite ridiculous. It seems like good fun. But the cat debate continues to this day. Hoping to avoid a dirty look, I sic Frank onto Wikipedia. Soon he's watching an alive-and-dead-cat video on YouTube.

That cat may make QM look ridiculous. But quantum mechanists aren't worried. QM's living high. It is the fashionable side of the Divide. I know he'll never get it. I don't get it either. Getting QM without math, I read, is swimming without water. Getting it with math one finds the math is all there is to get.

In this also, relativity is different. Einstein puts it in plain language. He writes a slim text which, he says, 'presumes a standard of education corresponding to' high school graduation. In other words it got a bum rap. Relativity is really not so hard.

But even this he doesn't need to get. A brief outline and key aspects—especially the politics—should be enough. Tomorrow, I imagine, is the day to pitch it. This is an optimistic thought that doesn't become action. I no sooner think it than she bursts into the room. Well, not bursts exactly but it's unexpected and she seems more in a hurry than she usually is.

Her cappuccino's cold. I zap it in the microwave as she explains she needs to be in Berlin. Potsdam actually. At the Einsteinturm, she says. When she says its name her accent is high German. For some reason I don't mention that I'm fairly fluent. Nor do I feel a need to tell her that I've seen the Einsteinturm. The outside of it, that is. It's next to the lab where, in the 1880s, Michelson and Morley found no variation in the speed of light. These days it's just a funky building with a fancy solar telescope. Strictly private. An appointment would require months of notice. Without one she won't even get inside. Does she know this?

I play travel agent for the balance of the day. She leaves me details of her passport, which is in, she says, her married name. So is the credit card. Whatever. I book it all except the Potsdam train, no reservation needed, and the Einsteinturm of which she says no more.

So I'm left with Frank to mind the store. Turns out for two days it is all mine. He's off to parts unknown. His training is in limbo. Trying to discount this latest letdown I digest documents, pore over books, draft up outlines till she returns.

Israel asked Einstein to be its president, she announces apropos of nothing as she walks in at eleven with her carry-on, looking like she flew from Sacramento, not Berlin. She is back too early. Does she catch my startled look? I'm staring at her suitcase—stupidly, because it has no baggage tag—as if it has an answer for my silent question: Why? I hide surprise by starting the caffeine machine. She rattles on: Citizen of five countries but *never* an Israeli. Overnight, physics is a Jewish conspiracy, she tells me, meaning long ago it seems. Check it out she tells me for the umpteenth time.

What is this about? From her, it's not just a lecture, it's a dissertation. Well, whatever. Not my problem. Me, I do googling and listing. I do hunt and peck. I do CliffsNotes. When moved I do eloquence. And I keep my hot head down. Or so I tell myself as I lug mugs back to my desk.

She took the early flight, she tells me. Is she watching my reaction? It's a momentary struggle to look bored, to turn back to the keyboard with no hint it *is* a struggle. I succeed, or so it seems. She looks through some stuff and soon enough she's gone.

The reason for the struggle is there is no early flight. There is no flight from Europe that will get you into LAX at any morning hour. She should know that. She should know too that I know. It is a stupid story. *If* she flew a sched from overseas this morning then she flew in from the west; she came from Asia. Or she caught a costly charter. I was sort of sure before but now I *know* she's up to something and she wants to keep it under wraps. I wonder what to do. And then I think, again, I do the CliffsNotes.

I turn back to relativity. I'm finding that SR is not about the universe. Not on the intergalactic scale. It deals with what happens in the 'hood. It's based on two ideas. One is that the laws of physics can't depend upon the speed of an observer. The other's that the speed of light's the same for all observers too.

My first thought when I read this is it's simple. Even he should get it. My next thought is this isn't fair to him. A further search turns up this from Eisenstaedt: 'Relativity deals with some tricky concepts that the ordinary physicist finds difficult to understand.' If the ordinary physicist has trouble with it he may be excused. And I'm no physicist; each day all day and half the night I bend my brain into a pretzel to absorb these strange ideas.

It helps when I go back to how we got here. For centuries physics is obsessed about two things. One is matter. Stuff that *is*. As in lead and gold. As in what *is* this stuff? And the other thing is stuff that *moves*. At first physics focuses on moving stuff even more than on what it is. By chance or by design this fits with practical reality. Turning lead into gold may make an alchemist rich. In his dreams. Moving stuff makes many rich in real life. The camel. The horse. The wheel. The ship. The steam engine. The eighteen wheeler. The 747. In back of my mind a ship's captain—he's a character of Simenon's—is saying, 'There's good money in carrying onions to England.' Wherever it may be, most stuff is worth more somewhere else. Trade is the lifeblood of civilizations. Moving stuff. Would it be cynical to think that physics follows fashion, that it goes where the money is?

Anyway, come 1680 Newton turns his mind to moving stuff. Not that he thinks of it that way, but he does think of it. He doesn't get it all exactly right. It doesn't

have to be exactly right. He gets it right enough that what he thinks gives moving stuff a boost. He lays a foundation for a scientific revolution and the first course of bricks for a science-based economy. Nothing, I think—thinking of a line to say to Frank—nothing is more practical than that.

When relativity arrives it changes almost nothing practical. The equations of SR matter if stuff moves very fast. For example, they apply to driving down the road. But they have no practical significance for drivers, as the rules we take for granted give them almost perfect answers. I tell Frank that they are so close he can't tell the difference. Which gives me a bright idea. I write up a couple of cop kind of reports.

> Incident Report No. 1
>
> We drive north, doing 70. It's a 60 zone. A vehicle approaches, going south. Our radar reflects back. The radar unit checks the frequency of the reflected signal. It shows its speed, relative to us, as 130 mph. A chip in the unit subtracts 70 to allow for our speed and shows its speed as 60. It uses Newton's math. The subtraction, 130 - 70 = 60, says no ticket. But Einstein says that Newton's math is wrong. It underestimates the speed by about 0.000000000001 mph. Of course that's far too small to matter; it's maybe half the thickness of a hair per year.

So who cares about the difference? Not the cops. Not Frank. Not even Einstein. On the other hand, at higher speeds the difference might matter.

> Incident Report No. 2
>
> We're in the police rocket. It's a routine run to Io at 70kmps. Relative, of course, to Earth. A hot rocket whizzes by the other way. As its pilot should know, the limit in the Solar-System's 60. The radar registers 130. Subtraction says 130 - 70 = 60. Looks like she's okay. But is she? The computer uses Einstein's math. It shows that subtraction underestimates the hotshot's speed by 25%. Her relative-to-Earth speed is just over 80 kmps! A light-speed call will issue her a ticket.

How can this be? Well, like I say it is the math of relativity. In other words, real speeds don't work the way that grade-school math might lead one to believe. And for speeds close to the speed of light the math may make a ticketable difference.

Here's something else for him to chew on. What if cop and hotshot were both doing 186,000 m.p.s.—the speed of light? Newton's math computes the radar reading as 372,000. Einstein's says this is impossible. The radar reads just 186,000 m.p.s. This is a limit of a different kind: No matter how the hotshot burns she can't exceed this speed.

Some physicists make particles like protons move as fast as they can push them. They find that they too can't push past this limit. This sort of thing leads

physicists to buy the SR package. Buy it? One might rather say they fall in love! But for the rest of us SR remains removed from real life.

Later when I show this to him he surprises me. He seems to catch on quickly. I watch him read it carefully, not once but twice. The cop-car caper seems to work for him. Of course there's much more to SR but I don't push too hard; the rest of it can wait. Now I need to introduce him to its better half.

GR also starts out simple. Think of this, I tell him. He's in a big sealed crate. How can he tell if it is here on Earth or in his spaceship that's accelerating at one gee in outer space? A peek outside might help him guess, but peeks and guesses aren't allowed. No matter what he has inside the crate, he can't find out which reality is real. Either way, his weight will be the same. Einstein thinks of this and takes a mental leap: Gravity's the same thing as acceleration! So he sets up a theory that treats them as the same. It starts out as a theory of how things move in space when one includes acceleration. But it becomes a theory of the shape (or, more precisely, the geometry) of space. That's right: He says space has a shape. *This* is the essence of the general theory.

It predicts some small but strange effects. They are soon found. For example it predicts that gravity bends light and by how much. In 1919 Eddington, secretary of the Royal Astronomical Society, narrowly escapes jail as a draft-dodger by travelling to Principe to watch stars near the sun in an eclipse. And lo, the stars appear to move. They move as far as GR says they should. The news is flashed across the world. For the first time in history a scientist is a celebrity. He soon finds he has lost control of his own message. The media take charge.

I've been thinking of her message off and on all day. What's her point? So they've been good at it. Lots of them. Jews, I mean. And physics. In the end I can't resist. I have to check it out. Knowing it's silly, I search israel+einstein+president+-jewish+conspiracy+physics. Whoa! Multi-thousand hits! One of them's billed as Cranks, crackpots, kooks and loons on the Net. Lots of sites confirm that he was asked. I look him up on Wikipedia. It says she's right, five countries, never Israel. Strange but true. But so? What's it to her? True to form I'm not about to ask; I just tuck it in my mental pocket.

Then there is another pocket thing. It darkens my horizon. It's clear to me Frank has no notion about how he should proceed. How *can* he? Einstein died in 1955. Fellow physicist Wolfgang Pauli in 1958. Schrödinger in 1961. Niels Bohr in 1962. Four architects of the 20th-century scientific revolution gone in seven years. The last of the greats of that great era, Born, died in 1970. It's not that no great physicists are left alive. It's not even that those who are seem stuck in the tracks of those who aren't. It's that his witnesses are dead.

When she stops by around five I say so. She says with a straight face, solemn even, that this is where he may need some help. Help? He needs hand-holding. Meanwhile she's bopping round the world. She brings back nothing useful. Or nothing that she tells me. Not a single expert contact who could help us on our way.

Next day when he comes in I tell him we will have to work from records. Which mostly means my Web stuff. Bowing to necessity he says he doesn't care. Witnesses, he says, are over-rated. What they say is often spin. He'd rather work

from records any day. We have a tacit, though not friendly, understanding of the way we'll work together. But 'work' is, for him I've found, a word in which one should not put great store.

After he has gone something still bugs me. Israel? Einstein? How does her outburst tie in with the Einsteinturm? If she went I bet that she did not get in but she says not a word about it. Is there some other place in Potsdam where she might have gone? Well, as she's always saying, check it out. In two hundred milliseconds good old Google finds a million hits (or so it says) for Potsdam+physics. Top of page one is a map for finding Max Planck Institute for Gravitational Physics. Aka the Albert-Einstein-Institut. At Golm, just a few klicks down the road the other way. Quantum Gravity and Unified Theories Division, I read. Black holes and stuff like that. A good place for her to visit. Totally legit. But if that's where she went, why not tell the truth?

They say one swallow does not make a summer. But three should make one think of spring.

BRIDGING DIVIDES

The whole world shall become as one book and the contradictions of science and theology shall be reconciled.

Fratras Rosa Crucis (1614)

A whole new field of reality was found, altogether beyond the appreciation of the Middle Ages during which supernatural revelation was the centre of all thought.

Werner Heisenberg (1934)

We are all agreed that your theory is crazy. The question that divides us is whether it is crazy enough to have a chance of being correct.

Niels Bohr (1958)

Einstein was simply ahead of his time. More than half a century later, his dream of a unified theory has become the Holy Grail of modern physics.

Brian Greene (1999)

Most mornings I'm here early and unlock the door, thinking the same thought: What are we doing? Each time I make to ask—when she shows up, that is—she waves me off. So today she starts her day by telling me America, the whole world really, could use a boost. That, she says—as if this should be obvious—is what we are about to do. The way she sees it, it is all already there. We just have to look it up. She means the Web. Maybe she's been listening to Frank. And she can't resist recycling her standard admonition: Check it out.

Yeah, right, ride the bullshit highway. And anyway her fancied field's been worked over by experts and picked over by millions. Her chances of pulling this thing off with Frank and me are nil, nix, nada. We'd need a *fictional* detective to have any chance at all. Whatever. She is paying. So I write.

But first I read. It soon comes to light that lots of thoughtful thinkers are now thinking about theories of gravity that might jibe with QM. In other words, they're hard at work to bridge the New Divide. String theory and quantum gravity are the main approaches. There are many papers about these two subjects—at least thousands, maybe millions—spanning more than fifty years. A goldmine of intellectual investment. Now there's a stylish turn of phrase. Frank, I think or maybe even say out loud, this is the record speaking. Listen up!

Is there some kind of echo in my head? I dismiss the thought. Only later do I think of it and wonder.

In the main the history of physics is a tale of bayous and backwaters. Seduced by visions of the sudden stream, the tide that will take them to (they think) a legendary land, physicists like mariners of old toil mainly near the waters they know

well, venturing within the margins of their maps. But once in many whiles one takes a longer leap. String theory may be one such.

Starting in the 1960s, string theory garnered physicists' attention. Actually, though, it's hard to say that this is so. There's a problem with the name string theory. What is loosely called string theory includes many different string theories. It's a problem. There are too darn many. How many? Nobody can say. Another problem is: Many physicists say none of them are theories and none will ever be. Why? Because none of them seems able to predict anything that can be disproved. But they are so beautiful that many physicists devote their careers to them.

So string theory is a mess. When I say so, he seems despondent. I can't imagine why. I'm like: Welcome to the Wild West of physics! In due course, I tell him, he will get a guided tour of its best sets. Till then I tell him all he needs to know about string theories in sixty words. They aim to reconcile GR and QM. How? They say particles that physics says are points with no size actually do have size when seen up close. They at least have length; they are like tiny bits of string. What they do is wiggle in a quantized kind of way. This means that only certain wiggles are allowed. Don't fret, I tell him, we will get to that.

Quantum gravity's a theory that we don't yet have. It's also a bunch of theories that we do have, some involving strings. The advantage of the one we *don't* have is that it will work. The advantage of the ones we *do* have is we have them. Physicists can fiddle with them hoping they may stumble on the *one*. What can I say? More of the Wild West? In a way it makes some sense but it's not easy to explain.

Once we have it *QG* will stitch GR and QM back seamlessly together. More important from our point of view, if there is any broad agreement across the New Divide it's that the ultimate theory must begin the way the universe begins. With no grasp of how the universe began, Physics wanders hand in hand with Mathematics chasing random rabbits, looking for tall trees, mindless of the ecosystem they inhabit. In principle the answer's simple: QG must be about the universe. All of it for all time.

There are many theories of the universe or of pieces of it. They could stock a cosmic zoo. Most are more or less dependent on a background. Background is a notion he will have to get his head around. I tell him it is like the cage for a zoo animal—the scene in which its life unfolds. Most people take the cage for granted but without it they would see no animal. The thing is: Someone had to build the cage before the animal arrived.

In physics, space and time or something like them are the background. So where did *they* come from? Many of his experts—physicists, that is—say that a theory must be background-independent—it must *explain* space and time rather than assume them—if it is to be a *Theory of Everything* like QG. So *he* will need to take a background-independent path to get to the Beginning. This will strain his brain. Masterly understatement. Many canny runs are taken at it, all in vain.

This is not the kind of problem that's a clue. It's a problem-problem. It might even be *the* problem. Hard to imagine but he may be in the bridging business, bridging what no one has bridged, the New Divide.

Of course this pep talk's nothing more than make-believe. It seems silly even as I think it. It's still silly when I write it down. But then I come across an

intimation—something less than a suggestion—that holds out a trace, the slightest hint of hope. Joan's cousin John Baez does physics. He's at home in heavy-duty math:

> Modern theoretical physics is difficult to understand for anyone outside the subject. Can philosophers really contribute to the project of reconciling general relativity and quantum field theory? Or is this a technical business best left to the experts? I would argue for the former. General relativity and quantum field theory are based on some profound insights about the nature of reality. These insights are crystallized in the form of mathematics, but there is a limit on how much progress we can make by just playing around with this mathematics. We need to go back to the insights behind general relativity and quantum field theory, learn to hold them together in our minds, and dare to imagine a world more strange, more beautiful, but ultimately more *reasonable* than our current theories of it. For this daunting task, philosophical reflection is bound to be of help.

True, it is a far stretch from reflection to detection. And maybe this would all be better if I'd asked her for a philosophical detective. A few sleuths in fiction have that kind of mind.

And the Old Divide? She's made it clear she doesn't want us to go near it. But if we are anywhere then near it is exactly where we are.

Tonight I go home early. Paycheck in my pocket I eat out for a treat. A classy restaurant on Wilshire. Confit, I am told, is any food cooked slow. I think but don't say to the waiter that slowly would be better grammar. I didn't know. What confit is, that is. I return to barracks sated. Then head down to the shoreline for a toke or two, trying not to think of what the coming day may bring.

RELATIVELY SPEAKING

There are no landmarks in space; one portion of space is like every other portion, so that we cannot tell where we are.

James Maxwell (1878)

Does Oxford stop at this train?

Albert Einstein (apocryphal)

To find another work … with the same range of scientific, philosophical and general intellectual implications [as relativity], one would have to go back to Newton's PRINCIPIA.

Gerald Holton (1960)

Any deviation from special relativity could point physicists toward an elusive goal, a quantum theory of gravity.

Adrian Cho (2005)

[Special relativity] was the beginning of a fundamental shift of philosophy in science, from asking questions of what *is* to asking what *can be known*.

Robert Oerter (2006)

I've been dreading this day. The big-three theories loom large. They are impossible to duck. But I'm sweating them myself. Even going easy there's no chance that he can handle them, no way that I can swot him up. Sometimes his driveway doesn't reach the road. I can see him walking out in sheer frustration. The end. I can't do that. It's not about the money. It's just I've come to like this job. To write? Too right! I get paid to play with words. It grows on you as the trite saying goes. And, yes, this writing thing is growing on me.

I'm late, the which I never am. I even walk up the back stairs to postpone the day's pain. He too must be flinching. He is even later.

When he gets here he is like: Let's get it done.

But as he pulls his chair up to my screen—a welcome innovation in itself—suddenly it all shifts in my head.

My inspiration of the day is that he doesn't need the physics; he needs *history*. He's not going to do physics so he doesn't need to know it. The scientific literature, the institutes, the books, the Internet, the *arXiv* site—they're full of physics. She doesn't need him to do that. Anyway, it's his needs that I should attend, not hers. He'll need a grasp of where the ideas come from and what role they play. If he was *fictional*, as he would be in a perfect world, he'd be haunting metaphysics' metaphoric neighborhood, strolling in its streets, browsing in its stores, imbibing in its inns. Not living in them; certainly not *working* on them. The whole idea is that he is an outsider. If, that is, there is a whole idea. Anyway, it seems my trauma has been all for naught.

So here I am. I scrap my script. Of course I didn't really have one. I take another tack, ad lib. What's in my mind is that he's barely on the job, reading up on what she likes to call the background, and relativity is popping up all over. He's been a gumshoe all his working life. He likely never knew what relativity's about though I assume he must have heard of it before he took this job. But where is it *from*? What *is* it? What does it *do*? What is *wrong* with it? Maybe he could handle some of that.

What he needs to know first is, as Einstein himself explains, it's not as difficult as advertised. The math of SR is no challenge to a college grad. But its ideas are deep.

Relativity is not Einstein's idea. In the early 1900s when he starts his work on it, it has been round for several hundred years. It's what he does with it that takes the world by storm. In fact, Poincaré has similar ideas but Einstein takes them further.

How does he do it? Well, he does a *Gedankenexperiment*. It translates as 'thought-experiment'. The great advantage of a *Gedankenexperiment* is one doesn't have to *do* it. Rather, one *imagines* it and figures how it has to go. So what does *he* imagine? It's this simple: Two things moving. Any two that don't accelerate and don't rotate. Einstein calls it 'inertial' motion. He calls the things 'bodies' or 'frames' but they are just things. In his mind's eye he has each one carry an observer. The observers watch what happens. It sounds boring but he uses this to see how things must move in space and time.

I've been rereading Reichenbach, another great Berliner, not a jelly donut. Einstein's bulldog, someone called him, I remember from college days. There is no way to get a grip on space. The first concept of relativity is that to measure something about one thing—where it is or how it's moving—it must be measured *relative* to something else. A position or a speed in space itself is meaningless. Hence 'relativity'.

Boring, but this stuff, I say to him, is basic. If something is, where is it? If it moves, how far? How fast? It's called kinematics. Eisenstaedt says of it: 'It is clearly the first of the physical sciences because the whole of physics makes use of it; it is the science of the foundations of physics.'

Just as I get into stride he stages a diversion. What's so special about special relativity? he says in an antagonistic tone.

Well, at least he's asking something, and the answer's easy. Special's just a bad translation that won't go away. Einstein's term in German, '*spezielle*', would translate better as 'specific'. It's *spezielle* because it's not *allgemeine*—or all-encompassing, aka general—the *other* kind. It's specific because it deals with a specific circumstance. The circumstance is: It deals with things that move steadily. No rotation, no acceleration. End of lesson one.

That, he says, was almost painless. He sounds surprised. So I get going while the going's good.

When she walks into the office there's Frank looking at my screen and talking relativity. Does she see this as the miracle it is?

SR as it is called among the cognoscenti is said to rest on two assumptions. Einstein bases *them* on his experience. Frank says he can live with that.

The first assumption is the laws of physics are the same for all observers, which is a fancy way to say that steady motion doesn't change the rules. It looks like

a good bet: No one has ever seen them change. Einstein gives it a confusing label that—translated—turns into 'the principle of relativity (in the restricted sense)'. Leave off the label and the principle is simple.

The second thing he assumes is: The speed of light's the same regardless of the source's or observer's motion. No matter where light comes from or who measures it, its speed must be the same. This is why it can be simply called the speed of light. *This* is the surprise! Einstein bases this one on experience too; it isn't new. But he takes it seriously. He says it's not just what's observed; it is a fundamental law. Of this law he says a decade later, or a translator later says it for him, 'Who would imagine that this simple law has plunged the conscientiously thoughtful physicist into the greatest intellectual difficulties?'

In 1905 Einstein launches SR in a paper titled: On the electrodynamics of moving bodies. Actually, it's in German so its title is *Zur Elektrodynamik bewegter Körper*. It is simple. It is also nothing short of revolutionary. It plunges physics into intellectual difficulties from which it will not fully emerge in a hundred years. Nearly a half-century later Polish physicist Leopold Infeld, himself a notable contributor to the theory, writes of it:

> The title sounds modest, yet as we read it we notice almost immediately that it is different from other papers. There are no references; no authorities are quoted, and the few footnotes are of an explanatory character. The style is simple, and a great part of this article can be followed without advanced technical knowledge. But its full understanding requires a maturity of mind and taste that is more rare and precious than pedantic knowledge, for Einstein's paper deals with the most basic problems; it analyzes the meaning of concepts that might seem too simple to be scrutinized.

So of course he won't understand relativity, not even in the restricted sense. But he does need to understand the *Frame of Reference*. It is relativity's key concept. I think of it as a platform from which an observer can observe the world. The key assertion of relativity is that there *is* no *Special Frame*. That is, there is no Frame of Reference that can be claimed to be at rest in some special way. There is, therefore, no frame that *should* be used for measurement of motion. This notion's known but rarely noted before 1900. More often cited is the notion of an aether that pervades the universe. It is thought to be the medium through which light moves. The thing is, if this medium exists, it *is* a Special Frame. After 1900 aether fails. Einstein leads the relativity revival.

He shows his assumptions lead to curious conclusions. For example, the length of any object depends upon the Frame of Reference of the observer. So does the rate of ticking of a clock. Hop on a bus and see clocks beside the road slow down and nearby racetracks become shorter. If it is an express bus. He shows too that we have no way to say events at different places are or are not simultaneous. Observers moving differently will disagree about their timing. They may disagree about which one was first. Experiments confirm all his conclusions. This is taken as support for his assumptions. But the *interpretation* of his theory—what it means—is still disputed to this day.

As a mere afterthought he shows that mass *is* energy—they're two forms of a single thing. This is the famous formula. The only one that everybody knows. It says $E = mc^2$ though that's not the way that Einstein puts it. This means that an observer (one who doesn't take the ride) sees an accelerating object's mass increase. Why? Well, because it is taking on kinetic energy. If one could get anything, no matter how small—say a single atom—up to the speed of light its mass would be infinite. And so could not go any faster: An infinite mass is an immovable object.

This phenomenon is routinely seen in particle accelerators—ponderous machines that propel particles to near the speed of light. A few that are as big as little cities propel protons fast enough to make their masses increase by a factor of a million. The high mass makes it hard to push them up to even higher speeds. This is the practical side of the cosmic speed limit—the idea that trying to go faster is just futile.

It also explains why smashing particles together near the speed of light can make hot, dense matter like that of the Big Bang. A noted physicist is reported as saying that a new high-energy benchmark set by the *LHC* 'is a huge step toward unraveling Genesis Chapter 1, Verse 1, what happened in the beginning.' What is not reported? Well, stepping toward chapter one doesn't mean that they can make it back to *verse* one. SR gives the reason why they can't.

SR phenomena seem strange because they are not seen in daily life. The reason they aren't seen isn't they aren't there; they are. But they're extremely tiny at the speeds a person can experience. He's seen this with my Incident Report. This time I tell him that to set an airspeed record the *SR-71* burns about ten tons of fuel. At top speed SR says the *SR-71* (no relative; aka the Blackbird) gains mass due to its motion. The increase is less than an extra grain of sand stuck to its pilot's boot. Of course this makes no noticeable difference to the flight. The flight crew plans for loss of fuel-mass and ignores the increase in mass-energy. However, increase in mass-energy gets large as speeds approach the speed of light. The flight crew for a particle accelerator *must* plan for this increase or their particle will crash.

For a few years SR rules the Spacetime roost. But soon its space and its time too turn out to be at best approximate. Ten years after SR hits the spotlights GR puts it in the shade. How do I tell him this? And it gets worse: The assumptions that SR is based on seem to be disintegrating. Craig and Smith sum up its problems: 'Unfortunately for Einstein's Special Theory, however, its … assumptions are now seen to be questionable, unjustified, false, perhaps even illogical.'

Maybe he doesn't need to know this. Not yet. What he does need is to feel dissatisfaction in the air, a longing to tear down the temple and to build anew. He needs to know new building is in order or *in Ordnung* as the master himself might have said.

In any case he's noted—or he should have, since I told him twice already with a *mea culpa* for the double negative—that SR does *not* show that absolute time and space do not exist. Einstein says he doesn't *need* them. He says he doesn't like them. He doesn't say that they're not real. Kennedy says, 'Einstein's *theory*, on the other hand, does not mention reality; it merely describes relations between measurements, that is, between appearances.' So SR is not *about* reality. It says how things *appear* to be when an observer measures them. Why should I mention this

to Frank? Well, for at least two reasons. One is he'll find that relativity's archrival, quantum theory, comes under heavy fire for being about measurement and saying nothing of reality. The other and more pressing reason is that he won't be making measurements. His efforts *must* be grounded in reality.

One more thing he'll need to note: Ten years after SR demolishes the Special Frame, general relativity makes such a splash few notice that it brings a whole new Special Frame in the back door. The few who do include another famous physicist: Lorentz. But I don't tell him this. Not yet. It wouldn't do to disillusion him too soon.

GENERALLY SPEAKING

Compared with this problem, the original theory of relativity is child's play.

Albert Einstein (1912)

The elevator was the self-operating kind that opens both doors automatically when it stops.

Raymond Chandler (1937)

We were in the position of a librarian whose books were still being arranged according to a subject scheme drawn up a hundred years ago, trying to find the right place for books on Hollywood, the Air Force and detective novels.

Arthur Eddington (1940)

Special Relativity gave us space-time. General Relativity in effect gives us matter-space-time…. It is the matter that bends, or distorts, the fabric of space-time.

John Gribbin (1986)

Physics is once more facing *conceptual* problems: What is matter? What is causality? What is the role of the observer in physics? What is time? What is the meaning of 'being somewhere'? What is the meaning of 'now'? What is the meaning of 'moving'? Is motion to be defined with respect to objects or with respect to space?

Carlo Rovelli (2001)

Maybe at first I thought of this as just a job. Now, though she pays me for the usual 8/5, I find I'm doing more like 18/7. The first train's before five. The last at one. It's not often I'm on both but it does happen. I'm always like this, always driven. Now this mission has my mind in overdrive. It makes it hard to sleep. Some nights I just walk along the beach and play mind games with words. Or, recently, with relativity.

I worry that I can't decide what she's about, why she needs Frank. I'm not doing much; he's doing zilch. Is he some kind of front? For what? It makes no sense.

Another trip. She has me book her ticket and print out her boarding pass. It must match her passport; maybe Birgit *is* her name. A last-minute, first-class, no-discount ticket has her heading off to Paris. So today I'm left to mind the store again. Or to keep on surfing. Surf, it never stops. Not on Kawailoa beach; nor on the Net.

My musing is cut short when he walks in, unkempt as usual. Why do I do the coat and tie? Today's agenda's heavy duty. General relativity's the second of the Big

Three theories. Einstein starts out with something like our usual concepts of space and time. He bends them. Space and time, I mean. It's scary stuff.

And she was right although I don't like to admit it. I am finding lots of stuff. Of course it's subject to the usual Web warning: It ain't necessarily so. So says Gershwin; he is hip and he has got it. Some of it is wrong, some is misleading. It needs a careful eye on what's authoritative and what's not. Even when it *is* it may be wrong. But that's less of a problem than it might be since we won't depend upon it either way. We can't. Nobody knows the way to go. I don't need a down with Echobelly so I soar with Mary Carpenter: On with the song.

I suppose it is his job to ask dumb questions, like what's general in general relativity? But I told him this already: GR is general because it's not specific. It covers frames of reference of every kind. So, unlike SR, it includes accelerating or rotating frames. But its name's not helpful. It's not really about relativity; it's more about gravity. And, I tell him, it's also about the fact that you can't tell the difference between acceleration and gravity. Anyone who's used an elevator knows acceleration feels like gravity. Even as a youth Einstein's pragmatic. He heeds facts like that.

In 1853, Elisha Otis doesn't invent the elevator. Someone did that already. He invents a brake to stop an elevator falling when its cable snaps. This gets more people into elevators. It makes him lots of money. So I figure Einstein *could* have thought of GR in an elevator. There were elevators in his city in his time.

Checking, it's not clear that he was ever in one. But I figure elevators got him thinking. His thought experiment uses 'a spacious chest resembling a room with an observer inside [to which] is fixed externally a hook with rope attached.' It sounds like an elevator. With a difference: Einstein puts his chest where there's no gravity—which Otis wouldn't want. He says a person in the chest can't distinguish between weight (when the chest is tugged by gravity) and inertia (when the chest is tugged by rope). His big leap is this: If you can't *tell* the difference, there *is* no difference. This comes to be called 'equivalence'. It is a big deal; before his big leap, weight and inertia are seen as two different things.

The person in the chest leads to a theory of gravity. It describes how matter, space and time behave, everywhere and (almost) everywhen. Heady stuff! Soon its predictions are confirmed. The *New York Times* says that it is 'perhaps the greatest of achievements in the history of human thought.' What the *Times* does not say is that few know what to do with it.

GR's equations show how matter causes curves in space and time. It shows how these curves make matter move. They answer a question that always troubled Newton. *His* equations calculate the force of gravity between two masses—let's say Earth and the Moon—at any given distance. They work well. Newton wonders why. How could the Moon know that there *is* a planet, let alone that it's 250,000 miles away? Einstein says the Moon knows nothing. Newton would be pleased.

Flatfoot Frank has never had a problem knowing there's a planet pushing on his shoes. But he seems to like the story of the Moon. GR says Earth's mass makes curves in space. The Moon goes with the curves it finds. They keep it, like a roller-coaster on its rails, in orbit around Earth.

It takes days of heavy-duty thought to bend my brain around the concept of the curvature of space. So he may take a while. It takes Einstein some time too.

Then it takes him years to do the math. Why? Well, for two reasons. One, he is not by trade a mathematician so he has to work at it. Two, the math is hard. Frank can't hope to understand it. Nor can I. But maybe he can see the reason *why* it was so hard.

Before 1915 math for things that move in space is well established. It has ancient roots in India and Persia. Newton and Leibniz independently create its modern form. It's called calculus, a word that sets an audience a-shrieking for the exits. But it's an easy idea. As one might expect from India, it's about elephants. Everybody knows the one that goes:

> Q. How do you eat an elephant?
> A. One bite at a time.

In calculus you take small bites you *can* solve from a problem that you *can't* solve. The key is to cut down the bite size to no size at all. Then add them up. That solves the problem.

Einstein doesn't have a problem with the calculus itself. He has a problem with its space. Newton's calculus is based on plain vanilla space that everybody takes for granted. Frank's eyes are already rolling. Think of it this way, I tell him: On a sheet of paper draw a diagram of a 2-D calculus problem. Like find the area under a curve. The kind of problem kids bring home to put their parents in their place, as Mead would say. It's simple. Well, sort of simple, because the paper's flat. But that's why this won't work for GR.

As I already told him, GR is about how gravity controls the shape of space. In GR there *are* no flat sheets of paper. And its problems are not 2-D like a sheet of paper. They're 4-D like . . . well, like Spacetime. It's like trying to draw a picture in soft chewing gum that's scrunched in someone's pocket. To make matters worse they're on the move; its shape is changing while he tries to draw. And as it's a 4-D problem, it's not just the shape of space that changes; time's shape changes too. Just to think about it is enough to bend my brain.

This is where Einstein gets lucky. Gregorio Ricci-Curbestrato is an Italian mathematician. In the 1890s he develops math that Einstein needs to work this cranky kind of problem. He and a student write a book about it with the catchy title *Méthodes de calcul différentiel absolu et leurs applications.* He has a pen name: Ricci. Rhymes with peachy. For some reason his full name is fast forgot. Then *he* gets lucky: After 1915 GR starts to sell the book for him. But its math is not easy for Einstein. A friend, Marcel Grossmann, helps with his homework.

What good's all this to Frank? Well, first thing he needs to understand about GR is that he doesn't need to understand it. It's no good to him anyway. It can't say how the universe began. If it could it would have done so long ago. But he does need to understand some things *about* it. Why? Well, because almost every physical cosmologist since Friedmann uses GR to investigate the early universe. Belgian physicist Georges Lemaître does. Einstein does. Lots of others do and there's no sign they will be stopping soon. So he needs to know *why* GR can't say how the universe began. In other words he needs to know: What's wrong with it?

The first thing that's wrong is that GR assumes that space and time exist. Well, strictly, just some aspects of them. I can already see that this will be a problem. Frank can't assume things. His Beginning must explain them. He can't do that with a theory that assumes them.

Second, like SR, GR assumes an object has a position relative to other objects and this position changes smoothly over time. The technical term is 'continuously.' It means with no discontinuities or jerks. Why does Einstein assume this? Well, that's what tensor calculus is all about. In this he doesn't have a choice. No one has the math for jerks. Not then; not now. But my reading says the early universe may jerk.

The third thing is it seems the early universe was tiny. GR doesn't work with very small.

However, when it comes to cosmology—and we soon will—GR puts SR in the shade. SR deals with Frames of Reference. In a Frame of Reference space is fixed. But in GR it's not. Billions of cosmic masses—planets, stars, black holes, galaxies—bend it out of shape.

A dramatic confluence of circumstances rockets GR onto the world stage. It's not exactly tuned up for ten-second clips, yet overnight it launches Einstein into unanticipated orbit. He isn't only the most famous scientist; he's the *only* famous scientist. As the world emerges from amaze, GR soon seems of little use. Then Penrose and Hawking find a perfect problem: black holes. GR is exactly what they need. It and its underlying math evolve. But to this day it cannot answer: What *is* a gravitational field?

Now Frank and I step back to 1917. Einstein's eye turns to the universe. Singlehandedly—as usual—he creates cosmology.

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.

QUANTALLY SPEAKING

Quantum mechanics, that mysterious, confusing discipline,
which none of us really understands but which we know
how to use … is not a theory, but rather a framework
within which we believe any correct theory must fit.

Murray Gell-Mann (1981)

The quantum theoretic description of physical reality is exquisitely
strange and profoundly mysterious.

David Mermin (1990)

Quantum theory is rife with conceptual problems
and contradictions.

Jim Baggott (1992)

It is often stated that of all the theories proposed in this
century, the silliest is quantum theory. Some say that the only thing
that quantum theory has going for it, in fact,
is that it is unquestionably correct.

Michio Kaku (1994)

There is, in principle, no knowable mechanism
behind quantum mechanics.

Spencer Scoular (2007)

It was Max Planck who solved the blackbody problem, at a cost.
The price was the quantum.

Manjit Kumar (2008)

Today he carries in a coffee from the Bean on Lankershim, gesturing he's sorry for preferring it to mine. Is this why he sits sedately as I tell him that today we cross a line? In physics the term 'classical' is flung around promiscuously. In relativity it signals absence of all quantum theory. Walking through the quantum door we cross the New Divide. He may feel we leave behind the classical. Truth is, he'll find, it tags along, as Cyco Miko sings.

What I don't tell him is that I don't know enough. Not about the physics, not about the history, not even the philosophy. Not about her. Everywhere I'm skating on thin ice. The only way I know to stay ahead of thin-ice trouble is to skate like stink.

So next I tell him relativity affects the stage where physicists play physics. QM changes physics.

Then I say that *speaking* about quantum theory runs a risk. Some physicists express strong views on the futility of speaking—using words—about QM. They

believe its math is the reality and words are fluff. Who knows? They may be right. No doubt they are right about *my* speaking. But then again the idea is not for me to teach him or for him to learn QM. It's for me to sketch and him to suss the 'hood. So I give him a heads-up: No math maybe means no substance.

Just the words 'quantum mechanics' likely made him want to skip it, fearing that he will not understand it. And he's right: He won't. But no one understands it. Absolutely no one. How can this be so? Well, everybody says QM is weird. A physicist with QM is a savage with an iPad, I go on. QM says little bits of matter should do things that seem supremely silly. No one knows why it would work at all. But it is stunningly successful. It drives all those gadgets people carry round.

Einstein famously rejects it. He worries that its physics has lost contact with reality. And too, it's rife with contradictions. No surprise that no one understands it. Fortunately Frank won't need to understand it; he'll just need to know it has two heads.

The first head is the theory. But then, as Gell-Mann says, it is not really a theory. He calls it a framework but from where I sit it is a mess of math. Its formulas say how a quantum system should behave. An atom, for example. It predicts everything an atom does. Or, more precisely, it gives odds for every thing that it could do. Its calculations may be messy; its results are rarely in dispute. In all kinds of situations they're right on.

The second is interpretation: What does it *mean*? Well, that's entirely up for grabs. Maybe it means nothing. It's a heated controversy. Memo to Frank, I say: You may need to know about this. Why? Well, QM says strange things about things that are small. The Beginning that he's seeking may be small. That's not to say QM can find it for him. There are reasons to anticipate it can't. But, in the world of small, QM is what he's got.

He tells me that tomorrow he'll bone up on what it means. This, it seems he thinks, should do the job. A bit pissed, I mutter 'roos are loose in his top paddock. He doesn't know what this means either.

To make matters worse, QM has more meanings than there are physicists—it's like that one about: Two Israelis make three parties. I flash him my list of its interpretations:

Consciousness causes collapse
Consistent histories
Copenhagen
Decoherence
Hidden variables
Incomplete measurements
The instrumentalist interpretation
Many minds
Many worlds
Modal interpretations
Objective collapse
The participatory anthropomorphic principle
Quantum logical

The wave function is real
The realistic statistical interpretation
Relational QM
The stochastic interpretation
The transactional interpretation

He doesn't need to read it. A glance should show QM has physics all at sea. I tell him he should check it out; he needs to get his own sense of this mess. What I don't tell him is each item on my list reflects a slew of views.

By far the best-accepted is the *Copenhagen Interpretation*. It's named for the city. That is where, in 1924, it all begins. Heisenberg is there. He's on a scholarship. He works with Niels Bohr. Bohr has a Nobel prize. It's for his work on QM and atomic structure. Werner soaks it up. He returns to Germany. He co-authors QM math with Born and Jordan in Göttingen. Next year he's back with Bohr in Copenhagen. The four cook up a consensus about what QM means. Or so it is now said. Actually, I tell him, no two of them saw it the same way. Through a tangle of upheavals—in ideas, politics, impending war—this non-consensus shapes terrain that he may need to reconnoiter.

Heisenberg's new QM math depends upon a concept. He calls it the *Uncertainty Principle*. Well, actually, in German it's a clunky über-German compound word: *Ungenauigkeit*. As in any language, German words have shades of meanings. My *Hochdeutsch* tells me that *genau* should translate in this context as 'precise,' not 'certain.' So his word for his concept, *Un·genau·igkeit*, means un·precise·ness, or would if this was a word. Haas calls it inexactitude. My two-bits' worth would be imprecision. The Imprecision Principle doesn't sound as sexy, but it might be more descriptive. The idea is, the more precisely one can measure one thing, the less precisely one can know some other. Whatever; *Ungenauigkeit* becomes uncertainty. Such twists in translation conceal nuances in writings on QM. And they have nuances. He needs to know they're there. His task is tough enough; he needs to get the message.

The message includes Heisenberg's new principle. It is basic to the QM picture of the quantum world. He's listening, intent. Last time it didn't work but I decide to push my luck. I say let's take a closer look. It works like this: QM says attributes of, let's say, a particle are linked in pairs. One pair is its speed and its position. QM says measuring one attribute, say speed, limits how much can be known about the other, in this case position. This can be expressed in numbers. Multiply the two 'uncertainties' together; the answer's always larger than a certain number, the *Planck constant*. So when one pins down one paired attribute there's not a lot to know about the other.

This Planck constant is a tiny number. It's called ħ (aitch-bar). Physics sees it as important. I explain it to him this way: If ħ could be tweaked a little—say 20% up or down—our universe would vanish, everything from atoms up to supergalaxies all gone.

Suddenly it strikes me *my* Frank would see ħ in another way. He wouldn't see it as a little number. He'd see it as a giant clue. He'd ask me questions that I couldn't answer. Like: How did it begin? Who chose the number? And: Why measure speed? Why pick position?

What would he be getting at? Could they be *wrong* things to measure? Maybe, he thinks—or I think for him, trying hard to think the way that I think he would likely think—it is like a code. Does he, as I do, see us setting out to crack it? Does he see us searching for the message, checking for a pattern in a cipher on a page?

I'm sure he would share my worry. He'd picture Holmes, smudged with chalk dust, looking for a pattern in the crooked men. What if they were coded with a one-time pad? There would *be* no pattern. I read papers saying speed is an illusion and position isn't real. Are we seeking to make sense of things that have no sense to make?

Another image: Einstein this time, sitting in the patent office setting out to measure space and time. He measures them with rods and clocks. If he could, my Frank would second-guess him. What else could he use? Maybe he wouldn't make a lot of sense. But one thing I'm sure of: *He'd* be on the case. A wave of keenness washes through me until I look at the Frank we've got; it dissipates and I think: Not.

The consensus crew turns to a simple question: What does it *mean*? Not because they give a damn. They say this isn't even physics. But they fear it is a PR problem that could undermine their physics, about which they *do* care. So they ponder and they argue and they hammer out a compromise. Born comes up with a name: *Quantenmechanik*. They get their ducks in a row behind it. Well, more or less, I say to Frank. But that can wait.

The compromise comes to be called the Copenhagen Interpretation. It is itself the subject of interpretations. It's sobering that many of them claim they're based on Bohr. Bohr's words are almost biblical. He writes a lot and what he writes may be important. I skim over it, then skip it. Why? I can't explain to my student. Fact is *I* can't understand it.

I find a version that I like. It comes from Mermin. He says: 'Shut up and calculate.' I hand it to Frank on a scrap of paper and suggest that he could check it out. A hopeful sign: He goes to Google.

So now I have to feed him Copenhagen. Just a little; it's not easy. Learned writers see it different ways. Heisenberg's way is the first one. It goes like this: A *Wave Function* describes a system (an electron, say, an atom, or a cat); this description is complete. That is, says Werner, it says all about the system that there is to know. It gives the odds that it will do the things that it can do. It's not that for some reason we can't find out more than that. There *is*, he says, no more to find out. As a worldview this seems consummately German.

My own worldview doesn't matter. But I don't buy this one, not even Mermin's version. QM is strangely, exquisitely mysterious. There must be more.

But Copenhagen says there's not. Heisenberg and Bohr are its movers and shakers. This phrase is O'Shaughnessy; I mean it his way—kindly. After the mid-1920s, QM gains acceptance as physicists discover how it works. Bohr says it works *because* its math ignores all world views, *because* it says there's nothing real behind the math.

Certain aspects all seem to accept. For example, QM assumes that space and time exist. Everyone agrees with that. Not that it *should* assume this, mind you, but that it does. Another thing most agree on is: The Wave Function isn't real. It's a mathematical idea, nothing more. Bohr goes further; he says there can never be a

theory in which any such thing *is* real. But there are nonconformists, David Bohm among them, who build theories in which something like it really does exist. Some say it runs the universe. Whatever *it* is.

But there is no broad consensus. For example, many say a particle is never *at* a place in space. It is spread like lumpy peanut butter on a universe-sized sandwich. Seems like it could be anywhere; no one knows until they look. In fact, it *isn't* anywhere until somebody finds it. This gives new meaning to her favorite expression: Check it out.

Then there is what happens when a particle is moving. SR and GR assume it has a path through space. This path is real. It is continuous. By contrast QM says a particle takes no path whatsoever. It is described by its Wave Function, which changes over time. This includes everything that *could* happen to it. Copenhagen says that nothing ever actually happens to it. If you want to know something, says Copenhagen, you must measure it. Strangely, it says you *must* use ordinary, non-quantum instruments. When you do, the Wave Function collapses and you find the particle. You discover its position and condition. They show up with a kind of jerk. As Cushing puts it, 'Central to Bohr's vision was his "quantum postulate"—the discontinuous transition of an atomic system from one stationary state to another during an interaction.' Discontinuous? To Einstein this is way beyond the pale. He's not buying the idea of a world that works in jerks.

Cruising pages, I soon find that ψ, the Greek letter psi, stands for the Wave Function. I find too that one multiplies its size by itself to get the odds of this or that. End of story: QM has nothing more to say. In especial it says nothing about *how* what happens happens. In fact Bohr and his buddies say 'How did that happen?' is a question physics doesn't ask. In other words, they say causality, aka cause and effect, has no place in physics. And I naively think that this relationship's what physics is about!

She walks in with her usual chit-chat after he has left. Then suddenly *she* wants to know what Copenhagen's all about. And what I think of it. Don't ask me why. I mean, isn't it all politics? Who cares about the technical details? Well, it turns out that she does, or that she says she does. I tell her it may take a day or two. Truth is I could tell her now but I don't need a new distraction. I've got him *doing* something for a change. He's interested. I'm on a roll or else he's putting on an act. I want him to get a feel for QM. One way would be for him to see that it's part of his life. So I dig deeper for tomorrow's lesson planning. I ask the Web: What does QM do?

It turns out there are many answers. QM shows what small things like atoms and electrons can do. But then these small things make up large things. For example, QM says: Add odd atoms to a single crystal; slice it up; add more layers; soon you have Intel Inside. There's no need to know *how* atoms do it. Knowing *what* they do is good enough. Anybody asks for more, the answer is: Shut up!

But my head won't stop asking. I can't do the math; not even close. But I can wonder why QM predicts weird things that make no sense. And with new techniques—often from QM itself—science sees these weird things happen just as QM says. Some are now ordinary, like:

Interference—particles behave like waves
Superconductivity—electric current flows forever; battery is not required
Switches—crystals control currents
Giant magneto-resistance—tiny heads track vast amounts of data
Superfluids—liquids flow with zero friction, even uphill
Lasers—solids, liquids, gases emit pure, straight beams of light

Others are more recent, like:

Teleporting—it's for real
Concealment cloaks—not Harry Potter
Quantum chemistry—makes grassoline from grass

QM is an economic engine. A host of things we take for granted depend on it—from MRI for diagnosis to the magnets of the LHC; from fridge magnets to cellphones; from electron microscopes that see cells to sensors that see mineral deposits. These are, I plan to tell him, things that QM does that are unthinkable according to the physics that was said to be complete before it came along. And it can predict things to one part in a billion. It's hard to argue with this sort of success.

All this leaves me with a quantum worry. Mermin sums it up: 'The mathematical language … refuses to talk about what actually happens, beyond giving you the odds for the various possibilities.'

Overall it's been a good day. But I don't want to kid myself. With him QM's truly good for one thing only. In the end it's guaranteed to turn him off. My problem is: Without it, can we figure out a thing that is the first that *ever* actually happens?

IT'S COMPLEMENTARY

In picturing an object at an absolutely definite position in space we cannot seem to help picturing it as fixed. In other words, we cannot think of the position of an object and of its velocity simultaneously.

David Bohm (1951)

Cosmologists, even more than laboratory physicists, must find the usual interpretive rules of quantum mechanics a bit frustrating.

John Bell (1981)

To the outside world, [scientists] present science as a series of great discoveries, as smooth upwards progress towards truth. But inside science, fierce debates and controversies rage constantly.

Jay Kennedy (2003)

Nothing is what it seems!

Slipknot (2004)

One thing's for sure: She may be educated but she can't even *spell* team. As is not uncommon, Frank is back to moping, helping nothing, rearranging books and papers with his butt. She sits with her back to him, paging through a diary on her Mac. Does she even notice? How does one spell disfunctional? Spell-check says *dys*functional.

He mostly shows up when she isn't in the office. Or vice versa, I don't know. But when she is there and he is and she talks to him she stands hipshot. She looks past him at the wall. What is that about?

So? is what I want to say aloud. Or maybe: So . . . ? in I suppose a less aggressive way. Just to say something that is nothing in particular to hack a hole in the emotive haze that hovers here today.

No one is saying much about the last few days. It's been like: Thud, thud, thud. My headache echoes the imagined sound as all my work on the three theories hits the dust. Frank is looking peevish, like he has something better he would like to do. Not. If he did he wouldn't be here. She is shoving slips of paper back and forth, receipts I imagine. She finds pleasure in receipts. Oh well, time to toggle off the markup. Maybe someday she will catch me at it and all this will end.

Late morning I kick off by telling him the pivot post of quantum theory is that it's complementary. This draws a blank look. Perhaps he thought the quantum stuff was done. I press forward to its noun, Complementarity—about as ugly as an English word can get. It's a hand-me-down from German: *komplementarität*.

And what is it? Well, like I tried to say, it is the heart and soul of quantum theory. You could say it is about *Duality*. That's the idea of opposites like

Yin and Yang. His disdainful look as I explain this is like: This is German? Or maybe: This is *physics*? Well, no, it's Taoist; it's philosophy. But the consensus crew adopts it, with a twist: It becomes not *a* principle but *the* most basic concept. Or so they say. For my money, I caution him, it's oversold. It's sad and hilarious how money—the mere mention of it—seems to wake him up. Like his brain is saying to him: What money? What he should be asking is: Is it real? Is it *the* most basic concept or an ad campaign?

The modern version of the principle kicked off its career about a hundred years ago courtesy of Einstein—I should have guessed. Its early permutations said that an object can behave as a particle or it can behave as a wave. It *is* both at the same time but it can't *do* both at the same time. One can check at any time to see which it is doing. But choosing *how* to check decides the answer. This may sound silly. But in a zillion tests it always works. It works for every kind and size of object, big or small, pachyderms and popsicles, protons and photons. It makes no measurable difference for big things so nobody wastes their time. For small things it makes all the difference in the world. As in, literally, now you see it, or you don't.

So, Hey! I say to him, welcome to the weird world of Complementarity. It's our world, or so we are supposed to understand. He doesn't need to say a word to let me know that he is unimpressed. He thinks I ham it up too much. He might be right, I want to capture the exhilaration that the physicists exude.

Its story starts with Huygens in the 1600s. He is a philosopher and so, as they all are in his time, he is a dilettante. He studies Saturn. He makes clocks. And he does things with light. He shows, or thinks he does, it is a wave. Like all his friends he knows a wave must wave *in* something—air, water, even sand, that kind of thing. So he must find a something for light's wave to wave in too—but what? Well, its medium, he says, must be invisible! He says it is an aether—an ancient label. The luminiferous aether, because it is the medium for light. Perhaps he thinks this is a harmless concept. If so, he's wrong. It's an idea.

Newton's next. It's 1704, a dozen generations of my ancestors ago. In his epic treatise *Opticks* he says light's a stream of particles: no waves so no need for an aether. He is the most influential thinker of the age. His view looms over scientific thought until the early 1800s when Young conducts a series of experiments that seem to show that light is like a wave. His experiments are simple. It's not that they are better than Newton's; but they are newer. Huygens is ascendant; waves and aether, welcome back. Soon Newton's particles of light might get forgotten in the rush to find an answer to the question: What *is* this new and interesting aether? Mark it well, I say to him. It may be fickle fashion but it will not disappear.

In 1847, Faraday's experiments with light lead him to say it is a wave that is electric and magnetic and it doesn't need an aether. Two decades later Maxwell does the math. For physicists math has a way of ending conversations. Talk turns to chalk. All is now clear: Light *is* a wave.

Well, it *is* clear until Einstein shows that light is made of quantum particles. But this doesn't lay the waves to rest; rather it kicks off the kludgy concept behind that ugly word, Complementarity. Soon Bohr is promoting it. The more

he talks it up the kludgier it gets. How come? Well, Beller says that 'the complementarity principle was a device of legitimation—it led to no new physical knowledge.'

In the washroom down the hall I show him an example. I cut a skinny slit into a piece of paper. I turn on the light pointer I bought for the lectures no one gives. It's a laser. I tape it to the counter. Lights off, it makes a red dot on the wall. I hold the paper so the light beam hits the slit. It makes a red band on the wall. Next I stick a piece of thin black thread along the middle of the slit. Now there are two slits. No doubt he expects to see two light bands on the wall. So he's surprised. There's a *bright* stripe on the wall right in the center. It's where he thinks the thread should block the light. Fainter stripes of light splay out on either side.

I try to enlighten him: The light beam is behaving like a wave. The wave that passes through one slit is interfering with the wave that passes through the other. Where they reinforce each other—for example, in the center—the light on the wall is bright. A little left or right of center, one half-beam must travel further than the other. Where the wave from one slit's going up as the other's going down and vice versa, they cancel so there is no light. The stripes are interference fringes. I can see he is impressed. But there's nothing strange about it. The light is just behaving like a wave. The same thing can be done with water waves. One might think the ball is back in Huygens' court.

But these days physicists can take a closer look. First they can turn the light source way down so that it emits one photon at a time. I ask him to guess: What will it do? Each photon that hits the wall must go through one slit or the other, right? It *can't* interfere with a photon from the other slit because there *is* no other photon. So it should just hit the wall in line with its slit. To see what happens physicists employ a fancy screen that records where each photon hits.

What they find is that the photon hits show interference fringes. It's as if each one can reinforce or cancel out itself! In fact QM seems to say that that's exactly what it does. The Wave Function for a single photon heading for the screen is in the mixed quantum state <went through left slit> and <went through right slit>. The probability of finding it at any particular location is given by the square of the Wave Function, which looks exactly like the interference pattern that's observed. But just a moment! QM also says these words, 'a single photon heading for the screen,' have no meaning. They describe the very thing that Heisenberg says can't exist. There really *is* no photon heading for the screen. There's just a source, a slit and an experimenter who sees something on a screen.

Now here's where it gets tricky. The experimenter adds a counter to detect each photon as it passes through a slit. When turned on, it clicks to show a photon passed. But now the interference pattern disappears! In its place there is what Frank expected—two bands of dots in line with the two slits. Just switch off the counter to get the interference pattern back.

It's called the double-slit experiment. Some say *the* most beautiful in physics. I show him movies on the Web. They can use electrons in place of the photons. I tell him: Check it out. They can shoot neutrons or even atoms, always

with the same result. If there's no information about which slit each particle goes through, they get an interference pattern. It's what QM predicts where the <left slit> and the <right slit> versions of each particle can interfere. But the instant the observer has any way to know which slit each particle goes through, the interference pattern disappears.

Classical theory says this cannot happen. QM says exactly what is seen. It makes no sense except it happens. QM is about results.

He heads out before rush hour as usual. Am I imagining that he is thoughtful?

I too am thoughtful. I view it from *my* Frank's perspective. On one hand he'd want QM's help to find the way the universe began. He's not alone. Most everybody says it's needed. But on the other hand QM needs an observer who's outside the system. Which is a thing a universe can't get.

I know what Real Frank's problem is. It's that he's real. In a business as taxing as discovering a universe, this could really stuff him up.