

THE PROBLEM OF INERTIA

Science moves, but slowly, slowly, creeping on from point to point.

Alfred, Lord Tennyson (1835)

In a consistent theory of relativity there can be no inertia *relatively to "space,"* but only an inertia of masses relatively to one another.

Albert Einstein (1917)

I see the most essential thing in the overcoming of the inertial system, a thing that acts upon all processes, but undergoes no reaction. This concept is in principle no better than that of the center of the universe in Aristotelian physics.

Albert Einstein (1954)

The law of inertia has no known origin.

Richard Feynman (1965)

The origin of inertia is and remains *the* most obscure subject in the theory of particles and fields.

Abraham Pais (1982)

Frank Fuzz is one reason why inertia figures largely lately in my world. Another is that it has fascinated physicists in every Age. But the real reason is: It bugs me.

For physicists, inertia's the resistance of a body to any change in its state of motion. Actually, inertia is the name for the *idea* that a body has such a resistance. This might seem picky, a distinction with no difference. But, as I gear up to embroil him in it, it is clear to me that picky is exactly what we've got to be. And, yes, there *is* a difference, because I find that there are lots of ideas tangled up together in this one supposed idea. I say 'supposed' because it presupposes 'state of rest' and 'state of motion' stand for something that we understand. They don't, because we don't.

Three intellectual giants—Newton, Mach and Einstein—wrestle with inertia. Their tag match takes three hundred years. None can pin it to the ground. It seems simple but it is so deep it is sublime. To this very day it stirs much anxious thought and philosophical debate. Clutching coffee cups I key the lock, my mind still in a state of woozy. Music and herb go together, says Bob Marley. But last night's weed must have been dusted; maybe PCP. In the moonlight by the pier I got the heavy heebie-jeebies. So I'm hoping that he'll skip this lesson. All the odds are on my side.

Inertia's such a touchy problem that I haven't even told him it's the topic of the day. Better that he has no chance to do a random read. It's not just the tangles that concern me though they are severe: It tangles, for example, with what's called the absolute-relational controversy. This is a mess of issues in the midst of which his Problem of the Special Frame resides. It tangles too with often-overlooked distinctions about: Absolute-or-relational *what?* As in: Position or velocity or acceleration? Or rotation even? Their issues differ deeply. All this tangles too with the distinction between what if anything is real and what we know about it, mill-grist for a Problem yet to come. And to cap it off—if any cap will fit this monster—there's the riddle of rotation to which in desperation thinkers tend to turn to try to get a grip.

So with a jaundiced eye like Tennyson's he might regard inertia as the steady eye of a gyrating whirlpool, or the Maelström of Poe's story. Not as a fact but as an abstract symbol of his very quest. In *my* mind's eye it's static in idea-space, smooth-surfaced, giving him no handhold, no hint even that it might contain contents, refusing, as it were, to be a clue. He might pass it with a shrug. Yet round it swirls from early times a tide of mental discontent. I read Earman's 1989 review; he holds out little hope these ancient questions will find answers. Physicists now tend to pass them by. They favor physics built on basics that might crumble if they looked too close.

All of which is only a pale picture of my problem. Merely sampling what I call the whirlpool, let alone—like Earman—essaying a summary, would be a challenge. The thought of essaying a summary for *him* has me undone. Yet for him it should be a key clue. *This* lies at the heart of why the topic is so touchy. It's why I'm happy he's not here. I need more time to dig around and to prepare the ground for something that I don't know how to do.

For here's the rub, as Shakespeare almost said: Whatever this inertia is, it's clear to me the entire universe can't have it. This is not a thing I've read. It just stands to reason when I think, as I do each day these days, about the universe as it begins. Take the GR version of its beginning for example, a point of vast mass and no size nowhere in not-even-nothing. To me it's not a problem that there's no one there to push it and detect resistance; I can *imagine* someone. It's that there is nowhere for them to push it *to*, or, for that matter, push it *from*; *that* is what's beyond imagination. This leaves me with something that is said to be here in the universe today that wasn't there in the beginning. Any way I look at this, it has to be a clue. How do I ease it into view?

One way would be Newton's Law. His First Law of Motion says that any body stays at rest or keeps on moving uniformly if it isn't pushed or pulled. Leaving out the question of what motion is, it seems that this is true. But why? Well, I can tell

him: Nobody knows. Cutting through a lot of stuff, the story seems to be: What else would it do? My question is: How do I get him to see why 'Why?' should be a question?

I could ask him to imagine some object in empty space. A stray apple for example. Nothing else in view. Is it moving? Well, the question is, relative to what? Newton has a ready answer: Relative to space itself. In other words, he thinks of space as absolute. So he thinks that he can specify the apple's speed through space. Three hundred years post-Newton, SR seems to say he's wrong. Will Frank see that he can only say it's moving if he has another object and can specify the first one's motion relative to that?

Next, is its motion uniform? That is: Is it accelerating? Well, that's a different question. The bottom line is this: Some who say that motion's relative say acceleration's absolute.

Newton weighs in on this issue. He has a bucket in addition to his apple. Both may in fact be in his mind. Maybe Frank can think along with him. He'll need conjured water in his fancied bucket. To lighten up the lesson I'll say Liza has made Henry fix the hole. Newton spins his bucket and he tracks his water. Soon it too begins to spin. As it spins its surface becomes curved. Now Newton stops his bucket but his water keeps on spinning; he sees that its surface is still curved. This makes him think: The water doesn't curve because the bucket spins. It curves because *it* spins. How does it know that it is spinning? Spinning relative to *what*?

The thing that Frank might miss about the bucket is: It forces water to accelerate. Left to its own devices—meaning with no bucket—the water would, as Newton says, keep going in straight lines. If not walled in by the bucket it won't stick around. But, walled in, it keeps turning round an endless corner; one moment it is going *this* way and the next it's going *that*.

What exactly is the lesson Newton's teaching? Well, that's a different kind of question, a question of ambition. And it's yet another question that can fuel an academic disputation. Digging through which, the best answer seems to be: It is a shot. He is not, as will later be promoted, arguing the case that space is absolute. Already wedded to this, Newton, whom Voltaire will call 'this famous Newton, this destroyer of the Cartesian system', merely wants to show Descartes' disciples that he, Newton, can distinguish absolute from relative rotation. Physics fashions hinge upon such things.

Much later Mach comes up with his own take on Newton's bucket. So 'tis said. He says the water is rotating relative to all the mass in all the universe. Mach's Principle it's called. It kills off absolute space or so some believe. Bye-bye Newton: Mach paves the way for relativity. Even Einstein says so. But this may

not make it true. Reading on, I find the evidence Mach's Principle is *Mach's* principle is hearsay.

All his life Einstein rejects the whole idea of *any* instantaneous non-local influence. Nonetheless he clearly says it is Mach's Principle that leads him to GR. In ensuing years some try to figure all this out. Barbour says, 'Einstein was quite wrong to attribute such an idea to Mach, who never put forward any such proposal.'

Here is a hidden irony. Einstein later uses GR to invent cosmology. Mach says that cosmology will never be a science. The universe, he says, is one thing science cannot study. Einstein seemingly does not agree.

Did Mach actually come up with Mach's Principle? Idly I wonder where a universe denier might find an idea like that. Could German philosopher Ernst Mach be moved by German philosopher Karl Marx? Marx's materialism sees events against the backdrop of history—that is, of the aggregate of all events. Mach's alleged concept of material sees mass against the backdrop of the universe—that is, the aggregate of all the mass. It seems far-fetched; I push the thought aside. But then, still idly, just to prove the point is pointless, I google: marx history mach inertia. And whoa: I should rethink my thoughts about the Web! My first hit is a book called *Beyond Marx and Mach*. A philosopher called Bogdanov attempts to bring their thoughts into accord. Maybe there is a point; but what do I know?

One way or another Einstein is much influenced by Mach. So what *is* Mach's Principle? Another way to state it is: Large-scale structure of the universe defines local laws. Does Mach mean to state this as a law of physics? He doesn't say so. Nor does he, when put on the spot, say not. Mind you, he's conflicted. GR says Mach's Principle is wrong. Mach returns the favor; having, asserts Einstein, got it going, *he* says that GR is wrong.

Set aside who says it; is it true? Well, the more I read, the more it looks like: Maybe. If so, nobody knows why. It's an oddball way for physics to explain a thing as fundamental as inertia.

So the Problem of Inertia is: After all this, no one can say what it is. It's not that Frank will ever need to know. Rather it's that this not-knowingness should tell him something but I don't know what.

At this moment he walks in the door. He has an air of gracing with his presence. I essay to be polite and friendly though he hasn't been in for a while, which has in truth turned out just fine. He looks over my shoulder at the screen. All that's showing is my paragraph about the Problem of Inertia and how he doesn't need to know. He says condescendingly it's tied up with rotation. I mean . . . What?!

She walks in a half a minute later. She too hasn't been here in a while. She too checks my screen. She smiles at him and says to no one: Newton's bucket.

He nods and half-smiles back at her. This tableau is the very essence of a mutual admiration society gone mad. It lasts two heartbeats then it's gone. They've set the perfect segue to the topic for tomorrow. Given neither of them knows the topic and the words they get to see don't cue it, it is far *too* perfect. Are they messing with my head?