

THE PROBLEM OF WHETHER SPACE IS SOMETHING

There is in truth only atoms and emptiness.

Democritus (ca. 380 BCE)

As for my own opinion, I hold space to be something purely relative,
as time is, that I hold to be an order of coexistences, as time is an
order of successions.

Gottfried von Leibniz (1716)

To deny the ether is ultimately to assume that empty space has no
physical qualities whatever. The fundamental facts of mechanics do
not harmonize with this view.

Albert Einstein (1920)

Newton clung to the Stoic picture of a finite world surrounded by an
infinite void space. He could imagine an empty space but not the
absence of space itself.

John Barrow (2000)

Experiments now strongly suggest that Einstein's most basic views
on space and time were somehow wrong: that they were fruitful half-
truths.

Jay Kennedy (2003)

I should ease up on Frank. She hired him; he's not to blame for that. I'm the one who's changing the agenda, not him, not he. And here he is today, almost on time. So I tell him that today it's space. Again? he asks. I can see he thinks the question whether space is Something was solved long ago. It wasn't. It's at the center of one of the longer-running intellectual disputes, a clash of views that's growing more, not less, intense. How does physics get along without an answer to this question? With much difficulty.

In the 300s BCE, amidst some stimulating but entirely wrong ideas about objects and their motion, Aristotle launches the debate when he says space does not exist. His dictum echoes down the ages. In 1021, Al-Haytham analyzes space as pure perception in his opus *Optics*. In the 1600s, Descartes renews the Democritian view that space has no reality without the bodies in it.

But decades later Newton asks 'what the space that is empty of bodies is filled with?' What he *thinks* is it is filled with God. But in his famous book

Philosophiæ Naturalis Principia Mathematica he ardently espouses the reality of space. He says it's a thing of substance independent of what's in it; and so things can be said to be at rest or moving relative to space. Then he invents the luminiferous-type aether to explain how light rays bend when passing from a vacuum into glass. His aether forms the classic Special Frame. One might say that it gives space its substance. This may seem a contradiction of his early view that space has substance of its own. But, like other greats, he isn't taking a position. His views evolve.

Around the same time Leibniz takes the opposite—the Cartesian—view that space has no existence independent of the objects in it. He sees space as no more than a mental framework in which to consider the behavior of real things.

Newton's aether is in fashion until 1887, when Michelson and Morley find no trace of aether breeze expected to attend Earth's plunge through space like wind outside a speeding car. For some, this is the kiss of death for aethers.

Yet a generation later Einstein bases SR on a space that's absolute, or so it seems. Then in 1952 he adds an Appendix—the Problem of Space—to the 15th edition of his book on relativity. He says an independent framework is no longer *needed* for describing objects. GR seems to provide a framework from which space emerges. He does not argue from this that space has no real existence—though this is now his view. Some think relativity's successes close the case. I must explain for Frank—for mine at least—why I think that he should not think so.

Whether space exists aside from matter may seem academic, a universe that has no matter having meaning only in an abstract mathematic like de Sitter's. But for Frank the question's practical. He's in search of the Beginning. His universe might not have matter yet; matter may come later. If so he's sure to need to know if space exists. Chown's question, 'How can nothing expand?' should be on his mind. Chown means that, since space (he says) is nothing, saying it expands is nonsense. Weinberg responds: 'The answer is: space does not expand. Cosmologists sometimes talk about expanding space, but they should know better.'

Rees agrees. But my digging shows that most cosmologists believe they *do* know better—better than Rees and Weinberg. They think, they say, they *measure* that space *is* expanding.

My guy ought to turn the question round: If space is expanding, how can it be nothing? As a fictional detective he'll know that to get to the right answer he must start with the right question. His question should be: Is space Something or no more than an idea? Pieced together, all my reading says this is the central problem. For him a central question is: Does space exist? Only if it does can he ask the next question: How did *it* begin?

And, thinking of the morrow, I think: What to say to him of time?