

# THE PROBLEM OF FILLING SPACE

The universe is expanding so as to double its dimensions every 1300 million years; that is no more than the period of geological time.

Arthur Eddington (1932)

The classical form of the Big Bang theory requires us to postulate, without explanation, that the primordial fireball filled space from the beginning.

Alan Guth (1997)

Okay, today should be an easy day. The universe fills space. An old idea. Anyone can close their eyes and see it right away. Why am I uneasy as I try to ease him into it? Could it be I hope to ease it into him?

Newton gets it and he doesn't like it. His universe does *not* fill space. He feels a need to say the universe is finite. He doesn't feel the same way about space. At root his view's religious but it carries weight. It hangs around till Einstein says it can't be right.

Nowadays few doubt that matter is from the beginning found in every reach of space. Yet the problem lingers to this day. And suddenly I see why I'm uneasy. It's an edgy question. He knows the Hubble telescope shows galaxies fill what we call the universe. He'll be, like: What's the problem? To see its full dimensions he will need to look outside the Hubble bubble for an edge. The edge he's seeking—if there is one—is so far out it is out of sight.

To show why, I take him on a slight digression. There is a view that relativity bans anything from moving faster than the speed of light. Actually, it says nothing can accelerate to trans-light speed *through* space. At light-speed the mass of anything—a proton, say—is infinite. So is its inertia. But relativity says nothing about how fast *space* can move. He squirms a bit at this. Maybe he senses that this concept seems a little absolute.

I recall for him: In the 1930s Hubble helps discover that space is expanding. The expansion rate—the Hubble constant—gets expressed in ugly units: kilometers per second per megaparsec; some 70 of them. A parsec is a handy thing to have. Not. It's the distance from which the radius of Earth's orbit round the Sun subtends a tiny angle, one arc second. It makes old measures—chains and leagues and gills and gallons—appear user-friendly. Eddington sets up another method of expressing the expansion: Expansion doubles distances to distant galaxies in thir-

teen hundred million years.

Thus the furthest galaxies that we can see are leaving us at close to the speed of light. Not through space; space is leaving with them. Any that are further from us must be going faster so we can't see them at all.

It's no good; he looks confused. But then, it is confusing. It gets physicists confused. For now he only needs to know there may be much more universe than we can see. In fact, cosmologists assume that almost all the universe is past the limit of our vision. Space has been expanding for a long time. Galaxies went with it for the ride. What Guth is saying is that *all* of space, not just the bit we see, has matter in it. Space and matter go together. We don't know how it got to be that way. This is the Problem of Filling Space.

If, as Guth says, it has always been that way, it must have been that way in the Beginning. It's another clue.