According to the big bang theory, the universe began as a singularity, a nucleus of infinite density that had zero dimensions. We sometimes refer to it as the “primordial egg.” The problems we have discussed so far—the origin of structure, the horizon and flatness problems, and so on—are all insignificant when compared to the problems associated with this singularity. To understand the singularity we must first understand what caused it, and where it came from. Is this possible? A few years ago most scientists would have said no, but today there is an air of optimism.

The first step in deciphering the mysteries of the singularity is understanding the infinitely short, but important era that occurred just before inflation. The best way to visualize it, or at least get a better feeling for it, is to think of the “big crunch” that will eventually occur if the universe is closed. First, clusters of galaxies will come together, then galaxies, until finally the universe is a roughly uniform cloud of densely packed stars. Then as stars merge, the universe will become a blindly bright cloud of white-hot gas. As it gets increasingly dense, the forces and particles of the universe will become simpler. The universe will enter an era of unification in which there is only one force and one type of particle. This occurs at an energy of $10^{19}$ GeV. The density at this time is extremely high, perhaps as high as $10^{90}$ grams per centimeter cubed.

This unification occurs $10^{-43}$ second before the universe becomes a singularity, if indeed it does become a singularity. Does it
The closed universe collapsing back to a singularity, and possibly "bouncing."

actually reach infinite density and zero dimensions, or does it somehow avoid it, perhaps as a result of quantum uncertainties?

Turning this question around, it becomes: Did the universe arise from a singularity? According to general relativity, it did. Stephen Hawking and Roger Penrose showed in the early 1970s that if general relativity was valid, there was no escaping a singularity. But many cosmologists, including both Hawking and Penrose, now refuse to accept this. They are convinced that the singularity can be avoided, and to most scientists this is good news because singularities are difficult to deal with. Einstein abhorred the singularities in general relativity; in fact, he was convinced that the theory was incomplete because of them. He struggled for years, trying to get rid of them, but failed.

Singularities are not, however, peculiar to general relativity. Literally all theories have them. In electromagnetic theory, for example, there is a singularity associated with charge; at the center of the charge the electric field is infinite. Quantum theory allows us to get around some of the problems associated with singularities, but not all.

If we are to truly understand the universe, and to explain where it came from, we have to determine whether a singularity really existed