STARS

By Marcia Bartusiak

A strange marriage between astronomy and particle physics is reshaping our understanding of that primordial explosion known as the Big Bang. Most recently particle physicists have suggested that the universe may have begun not only with a bang but with a sort of cosmic burp—an infinitesimally brief moment of superaccelerated expansion.

Why are particle physicists suddenly interested in astronomy and cosmology? They have recently realized that the tremendously hot birth of the universe provides the perfect laboratory to test their latest mathematical musings—grand unified theories, or GUTs for short.

With GUTs, investigators of the submicroscopic world of elementary particles are beginning to show how the three nongravitational forces of nature—electromagnetism; the weak interaction that governs some forms of radioactive decay; and the strong nuclear force—are really the same. Each force acts differently at the low temperatures of our everyday life but, say GUT theoreticians, they all become identical, or symmetrical, when energies get high enough.

Testing such ideas, however, is another matter. The energies required to achieve that wondrous symmetry are cosmic, on the order of 10^{23} electron volts. As MIT particle physicist Alan Guth points out, "Generating such energy in a lab would require a linear accelerator a light-year long." This is why particle physicists eagerly turned to cosmology. The forces of nature were assuredly one during the first moments of the Big Bang.

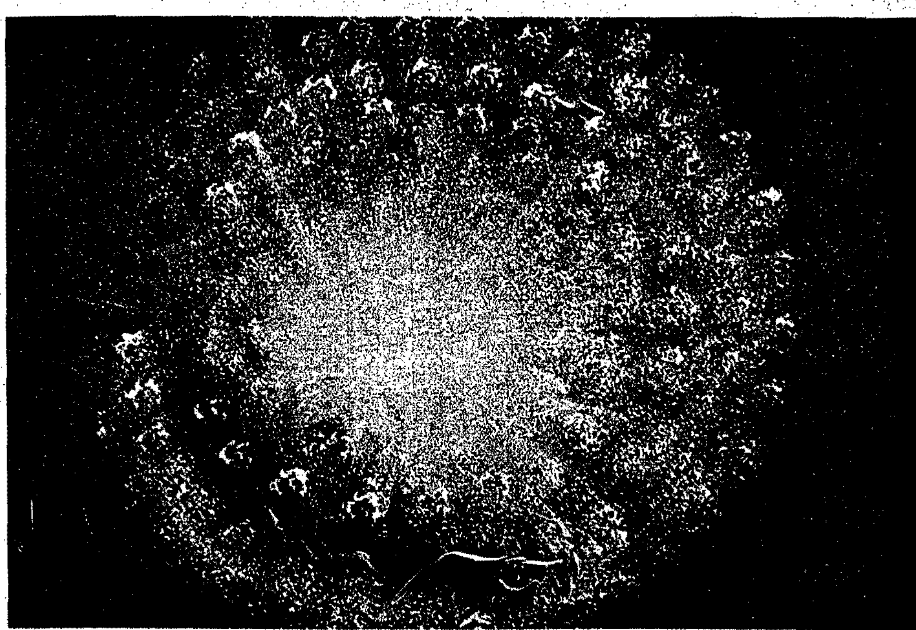
Guth was the first to suggest that at its inception the cosmos underwent a period of exceedingly rapid expansion, or inflation (the big burp). He arrived at this conclusion when he used GUTs to theoretically re-create the universe's cataclysmic birth. Guth's "inflationary" model was announced three years ago and has since been revised by particle physicists Andreas Albrecht and Paul Steinhardt, of the University of Pennsylvania, and Moscow physicist A. D. Linde. Their scenario begins 10^{-35} second after the Big Bang, when the universe was only one trillionth the size of a proton.

At that stage the submicroscopic, expanding ball of hot radiation was beginning to cool to less than 10^{27} degrees K. Normally that's the temperature at which symmetry should have broken—when the unified force would start to differentiate and subatomic particles like quarks, electrons, and neutrinos would become separate entities. But this did not happen right away. Instead, according to the inflationary model, the cosmos became supercooled and remained symmetrical as the temperature plunged, just as water can sometimes remain liquid below its freezing point. This delay in its "crystallization" placed the universe into a state of high energy that pushed it outward faster than had been postulated by previous Big Bang models. Once symmetry broke, the energy was suddenly converted into *all* the particles and radiation that surround us today.

Researchers are enthusiastic about the idea because it explains some long-standing cosmological mysteries. Why is the universe so flat, that is, neither measurably open (destined to expand forever) nor closed (ready to collapse)? Guth and his colleagues suggest that if inflation had occurred at the moment of creation, space would have quickly flattened out, much as the surface of a balloon smooths out under expansion.

And there are other questions. Why are galaxies and energy distributed so evenly in all directions? Because just before inflation, our universe was a fraction the size of an atomic particle, small enough for matter to get uniformly mixed.

But one problem remains: galaxy formation. The inflationary model can explain how dust and gas eventually clumped together to begin the formation of galaxies. "According to the simplest grand unified theories, however," admits Guth, "galaxies tend to collapse into black holes at a rather early point in the universe's history." That dire prediction obviously did not come true, but supporters of the inflationary model are confident that someday they'll be able to match theory with observation. ∞



We think the universe began with a Big Bang, but was it followed by a cosmic burp as well?