Chapter 2

Instant of Creation

Steady-State Model

The state of the universe prior to the creation of matter and forces is as yet unresolved, unless we believe that the universe was everlasting into the past as well as into the future. Taking the Bible as a base for reference, the world at large was created almost instantly by an act of God. In the end there will be a “big crunch” (“Weltuntergang”) but the essence will last from eternity to eternity. In spite of all the achievements of modern science, this is still a very logical and personally satisfying conception. Admittedly, one has to believe in it. Thus in a way, when it comes to the moment of creation, religious and scientific models have many things in common. With this in mind let us expand on the problem at hand.

One idea which overcomes many of the aforementioned difficulties had been submitted by Bondi, Gold and Hoyle in 1948: the “steady-state” or the “perfect cosmological principle”. According to this, the universe had the same general appearance at all times, as well as at all points in space. To explain how such a situation can arise when galaxies now appear to be moving apart, we need to generate new matter continually in between to maintain the average density of the universe at a constant value. The amount of matter generated in this fashion is about one hydrogen atom in every cubic meter of cosmos every 10^9 years. This matter will eventually give rise to new galaxies filling in the gaps created by the receding galaxies (Hoyle, 1975).

For about 20 years this was esthetically a very attractive model because it had the great advantage of making definite testable predictions. Observations of radio sources and the detection of the microwave background radiation (see p. 16), however, proved these predictions to be in error; but some still cling to their original idea of a “steady-state”. In his book “Steady-State Cosmology Revisited”, which appeared in 1980, Fred Hoyle questioned the validity of a young universe, which, according to various models on initial singularity has an assigned age of about 10 to 20 billion years. The primordial synthesis of enzymes he used as an argument in favor of steady-state. The logic runs as follows. The chance of a random shuffling of amino acids producing a workable set of enzymes is infinitesimally small, i.e., 10^{-40000}. This number was obtained from a calculation in which about twenty amino acids were required to be in specific sequential positions for each of two thousand enzymes. According to Hoyle (1982), it seems better to suppose that the origin of life was a deliberate intellectual act than to accept a probability as small as 1 part in 10^{40000} of life having arisen through the “blind” forces of nature. In this context “better” means less likely to be wrong. This is the strength of religion, its almost non-refutability. Nevertheless, by letting blind forces operate for eternities, any of the well-known amino acid sequences in enzymes can theoretically be fabricated. Unfortunately, Hoyle’s biochemical excursion must lead into a blind alley, since the rate of synthesis of biopolymers both in the living cell and in the abiotic world is governed by epitaxis and catalysis and is simply a function of structural regulation and not of chance. In the distant geologic past the principal polymeric building blocks of life were possibly formed in almost a matter of no time along mineral templates, if this concept proposed by Bernal (1954), Matheja and Degens (1971) and Cairns-Smith (1982) is correct.

Nothing to Speak of

Steady-state is out, initial singularity apparently is in, but there might be some “strings” attached. Since conservation laws of physics forbid the creation of something from nothing, we are faced with a fundamental problem. Some light could perhaps be shed by the fact that the universe has particular values for energy, electric charge, baryon and lepton number and so on. This has led to the rather intriguing idea that the universe is a large-scale vacuum fluctuation (e.g., Tryon, 1973). Contrary to general opinion, such an event need not have violated any of the conventional laws of physics. A universe coming from the
cold, from nowhere and nothing, must have certain specific properties. In particular, it should have a zero net value for all conserved quantities. For the moment this statement is correct but some adjustments have to be made later.

What is the state of true nothingness? A vacuum with energy and structure! 鬼無, having respect for the true nothingness is a basic principle of Daoism. From Dao, the way, sprung up two ancestral forces, 阴 and 阳, and their interaction and permutation gave rise to the cosmos. They are in a state of flux, constantly interacting among themselves, thereby triggering processes, which are mirrored in all of nature’s phenomena. 道, 阴 and 阳, Wu Xing (wood, fire, earth, metal and water) were the basic elements of Chinese cosmology until the recent past. A remarkable account on the “philosophy” of such a vacuum has been given by Trefil (1981). Here are some excerpts. Imagine a half-inch thimble filled with air. It would contain thousands of quadrillions of atoms. If placed inside a TV tube, the thimble would hold only a few billion atoms. By putting it into the best vacuum one could generate on Earth, about 500 atoms would still be left inside. On the surface of the Moon the number of atoms within the thimble would go down by a factor of ten. And finally, if the thimble were carried to interstellar space, one atom, on average, would be left behind. Except for that one isolated atom, all the remaining space in that thimble represents a perfect vacuum.

Quantum field theory predicts that any phenomenon that could happen in principle does happen from time to time, statistically. For example, QED reveals that an electron-positron pair and photon occasionally emerge spontaneously from a perfect vacuum. The particles exist for a brief interlude and then vanish. That this phenomenon is not fiction but real can be shown experimentally.

An isolated hydrogen atom inside a vacuum will be affected by electron-positron pairs appearing and disappearing in the empty space surrounding the hydrogen. That is, the electron circling the proton will feel the electrical forces exerted by the pair. The electron will be jostled, which in turn will affect the light emitted by the hydrogen atom. In short, the ghostly pairs not seen at all are brought to light. It is true that energy conservation is violated, but only for the brief particle lifetime permitted by the uncertainty principle originally conceived in 1927 by Werner Heisenberg:

$$\Delta t \Delta E \geq \frac{\hbar}{2\pi},$$

where $E$ is the net energy of the particle and $\hbar$ is Planck's constant ($= 6.6256 \times 10^{-27}$ erg/sec). The principle relates the uncertainty $\Delta E$ in the energy radiated to the uncertainty $\Delta t$ in the time at which it radiates, i.e., the uncertainty in its lifetime.

The spontaneous, temporary emergence of particles from a perfect vacuum is called vacuum fluctuation. Thus a vacuum is not simply the absence of matter; instead, the particle-antiparticle pairs it consists of are considered to be in a transitory state. From here to the initial singularity termed big bang it is only a “small” step, provided one takes the view that the energy of the Universe with matter is lower than the energy of the Universe without, and nature always proceeds to a state of lowest energy (Fig. 2.1; see Trefil, 1981).

Summarizing, going back in time and