COSMOLOGY AND HUMANISM

by Ralph A. Alpher

My remarks today will deal with the relationship of contemporary scientific cosmology with Humanism. I approach cosmology as a professional practitioner, but must apologize in advance for the fact that my discussion can only be superficial in the time I have. I approach Humanism as a non-professional practitioner and must plead relative ignorance of the history, literature and philosophy of Humanism as compared to many of you in the audience. But, the better part of a lifetime spent in research and contemplation on scientific cosmology has led me to the conclusion that there no evidence for the universe being other than completely neutral to our existence. This leads inevitably to my identifying philosophically as an agnostic and a humanist, and explains my temerity in sharing my views with you.

Some Definitions and Assumptions

Cosmology is that branch of science which deals with the origin, structure and evolution of the universe. The universe is defined to be the observable ensemble of atoms, molecules, radiation, gas, dust, stars, galaxies of stars and clusters of galaxies. To make any progress at all toward a scientific understanding of the universe certain assumptions are required. You may find the assumptions to be patently oversimplified, but it is good scientific practice in developing a theory to keep one's assumptions as simple as is consistent with developing a successful model. Thus we assume that what we now observe in the astronomical universe is a major fraction of what we shall ever be physically able to observe. Relativity theory postulates the constancy and finitude of the velocity of light (186,000 miles per second). Information travels at best at the velocity of light, so that ifthe universe is now 18 billion years old, then clearly we can observe at most only to a distance of 18 billion light years. This horizon to which we can in principle observe grows with the aging universe at the velocity of light. When the universe is a billion years older than it is now, we should be able to see to a distance of 19 billion light years, at most. But notice that if we observe a celestial otJ~;:~tat a distance of, say, 10 billion light years, we see that object by light emitted 10 billion years ago, when it was a younger and much less evolved entity. And so relativity provides us with a kind of "time travel."

A second point to be made is again a consequence of the theory of relativity. The generally accepted view is that the universe is infinite in extent. A simple way to think about this is to realize that if it were finite, then one would have to deal with the idea that there is something beyond. But the word universe, and the concepts we are pursuing, ascribe as the meaning of the word universe "all there is." All observers are assumed equivalent, wherever and whenever they may be; there are no privileged observers. It follows that we have assumed the universe to be the same everywhere, homogeneous on the large scale (i.e., when viewed on the scale of clusters of galaxies), and the same in whatever direction viewed, which is to say that it is isotropic, with no preferred direction. If I say the universe is 18 billion years old, then any observer elsewhere in the universe would say the same, given the same evidence at this time. Moreover, an observer on an object which we now see at a distance of 10 billion light years has the same 18 billion light year horizon that we have. If that distant observer could see the Milky Way galaxy in which we reside, he would see it as it existed 10 billion years ago.

Further, we have to suppose that the laws of nature which have been identified and studied in the terrestrial laboratory or in the local solar system are equally valid elsewhere and everywhere in the universe, at all scales of observation from the basic constituents of matter to the majestic clusters of galaxies, from nearby in space and time to great distances and times in the past, representing significant fractions of the age of the universe. This assumption of the universal validity of the laws of nature is subject to observational falsification, and has in fact been checked observationally on a cosmological scale for a number of laws. For example, the laws governing the emission of light by hot chemical elements have been checked by comparing light from objects as much as 5 billion light years distant with light from the same elements in the laboratory. The laws are the same.

Perhaps most important is the implicit assumption made in all cosmological studies that the universe can in fact be comprehended, and that if one finds it to be indifferent to human existence, chaotic, and operating in a probabilistic way, it is nevertheless not capricious. There is no one out there trying to obfuscate the behaviour and characteristics of the universe, trying to keep us from seeking and achieving the truth.

It is appropriate to remind you that in the end all that science can provide as understanding of any physical phenomenon is a theory and a model. In cosmology today the theory is widely accepted that the universe we observe has evolved from a very hot, very dense beginning - the so-called "Big Bang" theory. Moreover, we have a mathematical-physical model which is based on general relativity and which incorporates our contemporary understanding of the fundamental particles of matter and of force and radiation fields. General relativity models gravitation, the force which controls the macrocosm, the large scale features of the universe, while nuclear and particle physics lead to an understanding both of the past and present composition of the universe and also some of the more arcane features of the Big Bang model.

I want to reiterate that what I have been saying effectively removes anthroprocentrism from consideration in the physics of the model. To put the matter in perspective, it is interesting to realize how little of the universe could possibly be aware of the existence of humankind, how small a volume of space has been traversed by light carrying knowledge of our existence. For example, knowledge of the last 5000 years (our recorded history) is confined to a sphere about us of radius 5000 light years, which amounts to about half a percent of the volume of the Milky Way.

Later in my remarks I shall deal briefly with a relatively new wrinkle which some few cosmologists have begun to take seriously, an "anthropic cosmological principle" which they claim ascribes to the human observer on earth a preferred identity in space-time. You can probably guess ahead of time that I take a pretty dim view of this principle.

The Humanist Imperative

It is undoubtedly fair to say that religion and cosmology share the same roots. Both arise from the human curiosity about the universe in which he functions, from a need to relate to these surroundings, and, by understanding them, to establish a purpose and rationale for existence, for the cycle of life. The religious practitioner ascribes to an exterior entity, either extramundane or embedded in nature somehow, but frequently visualized in anthropic terms, that which he does not understand. The approach of the scientist is to accept as an intellectual challenge understanding that which is not yet understood. The scientist seeks to explain more and more of the hitherto unexplained, while many religionists are satisfied with a level of understanding which was achieved by our forebears at a time when scientific knowledge was at best in its infancy. Today the liberal religionist will argue that even though science is nibbling away and reducing areas not previously understood, there will always be areas unexplainable by science and requiring an act of faith. I want to emphasize that science is finding that there is more and more about the universe which is explicable as the tools and techniques of science improve. Increasingly those who understand what science is about and what it is discovering will find it less useful or necessary to employ the crutch of faith in some imagined entity, and more and more will understand the need to depend on their own resources. One might say in mathematical terms that the religion/science system must converge to Humanism as it becomes increasingly evident that we live in a completely indifferent and neutral universe.

It has been said, somewhat facetiously I hope, that cosmologists are frequently wrong but seldom uncertain. Indeed because scientific cosmology combines so many disciplines and because it impinges on areas where many not trained in the sciences replace scientific understanding with leaps of faith, strong feelings are aroused both in the scientist and in those who are agnostic about the results of science. I must comment that I am appalled at the number of religious fundamentalists who reject the work of science and insist that the biblical view of the universe is the only correct view. I wish that their number was so small that humanists could afford to ignore their existence. But such is not the case, I am afraid. Its hard to argue with people who do not accept the need for observational validation of models of reality.

As a scientist I must argue personally for the Big Bang model as a physical theory whose value lies in its predictive ability, in its ability to encompass simultaneously many and diverse observations, and in the fact that it is and has been subjected to the test of observational falsification, and has thus far passed. If it turns out to be wrong or inadequate in the future, I may shed a tear, but I will argue that science frequently progresses when existing ideas are proved wrong or inadequate and must be altered or replaced by new views. It is curious that it just on this point, which lies at the heart of good science, that religious fundamentalists describe evolution pejoratively as a "theory" and no better than their espousal of "creationism." As a participant in the development of the Big Bang model, I am personally pleased that it has not only survived, but has gotten stronger over a period of many decades, particularly since it came into general acceptance two decades ago.

Evidence for the Canonical Big Bang Model

The evidence for the current Big Bang model of the universe ranges weak to strong. We may classify as weak but provocative the fact that on a large scale the homogeneity and isotropy of the universe, as well as the uniformty of its composition, suggests a common origin for the major features of the universe. Moreover, the success of the general theory of relativity in modeling the force of gravity lends credence to the fact that the same theory argues against a static universe and for a dynamic universe, one that either expands or contracts and is therefore evolving.

There are number of observational features which suggest an evolving dynamic universe even more strongly. Modern observational techniques enable estimation of the age of the chemical elements from the present existence and relative abundance of radioactive nuclear species. We can estimate the age of stars from observation of their mass and radiative properties, coupled with a good theoretical model for energy generation in stellar interiors by thermonuclear reactions. Finally, we can calculate the limiting possible age of stellar clusters and clusters of galaxies, given the struggle between the natural proclivity of their constituents to disperse into surrounding space as a result of their relative motions, as against the restraint of those motions by the gravitational force of the composite cluster. Each of these yields an age of the universe as an upper limit to the age of its constituents of between 15 and 20 billion light years. Perhaps less obvious but nevertheless convincing is the evidence of radio sources and of quasars. The former, sources of radio emission of which there are many and which are undoubtedly galaxies, are counted and the number count is related to the intensity of their radio emissions as received here. This relationship can be shown to depend in a critical way on the underlying cosmology, and reveals that there are more sources in a given volume of space at greater distances (remember greater distance means longer ago), which in turn means that the separation of galaxies was less in the earlier universe. At the time these radio source counts were first published, the evidence was taken as a strong blow against a then-current view that the universe was really in a steady state, evolving locall)~but on the average the same everywhere and for all time.

Quasars, now thought to be very young galaxies emitting very large amounts of radiation, are seen to great distances. The largest confirmed distance is over 12 billion light years, which means we are seeing the object as it looked when the universe was only one-third its present age. Such distances are consistent with the estimated age of the universe, and it is now generally agreed that quasars are "cosmological" objects. (I might say, in an aside, that the evening before this talk there was a radio report that an quasar had been detected in Australia at a distance in excess of 20 billion light years. Since the conversion to distance from the quasar observations depends in a critical way on the underlying cosmological model, the 12 billion light year figure already mentioned is somewhat dependent on the underlying model, while 20 surely must be. We must reserve opinion until the scientific paper on this Australian observation is published. At the moment I feel safe in continuing my talk on the Big Bang.)

There are three pieces of most convincing evidence for the Big Bang model. First and most important is the famous observation by astronomers Hubble, Humason and Slipher in the 20's and 30's that when viewed on a large scale galaxies are seen to be receding from one another with a separation velocity proportional to their separation. The observations are based on progressive reddening of the light from galaxies as they are seen at greater (and independently determined) distances. No alternative physical explanation has been developed for the reddening or Doppler shift on which the Hubble expansion is based. The expansion is explained in relativistic terms as an expansion of space, of the yardstick which we use to measure distance, with no center in the space-time of experience, as consistent with there being no preferred observers.

The second piece of evidence has to do with the relative abundance in the cosmos of the light chemical elements helium and deuterium relative to the abundance of hydrogen. It is now clear that these elements, along with lithium, beryllium and boron, must have been synthesized in the early seconds of the Big Bang. It has not proved possible to model the production of these lightest elements in stellar interiors, where in fact it appears that all of the other chemical elements are produced in various thermonuclear reaction sequences beginning with hydrogen and helium. The prediction by the Big Bang model of the primeval nucleosynthesis of helium and deuterium is surprisingly good.

From a personal viewpoint I am very pleased that there is now known to be a pervasive electromagnetic radiation in the universe whose energy distribution (intensity versus wavelength) is that of a 2.8-degree Kelvin blackbody. Blackbody radiation at 2.8 degrees above the absolute zero of temperature can be visualized as the purely thermal or heat radiation emitted by a body cooled to that temperature. The maximum brightness of the 2.8 degree radiation is at a wavelength of 0.18 centimeters, in the microwave region of the electromagnetic spectrum. Robert Herman (now at the University of Texas) and I predicted in 1948 that such radiation should exist in a Big Bang universe, and it gave us great personal pleasure when the prediction was first confirmed by Arno Penzias and Robert Wilson in 1965. Their observation was rewarded by a Nobel Prize in 1978. Existence of the radiation is now well established, and its equivalent blackbody temperature is the most precisely known among cosmological parameters. It is popularly known as the three-degree radiation. There is no acceptable alternative physical explanation for this radiation other than as a fossil of the early Big Bang, a very much cooled relic of the radiation field existing in the universe some hundreds of thousands of years after the Big Bang. Paul Erdos, a noted mathematician, is quoted as having said that "God made two mistakes: he started the universe with a Big Bang, and then he left the three-degree radiation behind as evidence."

The Big Bang Model

What then is the picture of the evolving universe supported by the evidence I have briefly sketched? We run the equations from Einstein's relativity theory backward in time, making use of our knowledge of elementary particles and radiation, and develop the following. For the moment we shall stop our time reversal at about one second after the Big Bang, when the universe had expanded and cooled from conditions of high temperature and density which are almost unimaginable down to a temperature of some 10 billion degrees and with a density about a million times that of water. This density is ascribable almost entirely to the mass equivalent of the energy in the radiation field. At this time there was present a trace amount of matter in the form of neutrons, protons, electrons and neutrinos. Neutrinos are particles which are thought to be massless like photons, but which possess spin like electrons; with electrons they constitute a family of particles called leptons. Now consider time running in the usual sense. Thermonuclear reactions ensued between the neutrons and protons, building up such heavier nuclei as helium, deuterium, tritium (which subsequently disappeared as a result of radioactive decay), and some small amount of lithium, beryllium and boron. Reaction sequences were quenched by the continuing expansion and cooling of the universe, and by reduction of the supply of neutrons due to the reactions and to the radioactive decay of the free neutrons. All of this took a period of several minutes. Then nothing much of interest occurred for about a million years, by which time the temperature of the cooling plasma had dropped to several thousand degrees. Before this the universe had been opaque to the passage of radiation; now radiation could travel freely in the universe as the combination of protons with electrons formed hydrogen nuclei, removing the free electrons which had been principally responsible for the opacity. At this point the dynamics of the expansion changed, with the matter present controlling, rather than the radiation field, and it is hypothesized that perturbations in the density of matter led to the condensation of stars, stellar clusters, galaxies and clusters of galaxies. The universe has continued to expand and cool to the state in which we now observe it, with the evolution of the various objects, particularly stars, continuing, and the radiation field cooling to the three-degree value we measure today. The neutrinos probably did not contribute to the evolutionary formation processes, but are doubtless still present as an undetected background gas at several degrees Kelvin. I should note that cold neutrinos are extraordinarily difficult to observe.

Some Problems of the Canonical Big Bang

Let me hasten to add that this description of the universe is by no means problem-free. For one thing, there is as yet no fully satisfactory model for the evolution of galaxies or galactic clusters from density fluctuations in the primordial plasma. And such a model must account for the strange and diverse forms galaxies exhibit, as well as the presence of rotation and magnetic fields. While the three-degree radiation is most convincing fossil of the early universe, it is so isotropic as to cause conceptual problems. Thus far the radiation is found to be isotropic to better than about a part in ten thousand, even as observed in directions diametrically opposed. (There is an interesting exception to this statement, having to do with the fact that there is motion of the solar system, the Milky Way, and the local cluster of galaxies to which the Milky Way belongs, all in a particular direction in space. This motion shows up in a regular angular dependence of the background radiation, which acts pretty much like an "ether"- a fixed reference frame.) This high degree of isotropy reflects the smoothness of the distribution of matter at the time the universe went from being opaque to being transparent. Where then are the density fluctuations needed for galaxy formation in the early universe? And how do regions which apparenllv were never causally connected come to be so nearly at the same temperature~when we look in opposite directions we are seeing regions which apparently could not have "communicated" with each other, in the sense of sharing physical processes to insure their homogeneity, during the lifetime of the universe.

Another mysterious result is that the observed mean density of the universe - the density which would obtain on a large scale when we imagine all of the material spread out uniformly rather then concentrated in stars and galaxies-is only a factor of ten or so below that required for closure. By closure we mean that density which if exceeded would lead to a universe which would ultimately stop expanding and return upon itself in a "Big Crunch". Its rather like a rocket fired from earth with less than escape velocity, which ultimately falls back. So also would a universe which is closed, in which the mean density exceeds a particular value; the velocity of expansion vis-a-vis the mass density is less than the escape velocity. If the mean density is less than the closure density, then the velocity of expansion exceeds the escape velocity, and the universe will expand and cool forever. Such a universe is termed' 'open ."'

Measurements of the universal mean density are very much in a state of flux at present, for we are not certain of the amount or nature of unseen dark matter associated with galaxies or galactic clusters. It may turn out that the unseen neutrino sea will control the expansion if the neutrino has a non-zero mass. The search for a mass value ofthe neutrino is ongoing. With all of this why is the observed density so close to that required for closure, or is the closeness a coincidence?

Yet another question I would like to mention has to do with the origin of the ratio of the number of photons in the universe (the quantum wave-packets associated with the background radiation field) to the number of baryons (neutrons and protons). This ratio has a constant numerical value throughout the universal expansion, characterizing the particular Big Bang model. While this number had to be assigned on an ad hoc basis in the canonical Big Bang model, it has long been felt that it should be a quantity prescribed by the physics of the very early universe.

A final question I would like to mention has to do with the apparent lack of antimatter in the universe. Until recent work on symmetry-breaking, it had been taken for granted that there was a complete symmetry in the existence of particles and their anti-particles. Theory and observation had confirmed the existence of antiprotons, antineutrons, positrons (antielectrons), etc. Perhaps the most exciting ramification of the existence of antimatter is the fact that the collision of a particle with its antiparticle leads to their mutual annihilation and the appearance of their energy in the form of high-energy radiation. We can create antiparticles with accelerators, and some are created by high energy collisions of cosmic rays in the atmosphere, or by particle collisions in certain stellar atmospheres, but there is no evidence whatever for the existence of comparable amounts of matter and antimatter throughout the universe, as would be expected from symmetry considerations. It had been one of the ad hoc assumptions of the canonical model that somehow the symmetry in forming particles and antiparticles was destroyed in the very early universe, and that the period of nucleosynthesis which began a second or so after the Big Bang was free of antiparticles.

The Very Early Universe

In the last few years the very early universe-the time long before one second of the Big Bang had elapsed - has become a very popular area of research for physicists interested in high energy and elementary particle physics. The projected physical conditions in this regime are pretty much beyond the reach of large particle accelerators, present and projected, but appear to be sufficiently extreme that they may be of theoretical interest in the search for unification of the fundamental forces of nature. Physics has long had on its research agenda the attempt to find a single law which governs the four forcer-gravitation, electromagnetic (governing absorption and emission of radiation, as well as binding electrons in atoms and atoms to each other to form molecules), the weak nuclear force (which governs the radioactive emission of positrons or electrons in beta-disintegrations) and the strong nuclear force (which governs binding within nuclei). Unification of the electromagnetic and weak nuclear forces has already been achieved, and work continues on including strong nuclear forces and ultimately gravitation. This is a program on which Einstein spent much of his later career, without success.

Work already done on unification, under the rubric of "Grand Unified Theories"(GUTs) has not achieved the unification goal, but has already produced some insights into a possible model for the very early universe, and has provided some predictions which are subject to observational falsification, as required for any theory to be considered seriously. In particular, it appears that symmetry-breaking was a feature of the early universe physics, and the predominance of matter over antimatter a consequence. At some very early time the contents of the universe which we can now observe were compressed into such a tiny volume that there was indeed enough time for communication throughout the volume, with resulting homogenization of the contents. The particular ratio of photon number to baryon number which is required to understand the synthesis of the light elements beginning about a second after the Big Bang also appears to come out of the physics at early times. One of the consequences of these theories is the prediction that the proton, by far the major constituent of the universe, should be radioactive, with a decay life time which is almost unimaginably long, ten to the power thirty-two, years. With present experimental techniques, such decay should be marginally observable, and indeed there are a number of major experiments under way around the world to detect the decay of the proton. Finally the recent theories of the early universe appear to require that the mean density of the universe then and now must be the critical value, the value separating closed from open models. In terms of the presently observed expansion, it means that there is neither acceleration or deceleration -the universe is flying apart with just exactly the escape velocity. There are other consequences of the several GUTs theories which may be observable when new particle accelerators such as the proposed Superconduction Super Collider come on line.

For the moment I would characterize the sundry theories of the universe during the first fraction of a second of its existence as considerably more speculative than the canonical Big Bang, although their success in at least qualitatively explaining some of the problems of the canonical model is certainly provocative.

A most exciting aspect of the early universe research is the view now emerging that the universe originated as a fluctuation in a vacuum. More than a hundred years ago a famous physicist named Boltzmann suggested that the universe was a fluctuation in an equilibrium system, and that it might vanish as unexpectedly as it had appeared-a not unknown behaviour for fluctuations studied in laboratory systems. Alternative views now are that the universe started as a fluctuation in a normal vacuum, or in a vacuum in an excited state, a so-called "false vacuum", or that it may have emerged from a vacuum state by quantum-mechanical tunneling, a phenomenon well-known in terrestrial physics. Suffice it to say that the earliest fraction of a second of the existence of the universe almost certainly was governed by quantum mechanical phenomena. For example, the densities must have been so high as to require a quantum mechanical theory of gravitation. Again physicists are working on structuring such a theory at present.

In a sense the fact that we must consider the early universe in a quantum-mechanical context is somewhat distressing, for it is becoming increasingly clear that the world of quantum physics is particularly counter-intuitive. Theory proposes and experiment demonstrates more and more that events in the microcosmos are governed by quantum-mechanical behaviour which is difficult for us to visualize in terms of our everyday experience, and the same difficulties will obtain with a vengeance when we try to understand the universe in the epoch when it is much less than one second old. It is exceedingly important that we look forward to sorting out early universe phenomena by observational validation of theoretical predictions.

Alan Guth, who first proposed that the universe went through a very early period of rapid expansion-the so-called "inflationary universe"-which evolved into the canonical model within the first second, characterized the idea of a vacuum fluctuation by suggesting that "the universe may be the ultimate free lunch." Edward Tryon, who was among the first to propose an origin from a vacuum fluctuation, characterized the event as "merely one of those things which happen from time to time." In response to the usual question about what there was before a vacuum fluctuation or tunneling, or what have you, one can hardly do better than quote Gertrude Stein (who was actually referring to Oakland, California)-"there was no there there, no then then." Current cosmological research on the very early universe seems to be converging on the fact that space and time in universe as we observe and know it began with the Big Bang.

The Future (Now till ?)

Speculation on the future of the universe is an academic exercise in the truest sense of the words, but nevertheless is fascinating to many. I have already mentioned the importance of the mean matter density in the universe in determining the expansion dynamics. The answer is not yet in on what the precise density is. Present evidence, based on the luminous matter we observe, with some reasonable assumption about the amount of nonluminous or dark matter, suggests a low density universe, one which is open, and which will continue to expand and cool as it does now. Ultimately the formation of new stars from dust and gas in some galaxies will cease, and stars will snuff out or blow up as they run out of thermonuclear fuel. This would be very far in the future, I assure you. If on the other hand the mean density exceeds the critical density, the expansion of the universe will ultimately come to a halt and the universe will begin to fall in upon itself, with a Big Crunch as the end result. Stars, galaxies and clusters of galaxies would have merged long before the end, and any semblance of the present universe eliminated. It is interesting to speculate on whether there would be a bounce at the Big Crunch, followed by another expansion cycle. One could even speculate that the universe is a cyclic phenomenon, going from expansion to contraction to expansion and so on.

If the proton turns out to be a radioactive particle, then in a sufficiently long time all of the chemical elements as we know them would disappear, and the expanding and cooling universe will evolve to a cold dilute gas of leptons and increasingly low temperature radiation. If black holes exist, even the leptons would ultimately be swallowed up, and since theory suggests that black holes decay away by the emission of thermal radiation, then finally the universe would be left as a gas of cold radiation, nothing more. So we might speak of a "heat" death, or a "cold" death, according to whether the universe is open or closed.

Another possibility raised by the notion that the universe is a fluctuation would be that the fluctuation would vanish at some point, just as it arose. All would cease to exist-we would never be aware of what was happening. If the cessation were not uniform, the information that it was happening would travel at the speed of light, and we would never know what hit us. If the cessation were uniform, that would be it, also.

Before anyone panics about the very long term dismal future scenarios I have just described let me add that we have a much shorter term problem. Our understanding of the evolution of stars suggests that the sun will change from its present state as a "G-type main sequence star" to a "red giant" in some billions of years, the solar atmosphere will expand to beyond the orbit of Jupiter, and unless we have colonized the outer planets or other planetary systems in the universe, that will be it for us. In summary, I suggest it is still prudent for all of you to save for retirement as far as the cosmological future is concerned. I feel less sanguine about our ability to avoid wiping ourselves out in some stupid war long, long before.

The Anthropic Principle

Some few cosmologists have in recent years begun to display a kind of ultimate vanity. They, and they are small in number, propose an "Anthropic Cosmological Principle" which is very difficult to distinguish from a tautology, in my view. Timothy Ferris, a science writer, characterizes this principle as "I think, therefore the universe is:' Heinz Pagels, who works on the physics of the early universe, terms the anthropic principle Cozy Cosmology:' He goes on to remark about those espousing this principle that" ...faced with questions that do not really fit into the framework of science (now), they are loathe to resort to religious explanation, yet their curiosity will not let them leave matters unaddressed. Hence the anthropic principle. It is the closest that some atheists can get to God ."

I want to say a bit more about this principle than its probably worth, but the subject is a relevant one for a talk on cosmology and Humanism. There is a recent and very thorough book on the anthropic principle which has much to recommend it as a good technical survey of contemporary cosmology, but which is frustrating to me and to many others in its espousal of the principle (The book is *The Anthropic Cosmological Principle*, by

John D. Barrow and Frank J. Tipler, Clarendon Press, Oxford, 1986. If any of you undertake to read the book I urge you first to look at the review by Martin Gardner, in *The New York Review of Books*, May 8, 1986. I have borrowed some choice phrases freely from Gardner.) The authors describe various shades of anthropic principle. The Weak Anthropic Principle, which is clearly a tautology, states that because we exist, the universe must be so constructed as to have allowed us to evolve. Then there is a Strong-Anthropic Principle, which states that life of any sort in the universe is impossible unless the basic laws of nature are exactly what they are. We are here, therefore the constants of nature, which define the forces and fields underlying matter and energy, had to be what they are. Then there is a Participatory Anthropic Principle which goes further in suggesting that no universe can exist unless it contains conscious observers. This statement appears to derive from quantum mechanics in which the act of measurement collapses a wave function (for example, describing an electron) to a local quantity such as position or momentum while incorporating the measuring equipment (and observer) as a part of the system including the wave function. Lastly, there is a Final Anthropic Principle, which argues that although life probably exists only on earth, now that it exists it will be impossible to destroy. Were the earth, and therefore presumably the universe, to lose its observers, then the Participatory Anthropic Principle would ,argue that the universe would have demolished itself. This is beyond comprehension, and therefore the loss of all observers ruled out. This may provide comfort to those concerned that the residents of earth may be eliminated in a nuclear holocaust. Or could one argue that the hardy cockroach will survive and be an observer adequate to insure the survival of the universe?

Embedded in the various levels of anthropic principle are a number of things which I cannot accept easily. For example, it certainly suggests that humankind represents the only intelligent life in the universe. Which is rather an ultimate conceit. It renders unnecessary any further search for understanding by science. As science has developed, more and more of the constants of nature (the strength of the fundamental forces, the velocity of light, Planck's constant in the quantum unit of energy, etc.) are viewed as quantities which are or will turn out to be the natural consequence of theoretical models which are constructed. If they are all the way they are because otherwise we would not be here to observe and the existence of the universe irrelevant, then scientists might as well turn in their union cards. I see the principle as a thinly veiled attempt to subsume the as yet unexplained questions in nature under the rubric of "God-given." I might not go quite so far as Gardner, who abbreviated each of the anthropic principles as W.A.P., S.A.P., P.A.P.. and F.A.P., and who summed it all up as a Completely Ridiculous Anthropic Principle, C.R.A.P., but then who am I to argue with Gardner. The anthropic principle is certainly grist for the mill of humanist discussion.

The Inevitability of Humanism

From discussions which I have had with many colleagues in science and engineering, and particularly with others who have worked in cosmology, I have come to the conclusion that many, if not most, are really humanists. But, because of social pressure and fear of censure, they find it convenient and comfortable either to completely abstain from any association with religion, or to belong to a religious institution which will provide a place for their children to conform by going to a sunday school, as well as a place for ceremonial naming of children, marriages, and funerals. If the religions of the world practiced the tolerance many of them claim to have, many humanists would emerge from the closet, as it were, and humanist organizations would become much more popular.

I do not believe that humanist organizations can or should claim to be religious in nature. I believe such organizations can satisfy a need many have for a place to celebrate the major events of life in the company of people with like mind, but, as soon as Humanism claims to be a religion, it will be attacked, even more vociferously than now, by religious fundamentalists who want the biblical view of the universe taught in the schools as a theory, as an alternate to the scientific view of the universe, which they characterize as Secular Humanism and which they would dearly love to have identified as a religion. Its more important to me that we teach our children science correctly than that we argue on matters of principle that Humanism, be it called secular or religious, is a "religion."

To sum up my views based on my studies of cosmology and some philosophizing, I submit that we have only ourselves, one another, and a magnificent universe which is completely indifferent to our existence. We are in fact a part of that universe, embodying the same laws of nature, and made of the same stuff as the stars, but evolved in such a way that we have self-awareness. With this self-awareness has come a curiosity about the rest of the universe which drives intellectual evolution. By the processes inherent in evolution we have achieved modes of behavior that possess survival value. Our search for understanding and for improved modes of behavior will continue as we evolve, and it is the evolutionary process which gives me hope for the future of humankind. We are on our own, and Humanism, which is simply a statement that we are responsible for running our lives, is a viewpoint which all of us will come to finally for its survival value.

(I am indebeted to my colleague Dr. Robert Herman for his incisive comments on this presentation.)