Cosmology According to Hoyle

The universe according to Hoyle gets more and more mindblowing

BY DIETRICK E. THOMSEN

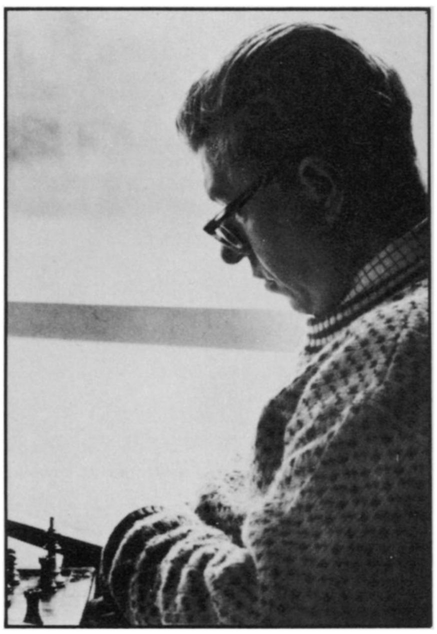
''Unto ages of ages, amen,'' is a phrase that ends Eastern Orthodox prayers. The Latin church echoes the sentiment: Per omnia saecula saeculorum. Ages of ages, worlds of worlds are ancient phrases. The idea that the sum of the universe is more than we can see or remember is a very old part of the human consciousness.

The usual modern cosmology rejects it: There is one cosmos. It started with a big bang, the moment of creation, time zero, *the* space-time singularity. Before that? Well, the phrase ''before time zero'' has no meaning. There's theology with this attitude too. St. Augustine of Hippo relates that his sermons were heckled by people who asked what God was doing before He created the world. Inventing hell for those who ask that question, the good bishop replied.

Implicit in the big-bang attitude is the notion that we see all there is to see. Some of the universe may be beyond the range of our telescopes, but what's there is not importantly different from what we can see. There's no barrier in space-time through which we intrinsically can't see, no worlds beyond worlds.

Not so, according to Hoyle. Fred Hoyle, that is. The universe is divided into a number of separate space-time volumes of quite different (in fact opposite) character separated by temporal and spatial boundaries of a very strange sort. Hoyle, who recently left Cambridge University after a long and distinguished career there and now signs himself from Kitt Peak National Observatory in Tucson, has been working for years with his former student and longtime colleague J. V. Narlikar in putting this heterodox cosmology together. His latest installment appears in a recent issue of the ASTROPHYSICAL JOURNAL (196:661).

But wait. Is there not definite evidence for the big-bang theory? For ten years proponents of the big-bang theory have



Hoyle postulates that blackbody radiation is starlight emitted on the other side that has come from 150 billion years ago. Stars and galaxies go back that far on the other side.

been waving the three-degree blackbody radiation like a flag of victory. Their theory predicts such a background flux of radio waves as a leftover from the big bang, and—see—it has been found. Hoyle's present paper is concerned, among other things, with showing that the blackbody radiation has a place in his cosmology too, and that the traditional cosmology applies only to a small region of his own.

Hoyle begins with the concept of a mass field analogous to a force field. Hoyle believes that the mass of a body is not constant, but can vary according to its position in space-time (in particular, its position in time). This can be explained by a postulate that the mass of every body depends on the distribution of the rest of the matter in the universe. This is a philosophical point often called Mach's principle after Ernst Mach, a theoretical physicist of the late 19th century. Einstein denied it, and it is at this fundamental point that modern heterodox cosmologists part company with him and with the big-bang people who follow him.

Hoyle proceeds to set up field equations analogous to those for an electromagnetic field. Field equations tell you how something varies with position. If you have electric field equations for a given space, you can plug in a body's position (and its charge) and calculate the force on it. Hoyle's mass-field equations allow the calculation of a body's mass from a knowledge of its position in space-time.

Hoyle finds that his mass-field equations have a possibility of both positive and negative contributions to a particle's mass like the opposite contributions of positive and negative electric charges to an electric force. In electromagnetism the forces are so strong that plus and minus charges become evenly distributed and a cosmic overall neutrality results. This is not the case with Hoyle's mass-field, and he proposes that aggregates of one sign or the other can exist separated by distinct time and space boundaries. This, then, is Hoyle's cosmos—a checkerboard of a number of such regions of alternating mass polarity. He doesn't say how many, and there doesn't seem to be any necessary limit. It is thus by implication a steady-state cosmology.

The regions or aggregates are large compared to the limits of astronomical observation. ''Cosmological distances, as ordinarily understood, fit into a single aggregate. Our experience in astronomy is therefore confined to one sign for the contributions to the mass field.''

Because there are such regions of opposed polarity does not mean that mass goes from positive to negative as a body crosses a boundary. There is another factor in the equations, the coupling constant that links particles to the field. This too can change sign crossing a boundary. Therefore mass is positive in all regions, but there are places where it can be zero, and they are very important places, as Hoyle points out after a short excursus into the theory of measurement and dimensional analysis.

The position of the speed of light as a universal speed limit allows Hoyle to establish a "natural system" of units for measuring physical quantities that is a cornerstone of his cosmology. In traditional units the numerical value of the speed of light and its dimensions must be dragged through every calculation. In Hoyle's system of measurement, velocity becomes a dimensionless quantity and the speed of light simply vanishes from the equations.

He begins by observing that every determination of a velocity involves measuring a time interval and a space interval. In modern technology we do both of these by counting the vibrations of a particular atomic energy transition. For time we use a cesium transition; for space a krypton one. Thus every velocity is the ratio between different counts of these two vibrations. A ratio between two numbers with the same dimensions is itself dimensionless so velocity is really a dimensionless number. If the same vibration is used to measure both time and space (and Hoyle can demand this in principle if not in practice), the speed of light becomes unity and vanishes from the equations.

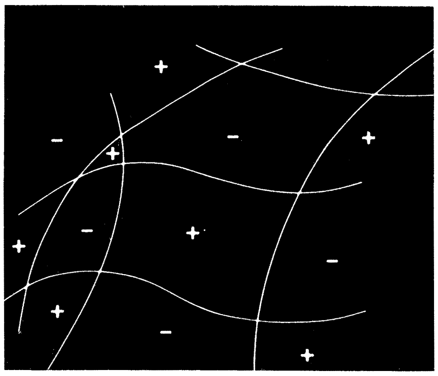
A similar procedure gets rid of Planck's constant. The result of all this is that the dimension called mass becomes simply the inverse of a length. Furthermore, all the variables of physics turn out to be definable as powers of mass.

Since the data derived in every physical experiment involve ratios of these variables (such things as pressure, energy density, charge density, luminosity, force, energy, mass), in Hoyle's system all experiments involve the counting of dimensionless numbers. This makes it very difficult to measure variations in the basic unit, mass, which goes into all parts of every ratio, if it varies only very little over a short distance in space-time.

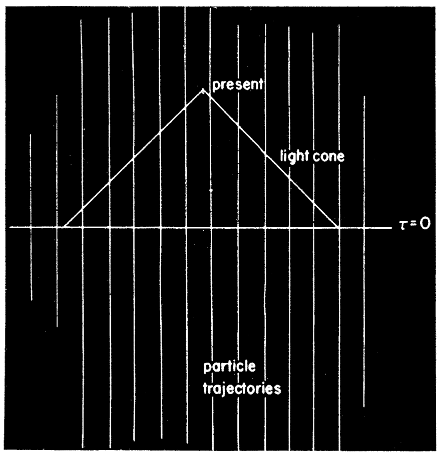
It is possible in principle to measure the difference over large intervals, say between a laboratory on earth and a distant quasar, by measuring the difference between the frequency of a given atomic transition in the light received from the quasar and the same transition from a source in the laboratory. That there are shifts, called redshifts, is well known. But there is an ambiguity here. The geometric characteristics of space may change from here to there, and that change may affect the mass-field equations and therefore the mass of an electron, and therefore the emitted frequency in an unknown way.

Hoyle begins to study the effect of changing the geometric characteristics of the space to see whether there is a way out of the ambiguity. He finds that there is really no way out, and that seeking one may be a wild goose chase. More significant, there is a geometry in which mass does *not* depend on position. In other words, by giving space particular geometric qualities a theory in which mass generally depends on location yields a particular solution in which that dependence cancels itself.

This is very significant because the



Checkerboard universe, a 2-D realization.



Hoyle/Astrophys. J.

Light crosses boundary perpendicularly.

Einstein equations are equations of that sort. The Einstein equations thus appear as a particular case of Hoyle's general hypothesis, provided the geometry is right. Hoyle proceeds to determine where the geometry is right.

One thing is immediately apparent. The Einstein equations cannot be used across the boundaries between regions of different mass polarities because they will not work where the mass goes to zero. The Einstein equations are restricted to single polarity regions. This explains a lot of things, according to Hoyle.

A cosmology based on the Einstein equations (usually called an Einstein-de Sitter model) cannot get beyond the boundary of our own aggregate so that the boundary looks like the origin of the universe.

Hoyle concludes: "Enough has been said to show that we may owe many aspects of our present-day world to remote ancestors on the other side of the barrier which has hitherto been thought to represent the origin of the universe."

Hoyle now wants to find what will carry across the boundary. He begins to study the space-time in a single aggregate near the boundary, using the Einstein solutions, which he can do because for the moment he does not intend to cross. Another important point emerges: Einstein geometry works for regions near boundaries, but not necessarily for those far away from boundaries. "Although the region over which the Einstein-de Sitter model applies is only a small element of the whole universe, it encompasses everything which the astronomer observes, even with the largest telescope." So we live near a boundary.

It turns out that what crosses the boundary is a geometry in which space is flat so that light propagates at right angles to the boundary. As well as being a place where mass is zero, the boundary is a time zero. "Before time zero" now has a meaning, and it can be defined in terms of the propagation of light. For on our side of time zero light propagates away from the boundary. On the other side it propagates toward it.

Light can thus cross the boundary between two polarity regions, between negative and positive time. And this is Hoyle's postulate about the blackbody radiation: It is starlight emitted on the other side that has come across the boundary. Taking the present estimate of time since time zero—15 billion years—he calculates how far on the other side it comes from—150 billion years. Stars and galaxies go back that far on the other side.

If stars and galaxies exist on the other side, do they, as they approach the boundary, condense into a formless blob in which their individuality is lost? Not quite, Hoyle finds. Matter that was associated in a star on the other side can somehow retain its connection as it comes through the boundary so that stars on this side may be related to ancestors on the other. This could lead to variations of density coming through the boundary. Nucleosynthesis would then vary according to the density, and that would affect the distribution of chemical elements on our side. Hoyle remarks: "Enough has been said to show that we may owe many aspects of our present-day world to remote ancestors on the other side of the barrier which has hitherto been thought to represent the origin of the universe." □