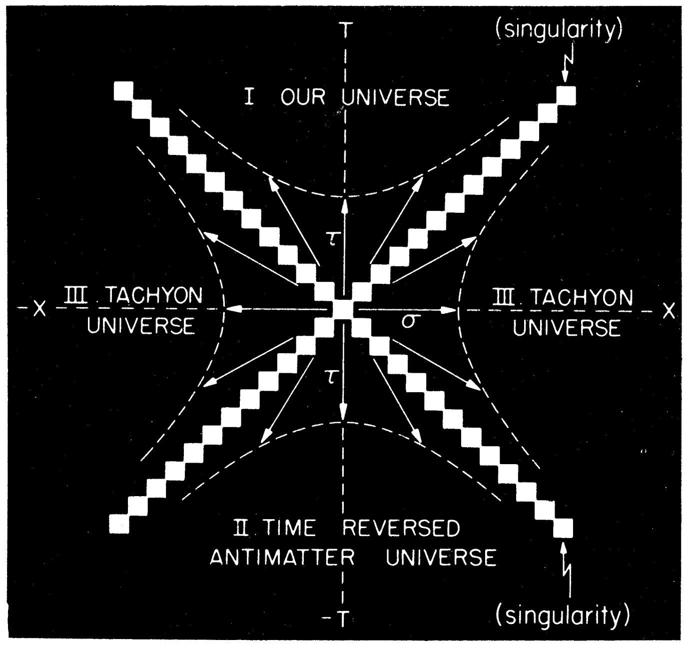
A Cosmological Triple Play

Is ours only one of three universes?

by Dietrick E. Thomsen



Space-time diagram of Gott's proposed three-universe cosmological model.

Gott/Astrophysical Journal

The usual big-bang cosmology connected with Einsteinian general relativity has the universe starting from a point of space-time that is called the singularity. "Singularity" is a mathematician's euphemism for something difficult to deal with, a point at which physically the universe has no dimensions and infinite density. From this point the universe expands as time proceeds, extending its dimensions and lowering its density.

Such is the usual picture of the expanding universe. But this universe occupies only one region of the space-time that physicists are used to dealing with, the region that lies to the future of the singularity. The question arises: What happens in the other regions of space-time that physicists are able to imagine? Does anything happen in the singularity's past? Can anything happen beside it, so to speak in the regions of space-time called spacelike?"

The answer, says J. Richard Gott III of California Institute of Technology, is yes. Writing in the latest ASTROPHYSICAL JOURNAL (Vol. 187 No. 1), he shows that if we look for the most general solutions of Einstein's equations, in flat space-time, we come up with three universes. One is our own, which we have just described, lying in the singularity's future and dominated by ordinary matter. Let us call it Universe I. Universe II lies in the singularity's past and is dominated by antimatter. Universe III lies in the spacelike region of space-time and is inhabited by tachyons, particles that travel faster than light.

To understand the geometry of this rather mind-boggling concept, it is necessary to spend a few words on a general description of space-time. In true space-time there are three spacelike dimensions and one timelike dimension. For graphic purposes two of the space dimensions are suppressed, and a two-dimensional graph is drawn in which the vertical axis is time and the horizontal space.

Every point in this two dimensional space-time represents an event: It specifies both the location and the time at which something happens. The start of a particular particle's flight may be one event; its finish, another. The slope of the line that joins them represents the velocity of the flight.

Calculation shows that the lines running at 45 degrees to the time and space axes are of particular importance. They represent objects moving at the speed of light (they define what is called the light cone), and in ordinary physics one cannot cross them in going from event to event. The light lines (or the light cone in more than two dimensions) divide space-time into two regions, the timelike (in the upper and lower quadrants) and the spacelike in the right and left quadrants.

For two events in the timelike region (where we live) it is possible to find an observer moving in such a way that the two events seem separated in time only. If observer A sees a particle moving from x to y while the time goes from t_1 to t_2, observer B, who happens to be going along with the particle, will see the time change only. If the particle was in his hand at the start of the flight it will be in his hand at the end. In the spacelike region, in a similar way one can find an observer for whom two events are simultaneous but appear to represent an instantaneous translation in space. Thus in the spacelike region our usual perceptions of space and time and cause and effect are overthrown, but we need not worry about it since we can never get there.

When observer B moves with respect to observer A, from A's point of view the motion represents a skewing of his time axis in the direction of the light line. It can also be shown that his space axis will skew and also in the direction of the light line. The faster B goes, the narrower becomes the angle between his space and time axes. When he reaches the speed of light his space and time axes meet in a grand flash of—well that's the singularity, as Gott considers it.

There's no crossing it. Gott puts our universe in the upper quadrant to the future of the singularity. His time-reversed antimatter universe lies in the lower quadrant to its past. And his tachyon universe lies in the spacelike region, which is not two regions but one. This can be seen if we add a third dimension and imagine the diagram rotated around the time axis: Regions I and II become cones; region III becomes a wedge-shaped ring.

There is no communication across the singularity. Antimatter and tachyons can exist in our universe occasionally and ephemerally—they are not visitors from the other universes. They are produced here. There are differences in perception: Our view of Universe II, if we could see it, would be that it is dominated by matter and contracting. To its own inhabitants it looks as if antimatter dominates and it is expanding. Finally the principal of causality, which says that neither information nor energy can be transmitted faster than light, is not violated in the tachyon universe. Though the tachyons themselves go faster than light, their radiation, which is the only way they can transmit energy or information, does not.

Gott concludes: "The model we have presented is a unified, time-symmetric model treating matter, antimatter and tachyons in a natural and equal fashion. The model is consistent with our present observations of the universe and could gain support from an experimental discovery of tachyons. . . ." □