PHILOSOPHY OF SCIENCE

Boundaries Not Established

Steve Fuller

Impossibility. The Limits of Science and the Science of Limits. JOHN BARROW. Oxford University Press, New York, 1998. ix, 279 pp. $25.00. ISBN 0-19-851890-0.

There are two reasons for surveying the concept of impossibility. One is to show that what had been thought impossible was eventually deemed possible. Another is to show that what had been thought possible was eventually deemed impossible. The first survey, inspired by Hegel, would recount the history of science as ever self-transcending. Here "impossible" refers to thoughts and actions that went beyond the moral and imaginative constraints of one age but were ultimately realized, perhaps in a somewhat different form, within the constraints of a later age. The second survey, inspired by Bertrand Russell, would recount the history of science as ever self-limiting. Here "impossible" refers to thoughts and actions that, after some hopeful attempts at realization, ultimately ran afoul of the most basic laws of logic and physics.

John Barrow's latest book belongs largely to the second genre. Consequently, the reader is treated to a selection of paradoxes and cognitive glass ceilings, some spurious but most genuine, which, taken on their own terms, are logically insurmountable: Goedel's incompleteness theorem, Heisenberg's uncertainty principle, various barriers to solving scientific problems that arise from the intractability of computations and the finitude of material resources, and the paradoxes associated with voting preferences or predicting human behavior more generally. Virtually all of Barrow's cases will be familiar to scientifically literate readers, though his efforts at theorizing their general characteristics give his book added value.

Why is Barrow, a professor of astronomy at Sussex University, interested in impossibility in the first place? The author of several best-selling popularizations of science, Barrow is probably best known to American readers for his collaboration with Tulane physicist Frank Tipler in developing the "anthropic principle," which injects an element of purpose into cosmology by arguing that a useful interpretation of the organization of the universe is that it was designed so that we can know it. To be sure, Barrow hides references to the principle in the notes and barely alludes to the principle's theistic implications in the text. Nevertheless, theism may lurk behind Barrow's antipathy to positivists such as Comte, Mach, and Haeckel, all of whom explicitly legislated the limits of scientific inquiry in terms of empirical verifiability. True, they underestimated science's possibilities, but they also portrayed science as a self-contained enterprise (a "language game in Wittgenstein's sense) that left space for a variety of supplementary beliefs and interests that lay beyond the empirically verifiable. Secular politics could fill the void just as easily as religious belief—as indeed it did in positivism's heyday. If, however, one wants the void filled only by God, then it is rhetorically more effective to let scientific inquiry encounter unplanned resistance that can then be traced to an extra-scientific intelligence.

Would Hegel have been impressed by Barrow's efforts? I am afraid not. Consider the section condescendingly entitled, "Time travel: Is the universe safe for historians?" Time travel usually founders on the shoals of semantics, not physics. Those willing to entertain the great leap backward generally concede the physical possibility of moving close enough to the speed of light to reverse time's arrow. The real problems arise upon arrival in the past. Can time travelers

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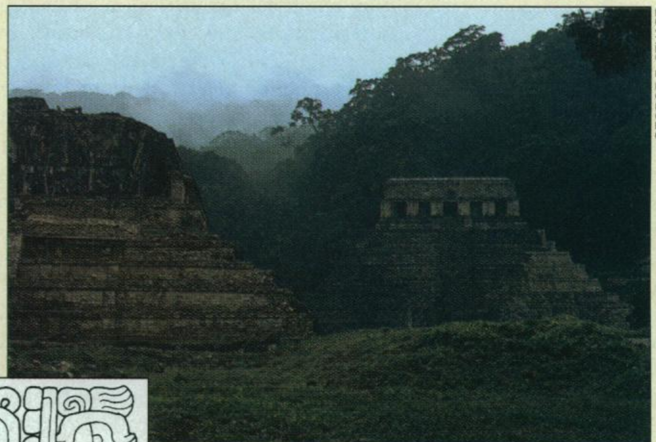
ALSO NOTEWORTHY

The Code of Kings. The Language of Seven Sacred Maya Temples and Tombs. Linda Schele and Peter Mathews. Scribner, New York, 1998. 432 pp., illus., $40. ISBN 0-684-80106-X.



GEORGE E. STUART

LINDA SCHELE

In the guise of a profusely illustrated guided tour of buildings from seven sites in Mesoamerica, Linda Schele and Peter Mathews offer a detailed introduction to the politics, religion, and histories recorded in the architecture and art of the ancient Maya. The authors provide vivid interpretations of the worlds of the once-great cities' rulers and inhabitants by using translations and explanations (many the result of their own research) of the hieroglyphic inscriptions covering the surfaces of Maya ruins in combination with other archeological evidence. One of the buildings featured is the Temple of the Inscriptions at Palenque (right). Inside, three huge hieroglyphic panels form the longest continuous Maya text to survive intact from the Classic period. The history recorded on them ends with the four glyphs (inset), now read as "He gave caring to the 9-Images-House, its holy name, the tomb of the Sun-faced Hanab-Pakal, Holy Palenque Lord." The photograph was taken during the 1973 conference at which Schele and Mathews helped launch a revolution in Mayan scholarship by recovering this dynastic history in a three-hour stint of translating. Through her many subsequent activities, Linda Schele played an especially important role in presenting the new interpretations to scholars, the public, and the living Maya. Unfortunately, this splendid book marks the end of her career, as she died last month.

–Sherman Suter

change the past without jeopardizing their subsequent existence in the present? Barrow argues that the causal significance of a time traveler should not be presumed. He holds that if the traveler were to have an impact, the effects would render history "different" but not "changed," since the latter expression implies a necessary course to history that contradicts the possibility of genuine action of any sort, be it by a native or an alien of a given time.

The conundra surrounding time travel arise if the past exerts an asymmetrical control over the present comparable to an imperial power over a distant colony. But what if the past is no more than a sphere of influence in the present? Even without eliminating the foreign presence, the natives can nevertheless substantially contain its influence. Take that favorite destination of time travelers, the moment Lincoln was shot by John Wilkes Booth. If future historians were to agree that prolonging Lincoln's life would have made little difference to the overall course of history, then little would be gained by replaying what happened on April 14, 1865. Indeed, if the "turning point" came to be seen as a motif in popular historical writing, rather than an important joint at which reality is cut, then the fascination with time travel might simply evaporate. Of course, Booth's murder of Lincoln would remain, but who ever said that altering an event is either necessary or sufficient for altering its significance?

Those who think they understand what is and is not possible should envisage what would happen if scientists succeeded in creating a workable time machine just when the idea of time travel came to be seen as old-fashioned. It would be like discovering limitless supplies of coal and petroleum on neighboring planets, just when we shift to more economical sources of fuel or simply learn to economize on fuel altogether. These are examples of what Hegel called the "cunning of reason," whereby knowledge and desire interact in ways that guarantee that all putative limits on human achievement will eventually become obsolete. Hopefully, in the second edition of his provocative book, Barrow will include a section entitled: "History: Is the universe safe for physicists?"

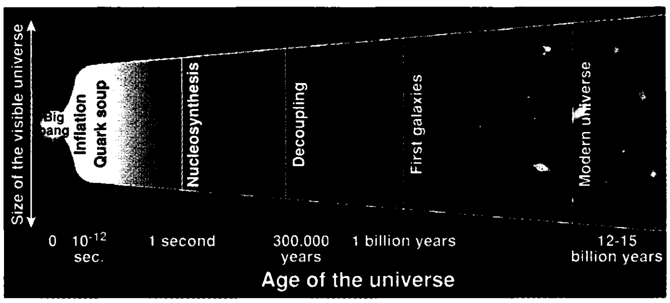
RESEARCH: COSMOLOGY

The Case of the Curved Universe: Open, Closed, or Flat?

Marc Kamionkowski

Determination of the geometry of the universe has been a central goal of cosmology ever since Hubble discovered its expansion 75 years ago. Is it a multidimensional equivalent of the two-dimensional surface of a sheet of paper ("flat"), a sphere ("closed"), or a saddle ("open")? The geometry determines whether the universe will expand forever or eventually recollapse, and it may also shed light on its origin. Particle theories suggest that in the extreme temperatures prevalent in the very early universe, gravity may have briefly become a repulsive, rather than attractive, force. If so, the ensuing period of "inflation" (*1*) could account for some of the most fundamental features of the universe, such as the remarkable smoothness of the cosmic microwave background, the afterglow of the big bang (see schematic timeline).

Until now, most astronomers have pursued the geometry by attempting to measure the mass density of the universe. According to general relativity, if the density is equal to, larger than, or smaller than a "critical density" fixed by the expansion rate, then the universe is flat, open, or closed, respectively. Several measurements currently seem to suggest a density only a fraction $\Omega \cong 0.3$ of the critical density (as opposed to $\Omega = 1$ predicted by inflation). However, most of these measurements probe only the mass that clusters with galaxies. If a substantial amount of some more diffuse component of matter exists, such as neutrinos or "vacuum energy" (Einstein's cosmological constant), then the measurements do not necessarily tell us the geometry of the universe. The research article by Gawiser and Silk (*2*) on page 1405 of this issue and an accompanying commentary on page 1398 by Primack tell this side of the story (*3*).



From smooth to structured. Schematic history of the universe. The big bang may have been followed by a period of rapid inflation, with the resulting "soup" of particles coalescing into nucleons and lighter elements. Matter and radiation eventually became decoupled, the former gravitationally clumping into the structure of the modern universe and the latter yielding the microwave background we see today. The seeds from which galaxies grew should be apparent in the variations in the radiation background.

ADAPTED FROM ILLUSTRATION BY B. SANDERS, THE NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS, UNIVERSITY OF ILLINOIS.

Another possibility is to look directly for the effects of a curved universe. As an analogy, consider geometry on a two-dimensional surface. On a flat surface, the interior angles of a triangle sum to 180° and the circumference of a circle is 2π times its radius. However, when drawn on the surface of a sphere, the interior angles of a triangle sum to more than 180°, and the circumference of a circle is less than 2π times the radius. Similar lines of reasoning show that in an open (closed) universe, objects of some fixed size will appear to be smaller (larger) than they would in a flat universe.

The problem, then, is to find distant objects in the universe of known size ("standard rulers"). It was recently proposed that features at the cosmic microwave background surface of last scatter could provide such standard rulers (*4*). The photons that make up the cosmic microwave background last scattered roughly 10 to 15 billion years ago, when the universe was only 300,000 years old. Therefore, when we look at the cosmic microwave background, we see a spherical surface in the early universe 10 to 15 billion light-years away. Although galaxies and clusters of galaxies had not yet formed, the seeds that later grew into these structures existed, and we know the distribution of their intrinsic sizes. By measuring the distribution of their apparent sizes on the sky, we can determine the geometry of the universe.

More precisely, one must measure the angular power spectrum of the cosmic microwave background: Suppose we measure the temperature $T(\theta)$ as a function of direc-

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