Another Aftershock for the Big Bang

Last year in this journal I reported evidence that the cosmological redshift of galaxy light may not indicate that the universe is expanding at all. Results from several cosmological tests favor instead an energy loss mechanism in a basically static universe. (*Apeiron*, January 1995, pp. 20- 24.)

The past year's research and discoveries have given mainstream cosmologists little consolation for shoring up the crumbling edifice of the standard big bang model. Much of the latest news concerns quasars. Here are the highlights of two of the most significant new findings reported in the series "Remarkable Papers in the Journals" in the *Meta Research Bulletin*, for which I serve as editor.

Galaxies are extended objects, the closest of which are clearly resolvable into individual stars. Quasars, by contrast, are generally point-like objects, sometimes visible only to radio telescopes, whose true nature is still debated.

Because many quasars have much higher redshifts than most visible galaxies, in the standard model that is taken as an indicator that quasars are at extreme distances, that their light has been in transit to us for hundreds of millions to billions of years, and that quasars therefore reveal what the universe looked like long ago, when it was presumed to be much younger. According to these ideas, most or perhaps all quasars have long since died out, which explains why we see very few of them in the local universe today. Since this view implies they are some sort of evolutionary stage in the development of galaxies, quasars are presumed to be the large, energetic, active cores of young, forming galaxies—most probably fueled by a huge "black hole". Although the host galaxies in which most quasars are embedded are not visible to astronomers, a faint, fuzzy glow surrounding many quasars was presumed to be from the host galaxy.

Yet recently, astronomers using the Hubble Space Telescope to image some relatively nearby quasars deeply and with high resolution were unable to find any trace of the host galaxies. Astronomers Bahcall & Kirhakos found no host galaxies for eight luminous quasars examined, and suggested the quasar phenomenon must precede star formation in primitive galaxies (*Ap. J.* 435, L11-L14, 1994). They conceded this finding was most unexpected. In later work, Bahcall, Kirhakos & Schneider explained that the most luminous quasars apparently do not reside in the most luminous galaxies, but instead must exist in a variety of environments (*Ap. J.* 450, 486-500, 1995).

But astronomers have been struggling for years to force-fit quasars into big bang cosmology without having to concede that the large redshift of their light might be caused by something other than the expansion of the universe. To maintain that part of the edifice, astronomers have already been obliged to assert several other strange hypotheses about quasars:

- In contrast to galaxies, little if any intrinsic relationship between redshift and apparent brightness for quasars appears to exist, according to new results from the Large Bright Quasar Survey.
- Knots in quasar jets are seen to move outward. If quasars redshifts are due to universal expansion, then these small angular motions correspond to speeds far greater than the speed of light. So astronomers conjectured that quasars are "relativistically beaming" the jets more or less into our line of sight, creating an optical illusion of faster-than-light motion.
- The energy emitted by some quasars, calculated on the assumption they are very distant, is far greater than any known mechanism is capable of generating. It corresponds to thousands of supernovas per year in some cases.
- Rapid light variations in quasars indicate that most of the light must come from a region near their core smaller than the planetary region of the solar system. Yet the jets from some such quasars must be far larger than even whole giant elliptical galaxies.
- The spectra of quasars contain metal emission lines, even iron lines in some cases. Because only light elements can arise from the big bang, several generations of stars must have formed, lived, and exploded as supernova, enriching the metal content of the medium from which the quasars were later formed. Observational evidence for this "pre-quasar" evolutionary stage is still being sought.

Indeed, almost all observed properties of quasars are easier to understand if quasars are small, relatively nearby objects than if they are distant cores of primitive galaxies. But astronomers are reluctant to consider that possibility seriously because it implies a redshift mechanism other than velocity is important in the field of cosmology. The fall of the big bang model would surely soon follow such an admission.

Now comes another startling result that addresses this specific point—the nature of the redshift mechanism in quasars. M.R. Corbin published in (*Ap. J.* 447, 496-504, 1995), the July 10 issue, an observational test of quasar redshift models. The new test used optical and ultraviolet emission lines in quasar spectra. When the lines are broad, often the profiles of the lines are not symmetrical, fading into the continuum less rapidly on one side than the other. This asymmetry can be on either the red or the blue side of the lines. Increasingly redward asymmetries are correlated with increasing soft X-ray luminosity.

These odd characteristics are challenging for quasar models to explain. Thin accretion disk models and Comptonization effects can explain either redward or blueward profile asymmetries, but generally not both, nor several of the other observed properties such as the absence of sharp edges to the lines and the predicted polarization (R.R.J. Antonucci, in *Testing the AGN Paradigm*, ed. S. Holt *et al.*, AIP, p. 486, 1992).

One model that does work well is based on gravitational redshift. The soft X-ray emission is known to arise from a small region at most a few light-minutes wide, and arguably traces the mass of a putative black hole in the quasar. So X-ray output and redward asymmetry in the line profiles are correlated with each other because both are correlated with the quasar's mass.

Although the authors consider only quasar masses of order one billion suns, as would be appropriate for galaxy cores, both total mass and overall size of the emitting object would scale linearly in gravitational redshift models. Therefore, the same data could be matched by small, relatively nearby objects that are dense enough to have a large gravitational redshift. Then all those other puzzling properties of quasars would start to make sense too.

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Book Review

Konrad Rudnicki: The Cosmological Principles, Krakow 1995, Jagiellonian University Publishing Office, 136 pages. (Price $25; available from Ksiegarnia Akademicka, ul. Sw. Anny 6, PL-31008 Krakow, Poland.)

The Cosmological Principles by Konrad Rudnicki is the first book devoted to totality of basic cosmological problems connected with the cosmological horizon and the possibility of crossing it theoretically with help of cosmological principles. The problem also can be formulated as follows: how to describe the totality of the (infinite) Universe when only a small area of it is observable in a direct way.

Some cosmological principles were used subconsciously from the ancient views of the Universe to the first works of Einstein and his followers. Some later methodological considerations have disclosed the great significance of cosmological assumptions and led to the formulation of the notion of a cosmological principles. First only one cosmological principle was known (which is called today the Generalized Copernican Cosmological Principle). Later on, the Perfect Cosmological Principle was formulated. Then some others were created while some old, historical ones were "discovered". Many cosmologists believe that cosmological principles are of secondary importance for the constructing of general pictures (models) of the Universe. Rudnicki shows in his book that these principles play a no less important role in constructing models of the Universe than astronomical observational facts and physical theories. In many cases they play the leading role. This is exemplified in an excellent way by the case of the Generalized Copernican Principle which induces some cosmologists to accept the Big-Bang hypothesis which, in spite of common conviction, does not result from any astronomical data alone.

Three chapters of the book are devoted to the three main cosmological principles used in today's cosmology: the Generalized Copernican Principle, the Perfect Principle and the Anthropic Principle. Three other principles of great historical importance (the Ancient Indian, the Ancient Greek and the Genuine Copernican) are also discussed. The last one forms the basis for the contemporary family of principles. Yet the two older ones also have some significance for contemporary cosmology and are sometimes used but in a modified form. Some minor principles—altogether about thirty—are discussed as well. This "catalogue" alone is of great value and shows how creative new philosophical assumptions in cosmology are today; in other words how basic assumptions of cosmology are a matter of individual preference in terms of world-view.

Rudnicki exposes many connections between various principles, points out their logical connections, groups some families of principles, which are also depicted in graphical form. It turns out that one of a very general cosmological principles is the so-called Mach's principle, which states that the features observed in a local environment contain information about the entire Universe and, thereby, form a basis for investigation of the Cosmos. The so-called Ancient Indian principle remains in opposition to this, and states that no extrapolation of local characteristics beyond the cosmological horizons is possible because the Universe is not only infinite in space and time but also infinitely heterogeneous. The contemporary model of the domain-Universe is based on the latter principle, whereas most others are based on one or another specific form of Mach's principle.

In the last chapters of the book, the author tries to depict possible avenues for the future development of cosmology. He discusses, among others, whether it is possible to construct models without any cosmological principles or to develop a cosmology without models. He gives (in an appendix) a concise exposition of the Goethean or morphological approach to scientific problems, based on the methodological ideas of Johann Wolfgang Goethe and developed in this century by the great Swiss-American astrophysicist Fritz Zwicky.

As I noted above, this book by Konrad Rudnicki is the first monograph in world literature devoted exclusively to the totality of problems of cosmological principles and related topics. You may agree or disagree with his particular statements and views, but his systematic review of existing cosmological principles and the richness of the problems introduced by him make the book a necessary starting point for anyone who wants to embark upon his own research in cosmology, whether it is considered a part of astronomy or a part of philosophy.

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The Bookshelf

New Publications on Physics and Astronomy

Plasma Astrophysics and Cosmology, Second IEEE International Workshop, Princeton, New Jersey, May 10–12, 1993 (edited by Anthony L. Peratt; Kluwer Academic Publishers, New York, 1995, 297 pages).