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BOOK REVIEWS

Quasars, Redshifts and Controversies by Halton Arp. Berkeley: Interstellar Media, 1987, 198 pp. (hardback). ISBN 0-941325-00-8. $19.95 (available from The Sourcebook Project, P. O. Box 107, Glen Arm, MD 21057).

In the early 1960s the first quasars were recognized and named: objects in the sky that look like bluish stars except for their peculiar spectrum. Unlike that of a star, the spectrum is characterized by very broad emission lines that are strongly redshifted with respect to the normal frequencies at which the elements radiate. Soon many more of these objects were found, each with its own, and different, redshift. Since the work of Edwin Hubble in 1924 it was known that ordinary galaxies are also redshifted (except for a few of those closest to us, like the Andromeda nebula). The further away from us, he found, the larger the redshift.

When Hubble announced this discovery, it was immediately interpreted in terms of the Doppler effect: the other galaxies are moving away from us, the faster, the further away they are. The universe expands. This interpretation was also immediately endorsed by Einstein, whose theory of gravitation predicted that the universe either expands or contracts, a static one just balanced between expansion and contraction being unlikely (though not impossible).

Against this background, the redshifts of the quasars discovered 40 years later were interpreted in the same way. This is called the cosmological interpretation: using Hubble's relation, the distance of a quasar can be derived from its redshift. But there appeared to be a problem: the redshifts of quasars were much larger than those of the most distant galaxies measured at the time. Several quasars are now known with redshifts ("z") greater than 4, meaning that the wavelength of light we receive from them is five times longer than from the same atoms measured on Earth. So quasars had to be very distant, many of them near the edge of the presently visible universe, and therefore enormously luminous to be visible from Earth. Also, their spectra were quite unlike those of normal galaxies. Were these objects really comparable to galaxies? Couldn't they be something new? Could not the redshifts be caused by something else? Other possibilities were quickly raised: these things, whatever they were, could be at the bottom of a deep gravitational potential (causing gravitational redshift, as described by Einstein's theory of gravity), or maybe the photons from the object had somehow "aged" by an as-yet-unknown agent on their long journey to us (the so-called "tired light" hypothesis).

Though a majority of the astronomical community favored the cosmological interpretation from the beginning, by analogy with galaxies, other possibilities were socially acceptable in these early days, at least in informal discussions. This soon changed and the community divided, asymmetrically, into two camps. As more and more observational details became known, the majority became convinced of the cosmological interpretation, in particular when objects with properties intermediate between those of quasars and ordinary galaxies (the so-called Seyfert galaxies) were studied in more detail. The minority view, that quasars and their redshifts were really something different, became less and less tolerated. A controversy was born that lasts until today.

The book reviewed here describes the arguments for the minority view in the debate. In the first eight chapters it reviews a number of independent observations collected by the author and others that are in conflict with the cosmological interpretation. The tenth chapter gives the author's view on the "sociology" of scientific controversies, illustrated by his own experience as well as a few other disturbing cases in the history of astronomy. The last chapter briefly discusses possible theoretical interpretations of the anomalies. This chapter draws attention especially to the theories of Hoyle and Narlikar, in which the universe expands but not from a big bang. The main thrust of the book is on the observations, however, which are carefully kept apart from possible theoretical interpretations.

The controversy started when the author of the book, a well-known and highly respected observer who had made several important discoveries with the telescopes on Mt. Palomar, became convinced around 1966 that quasars are not randomly distributed on the sky. Instead, there were some groups of quasars, containing objects with different redshifts, associated with a ***nearby*** ordinary galaxy of low redshift. If these quasars are associated with a nearby object they have to be nearby themselves, the reasoning went, and hence their large redshifts are not cosmological but would have to be due to some new effect. (This is not quite as straightforward as it might seem, though, since apparent associations could also be caused by a gravitational lensing effect. Both sides agree, however, that this effect is far too small to explain Arp's associations.)

The significance of these associations was doubted by many contemporary astronomers. A higher density of identified quasars at some place in the sky does not mean that the actual density is unusual there, the argument goes, because some places in the sky are observed much more carefully than others. Nearby galaxies are intensively studied objects, and unusual bluish objects that happen to be in a field studied for other reasons may or may not attract the observer's interest, depending on his inclination and the nature of his study. In practice, it is impossible to quantify how intensively a particular area of the sky has been searched, and so it is difficult to assign a meaningful statistical probability to an association of relatively infrequent objects like quasars. This objection is raised by the "establishment" against Arp's associations which, at face value, are undoubtedly quite striking.

In addition to these associations of quasars with galaxies, the book describes other anomalies, all inconsistent with the cosmological interpretation. This is not the place to describe them all in detail, but here are three of them.

1. The quasars associated with galaxies sometimes occur as "jets" , i.e. they concentrate in one direction with respect to the galaxy, as if they had been ejected from it (which is, indeed, the explanation suggested in the book). In these groups, as well as for quasars in general, those with the highest redshift tend to be the faintest. In Arp's interpretation, this is an "ageing" effect: he speculates that quasars may start their life as faint, high-redshift objects that mature into bright ones of low redshift. The high-redshift quasars would thus have been ejected recently from their parent galaxies. The conventional interpretation is that high-redshift quasars are faint just because they are distant; its adherents argue that Arp's need for the additional assumption of an "ageing" phenomenon speaks against his view.
2. Arp finds that the large-scale distribution of quasars across the sky is not as uniform as it should be if their distances were cosmological. Here we have again the difficulty that existing quasar catalogues are the result of highly selective, non-random sampling, so that the observed distribution cannot be used at face value. But why not take a random piece of sky and sample it in a truly unbiased way? This has indeed been done, by Arp himself as well as by others, and he shows some of the results in chapter 5. These are results about whose statistical significance the reader himself can make a fairly independent judgement. The need for large unbiased samples of quasars exists also in conventional cosmology and quasar research. The large amount of telescope time and work needed for such projects has made them unpopular until recently. Projects of this type, one of them using a telescope dedicated for the task and equipped with an automated data-collection and quasar-identification system, are currently under way. One may hope that they will settle the debate about the uniformity of the distribution of quasars.
3. Evidence that some nearby galaxies have anomalous redshifts (i.e. deviating from Hubble's relation). Arp shows several clusters of galaxies, especially unusual "disturbed" galaxies, where one or more have a redshift that deviates strongly from the others. Now a certain spread in the redshifts inside a cluster of galaxies is always observed, corresponding to random velocities of typically a few hundred km/s, and believed to be due to the mutual attraction of the galaxies in the cluster by the force of gravity. As expected in this interpretation, the velocities are higher in the more massive and the more compact clusters. Deviations exceeding the velocity of escape from the cluster cannot be explained in this way, however. In the conventional view, these must be due to chance coincidences of a background object with a foreground cluster. This view is supported

by the fact that the high-redshift galaxy usually appears smaller and the stars in it (if they can be resolved individually) fainter. Arp acknowledges this, but also finds evidence of a physical connection: bridges of gas, and evidence of mutual disturbance. He takes the view that the contradictory evidence here should be an incentive for further study, because it might lead to the discovery of fundamentally new physics.

4. Evidence for *quantization* of redshifts inside groups of galaxies. Smaller clusters of galaxies like our own local group contain many small companion galaxies in addition to a few big ones. Plotting a histogram of their measured velocities (from the red- or blue-shifts), W. Tifft noted a periodicity: the velocities occur in multiples of about 72 km/s. Arp confirms this effect. If real, this is perhaps the most disturbing anomaly, because it requires much more than some new cause of redshifts. Even if such a new cause produced, say, redshifts at multiples of 72 km/s, the random velocities of the galaxies in each other's gravitational fields should still completely smear out that periodicity. The opposition from the establishment is particularly severe here, and centers again on the statistical significance of the data. The histograms are shown in the book, and the reader may judge for himself.

The last kind of phenomenon discussed in the book is the jets seen emerging from many galaxies. They are seen especially in radio observations, but some are even visible in normal light. Spectacular pictures like those of Cynus A and the M87 jet feature in all popular books on astronomy. These observations are not central to the controversy, since the difference between Arp's view and the conventional one is only partial in this case. Both sides agree that one is here witnessing the ejection of gas from the nuclei of galaxies. Controversial is only Arp's view that the jet phenomenon is related to his observations of quasars expelled from galaxies.

As with anomalies in other fields, the debates surrounding Arp's findings rapidly get bogged down in arguments about statistics. This starts with disagreement about what null hypothesis should be tested. In the case of associations of quasars with galaxies, for example, the conventional view is that one should test the hypothesis that quasars are distributed uniformly, whereas Arp argues that this masks the most interesting effects and that one should test the hypothesis separately for quasars of redshift around $z=1$, where he finds the most striking effects. Not making use of this fact, he says, is throwing away the most important piece of information, the piece that could tells us something new about physics. All just artifacts of *a posteriori* statistics, the majority replies; and so on. This kind of debate will sound familiar to readers of this journal. It is important to remember, though, that *accidental* associations of objects in the sky, of high *apparent* significance, do occasionally appear within conventional astronomy. A famous recent case is that of Sco X-1, the brightest steady X-ray source in the sky. It is a binary containing a neutron star, not too far from us in our own galaxy. Since it is also a radio source, its position can be determined with extremely high precision. Its radio map shows two blobs, symmetrically on either side of the central source: Sco X-1 emits jets (the only source of its kind known to do this). A significant literature with models of these jets followed. Then, after years of observation the central source had moved away from its position between the blobs, and it became clear that this was a chance coincidence with a background object, one of the numerous double-lobed extragalactic radio-sources. The a priori chance of such an alignment was computed to be 1 in 100,000. A colleague once told me of a periodicity he found in a time sequence of X-ray data, at a formal level of significance of 9 times the standard deviation (s) of the background. It disappeared on closer examination. Hundreds of plates and CCD frames are scanned every day by trained eyes eager to find something unusual worth publishing; this has to be taken into account when significance levels are quoted. In fields of astronomy where large amounts of data are processed routinely (by computer), high standards for accepting something as real have been found necessary. In radio and X-ray maps of the sky, apparent sources that stick out less than 5 to 7 s above the noise are usually ignored, for example.

The conventional and the minority views of quasar redshifts are each self-contained little universes. Both parties have the feeling that their picture, however incomplete, just "hangs together", and discussion between the two has virtually ceased. One may wonder why quasar redshifts have turned into a controversy like this, while other spectacular phenomena in astronomy, for which the current explanations are controversial even inside the "establishment", have not done so. For example, there are the gamma-ray bursts: short bursts (typically a second) of gamma rays from well-defined directions in the sky (at a rate of about one per day), not (yet) associated with radiation at other wavelengths. Here it is not even known if their sources are as close as nearby stars or as far away as the edge of the universe. The debate is lively, but the possibilities discussed are all inside the bounds of known physics. Another instance is the so-called "missing mass" problem. The universe as a whole, as well as clusters of galaxies, and even galaxies themselves behave as though they contain ten times more mass than can be identified with stars, gas clouds, and the other forms of visible mass. The possibilities discussed include neutrinos, black holes, very small stars and exotic kinds of particles considered in some theories of elementary particles.

The chapter on "The sociology of the controversy" is recommended reading, especially for astronomers. It is not pleasant to be reminded of past mistakes, and sobering to see how strong is our emotional attachment to our view of the universe. But such reminders are necessary, if only to help us maintain a healthy culture of scientific exchange.

The book contains many beautiful pictures of the galaxies involved in the anomalies. It also has a very useful glossary of technical terms, but I suspect that non-astronomers will still be forced to skip over some of the discussion as too technical. The book clearly addresses the author's professional colleagues as well as the general scientifically literate public. The style of the text is very readable and elegant. It is spiced with Arp's pleasant sense of humor but avoids polemical digressions. Only occasionally does the wording betray bitter feelings about his treatment by the astronomical community. Considering that this treatment has not been very kind, often polemical and sometimes rather personal, the book is impressive testimony that a controversial point of view can be defended without falling into the trap of descending to the level of one's opponents.

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Advanced Aerial Devices Reported During the Korean War, by Richard F. Haines. Los Alto, CA: LDA Press, 1990. 75pp. ISBN 0-9618082-1-7 (available from LDA Press, P.O. Box 880, Los Altos CA 94023-0880).

This is a presentation of data on 42 UFO sightings in or near Korea from 1950 through 1954. Thirty-one are official reports by American pilots taken from military records and ten are ground observations taken from Project Blue Book files. One is an interview, conducted 36 years later, with a GI who fired on a UFO in 1951. The descriptions of the events vary considerably in length and detail. The sighting reports are preceded by a brief description of both sides' combat planes and their capabilities.

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Secret Life: Firsthand Accounts of UFO Abductions by David Jacobs, Simon and Schuster, NY, 1992, 336 pp.; ISBN 0-671-74857-2, $21.00.

In 1975 David Jacobs published *The UFO Controversy in America,* a widely acclaimed classic (for instance, described by Arthur C. Clarke as "one of the few volumes ever published on the subject that is worth reading"). For that reason alone, *Secret Life: Firsthand Accounts of UFO Abductions* would be an important addition to the literature; it is the more so because American ufology is currently being polarized between those who take claims of abduction seriously and those who dismiss them. In view of this polarization, JSE is publishing two reviews, by writers who hold different beliefs on the matter.