calculations or graphical analysis. The end result in each case is some quantity of astronomical interest. The topics range from a measurement of the astronomical unit through spectroscopic parallax to the determination of the Hubble constant.

Several of the experiments could be extended by an interested amateur. With this book as a guide, anyone with a camera-equipped telescope should be able to measure for himself the mass of Jupiter or establish a photometric calibration curve for a variable star field. Another possible extension would be to apply the methods introduced in this manual to the high quality pictures found in the coffee table astronomy books. For example it should be possible to construct a Wolf diagram and estimate the distance to dark nebulae in this way.

This book was intended as a laboratory text at the college level, but a reader with a background in general astronomy and a good command of high school math should have no difficulty with the material. In a few cases better picture reproduction would have improved accuracy but in most cases the results agree well with accepted values. I would recommend this book to anyone interested in learning more about the methods used in experimental astronomy.

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BOOK REVIEW

BLACK HOLES, QUASARS, AND THE UNIVERSE

Harry L. Shipman, Houghton Mifflin Company, Boston, MA, 1976. 303pp. $12.95

Shipman has written this book for the nonscientist. He has put into easy-to-understand terms three of the most interesting topics of astronomy: black holes, quasars, and the universe. The Preliminary section gives the reader some basic astronomical terminology. In the Introduction, Shipman explains the difference between the "model-world" which exists in the mind of the theoretician, and the "real-world", the world in which we live. This section is like the scent of chocolate - you know that what is to follow will be very enjoyable...and it is!

The first section, "Black Holes", describes the type of stars that makes the best candidates for black holes (stellar corpses) and why. It also explains why some stars couldn't possibly evolve this way. Shipman constantly distinguishes between knowledge from the "model-world" and from the "real-world". This is important because newspapers give the general public the idea that black holes have actually been discovered. They don't adequately stress the uncertainties involved in the research.

After we learn the possible properties of a black hole, we accompany an imaginary astronaut on a mission to see what's in a black hole. He takes an armload of clocks. He will place them, one at a time, in different points of orbit around the black hole. Back on the rocket ship, observers will learn much about the tremendous gravity of the black hole, but unfortunately, the poor astronaut can never return from inside the black hole. Once inside, nothing, not even light can escape, much less his radio signals to the ship. It's rather like saying, "I'm going to find out if there's life after death if it kills me".

Shipman, in this chapter has given me the clearest idea I have had yet about what a black hole might be like. The parallel he draws between it and the probable fact that Cygnus X-1 is a black hole is the finest example of explanatory writing I have yet come across.

Section 2, "Quasars & Galaxies", states that the theory on the subject is rather crude since they were discovered by observers looking at strange objects and not something built in the "model-world". Although it was not the first quasar discovered, 3C 273 is the brightest of the known quasars. Seen as a 12th magnitude starlike object, it is on the AAVSO observing program. Just as an example of its tremendous light emitting power, we could put a giant elliptical galaxy at the same distance as 3C 273 and it would require a 60-inch telescope to see that galaxy as 12th magnitude. The book tells about the energy, but nothing is known about how it is produced.

Later, we learn that 3C 273 might be a missing link between galaxies and quasars. 3C 120 is the most active of the N-Galaxies. (N-Galaxies have a small, brilliant, almost stellar nucleus.) 3C 120 emits about 3×10^{46} ergs/sec of nonstellar radiation, not too much less than that of the quasars. And, if BL Lacertae (also on the AAVSO program) could be definitely identified as a galaxy it would be a great help in solving the quasar puzzle. The "Lacertids" (named for the prototype BL Lac) are strange star-like objects not clearly understood. Most of what we know about quasars is from the "real-world" of observations. To find the incredible power source in a quasar may mean a return to the "model-world".

The final chapter, "The Universe" tells why the Big-Bang theory of creation ("model-world") is now the most widely accepted. Page 230 states very neatly: "The story starts with a homogeneous glob of matter containing all the substance of the universe...Through particle reaction...every reaction being balanced by inverse reaction" ...suddenly...the Big-Bang!! Seven hundred thousand years after the first second of the big bang, the universe had cooled to 3000°K.

The last photons that interacted with matter when they scattered off electrons (just before recombination) became redshifted into radio photons now being observed by radio astronomers. It is just possible we are actually looking back in time to a young 700,000 year-old universe. The "model-world", however, cannot explain fully how the formation of galaxies fits into the Big Bang.

Will the universe eventually collapse back to the original "glob" (Closed theory) to start over, or will it continue to expand and die? (Open theory). We must understand our own universe better. On pp 244-245 Shipman states, "You would not normally believe variable star observing would turn out to be a critical step in our understanding of distances in the universe...Cepheids turn out to be the key pieces to solving parts of the cosmic puzzle". (Satisfying words to the AAVSO'er).

I believe Shipman reaches his goal in showing us what the "model-world" and the "real-world" astronomers know about cosmology. He certainly teases the mind of the reader to speculate on what may lie ahead. His final paragraph on p. 288 sums up the research yet to come: "The Big Bang theory leaves one unanswered question. WHO created the material that exploded as the Big Bang? For this the astronomer has no answer".

Every variable star observer should read this book. Observing is now even more exciting for me, and I certainly understand much more clearly the articles I have since read about black holes, quasars, etc. His ability to describe exotic subjects such as these in the layman's language tells me that Shipman really understands what he knows!

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