

Book Reviews

Reconnaissance of Outer Space

The Hubble Atlas of Galaxies. Allan Sandage. Carnegie Institution of Washington, Washington, D.C., 1961. viii + 32 pp. Illus. + 50 plates. \$10.

Astronomy is an observational science, not an experimental one. We cannot change the temperature of a star by a chosen amount in order to discover the nature of the resulting change in the spectrum. We can only observe the spectra of different stars that have differing temperatures, and we can watch the concomitant changes in the spectra and temperatures of pulsating stars. We cannot even watch evolutionary changes in stars and galaxies take place; the time scale is too long.

The Hubble Atlas of Galaxies is a major contribution to the observational study of cosmology. Any acceptable theory of the origin and evolution of galaxies *must* be capable of explaining the large variety of observed forms and stellar content found among these objects. The classical presentation of this subject may be found in chapter 2 of Hubble's book *The Realm of the Nebulae*, first published in 1936 and now available in a Dover paperback edition (1958).

Allan Sandage has written an excellent introduction to the atlas, but Hubble's earlier book is still well worth rereading. Many readers of this review, and even some of the users of the new atlas, may not be familiar with the evolution of the terminology used in this subject. Some quotations from Hubble's book may be helpful here:

"The astronomical term *nebulae* has come down through the centuries as the name for permanent, cloudy patches in the sky that are beyond the limits of the solar system. The interpretation of these objects has frequently changed, but the name has persisted. . . .

"Today, the term *nebulae* is used for two quite different kinds of astronomical bodies. On the one hand are the clouds of dust and gas, numbering a few score in all, which are scattered

among the stars of the galactic system. These have been called *galactic nebulae*. On the other hand are the remaining objects, numbering many millions, which are now recognized as independent stellar systems scattered through space beyond the limits of the galactic system. These have been called *extragalactic nebulae*. The nomenclature is followed in this book with the exception that, since extragalactic nebulae are mentioned so frequently, the adjective will be dropped. Therefore the term *nebulae* will refer to extragalactic nebulae alone, unless otherwise specified.

"Some astronomers consider that since nebulae are now known to be stellar systems they should be designated by some other name, which does not carry the connotation of clouds or mist. Such a revision might be useful, but, as yet, no entirely suitable alternative name has been suggested. The proposal most frequently discussed is a revival of the term *external galaxies*.

". . . Usage, however, is not always determined by logic. The established definition may be dropped and the variant, revived, may flourish. No prediction is ventured. The term *nebulae* offers the values of tradition; the term *galaxies*, the glamour of romance."

The title of the new atlas shows that tradition lost out here, and rightly so.

The introductory material Sandage wrote for the atlas consists of a preface and 32 additional pages of historical and descriptive material. The historical discussion begins with the island-universe speculations of Kant (1724–1804), Swedenborg (1688–1772), and Wright (1711–1786) and includes a description of the work of Shapley, Curtis, and Lundmark during the period 1917 to 1921. Sandage's description and evaluation of the conflict between Shapley and Curtis, which culminated in the historic debate held before the National Academy of Sciences on 26 April 1920, is objective and fair. Sandage continues:

"Clearly neither side had convinced the other. New data were needed to place the solution beyond all doubt. Edwin Hubble provided these crucial

data by his discovery, analysis, and interpretation of cepheid variable stars in M31, M33, and NGC 6822. This discovery settled the controversy once and for all. It proved beyond question that nebulae were external galaxies of dimensions comparable to our own. It opened the last frontier of astronomy, and gave, for the first time, the correct conceptual view of the universe. Galaxies are the units of matter that define the granular structure of the universe itself."

Hubble was working on the preparation of an atlas such as this one at the time of his death in September 1953. The work had not progressed to the point where a simple editorial job was all that was needed to finish the work. Sandage states:

"I have acted mainly as an editor, not an editor of a manuscript but rather an editor of a set of ideas and conclusions that were implicit in the notes, in Hubble's grouping of galaxies into lists, in his notations on plate envelopes, and in conversations with him from 1949 to 1953, and in the scheme as it emerged from inspection of the same material that he had used to define his system."

To me this seems to be too modest an evaluation of Sandage's contribution. There are 186 photographs of 176 different galaxies reproduced here; Sandage, himself, took one-third of the photographs. Hubble took 72, Sandage 63, Milton Humason 24, and seven others were responsible for the rest.

The atlas is very conveniently organized. A table of data lists the galaxies in order of their NGC (*New General Catalogue of Nebulae and Clusters of Stars*) number and gives the type of the galaxy, the telescope used, the atlas page, the enlargement of the picture, and the scale of the picture in seconds of arc per millimeter. The arrangement of the photographs is by class in the order Elliptical (E), Normal Spirals (S), Irregular (Irr.), and Barred Spirals (SB). Descriptive material for each photograph is printed on a page facing the photograph. The halftone reproductions are of excellent quality, and I did not realize they were halftones until I inspected them with a pocket magnifier.

Allan Sandage and the Carnegie Institution of Washington deserve the gratitude of astronomers, cosmologists, and all who have esthetic appreciation for fine astronomical photographs.

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