

successful hunt for Neptune. The similarity extends even further, for one of Lowell's contemporaries, W. H. Pickering, had predicted the existence of a planet at about the same place as that suggested by Lowell. (The parallel with Leverrier and Adams cannot be pushed too far, however, for Pickering enthusiastically predicted the existence of several planets at various distances from the Sun.) There was one major difficulty: both Lowell and Pickering supposed in their calculations that Planet X must be a reasonably massive body. Pluto, when found, proved to be fainter, and so presumably smaller, than expected. Was it really the predicted planet? The arguments started once again:

rather unproductively this time, because no mass was available for Pluto. The climax both of this dispute and of the book has actually only just occurred: for, in 1978, a Plutonian satellite was finally discovered. The consequences are remarkable — to quote Mr. Hoyt:

"The discovery of a Plutonian satellite [named Charon], of course, permitted the first direct and reasonably accurate determination of Pluto's mass since the planet's discovery forty-eight years ago . . . Pluto is thus a very, very small planet indeed, only about 20 percent as massive as the earth's moon, and with a probable diameter of only 1500 miles (2420 km), about two-thirds that of the earth's moon.

"The discovery of Charon, and the consequent determination of Pluto's very small mass, made it certain that Pluto could not be Percival Lowell's predicted Planet X, and thus the long controversy over this question ended."

The result is stated firmly; but it leads to the very odd conclusion that the positions of Pluto (certainly) and Neptune (possibly) were correctly predicted by accident. The Einstein centenary reminded us that God does not play dice. Perhaps the Uranus bicentenary should assure us that He does.

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New astronomies

R.J. Tayler

A Source Book in Astronomy and Astrophysics, 1900-1975. Edited by K.R. Lang and O. Gingerich. Pp.922. (Harvard University Press: Cambridge, Massachusetts, and London, UK, 1980.)\$50.

THIS book provides an attractive invitation to review the great increase in our knowledge of the Universe over the present century. In 1900, most astronomers believed that the Milky Way system was the whole Universe and that the Sun was near its centre. The existence of interstellar matter was suspected but not established and it was not known that interstellar dust absorbed starlight and produced a seriously biased view of the Universe. Although spectroscopy had shown that stars contain the same chemical elements as the Earth, a quantitative discussion was impossible because the structure of atoms and the origin of spectral lines were not understood. A study of stellar structure had started but its further development required more knowledge of atomic physics and of nuclear structure, leading to an explanation of the source of stellar energy.

For the first two-thirds of the period under review, observational advances were restricted to optical astronomy. The Universe was seen to be an immense expanding system of galaxies and the structure of our Galaxy and its constituent stars and gas clouds was studied in great detail. Towards the end of this great period of optical astronomy, many astronomers believed that all the important components of the Universe had been discovered. This view has been transformed in the past twenty-five years by the development of new astronomies — radio, infrared, ultraviolet, X-ray and γ -ray — studying the 'invisible Universe', and by the discovery, for example, of quasars, pulsars, X-ray binaries, interstellar neutral hydrogen and molecules and the cosmic microwave radiation. Theoreticians have

used developments in physics, such as quantum theory and general relativity, to explain the properties of objects already known and to predict the existence of new types of object.

Drs Lang and Gingerich have selected about 150 key papers to trace the increase in our knowledge. In some cases the papers are printed in full and in others the less essential parts of the discussion have been paraphrased. In every instance, they have introduced their selection by some general remarks on the development of the subject; this enables them to give due credit for key work which they could not include in the anthology. I find this a fascinating collection of papers and I am impressed by

the quality of the editorial work. In reading the book, I have learnt many things which I had not previously known and others which I had forgotten. The book should certainly be widely available to both young and old students of astronomy. It is inevitable that not all astronomers will agree with the choice of key papers. In general, I did find what I expected but I was surprised that, although the work of Chandrasekhar is widely quoted, not one of his papers is included and I would have included Parker's paper on the solar wind.

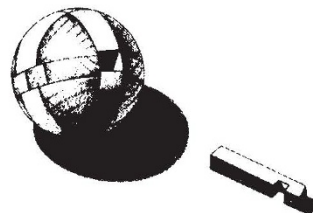
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