Gravitational lenses

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Gravitational Lenses: Proceedings of a Conference Held at the Massachusetts Institute of Technology, Cambridge, Massachusetts, June 20, 1988. **Eds. J. M. Moran, J. N. Hewitt, and K. J. Lo.** Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1989. 238 p. (Springer Lecture Notes in Physics, Vol. 330).

The proceedings of the conference held in honor of the sixtieth birthday of the well-known American astrophysicist (radio astronomer) Bernard Burke are devoted to the theory and observations of gravitational lenses. The study of the structure of images produced by gravitational lenses has extensive application both in astrophysics and also in cosmology. It enables one to obtain independent information about the distribution of not only visible matter, but also, which is especially important, of dark matter on a range of scales from stars to clusters of galaxies. At present, the search for and investigation of gravitational lenses is one of the most promising and actively being developed directions of modern astrophysics.

The scientific part of the symposium is preceded by the introductory paper of G. W. Clark, which is devoted to B. Burke's personal contribution to science, and also by two papers of a historical nature devoted to the history of the development of opinions on gravitational lenses (J. M. Barnothy) and to the discovery of the first of them (D. Walsh).

The optical properties of gravitational lenses are described in the papers by R. D. Blandford, R. Narayan, and S. Grossman. The dependence of the number and arrangement of the images of a point source on its position relative to the observer and the lens is discussed in detail. It is shown that an elliptical lens with an "isothermal" density distribution is a fairly good model for many actual lenses and successfully describes a number of observations.

The possible forms of the images of extended sources such as galaxies are discussed in a note by S. M. Chitre and D. Naraskhimkhi, and also in the already mentioned paper by R. D. Blandford. M. Birkinshaw estimates the effect of the motion of a gravitational lens on the difference of the red shifts of the different images of the same quasar and on the intensity distribution of the background radiation in its vicinity. A short review of the most recent (for June 1988) optical observations of quasar images is made in E. L. Turner's paper. The results of using radio interferometers with very long baselines for similar observations are shown in the papers by M. V. Gorenstein, A. E. E. Rogers, R. U. Porkas *et al.*, and by G. Langston *et al.* Two papers report on measurements of the displacement over time between two images of the quasar 0957 + 561 made in the optical (K. van der Est *et al.*) and radio (J. Lehar, J. N. Hewitt, and D. H. Roberts) regions. Both observations confirm the predictions of the theory of gravitational images. By analyzing luminous arcs in clusters of galaxies, V. Petrosian, Zh. Soukal, and R. J. Lavery demonstrate that they are images of distant galaxies produced by the gravitational fields of the corresponding clusters. These observations indicate the presence of a large amount of dark matter in the clusters.

The problems and results of the search for new gravitational lenses are generalized in the following series of papers. J. N. Hewitt *et al.* discuss observations in the radio region, and R. L. Webster and P. C. Hewett and also S. Djorgovskii and G. Maylan analyze the optical observations. Estimates of the prevalence of clusters of gravitating matter in intergalactic space are made by independent methods by L. M. Krauss and C. J. Lonsdale.

The final section of the book is devoted to microlensing, i.e., to the phenomenon of distortion of the images of a source by the gravitational fields of low mass objects passing near the line of sight. The nature of the temporal fluctuations of image brightness and also the change of the brightness distribution of quasars due to microlensing are considered in W. D. Watson's paper. An analysis of the effect of low mass objects on the brightnesses of quasar images is used to estimate the concentration of compact gravitating bodies in the universe (H.-U. Ricks and C. J. Hogan). A comparison is also made of the calculated temporal brightness variations with observations (J. Vambsganss, B. Paczynski, and N. Katz). The explanation by a gravitational lensing effect of clustering of projections of quasars near projections of galaxies on the celestial sphere is analyzed and refuted in P. Schneider's paper.

As a whole, considering the conciseness of the explanation of the material, the book reflects fairly completely the state of gravitational lens astrophysics for 1988 and can be useful both to specialists and also to those who are starting to get acquainted with this field.

Translated by Frederick R. West