the orbit and periodic time is known, and also the parallax, the masses of the stars can be found. (If only the relative orbit is known, the sum of the masses can be determined; but if absolute positions of one component have been observed, both masses can be determined separately.) But even when, as in most cases, the parallax is unknown or uncertain, the ratio of the brightness to the mass can be accurately found. Thus it is found that Procyon gives about three times as much light as the sun in proportion to its mass, Sirius about sixteen times, and *ζ* Orionis more than ten thousand times. In these cases evidently either the star has a greater intrinsic brilliancy per square mile of surface than the sun, or is less dense. Probably both causes contribute. The phenomena of long-period variables show that the surface brilliancy may vary very greatly, even in the same star. The Orion stars have the highest temperature of all and have admittedly the greatest surface-luminosity, but the extreme brilliancy of ζ Orionis in proportion to its mass must be mainly due to a small density. For the Algol variables it is possible to form even more direct calculations of the density, for from the duration of the eclipse an approximate estimate of the size of the star may be made. A. W. Roberts concluded in this way that the average density of the Algol variables and their eclipsing companions is about one-eighth that of the sun. For *ß* Lyrae G. W. Myers found a density a little less than that of air; the density is certainly small, but J. H. Jeans has shown that for this type of star the argument is open to theoretical objection, so that Myers’s result cannot be accepted.

There are many stars, however, of which the brightness is less than that of the. sun in proportion to -the mass. Thus the faint companion of Sirius is of nearly the same mass as the sun, but gives only 1/4000 of its light. In this case the companion, being about half the mass of Sirius itself, has probably cooled more rapidly, and on that account emits much less light. T. Lewis, however, has shown that the fainter component of the binary system is often the more massive. It may be that these fainter components are still in the stage when the temperature is rising, and the luminosity is as yet comparatively small; but it is not impossible that the massive stars (owing to their greater gravitation) pass through the earlier stages of evolution more rapidly than the smaller stars.

*Distances and Parallaxes of the Stars.—*As the earth traverses annually its path around the sun, and passes from one part of its orbit to another, the direction in which a fixed star is seen changes. In fact the relative positions are the same as if the earth remained fixed and the star described an orbit equal to that of the earth, but with the displacement always exactly reversed. The star thus appears to describe a small ellipse in the sky, and the nearer the star, the larger will this ellipse appear. The greatest displacement of the star from its mean position (the semi-axis major of the ellipse) is called its parallax. If *π* be the parallax, and R the radius of the earth’s orbit, the distance of the star is R/sin*π*. The determination of stellar parallaxes is a matter of great difficulty on account of the minute­ness of the angle to be measured, for in no case docs the parallax amount to 1*''*; moreover, there is always an added difficulty in determining an annual change of position, for seasonal in­strumental changes are liable to give rise to a spurious effect which will also have an annual period. Very special precautions are required to eliminate instrumental error before we can compare observations, say, of a star on the meridian in winter at 6 p.m. with observations of the same star in summer on the meridian at 6 a.m. The first determination of a stellar parallax was made by F. W. Bessel in the years 1837-1840, using a helio­meter. He chose for his purpose the binary star 61 Cygni, which was the star with the most rapid apparent motion then known and therefore likely to be fairly near us, although only of the sixth magnitude. He found for it a parallax of 0∙35" a value which agrees well with more modern determinations. T. Henderson at the Cape of Good Hope measured the parallax of *α* Centauri, but his resulting value 1*''* was considerably too high. More accurate determinations have shown that this star, which is the third brightest star in the heavens, has a parallax of 0∙75*''*, this indicates that its distance is 25,000,000,000,000 m. So far as is known *α* Centauri is our nearest neighbour.

Formerly attempts were made to determine parallaxes by mea­suring changes in the absolute right ascensions and declinations -of the stars from observations with the meridian circle. The results were, however, always untrustworthy owing to annual and diurnal -changes in the instrument. Nowadays the determination is more usually made by measuring the displacement of the star relatively to the stars surrounding it. Hitherto the heliometer has been most extensively used for this purpose, D. Gill, W. L. Elkin, B. E..A. Peter and others have made their important determinations with it. The photographic method, however, now appears to yield results of equal precision, and is likely to be used very largely in the future. The quantity determined by these methods is the relative, parallax between the star measured and the stars with which it is compared. To obtain the true parallax, the mean parallax of the comparison stars must be added to this relative parallax. It is, however, fair to assume that the comparison stars will rarely have a parallax as great as 0·01*''*; for it must be remembered that it is quite the exception for a star taken at random to have an appreciable parallax; particularly if a star has an ordinarily small proper motion, it is likely to be very distant. Still exceptional cases will occur where a comparison star is even nearer than the principal star; it is one of the advantages of the photographic method that it involves the use of a considerable number of compari­son stars, whereas in the heliometric method usually only two stars, chosen symmetrically one on each side of the principal star, are used.

In. the table are collected the parallaxes and other data of all stars for which the most probable value of the parallax exceeds 0∙20*''*. Although much work has been done recently in measuring parallaxes, the number of stars included in such a list has not been increased, but rather has been considerably diminished; many large parallaxes, which were formerly provisionally accepted, have been reduced on revision. It cannot be too strongly emphasized that many of these determinations are subject to a large probable error, or even altogether uncertain. For one or two of the more famous stars such as α Centauri the probable error is less than ±0·01*''*; but for others in the list it ranges up to ±0∙05*''.* To convert parallaxes into distance we may remember that a parallax of 1*''* denotes a distance of 181/2 billion miles, or 206,000 times the distance of the sun from the earth. A parallax of 0·01*''* denotes a distance a hundred times as great, and so on, the distance and parallax being inversely proportional. A unit of length, which is often used in measuring stellar distances, is the *light year* or distance that light travels in a year; it is rather less than six billion miles.

Stars with Large Parallax.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Star. | Position R.A. Dec. | | | Mag. | Annual  Proper Motion. | Parallax. | Authority for Parallax |
| Gr. 34 , . | h.  0 | m.  13 | sec.  +43 | *''*  8∙1 | *''*  2∙8 | *''*  ∙27 | R, Sc, C |
| *τ* Ceti . | 1 | 39 | -l6 | 3∙7 | 1∙9 | ∙31 | S |
| C. Z. 5h 243. | 5 | 8 | -45 | 8∙5 | 8∙7 | ∙31 | S |
| Sirius | 6 | 41 | -17 | -1∙4 | 1∙3 | ∙38 | G, E |
| Procyon . | 7 | 34 | +5 | 0∙5 | 1∙2 | ∙30 | A, E |
| LI. 21185 | 10 | 58 | +37 | 7∙6 | 4∙8 | ∙37 | R, C |
| LI. 21258 | 11 | 0 | +44 | 8∙5 | 4∙4 | ∙21 | A, k, K, R |
| LI. 25372 . . | 13 | 40 | +15 | 8∙5 | 2∙3 | ∙20 | R, E |
| *a* Centauri . | 14 | 33 | -60 | 0∙2 | 3∙7 | ∙76 | G, E |
| O.A. 17415—6 | 17 | 37 | +68 | 9∙1 | 1∙4 | ∙22 | k |
| Σ 2398 .. . | 18 | 42 | +59 | 8∙8 | 2∙3 | ∙29 | Sc, R |
| σ Draconis . | 19 | 32 | +70 | 4∙8 | 1∙9 | ∙22 | s, P  E |
| Altair . . | 19 | 46 | +9 | 0∙9 | 0∙6 | ∙24 |
| 61 Cygni | 21 | 2 | +38 | 4∙8 | 5∙2 | ∙31 | many |
| ε Indi | 21 | 56 | -57 | 4∙8 | 4∙7 | ∙28 | G, E |
| Krueger 60 . | 22 | 24 | +57 | 9∙2 | 0∙9 | ∙26 | B, Sc, R |
| Lac. 9352 . | 22 | 59 | -36 | 7∙4 | 7∙0 | ∙28 | G |

*Authorities.—A—A.Auwers;* B—E. E. Barnard; C—F. L. Chase; E—W. L.Elkin; G—Sir David Gill; K—J.C.Kapteyn; k—K.N. A. Krüger; P—B. Peter; R—H. N. Russell and A. R. Hinks; S—W. de Sitter; s—Μ. F. Smith; Sc—F. Schlesinger.

The stars selected to be examined for parallax are usually either the brightest stars or those with an especially large proper motion. Neither criterion is a guarantee that the star shall have a measur­able parallax. Brightness is particularly deceptive ; thus Canopus, the second brightest star in the heavens, has probably a parallax of less than 0·01*''*, and so also has Rigel. These two stars must have an intrinsic brilliancy enormously greater than that of the sun, for if the sun were removed to such a distance (parallax 0∙01*''*), it would appear to be of about the tenth magnitude.

Although the parallaxes hitherto measured have added greatly to our general knowledge of stellar distances and absolute luminosities of stars, a collection of results derived by various observers choosing specially selected stars is not suitable for statistical discussion. For this reason a series of determinations of parallax of 163 stars on a uni­form plan by F. L. Chase, Μ. F. Smith and W. L. Elkin *(Yale Transactions* , vol. ii., 1906) constitutes a very important addition to the available data. The stars chosen were those with centennial proper motions greater than 40*''*, observable at Yale, and not hitherto attacked. It is noteworthy that no parallaxes exceeding 0∙20*''* were found; the mean was about 0∙05*''*. It is greatly to be desired that a general survey of the heavens, or of typical regions of the heavens, should be made with a view to determining all the stars which have an appreciable parallax. This is now made possible by photography. If three plates (or three sets of exposures on one plate) are taken at intervals of six months, when the stars in the region have their maximum parallactic displacements, the first and third plates serve