to eliminate the proper motion of the star, and the detection of a parallax is easy. Some progress with this scheme has been made.

But even such an attempt to systematically plumb the universe can only make us acquainted with the merest inside shell. We should learn perhaps the distribution and luminosities of the stars within a sphere of radius sixty light years (corresponding to a parallax of about 0∙05*"*), but of the structure of the million-fold greater system of stars, lying beyond this limit, yet visible in our telescopes, we should learn nothing except by analogy. Fortunately the study of proper motions teaches us with some degree of certainty some­thing of the general mean distances and distribution of these more distant stars, though it cannot tell us the distances of individual stars.

There is another method of determining stellar distances, which is applicable to a few double stars. By means of the spectroscope it is possible to determine the relative orbital velocity of the two components, and this when compared with the period fixes the absolute dimensions of the orbit; the apparent dimensions of the orbit being known from visual observations the distance can then be found. The method is of very limited application, for in general the orbital velocity of a visual binary is far too small to be found in this way; one of its first applications has been made to α Centauri, with the result that the parallax found in the ordinary way is completely confirmed.

*Proper Motions of Stars.—*The work of cataloguing the stars and determining their exact positions, which is being pursued on so large a scale, naturally leads to the determination of their proper motions. The problem is greatly complicated by the fact that the equator and equinox, to which the observed posi­tions of the stars must be referred, are not stationary in space, and in fact the movements of these planes of reference can only be determined by a discussion of the observations of stars. Halley was the first to suspect from observation the proper motions of the stars. From comparisons between the observed places of Arcturus, Aldebaran and Sirius and the places assigned to them by Alexandrian astronomers, he was led to the opinion that all three are moving towards the south *(Phil. Trans.* 1718). Jacques Cassini also proved that Arcturus had even since the time of Tycho Brahe shifted five minutes in latitude; for *η* Bootis, which would have shared in the change, if it had been due to a motion of the ecliptic, had not moved appreciably. It was early realized that the proper motions of the stars were changes of position relative to the sun, and that, if the sun had any motion of its own as compared with the surrounding stars as a whole, this would be shown by a general tendency of the apparent motions of the stars to be directed away from the point to which the sun was moving.

To determine proper motions it is necessary to have observations separated by as long a period of time as possible. Old catalogues of precision are accordingly of great importance. By far the most valuable of these is Bradley’s catalogue of 3240 stars observed at Greenwich about 1750-1763, which has been re-reduced according to modern methods by A. Auwers. These stars include most of the brighter ones visible in the latitude of Greenwich, ranging down to about the seventh magnitude. An early catalogue which includes large numbers of stars of magnitude as low as 8∙5 is that of S. Groom­bridge, containing 4200 stars within 52° of the north pole observed between 1806 and 1816. This has been re-reduced by F. W. Dyson and W. G. Thackeray, and proper motions derived by comparison with modern Greenwich observations. A very extensive determina­tion of proper motions from a comparison of all the principal catalogues has been made by Lewis Boss. The results are given in his *Prelimina,y General Catalogue* (1910), which comprises the motions of 6188 stars fairly uniformly distributed over the sky, including all the stars visible to the naked eye. Of rather a different nature are J. G. Porter’s catalogue *(Publications of the Cincinnati Observatory,* No. 12) and J. F. Bossert’s catalogue *(Paris Observa­tions,* 1890), which consist of lists of stars of *large* proper motion determined from a variety of sources. Recently the proper motions of faint stars have been determined by comparing photographs of the same region of the sky, taken with an interval of a number of years. At present the available intervals are too small for this method to have met with marked success. Large proper motions can however be found in this way. Their detection is especially simple when the stereo-comparator is used; this instrument enables the two eyes to combine the images of each star on two plates into one image (as in the stereoscope) ; when the star has moved consider­ably in the interval between the taking of the two plates, it appears to stand out from the rest in relief and is at once noticed.

The star with the greatest proper motion yet known was found by J. C. Kapteyn on the plates of the Cape Photographic *Durch­musterung.* Its motion of 8∙.7" per year would carry it over a portion of the sky equal to the diameter of the full moon in about two centuries. In the table is given a list of the stars now known to have an annual proper motion of more than 3". The faintness of the majority of the stars appearing in this list is noteworthy.

*Stars with Large Proper Motion.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name. | R.A. 1900. | Dec. 1900. | Annual Proper Motion. | Mag. |
|  | h. m. | ° | *''* |  |
| C.Z.5h243 . . | 5 8 | -45∙0 | 8∙70 | 8∙5 |
| Gr. 1830 . . | 11 47 | +38∙4 | 7∙04 | 6∙9 |
| Lac. 9352 . . | 22∙59 | -36∙4 | 6∙94 | 7∙5 |
| Cor.32416 . .  611 Cygni . | 0 0  21 2 | -37∙8  +38∙3 | 6∙07  5∙20 | 8∙5  5∙5 |
| LI. 21185 . . | 10 58 | +36∙6 | 4∙76 | 7∙3 |
| elndi | 21 56 | -57∙2 | 4∙61 | 5∙2 |
| LI. 21258 . . | 11 0 | +44∙0 | 4∙41 | 8∙7 |
| *o*2 Eridani . | 4 11 | - 7∙8 | 4∙05 | 4∙6 |
| µ Cassiop | I 2 | +54∙4 | 3∙73 | 5∙6 |
| O.A. 14318 | 15 5 | -16∙0 | 3∙68 | 9∙1 |
| O.A. 14320 | 15 5 | -15∙9 | 3∙68 | 9∙ι |
| α Centauri . | 14 33 | -60∙4 | 3∙60 | 0∙1 |
| Lac. 8760 . | 21 11 | -39∙2 | 3∙53 | 7∙3 |
| *e* Eridani . . . | 3 16 | -43∙4 | 3∙12 | 4∙4 |
| O.A. 11677 | 11 15 | +66∙4 | 3∙02 | 9∙0 |

The majority of the stars have far smaller proper motions than these. Only 24% of the stars of Auwers-Bradley have proper motions exceeding 10*''* per century, and 51% exceeding 5*''* per century. With catalogues containing fainter stars the proportion of large proper motions is somewhat smaller, thus the corresponding percentages for the Groombridge stars are 12 and 31 respectively.

When the parallax of a star is known, we are able to infer from its proper motion its actual linear speed in miles per hour, in so far as the motion is transverse to the line of sight. The velocity in the line of sight can be determined by spectroscopic observation, so that in a few cases the motion of the star is completely known. Several stars appear to have speeds exceeding 100 m. per second, but of these the only one reliably determined is Groombridge 1830, whose speed is found to be about 150 m. per second. Probably the velocity of Arcturus is also over 100 m. per second; there is, however, no real evidence for the velocity of 250 m. per second which has sometimes been credited to it. The above are velocities transverse to the line of sight. The greatest radial velocities that have yet been found are about 60 m. per second; several stars (Groombridge 1830 among them) have radial speeds of this amount. The stars of the Helium type of spectrum are remarkable for the smallness of their velocities; from spectroscopic observations of over 60 stars of this class, J. C. Kapteyn and E. B. Frost have deduced that the average speed is only 8 m. per second. Accord­ing to W. W. Campbell the average velocity in space of a star is 21∙2 m. per second.

When the proper motions of a considerable number of stars are collected and examined, a general systematic tendency is noticed. The stars as a whole are found to be moving towards a point somewhere in or near the constellation Canis Major. The motions of individual stars, it is true, vary widely, but if the mean motion of a number of stars is considered this tendency is always to be found. Now it is necessary to bear in mind that all observed motions are *relative\*,* and, especially in dealing with stellar motions, it is arbitrary what shall be considered at rest, and used as a standard to which to refer their movements. Accordingly this mean motion of the stars relative to the sun has been more generally regarded from another point of view as a motion (in the opposite direction—towards the constellation Lyra) of the sun relatively to the stars. In what follows we shall speak of this relative motion as a motion of the sun or of the stars indifferently, for there is no real distinction between the two conceptions. One of the problems, which has engaged a large share of the attention of astronomers in the last century, has been the determination of the direction of this "solar motion.”

The first attempt to determine the solar apex (as the point towards which the solar motion is directed is termed) was made in 1783 by Sir William Herschel. Although his data were the proper motions of only seven stars, he indicated a point near λ Herculis not very far from that found by modern researches. Again in 1805 from Maskelyne’s catalogue of the proper motions of 36 stars (published in 1790), he found the position, R.A. 245° 52' and Dec. 49° 38*'* N. The systematic tendency of the proper motions is so marked that the motions of a very few stars are quite sufficient to fix roughly the position of the solar apex; but attempts to fix its position ∙to within a few degrees have failed, notwithstanding the many thousands of determined proper motions now available. The difficulties of the determination are twofold. There is a close interdependence between the constant of procession and the solar motion; the two determinations must generally be made simul­taneously, and both depend very considerably on the systematic