and more generally recognized that the stars are not unrelated; they are parts of a greater system, and we have to deal with, not merely the history of a number of independent units, but with a far vaster conception, the evolution and development of an ordered universe.

Our first inquiry is whether the universe extends indefinitely in all directions, or whether there are limits beyond which the stars are not distributed. It is not difficult to obtain at least a partial answer to this question ; anything approaching a uniform distribution of the stars cannot extend indefinitely. It can be shown that, if the density of distribution of the stars through infinite space is nowhere less than a certain limit (which may be as small as we please), the total amount of light received from them (assuming that there is no absorption of light in space) would be infinitely great, so that the background of the sky would shine with a dazzling brilliancy. We therefore conclude that beyond a certain distance there is a thinning out in the distribution of the stars; the stars visible in our telescopes form a universe having a more or less defined boundary; and, if there are other systems of stars unknown to us in the space beyond, they are, as it were, isolated from the universe in which we are. It is necessary however to emphasize that the foregoing argument assumes that there is no appreciable absorption of light in interstellar space. Recently, however, the trend of astronomical opinion has been rather in favour of the belief that diffused matter may exist through space in sufficient quantity to cause appreciable absorption; so that the argument has no longer the weight formerly attached to it. Another line of reasoning indicates that the boundary of the universe is not immeasurably distant, and that the thinning out of the stars is quite perceptible with our telescopes. This depends on the law of progression in the number of stars as the brightness dimin­ishes. If the stars were all of the same intrinsic brightness it is evident that the comparison of the number of stars of successive magnitudes would show directly where the decreased density of distribution began. Actually we know that the intrinsic brightness varies very greatly, so that each increase of telescopic power not

examination of the line-of-sight velocities of stars from the same point of view, this physical interpretation must be received with some degree of caution; but there can be no doubt of the reality of the anomalies in the statistical distribution of proper motions of the stars, and of these it offers a simple and adequate explanation.

Having determined the motions of the two drifts, and knowing also that the stars are nearly equally divided between them, it is evidently possible to determine the mean motion of the drifts com­bined. This is of course that relative motion of the sun and stars which we have previously called the solar motion. The position of the solar apex calculated in this way agrees satisfactorily with that found by the usual methods. It is naturally fairly close to the apex of the faster drift, but is displaced from it in the direction of the apex of the other drift. In this connexion it may be noticed that, when the smaller and larger proper motions are discussed separately, the latter category will include an unduly great proportion of stars belonging to the fast-moving drift, and the resulting determination will lead to a solar apex too near the apex of that drift, *i.e.* with too low a declination. This appears to be the explanation of Stumpe’s and Porter’s results; they both divided their proper motions into groups according to their numerical amount, and found that the declination of the solar apex progressively increased as the size of the motions used diminished. Another anomalous determination of the apex, due to H. A. Kobold *(Astro. Nach.,* 3163, 3451, and 3491) is also explained when the two drifts are recognized. Kobold, using a peculiar and ingenious method, found for it a declination -3°, which disagrees very badly with all other determinations; but it is a peculiarity of Kobold's method that it gives the line of symmetry of motion, which joins the apex and antapex, without indicating which end is the apex. Now the position of this line, as found by Kobold, actually is a (properly weighted) mean between the corresponding lines of symmetry of the two drifts, but naturally it lies in the *acute* angle between them, whereas the line of the solar motion is also a weighted mean between the two lines of drift, but lies in the *obtuse* angle between them.

*The Structure of the Universe.—*We now arrive at the greatest of all the problems of sidereal astronomy, the structure and nature of the universe as a whole. It can by no means be taken for granted that the universe has anything that may properly be called a *structure.* If it is merely the aggregate of the stars, each star or small group of stars may be a practically independent unit, its birth and development taking place without any rela­tion to the evolution of the whole. But it is becoming more

only enables us to see stars more remote than before, but also reveals very many smaller stars within the limits previously penetrated. But notwithstanding the great variety of intrinsic brightness of the stars, the ratio of the number of stars of one magnitude to the number of the magnitude next lower (the “ star-ratio ”) is a guide to the uniformity of their distribution. If the uniform distribution extends indefinitely, or as far as the telescope can penetrate, the star-ratio should have the theoretical value 3∙98,@@l any decrease in density or limit to the distribution of the stars will be indicated by a continual falling off in the star-ratio for the higher magnitudes. H. H. Seeliger, who investigated this ratio for the stars of the *Bonn Durchmusterung* and *Southern Durchmusterung,* came to the conclusion (as summarized by Simon Newcomb) that for these stars the ratio ranges from 3∙85 to 3∙28, the former value being found for regions near the Milky Way and the latter for regions near the galactic poles. There is here evidence that even among stars of the *Durchmusterung* (9·5 magnitude), a limit of the universe has been reached, at least in the direction normal to the plane of the Milky Way. For the higher magnitudes J. C. Kapteyn has shown that the star-ratio diminishes still further.

In all investigations into the distribution of the stars in space one fact stands out pre-eminently, viz. the existence of a certain plane fundamental to the structure of the heavens. This is the *galactic plane,* well known from the fact that it is marked in the sky by the broad irregular belt of milky light called the Galaxy or Milky Way. But it is necessary to make a careful distinction between the galactic plane and the Galaxy itself; the latter, though it is neces­sarily one of the most remarkable features of the universe, is not the only peculiarity associated with the galactic plane. Its par­ticular importance consists in the fact that the stars, bright as well as faint, crowd towards this plane. This apparent relation of the lucid stars to the Galaxy was first pointed out by Sir W. Herschel. For the stars visible to the naked eye a very thorough investigation by G. V. Schiaparelli has shown the relation in a striking manner. He indicated on planispheres the varying density of distribution of the stars over the sky. On these the belt of greatest density can be easily traced, and it follows very closely the course of the Milky Way; but, whereas the latter is a belt having rather sharply defined boundaries, the star-density decreases gradually and con­tinuously from the galactic equator to the galactic poles. The same result for the great mass of fainter stars has been shown by Seeliger. The following table shows the density with which stars brighter than the ninth magnitude are distributed in each of nine zones into which Seeliger divided the heavens:—

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | N. Pole | 70° N. | 50° N. | 30° N. | 10° N. | 10° S. | 30° S. | 50° s. | 70° S. |
| Galactic latitude | to | to | to | to | to | to | to | to | to |
|  | 70° N. | 50° N. | 30° N. | 10° N. | 10°S. | 30° s. | 50° S. | 70° S. | S. Pole |
| Number of stars per square degree | 2∙78 | 3·03 | 3·54 | 5∙32 | 8∙17 | 6∙07 | 3∙71 | 3·21 | 3∙14 |

The table, which is based on over 130,000 stars, shows that along the galactic circle the stars are scattered nearly three times more thickly than at the north and south poles of the Galaxy. What, however, is of particular importance is that the increase is gradual. No doubt many of the lucid stars which appear to lie in the Milky Way actually belong to it, and the presence of this unique cluster helps to swell the numbers along the galactic equator; but, for example, the increased density between latitudes 30° to 50° (both north and south) as compared with the density at the poles cannot be attributed to the Galaxy itself, for the Galaxy passes nowhere near these zones. The star-gauges of the Herschels exhibit a similar result; the Herschels counted the number of stars visible with their powerful telescopes in different regions of the sky, and thus formed comparative estimates of the density of the stars, extending to a very high magnitude. According to their results the star-density increases continuously from 109 per square degree at the poles to 2019 along the galactic equator. In general, the fainter the stars included in the discussion the more marked is their crowding towards the galactic plane. Various considerations tend to show that this apparent crowding docs not imply a really greater density or clustering of the stars in space, but is due to the fact that in these directions we look through a greater depth of stars before coming to the boundary of the stellar system. Sir William Herschel and afterwards F. G. W. Struve developed the view that the stars are contained in a comparatively thin stratum bounded by two parallel planes. The shape of the universe may thus be compared to that of a grind­stone or lens, the sun being situated about midway be­tween the two surfaces. Thus the figure represents a section the (ideally simplified) uni­verse cut perpendicular to the planes AB and CD between which the stars are contained,.

@@@1 This number is the 3/2th power of the ratio of the brightness of stars differing by a unit magnitude.