progress of a nova.\* 17 Argus is surrounded by a nebula, the famous "Keyhole nebula”; in this respect it resembles Nova Persei.

*System of Stars.—*On examining the stars telescopically, many which appear single to the unaided eye arc found to be composed of two or more stars very close together. In some cases the proximity is only apparent; one star may be really at a vast distance behind the other, but, being in the same line of vision, they appear close together. In many cases, however, two or more stars arc really connected, and their distance from one another is (from the astronomical standpoint) small. The evidence of this connexion is of two kinds. In a number of cases measures of the relative positions of the two stars, continued for many years, have shown that they are revolving about a common centre; when this is so there can be no doubt that they form a binary system, and that the two components move in elliptic orbits about the common centre of mass, controlled by their mutual gravitation. But these cases form a very small proportion of the total number of double stars. In many other double stars the two com­ponents have very nearly the same proper motion. Unless this is a mere coincidence, it implies that the two stars are nearly at the same distance from us. For otherwise, if they had from some unknown cause the same *actual* motion, the *apparent* motion in arc would be different. We can therefore infer that the two stars are really comparatively close together, and, moreover, since they have the same proper motion, that they remain close together. They may thus be fairly regarded as constituting a binary system, though the gravitational attraction between some of the wider pairs must be very weak.

Several double stars were observed during the 17th century, ζ Ursae Majoris being the first on record. In 1784 Christian Mayer published a catalogue of all the double stars then known, which contained 89 pairs. Between 1825 and 1827 F. G. W. Struve at Dorpat examined 120,000 stars, and found 3112 double stars whose distance apart did not exceed 32''. W. S. Burnham’s *General Catalogue of Double Stars* (1907) contains 13,655 pairs north of declination -31°. Undoubtedly a large number of these are only optical pairs, but mere considerations of probability show that the majority must be physically connected. For only 88 of them has it been possible as yet to deduce a period, and at least half even of these periods are very doubtful. The rates of motion are so slow that many centuries’ observations are needed to determine the orbit.

The most rapid visual binary (leaving aside Capella for the moment) is δ Equulei, which completes a revolution in 5∙7 years. Next to it come 13 Ceti, period 7∙4 years, and *κ* Pegasi, period 11∙4 years. From a list of systems with determined periods given by Aitken *(Lick Observatory Bulletin,* No. 84) there are 20 with periods less than 50 years, and 16 between 50 and 100 years. δ Equulei, 13 Ceti and *κ* Pegasi are all extremely close pairs, and can only be resolved with the most powerful instruments. Capella, whose period is only 104 days, was discovered to be double by means of the spectroscope, but has since been measured frequently as a visual binary at Green­wich. With the best instruments a star can be distinguished as double when the separation of the two components is a little less than 0∙1*''*. From the very few orbits that have as yet been determined one interesting result has been arrived at. Most of the orbits are remarkably eccentric ellipses, the average eccentricity being about 0∙5. There is a very striking relation between the eccentricity and the period of a system; in general the binaries of longest period have the greatest eccentricities. The relation applies not only to the visual but to the spectroscopic binaries; these, having shorter periods than the visual binaries, have generally quite Small eccentricities. Another interesting feature is that, where the two components differ in brightness, the fainter component is often the one possessing the greater mass.

Far within the limit to which telescopic vision can extend binary systems are now being found by the spectroscope. These systems appear as a connecting link between short-period variable stars on the one hand and telescopic double stars on the other. Stars of the class to which the Algol type of variables belongs will appear to us to vary only in the exceptional case when the plane of the orbit passes so near our sun that one body appears to pass over the other and so causes an eclipse. Except when the line of sight is perpendicular to the plane of the orbit, the revolution of. the two bodies will result in a periodic variation of the motion in the line of sight. Such a variation can be detected by the spectroscope. If both the bodies are luminous, especially if they do not differ much in brilliancy, the motion of revolution is shown by a periodic doubling of the lines of the spectrum ; when one body is moving towards us and the other away their spectral lines are displaced (according to Doppler’s principle) in opposite directions, so that all the lines strong enough to appear in both spectra appear double when the two bodies are in conjunction, and therefore moving transversely, their spectra are merged into one and show nothing unusual. More usually, however, only one component is sufficiently luminous for its spectrum to appear; its orbital motion is then detected by a periodic change in the absolute displacement of its spectral lines. Up to 1905, 140 spectroscopic binaries had been discovered ; a list of these is given in the *Lick Observatory Bulletin,* no. 79. Details of the calculated orbits of 63 spectroscopic binaries are given in *Publications of the Alleghany Observatory,* vol. i. No. 21. According to W. W. Campbell one star in every seven examined is binary.

A continuous gradation can be traced from the most widely separated visual binaries, whose periods are many thousand years, to spectroscopic binaries, Algol and *ß* Lyrae variables, whose periods are a few hours and whose components may even be in contact, and from these to dumb-bell shaped stars and finally to ordinary single stars. It is a legitimate speculation to suppose that these in the reverse order are the stages in the evolution of a double star. As the simple star radiates heat and contracts, it retains its angular momentum; when this is too great for the spheroidal form to per­sist, the star may ultimately separate into two components, which are driven farther and farther apart by their mutual tides. Tidal action also accounts for the progressively increasing eccentricities of the orbits, already referred to. This theory of the genesis of double-stars by fission is not, however, universally accepted; in particular objections have been urged by T. C. Chamberlin and F. R. Moulton. It is true that rotational instability alone is not com­petent to explain the separation into two components; but the exist­ence of gravitational instability, pointed out by J. H. Jeans, enables the principal difficulties of the theory to be surmounted. Whilst there is thus no well-defined lower limit to the dimensions of systems of two stars, on the other hand we cannot set any superior limit either to the number of stars which shall form a system or to the dimensions of that system. No star is altogether removed from the attractions of its neighbours, and there are cases where some sort of connexion seems to relate stars which are widely separated in space. A curious case of this sort is that of the five stars *ß, y, δ, ε* and *ζ* of Ursa Major. These have proper motions which are almost identical in amount and in direction. The agreement is too close to be dis­missed as a mere coincidence, and it is confirmed by a corresponding agreement of their radial motions determined by the spectroscope; and yet, seeing that *ß* and *ζ* Ursae Majoris are 19° apart, these two stars must be distant from each other at least one-third of the dis­tance of each from the sun; thus the members of this singular group are separated by the ordinary stellar distances, and probably each has neighbours, not belonging to the system, which are closer to it than the other four stars of the group. Further, E. Hertzsprung has shown that Sirius also belongs to this same system and shares its motion, notwithstanding that it is in a nearly opposite part of the sky. It is difficult to understand what may be the connexion between stars so widely separated ; from the equality of their motions they must have been widely separated for a very long period.

Of multiple stars the most famous is *0* Orionis, situated near the densest part of the great Orion nebula. It consists of four principal stars and two faint companions. From the more complex systems of this kind, we pass to the consideration of star-clusters, which are systems of stars in which the compo­nents are very numerous. When examined with a telescope of power insufficient to separate the individual stars, a cluster appears like a nebula. The “ beehive cluster ” Praesepe in Cancer is an example of an easily resolved cluster composed of fairly bright stars. The great cluster in Hercules (Messier 13), on the other hand, requires the highest telescopic power for its complete resolution into stars. Doubtless with improved telescopes many more apparent nebulae would be shown to be clusters, but there are certainly many nebulae which are otherwise constituted. Many of the clusters are of very irregular forms, either showing no well-marked centre of condensa­tion, or else condensed in streams along certain lines. There is, however, a well-marked type to which many of the richest clusters belong; these are the *globular clusters.* They have a symmetrical circular shape, the condensation increasing rapidly towards the centre. The Hercules cluster is of this form ; another example is *ω* Centauri, in which over 6000 stars have been counted, comprised within a circle of about 40' diameter. These clusters present many unsolved problems. Thus Perrine, from an examination of ten globular clusters (including Messier 13 and *ω* Centauri), has found in each case that the stars can be separated into two classes of magnitudes. About one-third of the stars are between magnitudes 11 and 13, and the remaining two-thirds are between magnitudes 15∙5 and 16∙5. Stars of magnitudes intermediate between these two groups are almost entirely absent. Thus each cluster seems to consist of two kinds of stars, which we may distinguish as bright and faint; the bright stars are all approximately of one standard size, and the faint stars of another standard size and brightness.

The question of the stability of these clusters is one of much interest. The mutual gravitation of a large number of stars crowded in a comparatively small space must be considerable, and the indivi­dual stars must move in irregular orbits under their mutual attrac­tions. It does not seem probable, however, that they can escape the fate of ultimately condensing into one confused mass. If this sur­mise be correct, we are witnessing in clusters a counter-process of