variables. It is therefore perhaps misleading actually to class the sun with them; but it seems highly probable that whatever cause produces the periodic outbursts of spots and faculae on our sun differs only in degree from that which, in stars under a different physical condition of pressure and temperature, results in the gigantic conflagrations which we have been considering.

*Short-period Variables.—*Besides the shortness of the period these variables possess other characteristics which differentiate them from the long-period variables. The range of variation is much smaller, the difference between maximum and minimum rarely exceeding two magnitudes. Also the variations recur with perfect regularity. There is reason to believe that all the stars of this class are binary systems, and that the variations of brightness are deter­mined by the different aspects presented by the two component stars during the period of revolution. There are, several well- marked varieties of short-period variables; the most important are typified by the stars Algol, *ß* Lyrae, *ζ* Geminorum and δ Cephei.

In the Algol variables one of the component stars is dark (that is to say, dark in comparison with the other), and once in each revolu­tion, passing between us and the bright component, partially hides it. This class of variables is accordingly characterized by the fact that for the greater part of the period the star shines steadily with its maximum brilliancy, but fades away for a short time during each period. The variability of Algol *(ß* Persei) was discovered in 1783 by John Goodricke (1764-1786), but, judging from its name, which signifies “ the demon,” it seems possible that its peculiarity may have been known to the ancient astronomers. Algol is ordinarily of magnitude 2∙3, but once in a period of 2d∙ 20h∙ 49m∙ it suffers partial eclipse and fades to magnitude 3·5. The duration of each eclipse is 91/4 hours. Ever since the variability of Algol was observed it was suspected to be due to a partial eclipse of the star by a dark body nearly as large as itself revolving round it; but the explanation remained merely a surmise until K. H. Vogel of Potsdam, by repeated measurements of the motion of Algol in the line of sight, showed that the star is always receding from us before the loss of light and approaching us afterwards. This leaves no room for doubt that an invisible companion passes between us and Algol about the time the diminution of light takes place, and so proves the correct­ness of the explanation. The dimensions of the Algol system have been calculated, with the result that Algol appears to have a diameter of 1,000,000 m. and its companion a diameter of 830,000 m.; the distance between their centres cannot be deduced without making certain doubtful assumptions, but may be about 3,000,000 m. When this distance is compared with those prevailing in the solar system, it seems an extraordinarily small separation between two such large bodies; we shall, however, presently come across systems in which the two components revolve almost or actually in contact. About 56 Algol variables were known in 1907; the variables of this class are the most difficult to detect, for the short period of obscuration may easily escape notice unless the star is watched continuously.

The variable star *ß* Lyrae, which is typical of another class, was also discovered by Goodricke in 1784. It differs from the Algol type in having two unequal minima separated by two equal maxima. Thus in a period of 12d∙ 22h∙ from a maximum of magnitude 3∙4 it falls to 3∙9, rises again to 3∙4, then falls to 4∙5 and returns to magnitude 3∙4. The changes take place continuously, so that there is no period of steady luminosity. The hypothesis of G. W. Myers *(Astrophysical Journal,* vol. vii.) affords at least a partial explanation of the phenomena. Two stars are supposed to revolve about one another nearly or actually in contact. In such a system the tidal forces must be very great, and under their influence the stars will not be spherical, but will be elongated in the direction of the line joining their centres. When the line of centres is at right angles to our line of sight, the stars present to us their greatest apparent surface, and therefore send us the maximum light. This happens twice in a revolution. As the line of centres becomes more oblique, the surface is seen more and more foreshortened and the brilliancy diminishes continuously. Supposing that the two stars are of unequal surface brilliancy, the magnitude at minimum will depend on which of the two stars is the nearer to us, accordingly there are two unequal minima in each revolution. When the two stars are of equal brilliancy the minima are equal; this is the case in variables of the *ζ* Geminorum type. When the orbits are eccentric, the tidal disturbance varying with the distance between the two components will probably cause changes in their absolute brilliancy; the variation due to change in the aspect of the system presented to us may thus be supplemented by a real intrinsic varia­tion, both, however, being regulated by the orbital motion. A large eccentricity also produces an unsymmetrical light variation, the minimum occurring at a time not midway between two maxima; stars of this character are called Cepheid variables, after the typical star δ Cephei. All the best-known short-period variables have been proved to be binary systems spectroscopically, and to have periods corresponding with the period of light variation, so that to this extent the hypothesis we have described is well founded; but it is doubtful if it is the whole explanation. S. Albrecht has shown that, of the 10 members of the δ Cephei class for which both the orbits and the light-variations are thoroughly known, the maximum light always occurs approximately at the time when the brighter component is approaching us most rapidly ; this relation, which seems to be well established, is a most perplexing one.

No hard and fast physical distinction can be drawn between the various classes of short-period variables; as the distance between the components diminishes the Algol variable merges insensibly into the *ß* Lyrae type. The latter, on the other hand, is perhaps connected by insensible gradations with the ordinary simple star. Sir G. H. Darwin and H. Poincaré have investigated the forms taken up by rotating masses of fluid. When the angular momentum is too great for the usual spheroidal form to persist, this gives place to an ellipsoid with three unequal axes; this is succeeded by a pear-shaped form. The subsequent sequence of events cannot be traced with certainty, but it seems likely that the pear-shaped form is succeeded by an hour-glass-shaped form, which finally separates at the neck into two masses of fluid. Ellipsoidal, pear-shaped or hour-glass- shaped stars would all give rise to the phenomena of a short-period variable, and doubtless examples of these intermediate forms exist.

Certain clusters contain a remarkable number of short-period variables. Thus the cluster Messier 5 was found at Harvard to contain 185 variables out of 900 stars examined. Solon I. Bailey, on examining 63 of them, found that with one exception their periods lay between 10h∙ 48m∙ and 14h∙ 59m∙, and the range of varia­tion between 0∙7 and 1∙4 magnitudes. Moreover, the light-curves were all of a uniform type, a distinctive feature of “ cluster variables ” being the rapid rise to a maximum and slow decline.

*Temporary Stars or Novas.—*From time to time a star, hitherto too faint to be noticeable, blazes out and becomes a prominent object, and then slowly fades into obscurity. According to Miss Agnes Clerke there are records of ten such stars appearing between 134 b.c. and a.d. 1500. Since that time nine novas have appeared, which have attained naked-eye visibility; and in recent years a number of very faint objects of the same class have been detected. The brightest star of all these was the famous “ Tycho’s star ” in Cassiopeia. It was first observed on the 6th of November 1572 by Wolfgang Schuler. In five days its light had reached the first magnitude, and a little later it even equalled Venus in brilliancy and was observed in full daylight. After three weeks it began to decline, but the star did not finally disappear until March 1574. “ Kepler’s ” nova in Ophiuchus broke out in 1604 and attained a brightness greater than that of Jupiter; it likewise gradually waned, and disappeared after about fifteen months. For nearly three centuries after these two remarkable stars no nova ‘attained a brilliancy greater than that of the ordinary stars, until in 1901 Nova Persei appeared. This star was discovered by T. D. Anderson on the 21st-22nd of February, its magnitude at that time being 2∙7. In the next two days it reached zero magnitude, thus becoming the brightest star in the northern heavens, but after that it rapidly decreased. On the 15th of March it was of the fourth magnitude; during the next three months it oscillated many times between magnitudes 4 and 6, and by the end of the year it had faded to the seventh magnitude. In July 1903 it was of the twelfth magni­tude, and its light has remained constant since then. In the case of this star there is evidence that the outburst must have been extremely rapid, for the region where Nova Persei appeared had been photographed repeatedly at Harvard during February, and in particular no trace of the star was found on a plate taken on the 19th of February, which showed eleventh magnitude stars. Thus a rise of at least eight magnitudes in two days must have occurred.

On the 21st of August, six months after the discovery of Nova Persei, C. Flammarion and E. Μ. Antoniadi discovered that a nebula surrounded it. Subsequent photographs showed that this nebula, which consisted mainly of two incomplete rings of nebulosity, was expanding outwards at the rate of from 2\* to 3\* per day. This expansion continued at the same rate until the following year. Spectroscopic examination had already suggested prodigious veloci­ties of the order of 1000 m. per second in the gases of the atmos­phere of the nova; but the velocity implied by this expansion of the nebula was unprecedented and comparable only with the velocity of light. The suggestion was made., and seems to be the true explanation, that what was actually witnessed was the wave of light due to the outburst of the nova, spreading outwards with its velocity of 186,000 m. per second, and rendering luminous as it reached them the particles of a pre-existing nebula, whose own light had been too faint to be visible.

Two possible explanations of the phenomena of temporary stars have been held. The collision theory supposes that the outburst is the result of a collision between two stars or between a star and a swarm of meteoric or nebulous matter. The explosion theory regards the outburst as similar to the outbreak of activity of a long- period variable. Probably the latter hypothesis is the one more generally accepted now.. There is one unique star, which is of special interest as occupying rather an intermediate position between a nova and a long-period variable. This is the southern star *η* Argus (sometimes called *η* Carinae). From 1750 until about 1832 it seems to have varied irregularly between the second and the fourth magnitudes. For the next ten years it slowly increased (though with slight check), and in 1843 was nearly as bright as Sirius; since then it has slowly faded, but it was not till 1869 that it ceased to be visible to the naked eye. It is now about magnitude 7∙5. The slowness both of the rise and decline is in great contrast with the