its period. This is illustrated in fig. 13, where the effect of a single absorbing system upon vibrations of all wave-lengths is shown.

The line *η* shows the factor by which the index of refraction of the transmitted vibration is multiplied, and the curve *p* the intensity of the absorbed vibra­tion for that wave-length. The relative increase of index takes place on the side where the wave­length is greater than that of the absorbing system. The effect of such a change may be to bend back the coloured ribbon of the spectrum upon itself, but just where this is done all its light will be robbed to maintain the absorbing system in vibration. Theory is here much less intricate than fact, but it seems to cover the most important features and to be well confirmed. Omitting extreme examples, like fuchsin, where the spectrum is actually cut in two, it is of more general. importance to detect the phenomenon in the ordinary absorption lines of the metallic elements. This has been done most completely by L. Puccianti, who measured it by the interferometer in the case of more than a hundred lines of different metals; he found its degree to differ much in different lines of the same spectrum.

Differences, of refractive index produce their, greatest dispersive effects when incidence on. the refracting surface is nearly tangential. W. H. Julius has used this fact in an admirable experiment to make the effects visible in. the case of the D lines of sodium. A burner was constructed which gave a sheet of flame 750 mm. long and I mm. thick and to which sodium could be supplied in measured quantity. Light from an arc lamp, was so directed that only that part reached the spectroscope which fell upon the flame of the burner at grazing incidence, and was thereby refracted. As the supply of sodium was increased, the lines, besides becoming broader, did so unsymmetrically, and a shaded wing or band appeared on one side or the other according as the beam impinged on one side or the other of the flame. These bands Julius calls dispersion bands, and then, assuming that a species of tubular structure pre­vails within a large part of the sun (such as the filaments of the corona suggest for that region), he applies the weakening of the light to explain, for instance, the broad dark H and K calcium lines, and the sun-spots, besides many remoter applications. But it should be noted that the bands of his experiment are not due to anomalous dispersion in a strict sense. They are formed now on one side, now on t.ne other, of the absorption line; but the rapid increase of refractive index which accompanies true anomalous dispersion, and might be expected to produce similar bands by scattering the light, appears both from theory and experiment to belong to the side of greater wave-length exclusively. Julius’s phenomenon seems inseparable from grazing incidence, and hence any explanation it supplies depends upon his hypothetical tubular structure for layers of equal density. There are other difficulties. In calcium, for instance, the g line shows in the laboratory much stronger anomalous dispersion than H and K; but in the solar spectrum H and K are broad out of all comparison to *g.* . Hale has pointed out other respects in which the explanation fails to fit facts. In connexion with the question whether the phenomena of the sun are actually very different from what they superficially appear, A. Schmidt’s theory of the photosphere deserves mention; it explains how the appearance of a sharp boundary might be due to a species of mirage.

Consider the rays which meet the eye (at unit distance) at an angle *d* from the centre of the sun’s disk; in their previous passage through the partially translucent por­tions of this body we have the equation sin *d=rμ* sin *i* (fig. 14). Now. generally µ will decrease as *r* increases, but the initial value of μ. is not likely to be more than, say, twice its final value of unity,, while r increases manifold in the same range, hence in general *rµ* will increase with *r,* and therefore for a given value of d, *i* will continually, increase as we go inwards up to 90o, which it will attain for a certain value of r, and this will be the deepest level of the sun’s body from which rays will reach the eye at the given angle *d.* But if there is a region, say from *r'* to *r"* throughout which *rµ* decreases as *r* increases, any ray which cuts the outer envelope *r'* at an acute angle will cut the inner one r" also, and can be traced still further inwards before the angle *i* amounts to 90°.

Apart then from absorption there will be a discontinuous change in brightness in the apparent disk at that value of the angular radius *d* which corresponds to tangential emission from the upper lever r' of this mirage-forming region. Of course we are unabíe to say whether such a region is an actuality in the sun, on the earth it is an excèption and transient, but the greater the dimensions of the body the more probable is its occurrence. The theory can be put to a certain test by considering its implications with respect to colour. The greater µ is, the greater would be the value of *d,* the apparent angular radius, corresponding to horizontal emission from a given level *r,* and that whether we accept Schmidt’s theory or not. Hence if the sun’s diameter were measured through differently coloured screens, the violet disk must appear greater than the red. Now measures made by Auwers with the Cape heliometer showed no difference, amounting to 0·1" and so far negative the idea that the rays reach us after issuing from a level where µ is sensibly differ­ent from unity. Presumably, then, the inner emissions are absorbed and those which reach us start from very near the surface.

The sun’s distance is the indispensable link which connects terrestrial measures with all celestial ones, those of the moon alone excepted; hence the exceptional pains taken to deter­mine it. The transits of Venus of 1874 and 1882 were observed by expeditions trained for the purpose before­hand with every possible foresight, and sent out by the British, French and German governments to occupy suitable stations distributed over the world, but they served only to demonstrate that no high degree of accuracy can ever be expected from this method. It is the atmosphere of Venus that spoils the observation. Whatever be the subsequent method of reduction, the instant is required when the planet’s disk is in internal contact with that of the sun ; but after contact has plainly passed, it still remains connected with the sun’s rim by a "black drop,” with the result that trained observers using similar instruments set up a few feet from one another sometimes differed by half a minute of time in their record. It is little wonder, then, that the several reductions of the collected results were internally discordant so as to leave outstanding a considerable "probable error,” but showed themselves able to yield very different conclusions when the same set was discussed by different persons. Thus from the British observations of 1874 Sir G. B. Airy deduced a parallax of 8∙76" and E. J. Stone 8·88\*; from the French observa­tions of the same date Stone deduced 8∙88" and V. Puiseux 8·91". The first really adequate determinations of solar parallax were those of Sir David Gill, measured by inference from the apparent diurnal shift of Mars among the stars as the earth turned diurnally upon its axis; the observations were made at the island of Ascension in 1878. The disk of Mars and his colour are certain disadvantages, and Gill afterwards superseded his own work by treating in the same way the three minor planets Victoria, Iris and Sappho—the last was observed by W. L. Elkin. These planets are more remote than Mars, but that loss is more than outweighed by the fact that they are indistinguishable in appearance from stars. The measures were made with the Cape heliometer and have never been superseded, for the latest results with the minor planet Eros exactly confirm Gill’s result—8∙80"—while they decidedly diminish the associated probable error. The planet Eros was discovered in 1899, and proved to have an orbit between the earth and Mars, while every one of the other five or six hundred known asteroids lies between Mars and Jupiter. Its mean distance from the sun is 1∙46 times that of the earth; but, besides, the eccentricity of its orbit is large (0∙22), so that at the most favourable opportunity it can come within one-seventh of the distance of the sun. This favour­able case is not realized at every opposition, but in 1900 the distance was as little as one-third of that of the sun, and it was observed from October 1900 to January 1901 photographically upon a concerted but not absolutely uniform plan by many observatories, of which the chief were the French national observatories, Greenwich, Cambridge, Washington and Mount Hamilton. The planet showed a stellar disk varying in magnitude from 9 to 12. On some plates the stars were allowed to trail and the planet was followed, in others the reverse procedure was taken; in either case the planet’s position is measured by referring it to ".comparison stars ” of approximately its own magnitude situated within 25' to 30' of the centre of the plate, while these stars are themselves fixed by measurement from righter " reference stars,” the positions of which are found by meridian observations if absolute places are desired. The best results seem to be obtained by comparing an evening’s observations with those of the following morning at the same observatory; the reference can then be made to the same stars and errors in their position are therefore virtually eliminated; even if the observations of a morning with those of the following evening are used the prob­able error is doubled. The observations at Greenwich thus reduced gave errors ±0∙0036" and ±0∙0080" respectively. The. general result is 8∙800" ±0∙0044\*. To collate the whole of the material accu­mulated at different parts of the world is a much more difficult task; it requires first of all a most carefully constructed star-catalogue, upon which the further discussion may be built. The discussion was completed in 1909 by A. R. Hinks, and includes the material from some hundreds of plates taken at twelve observatories.; in general it may be said the discussion proves that the material is distinctly