ADDITIONAL AND CORRECTED ELEMENTS FOR THE TRANSIT OF VENUS, December 9th, 1874.

WITH NOTES FOR REDUCING THE EFFECTS OF IRRADIATION, AND ERRORS FROM OBSERVATIONS MADE IN THE PLANE OF THE MERIDIAN, Etc., Etc.

By F. Abbott, F.R.A.S., F.R.M.S.

Read at a meeting of the Royal Society of Tasmania, 9th of June, 1874.

	h.	m.	s.	
External contact at Ingress	11	35	27	a.m.
Internal contact at Ingress	12	04	53	p.m.
Least distance of centres, 13′ 46″ ·7	1	56	01	p.m.
Internal contact at Egress...	3	46	55	p.m.
External contact at Egress...	4	16	23	p.m.

Mean Time at Hobart Town.

For direct image. Angle from N. pole of
- first external contact 50° towards the E.
- first internal contact 44° towards the E.
- last internal contact 14° towards the W.
- last external contact 20° towards the W.

	°	′	″
The Sun's true Semidiameter	0	16	16·2
Venus's true Semidiameter	0	0	32·1
The Sun's apparent Declination...	22	51	2·9 S.
The Approximate Meridian Altitude	69	59	0
	h.	m.	s.
The Meridian Passage	11	52	22·71
	°	′	″
At Ingress the Sun's Elevation will be	67	0	0
,, ,, ,, Retardation		2·8	
At Egress the Sun's Elevation will be	40	0	0
,, ,, ,, Acceleration		7·6	

The exact moment of contact is a little doubtful; it de-depends on the real size of Venus, as well as on her motions, the size being necessarily a matter of estimation, and the motion of Venus, although well determined, will be, if necessary, corrected by the observations during the transit; so that the circumstances of the transit will not be appreciably affected, even though there should be a minute or two of error.

The greatest difficulty to encounter at the coming transit, next to that of a cloudy atmosphere, is irradiation. The eye is by no means a perfect optical instrument. It suffers from spherical aberration; a scattered luminosity, more or less strong, always surrounding the defined images of luminous objects upon the retina. It is well known that images of objects frequently persist on the retina of the eye, *i.e.*, we continue to see light for a certain period after the light itself has gone out, as in the case of an electric spark, bolides, falling stars, or meteors, &c. Irradiation is a similar action of the retina, in respect of space. The retina does not lose

its impression at once, nor can any part of it be affected apparently, without its neighbourhood being affected also, any brilliant object dazzles the eye, and in this way objects will appear slightly longer than they really are. Both the correct limb of the sun, and Venus appear a little larger from irradiation than the real size, of either the sun or planet, by the breadth of the irradiated circle; hence from irradiation between the two lights is produced the so-called black drop or ligament. The effect of these irradiations is at times so great, that it becomes quite impossible to execute correct measurements of them. This troublesome illusion, for such it is, has been investigated with great acuteness by M. Plateu, who has thrown much light on the subject. For the sake of distinctness, and because of their practical value, they are here given in the form of separate and substantive propositions. Irradiation is a fact completely established, and readily confirmed, very variable, but capable of being measured with precision. It occurs whatever the distance of the object at which we look, its amount, or the visual-angle which it subtends is independent of that distance, and therefore the absolute breadth to be attributed to it is, all else being equal, proportional to the distance which seems to exist between the object and the eye. It increases with the brightness of the object, but not proportionally, "if its increase is represented by a curve, whose abscissæ represent increasing brightness, beginning at darkness or zero, and having for its ordinates the corresponding amount of irradiation, this curve would pass through the origin of the co-ordinates, with its concavity towards the axis of the abscissæ, and finally pass into an asymptote parallel to that axis. For a brightness equivalent to that of a star in a clear sky, the curve will be found very close to its asymptotes." When the space surrounding the object looked at is not wholly dark, the irradiation belonging to the object is diminished, and when the illumination of the field of view approaches equality with the brightness of the object, the illusion attributable to irradiation altogether vanishes. Here, then, are two important practical consequences, when two objects of equal brightness touch, irradiation is at zero at their point of contact, and any two irradiations occurring in the same neighbourhood diminish each other, the diminution being the greater in proportion as the edges of the luminous spaces are nearer to each other.

Irradiation depends very much on the state of the eye, or impressibility of the retina, it varies considerably in the same individual, or by personal equation; it is greatly modified when a lens is placed before the eye, it is diminished by

converging lenses, and augmented by diverging lenses. This action of lenses will depend on their focal-length and not on their diameters or curvature ; the shorter the focal-length, the more decisive it is. The theoretical difficulty, and practical remedy lie in the action of lenses, as affecting the action of vision though the telescope. The error produced in astronomical observations by what is called irradiation, springs from two causes, essentially distinct, viz., the ordinary irradiation now described, and the aberration of the instrument. The part of the total error due to irradiation properly so-called, depends on the magnifying power of the eye-piece, the brightness of the image, and state of the eye of the observer, and is greatly diminished by the action of the eye-piece in proportion to its magnifying power, and its convergency as a lens, varying, however, with the state of the observer's eye. This portion of the total error is made to disappear, when a double image micrometer is made use of, and the observation is only slightly affected with the Heliometer. The Astronomer Royal recommends that the cusps of Venus should be measured as rapidly as possible, and much information as to the distance of the planet's centre from the sun's limb, will be gained in this way. The remaining portion of the total error, viz., that which originates in the aberration of the telescope, will vary with the quality of the instrument, but it will be constant for the same telescope ; it will therefore appear possible, even in the case of an imperfect instrument, with an eye sensitive to irradiation, to obtain means of freeing observation from the effect of this peculiar error. In many cases observations may in themselves possess the means of eliminating any error that might arise from personality, by not making contacts too deep or too shallow ; or from the effects of greater or less irradiation due to the instrument or to the eye. Personal errors may also be eliminated by observing both limbs of the planet in the series.

There are other apparent difficulties attending the observation of the transit, independent of irradiation. Sir Isaac Newton demonstrated that, as a consequence, the poles of the earth must be flattened. About two hundred years ago, Picard found that the pendulum of his transit clock, which beat seconds at the Paris Observatory, must be shortened to beat seconds at Cayenne, near the equator. Subsequent experiments have shown the same results, confirming the fact that the earth is flattened at the poles, giving an elliptic shape to any meridian coinciding with the sea level. A short time ago the problem was again renewed, proving the equatorial curve itself at the sea level to be an ellipse, having a major axis 8,800 feet, or 1—2·8 miles, longer than the minor axis. The

earth's crust is known not to be homogeneous, experiments have been made by Maskelyne, Cavendish, &c., for determining its force of gravity ; which prove the average density to be 5·4, the whole mass being double that of the crust. It is known that the excess of the equatorial over the polar radius, divided by the latter, would be one in 230, if the earth were homogeneous throughout, all the particles attracting each other, while it would be one in 580 if the force of attraction acted solely at the centre of the mass, or nearly as 289·44 to 308·27. In applying these remarks for obtaining a true parallax at the coming transit of Venus, there is the following difficulty, for all observations made on the plane of the meridian, the perpendicular, or line pointing to the zenith, does not coincide with the line directed from the earth's centre through the place of observation, except at the equator and the poles.

Respecting the figure of the earth as a whole, says the late Sir John Herschel, it may be considered as spherical ; the diameter coinciding with the axis is about $\frac{1}{300}$th part shorter than the equatorial circle, which is, says the same authority, so trifling that if a model of such proportions were turned in wood, the nicest eye would not detect the flattening, since in the diameter of a globe of 15 inches, the difference would be only one-twentieth of an inch, and with the means employed for obtaining the true figure of the earth, any error in observation, with proper care, in measuring its true meridional value, can hardly exceed half a second. Any suspicion then that the above quoted idea of a double ellipticity is only an approximation to truth, and may have an important bearing in ascertaining the sun's distance, is much lessened when it is known that the discrepancy is not so great as at first sight may be supposed, and that it may entirely disappear in working out this great problem at the forthcoming transit.

The application of the transit of Venus to the determination of the sun's distance, is not an easy subject, from the enormous distance of the sun, when compared with the smallness of our own globe, for a base line; if it was otherwise the parallax question would be a simple matter. Mr. Procter (whose beautiful sun-views of the earth, drawn to illustrate the seasons, shew changes similar to those of sun-spot curves, irrespective of the sun's hemisphere) remarks :—

"During a December transit, the earth which is supposed to be seen from the sun, moving from right to left, with rotation shifting points on her surface ; the shifting due to this cause, is greatest on the Equator, which is adverse to that of the earth's motion of rotation, except at stations in high latitudes, where Venus transits with the excess of

her motion of revolution over the earth, and anything which tends to reduce the effect of the earth's motion of revolution, increases the excess of Venus's motion, or hastens Venus in her transit. So that towards the Equator, Venus is hastened more or less by the effects due to the earth's rotation. And, on the contrary, at every point in high latitudes, Venus is retarded in her transit by rotation; these circumstances affect both transits diversely, 1874 and 1882."

In the Astronomer Royal's report of the stations to be occupied by different countries, for the transit, not a word is said of Hobart Town, as being fixed upon by the Americans; what he said was, that they, the English, had abandoned Macdonald Islands, as it is considered that the observations there will be sufficiently provided for by the Americans and the German parties.

It is not however, therefore, certain that any expedition will be sent to Tasmania, for the purpose of observing the transit of 1874. It has been said that the Australian colonies can provide means for observing the transit within themselves, and so they can, where they have qualified observers to assist in observing this rare and special phenomenon, which is the very foundation of all astronomical researches; for, until we know the sun's distance, we can determine neither his bulk, nor his weight, nor his proper relationship with the planets; a small error in the solution of this problem would also result in the withdrawing from our knowledge the great power and wisdom employed in the researches of solar physics.

In the absence of other astronomers, with more ample and different means for observing, the instruments in use at the Private Observatory, with a few accessories that have been added,are quite sufficient for the direct observation of the transit, or for obtaining longitude and local time. The difficulty at present appears to be, finding suitable observers, who are accustomed to the use of astronomical instruments. The only volunteer at present, is Commander Bedwell, who, at the suggestion of the Hon. Sir J. M. Wilson, wishes to take part in the observation, and render what assistance he can, provided he is able to make arrangements to be in Hobart Town at the time.