

P A P E R S.

I. *On a Remarkable Phenomenon that occurs in Total and Annular Eclipses of the Sun.* By FRANCIS BAILY, Esq., Vice-President of this Society, &c. &c.

Read December 9, 1836.

THE eclipse of the sun, which took place on May 15, 1836, was annular in the northern part of Great Britain; the central part of the moon's shadow extending, nearly in a straight line from Ayr on the western coast of Scotland, to Alnwick on the eastern coast of Northumberland. Being desirous of viewing this rare phenomenon, and of witnessing certain singular appearances which are recorded as having taken place on former occasions of this kind, I proceeded to Scotland for that express purpose. Having computed from the elements given in the *Nautical Almanac*, that the central line of the moon's umbra would pass directly over, or very near to Jedburgh in Roxburghshire, and having ascertained that this place was within eight or ten miles of Makerston, the seat of Lieut.-Gen. Sir THOMAS MACDOUGAL BRISBANE, Bart., who has a well-furnished observatory there, and from whom I was sure of obtaining the correct time for my chronometers, I resolved to make that town my headquarters.

I took with me from London a $3\frac{1}{2}$ -feet refracting telescope by DOLLOND, of $2\frac{5}{8}$ inches aperture;* a 20-inch ROCHON's prismatic telescope for measuring the distances between the borders of the sun and moon; two thermometers; a burning-glass; and four pocket chronometers.

* The magnifying power used was about 40.

I arrived at Kelso on the 13th of May, and immediately proceeded to the seat of Sir THOMAS BRISBANE, for the purpose of comparing my chronometers with his excellent timepieces. On the following morning they were again compared before I started for Jedburgh: and immediately after the eclipse was over, I again visited Sir THOMAS BRISBANE, and again compared the chronometers as before. So that I apprehend that the time was obtained as correctly as possible under the disadvantageous circumstances in which I was placed; having no instrument with me for taking altitudes. But the noting of the exact times of the several phenomena was not my principal object; since I well knew that I should not be able to make any observations that would compete with those made at an established observatory, or that would be available for any nice astronomical purpose; and I therefore do not lay much stress upon this portion of my labours. My attention was drawn off and directed to other more interesting points.

On my arrival at Jedburgh I looked about for a convenient place for mounting my telescopes, and where I should be free from any interruption: * and having heard of Mr. JAMES VEITCH, a very ingenious gentleman, residing at Inch Bonney, about half a mile to the southward of the town of Jedburgh, I proceeded thither, and was with the greatest readiness and kindness furnished by him with every convenience I required for making my observations. The telescope was placed on a temporary equatorial stand on his premises, in a situation quite detached from any houses, and in the centre of a beautiful and romantic country, renowned in former times as the scene of many an action in the border feuds of that period.

Sir THOMAS BRISBANE'S observatory is situate in Lat. $55^{\circ} 34' 45''$ and Long. $10^{\text{m}} 4^{\text{s}}.0$ west from Greenwich: and, from the best information I could obtain on the spot, Inch Bonney is about 8 miles south, and about $1\frac{3}{4}$ mile west of that observatory. Mr. VEITCH however, who is conversant with the use of instruments and well acquainted with the country, does not make these distances quite so much. If we assume, as I shall do in the present

* It is stated by Dr. HALLEY, in his account of the total eclipse of the sun in April 1715, that "the Rev. Mr. ROGER COTES at Cambridge had the misfortune to be *opprest by too much company*, so that though the heavens were very favorable, yet he missed both the time of the "beginning of the eclipse, and that of total darkness." This *pressure of company* is always to be avoided in observatories, on these and other important occasions: since it generally happens that it tends to defeat the main object in view.

instance, that the position of Inch Bonney is in Lat. $55^{\circ} 27' 30''$ and Long. $10^m 12^s,0$ west from Greenwich, I apprehend that we shall not be far from the truth: and as I am not about to draw any distinct conclusions from these assumptions, they will answer the purpose of the present inquiry. The same reasons induce me not to trouble the Society with a detail of the comparisons of my chronometers with the clocks at Sir THOMAS BRISBANE'S observatory: it will be sufficient to state that each chronometer was, on each occasion, compared not only with his sidereal clock, but also with his mean solar time clock; and although, in the final comparisons, some discordances were observed to have occurred, as might be expected from the motion of the carriage in travelling to and from Jedburgh, yet I consider that the absolute times of the beginning and ending of the eclipse (independent of the error of observation) may be depended upon within about two seconds at the utmost.

This being assumed, I shall proceed to state the times observed, in order to get rid at once of this part of the subject, to which I shall not again have occasion to refer: except as to the formation and dissolution of the annulus, which are here set down approximately only, and which may be considered as liable to alteration according to the view which each person may take of the subject, after hearing the description which I shall give of the phenomena. The following are the observations as shewn by one of the chronometers, adjusted, from a mean of all the comparisons, to the correct mean time at Inch Bonney.

Beginning of the eclipse	1 ^h	36 ^m	44 ^s	} subject to discussion. See page 28.
Formation of the annulus	3	0	57	
Dissolution of the annulus	3	5	23	
End of the eclipse	4	23	7	

The diminution of light was not so great, during the existence of the annulus, as was generally expected; being little more than might be caused by a temporary cloud passing over the sun: the light however was of a peculiar kind, somewhat resembling that produced by the sun shining through a morning mist. The thermometer in the shade fell only about three or four degrees: it was 61° during the time of the annulus. About twenty minutes before the formation of the annulus *Venus* was seen with the naked eye: and a few minutes afterwards I found it impossible to fire gunpowder with the concentrated rays of the sun through a lens of three inches in diameter. The

same lens likewise had no effect on the bulb of a thermometer, during the existence of the annulus. Similar results also were obtained by Sir THOMAS BRISBANE.

As preceding writers have noticed the tendency of the birds of the field and of the poultry, to go to roost during the darkness occasioned by a great eclipse, I would here remark that nothing of the kind occurred on this occasion in the district where I was placed.* On the contrary the birds in the hedges were in full song during the whole time of the eclipse: and I noticed to Mr. VEITCH that one cock in particular, in a neighbouring farm-yard, was crowing with all his might, whilst we were observing the remarkable phenomenon of the annulus.

During the progress of the eclipse I made several observations of the distances of the limbs of the sun and moon with ROCHON'S prismatic telescope: but, from some circumstances, for which I cannot well account, the discordances were so great, that I shall not venture to detail them; more especially as the observations themselves would not lead to any practical advantage, were they strictly correct and accordant. I experienced on this occasion the same inconvenience in the use of the instrument, as that which I have already recorded in my account of the eclipse of September 7, 1820, in the first volume of the *Memoirs* of this Society.

Having made these general remarks I shall now proceed to detail those singular appearances which occurred at the formation and dissolution of the annulus; and which have never yet, as far as I have been able to ascertain, been described in a complete and connected manner, in any preceding accounts. For, although detached portions of the phenomenon have been recorded by different observers, as seen at different places, yet it is impossible, from those descriptions, to form an accurate idea of the *whole*, or to trace the origin, progress, and termination of that remarkable phenomenon which immediately precedes the complete formation of the annulus, and which again takes place (but in an inverse order) immediately after the commencement of the dissolution of the annulus. In fact, since the phenomenon itself, during its short period of existence, is constantly varying in

* This supposed *darkness* has always been over-rated, even in total eclipses. The light which remains, after the sun is wholly covered, is sometimes as great as that of the *full moon*.—See the note in page 11.

some minute particulars, no description of any one detached portion of it will enable us to judge of the remainder: and thus the partial accounts of different observers (alluding probably to different stages of the phenomenon) become confused and perplexing.

The weather at Inch Bonney was remarkably favourable for observation: the sky was perfectly clear and serene; not a cloud to be seen in any part of the heavens, during the whole time of the eclipse. When the last portion of the moon's disc was about to enter on the face of the sun, I prepared myself to observe the formation of the annulus. I was in expectation of meeting with something extraordinary; but imagined that it would be momentary only, and consequently that it would not interrupt the noting of the time of its occurrence. In this however I was deceived, as the following facts will shew. For when the cusps of the sun were about 40° asunder, a row of lucid points, like a string of bright beads, irregular in size and distance from each other, *suddenly* formed round that part of the circumference of the moon that was about to enter, or which might be considered as having just entered, on the sun's disc. Its formation indeed was so rapid that it presented the appearance of having been caused by the ignition of a fine train of gunpowder. This I intended to note as the correct time of the formation of the annulus, expecting every moment to see the thread of light completed round the moon; and attributing this serrated appearance of the moon's limb (as others had done before me) to the lunar mountains, although the remaining portion of the moon's circumference was comparatively smooth and circular, as seen through the telescope. (See Plate I. fig. 1.) My surprise however was great on finding that these luminous points, as well as the dark intervening spaces, increased in magnitude, some of the contiguous ones appearing to run into each other like drops of water: for, the rapidity of the change was so great, and the singularity of the appearance so fascinating and attractive, that the mind was for the moment distracted, and lost in the contemplation of the scene, so as to be unable to attend to every minute occurrence. Finally, as the moon pursued her course, these dark intervening spaces (which, at their origin, had the appearance of lunar mountains in high relief, and which still continued attached to the sun's border) were stretched out into long, black, thick, parallel lines, joining the limbs of the sun and moon; when, all at once, they *suddenly* gave way, and

left the circumferences of the sun and moon in those points, as in the rest, comparatively smooth and circular; and the moon perceptibly advanced on the face of the sun. This moment therefore may, by some persons, be considered as the complete formation of the annulus, and has, I believe, in most cases, been recorded as such: but I shall state my reasons presently why I think this should not be assumed as the true moment of the astronomical phenomenon.

The appearances here recorded passed off in less time than it has taken me now to describe them; but they were so extraordinary and so rapid, that all idea of time was lost, except by the recollection afterwards of what had passed: for, I was so riveted to the scene, that I could not take my eye away from the telescope, to note down any thing, during the *progress* of this phenomenon. I estimate, however, that the whole took up about six or eight seconds, or perhaps ten at the utmost. In the plate annexed to this memoir, I have endeavoured to delineate the several phases above mentioned, in three of its most striking stages. Fig. 1 represents the first appearance of the luminous string of beads just formed round the edge of the moon; which was almost instantaneous. Fig. 2 represents a *continuation* of the same phenomenon; or the moon further advanced on the face of the sun, but still apparently adhering to its border by means of the dark, thick, irregular spaces which separate the luminous portions, now become somewhat enlarged in size. Fig. 3 represents still a *continuation* of the same phenomenon; the dark parts being now stretched out into long, black, lines which seemed to connect together the limbs of the sun and moon; and are here represented as they appeared immediately before their sudden rupture, and total disappearance. In all these representations on the plate, the moon is supposed to be proceeding in a horizontal direction, from the left hand towards the right. I cannot describe these phenomena (or rather this phenomenon, for it was one *continuous* appearance) more correctly, than by supposing, for the moment, that the edge of the moon was formed of some dark glutinous substance, which by its tenacity adhered to certain points of the sun's limb, and by the motion of the moon was thus drawn out into long threads, which suddenly broke and wholly disappeared.

After the formation of the annulus thus described, the moon preserved its usual circular outline during its progress across the sun's disc, till its

opposite limb again approached the border of the sun, and the annulus was about to be dissolved. When, all at once, (the limb of the moon being at some distance from the edge of the sun) a number of long, black, thick, parallel lines, exactly similar in appearance to the former ones above mentioned, *suddenly darted forward* from the moon and joined the two limbs as before: and the same phenomena were thus repeated, but in an inverse order. For, as these dark lines got shorter, the intervening bright parts assumed a more circular and irregular shape, and at length terminated in a fine curved line of bright beads (as at the commencement) till they ultimately vanished, and the annulus consequently became wholly dissolved.

The time employed in this act of dissolution (if I may so express myself) was about the same as that at its formation: but the rapid and progressive change in the appearances, and their striking character, so riveted my attention again, that I am unable to speak more decidedly on the time occupied, than on the first occasion. The same reason also prevents me from stating the precise number of the dark lines: I should think however that they were not fewer than six nor more than ten. The impression on my mind, from recalling all the circumstances to my recollection, is that there were about eight. They were as plain, as distinct, and as well defined, as the open fingers of the human hand held up to the light.

For the cause of this optical deception I shall not attempt to account. That it does not depend on the instrument employed, or on the eye of the observer, would appear from the concurring testimony of those who witnessed the phenomenon, at various places and with different telescopes, and who yet agree in the main facts here stated. The account given by Mr. VEITCH, who used a 30-inch refractor, coincided exactly with my own, as compared immediately after the termination of the annulus. The description also by Sir THOMAS BRISBANE, who used a 2-feet reflector, and whom I visited immediately after the eclipse, agreed in all the essential particulars; and differed only in those points on which I had myself some doubt.* Mr. HENDERSON

* Sir THOMAS, for instance, thinks that the number of *lines* or filaments did not exceed six: and that they were not so regular as I have described them. Mr. VEITCH, on the contrary, thinks that the dark ligaments, although correctly delineated, were far more numerous than those represented on the plate; and he says that the string of bright beads extended much farther round the circumference, and appeared suddenly like a train of gunpowder set on fire, running along the lunar disc with beautiful coruscations of light (as Sir THOMAS BRISBANE also expressed it), from one cusp to the other, like liquid fire.

also, who observed the eclipse at Edinburgh with a $4\frac{1}{4}$ -feet refractor, noticed appearances very similar to those which I have here described.*

I have been the more particular in making these remarks from having observed that in no one of the published accounts which I have yet seen of this eclipse, is any special notice taken of the remarkable phenomena above alluded to: although, as I shall presently shew, those phenomena, being seen under different circumstances at different places, must materially affect the astronomical results. Or, if any notice has in some instances been taken, the allusion is so slight (being confined principally to the formation of the string of luminous beads, at the very commencement of the annulus), that few readers would suspect that any thing further remarkable had occurred. I cannot account for this general reluctance to record so singular a phenomenon as that of the dark lines, which I apprehend could not possibly have passed unobserved by any astronomer.†

There is however another extraordinary phenomenon, usually accompanying annular eclipses, of a totally different kind from that just described, and arising from a totally different cause; and which takes place immediately

* Mr. HENDERSON was good enough to favour me with a letter, a few days after the eclipse, describing the appearances which he had observed: and, as this letter enters into several minute details, I have inserted it, at full length, at the end of the present paper. See page 37.

† Since this was written I have seen the MS. account of the observations of the eclipse of May 15th made by Mr. T. H. BELL at High House farm, near Alnwick in Northumberland, which was read before the Philosophical and Literary Society at Newcastle, accompanied by drawings representing the phenomena at the formation and dissolution of the annulus; and which in a great measure confirm the details which I have here given. Mr. BELL states that, at the formation of the annulus, he saw "two black streaks, like small threads, which seemed for an instant to connect the limbs of the sun and moon, and then suddenly break in the middle, giving the idea of viscosity in the margins of the two bodies when in apparent contact." At the termination of the annulus "four or five black streaks appeared to run from the body of the moon to the margin of the sun, thus seeming to make the internal contact before the body of the moon itself blended with the concavity of the solar disc." The drawings which he has made to represent these black streaks are *precisely similar* to those given in fig. 3 in the accompanying plate, except as to the number of the lines. Mr. BELL says that the annulus continued $4^m 30^s$; but he does not state whether this is reckoned from the rupture of the dark threads, or from the moment when the discs of the sun and moon osculated. The telescope employed was a 5-feet refractor, with a power of 50.

before the whole body of the moon is projected on the face of the sun. I allude to the arch of faint light, or rather to the luminous edge, which encircles that portion of the moon's border that is *off* the sun's disc. This has been seen on several occasions, as I shall more fully detail in the following pages; but I must confess that I did not myself observe this phenomenon in the present eclipse: a circumstance owing, in the first place, to my attention not having been specially directed to it; and secondly, to my whole time being occupied in looking out for the distinct formation of the annulus. So many interesting objects indeed are crowded into such a short space of time, just at that instant, that there is no opportunity of noting down appearances during their actual occurrence: and the memory must be taxed afterwards for the recollection and description of minute details.

I have already stated that, from the accounts given of preceding annular eclipses, I was led to expect some extraordinary appearances. To those accounts I shall now more particularly refer, not only as confirmatory of what I myself observed on this occasion, but also to shew the imperfect manner in which the phenomenon has been hitherto described, as well as the variety of forms it may assume according to circumstances either accidental or local. For, the position of the spectator, with respect to his distance from the central line, will doubtless cause a difference in the formation, progress, and whole appearance of the phenomenon. A person placed just within the limits of the moon's umbra would probably not witness any of the dark lines to which I have so frequently alluded: but the border of the moon, which in such case just grazes the edge of the sun, would perhaps have a serrated appearance, like lunar mountains of extraordinary height and magnitude; for which indeed they might be readily mistaken at first sight: or would, perhaps exhibit only the luminous string of beads, or broader luminous spaces, throughout the whole progress and existence of the annulus.* And thus we might have, from this almost imperceptible and unobservable annular appearance, all the intermediate grades up to the extraordinary phenomenon which I have above described.

* Since this was written I have seen M. BESSEL's interesting account of his observations of the late annular eclipse, on May 15, 1836, which appears to have been seen under the very circumstances here described: and to which I shall more fully allude, at the end of this paper.

Intervening clouds likewise, just at an unfortunate moment, may in some cases have prevented a full and connected view of each minute occurrence; a circumstance which may in some measure account for the partial and imperfect statements which have hitherto appeared. And I cannot but consider myself as extremely fortunate in having experienced so fine a day for witnessing the whole of the phenomena which I have here recorded.

The first account in which I find any thing recorded that relates to the subject of the present inquiry, is that of the *total* eclipse of the sun on April 22, 1715, as given in the *Phil. Trans.* Vol. XXIX. It is there stated by Dr. HALLEY (page 248) that “about two minutes before the total immersion, the remaining part of the sun was reduced to a very fine horn, whose extremities seemed to lose their acuteness, and to become round like stars: and, for the space of about a quarter of a minute, a small piece of the southern horn of the eclipse seemed to be cut off from the rest by a good interval, and appeared like an oblong star rounded at both ends.”

In a subsequent *total* eclipse, which occurred on May 22, 1724, M. CASSINI could not discover any appearance of this kind. For he says (*Mém. de l'Acad.* for 1724, page 180) “on continua ensuite de voir le croissant du soleil diminuer de longueur à mesure qu'il paroissoit se rétrécir, sans qu'on y découvrit aucune interruption; et on n'apperçût à la fin qu'un point lumineux, semblable à une étoile fixe, qui disparu entièrement à 6^h 48^m 4^s que le soleil fut entièrement éclipsé.” M. DELISLE, however, says (page 317) “le bord de la lune, regardé attentivement avec ma lunette de 7 pieds, à l'endroit où devoit se faire le commencement de l'obscurité totale, m'a paru inégal et dentelé.”

In the *total* eclipse of June 16, 1806, observed by Mr. ELLICOT in America, as related in the *Transactions of the American Philosophical Society*, Vol. VI. page 256, he states that “the irregular decrease and increase of the distances between the points of the cusps, is greater than would arise, in so excellent a micrometer, from the small imperfections inseparable from such observations. These irregularities were principally occasioned by the uneven surface of the moon, particularly that part which formed the southern cusp or horn. The northern cusp was well defined and finely terminated; but the southern one sometimes obtuse, at others terminated by a parallel

“ thread of light which disappeared from one end to the other at the same
 “ time : and frequently one or two points of the sun’s limb were observed to
 “ be *completely detached* from the point of the cusp. [Here references are
 given to several drawings which accompany the statement.] These detached
 “ luminous points of the sun’s limb seemed to retain their brilliancy till the
 “ instant of their disappearance.”

Mr. JOACHIM FERRER, who also observed this eclipse, at Kinderhook in America, and who states the duration of total darkness to have been $4^m 37^s$, remarks in some additional notes in the same volume, page 297, that a few seconds before the total obscurity “ the most *prominent points of the lunar disc were projected on the sun* : consequently the duration of total obscurity “ (had it not been for the concavities of the limb of the moon) would have “ been, at Kinderhook $4^m 46^s$ instead of $4^m 37^s$.”*

The first *annular* eclipse, in which I find that any of these phenomena are recorded, is that of February 18, 1736-7, as given by Mr. MACLAURIN in the *Phil. Trans.* for that year, Vol. XL. page 177 : a portion of which I shall here transcribe. “ A little before the annulus was complete, a remarkable
 “ point, or speck of pale light appeared near the middle of the part of the
 “ moon’s circumference that was not yet come upon the disc of the sun ; and
 “ a gleam of light, more faint than this point, seemed to be extended from it
 “ to each horn. I did not mark the precise time when I first perceived this
 “ light, but am satisfied that it could hardly be less than one-fourth of a
 “ minute before the annular appearance began. Mr. SHORT (who was in
 “ another chamber at some distance, and made use of a larger telescope)
 “ assures me that he saw it twenty seconds before the annulus was com-
 “ pleted : and this is confirmed by a call that was then heard from the
 “ chamber where he was (of which I did not understand the meaning till we
 “ met afterwards) and upon which the person, who made our signals, was
 “ about to fire, if I had not forbid him. I was surprised with this light at
 “ first, and did not immediately recollect that it proceeded probably from the
 “ same crown [of light] that was seen about the moon in a total eclipse of
 “ the sun at Naples in 1605 ; and was observed by many in different parts of

* The term *total obscurity* must be received with the requisite definition : for Mr. FERRER remarks (page 266) that “ the darkness was not so great as was expected ; and without doubt “ the light was *greater than that of the full moon.*”

“ Europe in the three late total eclipses of 1706, 1715 and 1724. I did not expect to have seen this light when so much of the sun’s disc was uncovered; but, as I kept only so much of the disc in the telescope as was necessary for ascertaining the time of the formation of the annulus, this must have contributed to my discovering it: for this light was very faint compared with that which appeared upon the sun’s arch near the same place the moment it was uncovered and the annulus completed.”

Thus much concerning the arch of faint light which (as I have already stated, page 9) is sometimes observed to encircle that part of the moon, which is *off* the sun. The subsequent description alludes to the phenomena attending the formation and dissolution of the annulus.

“ Most of those who observed the eclipse with telescopes mention in their letters that as the annulus was forming they perceived *the light to break in several irregular spots near the point of contact, and that the limb of the moon seemed to be indented there*. Some express themselves as if those irregular parts had appeared to them in a kind of motion. It is thus described by Mr. BAYNE (Professor of the Municipal Law, a worthy gentleman whom we have since lost) in a letter to Lord ABERDOUR. ‘What appeared to me most entertaining (says he) considered as an object of sight was, when the extremities of the horns, formed upon the face of the sun, seemed as if they had been in the action of uniting their points, the *inequalities on the extremity of the moon’s disc* gave the appearance as it were of small bodies in particular motion.’ There was not any undulation at this time on the circumference of the sun. I find that such appearances of a tremulous motion in certain periods of solar eclipses are mentioned by HEVELIUS and others. Lord ABERDOUR observed the beginning of the annular appearance with a smaller telescope, and perceived only a narrow streak, of a dusky red light, colour the dark edge of the moon, immediately before the ring was completed, and after it was dissolved. It was observed that *the motion of the moon appeared more quick* in the formation and dissolution of the annulus, than during its continuance. This is particularly described by Mr. FULLARTON of Fullarton, in a very exact account of the eclipse, as it appeared at his seat at Crosby near Air, on the west coast of Scotland, that has been communicated to me by a friend. He writes—‘that the annulus appeared to be nearly of an uniform breadth during the greater part of the

“ ‘time of its continuance, but seemed to go off very suddenly : so that when
 “ ‘the disc of the moon approached to the concave line of the sun’s disc,
 “ ‘*they seemed to run together like two contiguous drops of water* on a table,
 “ ‘when they touch one another.’ And he adds that it came on in the
 “ ‘same way.’”

Mr. SHORT has described the appearances of the annular eclipse which happened on July 14, 1748, in the *Phil. Trans.* for that year, page 582, as seen at Aberdour Castle, in Scotland ; a portion of which, relating principally to the subject of the luminous arch of faint light, I shall here transcribe. “ The eclipse was so nearly annular that, at the nearest approach, the cusps “ seemed to want about one-seventh of the moon’s circumference to be “ joined : yet a *brown light was plainly observed*, both by my Lord MORTON “ and myself, *to proceed or stretch along the circumference of the moon* from “ each of the cusps, about one-third of the whole distance of the cusps from “ each cusp ; and there remained about one-third of the whole distance of the “ cusps not enlightened by this brown light : so that we were for some time “ in suspense whether or not we were to have the eclipse annular with us. “ I observed at the extremity of this brown light, which came from the “ western cusp, a larger quantity of light than in any other place, which at “ first surprised me : but afterwards I imagined it must have proceeded from “ some *cavity or valley made by two adjoining mountains on the edge or limb* “ *of the moon.* I had often formerly observed mountains on the circumference “ of the moon, more or less every where round it, but never saw them so “ plain as during the time of this eclipse ; for we had the air exceeding clear, “ and free of all agitation, notwithstanding it blew a perfect hurricane of “ wind, which began about the middle of the eclipse : and I remember in the “ annular eclipse of the sun in the year 1737 it did the same. The *moun-* “ *tainous inequalities* on the southern limb of the moon *were particularly* “ *remarkable* : in some parts mountains and valleys alternately ; others “ *extended a considerable way along the circumference*, and ended almost “ perpendicularly like a precipice. My Lord MORTON was able to see them “ very easily through his small reflector.” In the same paper is a statement from the Rev. Mr. IRWIN who observed the same eclipse at Elgin, who remarks that “ before the joining of the cusps of the sun, as also at the “ breaking of the annulus, he observed a quick tremulous motion, and *several* “ *irregular bright spots between the cusps*, which disappeared in a few mo-

ments : and he thought *the moon's body passed quicker* about the time of “ the annulus (especially as it was forming) than at any other time during “ the eclipse.”

The annular eclipse of April 3, 1791, was observed in America by Mr. S. WEBBER ; an account of which is given in the *Memoirs of the American Academy of Arts and Sciences*, Vol. II. Part I. page 20, and is as follows : “ At both the internal contacts there was a curious and striking appearance “ of what may be called *drops*, on account of their resemblance to drops of a “ fluid. At the first contact, when the horns of the sun were forming a ring “ about the moon, these *luminous drops* suddenly appeared, at several differ- “ ent points, with very little difference of time. At first they were nearly “ circular : but they rapidly extended themselves along the limb of the sun, “ till uniting they completed the annulus. At the second contact, several “ breaches in the annulus almost instantaneously succeeded the first, at “ different distances from each other ; and the *oblong drops*, included “ between them, contracted and vanished.”

In a paper on the annular eclipse that took place on September 7, 1820, which I presented to this Society, and which is printed in the first volume of its *Memoirs*, I have given an account of the observation made by M. NICOLAI of Mannheim, who states (page 142) that “ the actual formation of the annulus “ was very remarkable : for about a second before it occurred the fine curve “ of the moon's disc, then immediately in contact with the edge of the sun, “ appeared *broken into several parts ; and in a moment these parts flowed “ together like drops of water or quicksilver* placed near each other. At the “ dissolution of the annulus, a similar appearance presented itself : for, the “ delicate thread of light, then formed by the annulus, instead of being broken “ in one place, was in an instant divided *in several places at once.*” * And Professor SCHWERD, who observed the same eclipse at Spire (as recorded in the same volume, page 143) states that “ about six seconds before the form- “ ation of the annulus, a bright spot was seen on the point of one of the “ horns, which shortly after appeared to flow into it. About half a second “ before the complete junction of the two horns, there appeared a row of “ bright points. A similar appearance was observed at the dissolution of the “ annulus.” Neither of these astronomers however says any thing about the

* See also M. NICOLAI's account in BODE's *Jahrbuch* for 1823, page 236.

dark ligaments, uniting the borders of the sun and moon ; which doubtless succeeded to the string of beads, and which ought to have been seen at both places, as the annulus lasted nearly five minutes. Nor do they notice the luminous arch, prior to the existence of the annulus.

All these circumstances however are stated in another paper by Professor MOLL, inserted in the same volume, page 144 ; where he gives the accounts of various observers. And, first, those made by Professor VAN SWINDEN at Amsterdam. “ Just before the annulus was formed, he perceived above the “ yet obscured part of the sun, a very small arch of light : it was no part “ of the sun’s disc, and the space between it and the moon’s dark limb was “ not illuminated. This arch appeared like a thin reddish thread of light : “ it might have been compared, as to colour and appearance, with the end of “ the flame of an Argand lamp, projecting beyond the chimney or glass tube. “ A few moments afterwards the annulus was actually formed. The appear- “ ance was striking beyond description. In the superior annular part some “ slight undulation was observed, as if a thin cloud of smoke was passing. “ Professor VAN SWINDEN expected that the moon’s disc passing the sun, “ would have remained a perfect circular orb, leaving an annulus of pure “ light : but before the annulus was completely formed, a very curious “ phenomenon presented itself. Between the limbs of the sun and moon “ *several dark threads, lines, or belts, were observed as if attaching the sun’s “ and moon’s discs together.* These belts or threads were lacerated, and dis- “ appeared soon after, leaving the annulus completely formed. But when “ the annulus was about again to disappear, and when the moon’s disc “ approached again the sun’s limb, *these belts or threads formed themselves “ again :* then drew shorter and shorter till the annulus vanished entirely. “ *At the end of the eclipse some black threads were perceived again.*” Here again we have another imperfect account : for no mention is made of the string of luminous beads, which must have preceded the formation of the dark lines here alluded to. This omission however is supplied by Mr. GREVE, who observed the same eclipse at the same place ; and whose description of the phenomenon I shall also give in the words of Professor MOLL. “ The “ formation of the annulus appeared to Mr. GREVE the most beautiful phe- “ nomenon which he ever beheld. The sky was very bright : its blue colour “ by degrees became darker as at the approach of evening. About the

“ middle of the eclipse the westerly cusp of the sun grew obtuse : from this
 “ cusp downwards was formed an indenture which very soon cut out from
 “ the dark limb of the moon a semicircular space equal in diameter to
 “ *Jupiter*. This illuminated semicircle shewed in that place of the moon’s
 “ superficies an excavation of extraordinary depth.* The easterly cusp was
 “ now rough in its inferior part, with some slight undulations and reflections.
 “ Soon afterwards, beyond the apex of the cusp, sprung up *a number of*
 “ *illuminated spots and lines*, of greater or less magnitude, and of different
 “ forms, *with dark spaces between*. The same appearance was seen after in
 “ the westerly cusp : and on a sudden an illuminated arch of a clear purple
 “ colour was formed between both cusps, the extreme points of which were at
 “ a distance from each other of about 40° of the sun’s circumference. This
 “ arch lasted for about 2” of time : † then darted forward, from the illumina-
 “ ated cusps, many luminous spots and *lines*, with darker places between
 “ them, which gradually grew brighter and brighter. Then the cusps grew
 “ nearer and nearer ; and these luminous points and lines had the appear-
 “ ance of some crystallisation of a bright salt when viewed with the micro-
 “ scope. They at length melted together, and the cusps of the sun could
 “ not be any longer distinguished. About seven or eight seconds after, the
 “ annulus was seen completely formed. *The scars in the moon’s disc dis-*
 “ *appeared entirely* : the annulus grew broader till it was again suddenly
 “ dissolved in many spots and belts of different forms. Then could the cusps
 “ again be distinguished ; and *the phenomenon ended as it began*.”

I would here remark that, prior to the eclipse, it was doubtful whether or not it would be seen annular at Amsterdam ; as this city was situate on the border of the moon’s umbra. The result however shews that it was annular there ; but the annulus, according to Mr. GREVE’s observation, did not continue more than forty-four seconds.

* There is a plate given, in the paper here referred to, which represents the appearance here mentioned, as well the others subsequently alluded to ; more especially the *dark lines* seen by M. VAN SWINDEN, which are precisely similar to those given in Fig. 3, in the plate which accompanies this paper.

† In the printed paper this is stated to be 2’, which I apprehend to be a mistake, as being at variance not only with the subsequent statement, but also with that of Professor VAN SWINDEN, who observed the same arch, and who describes it as existing for a few moments only.

The late Baron ZACH was also an eye-witness of this eclipse, which he observed at Bologna, and an account of which is given in his *Correspondance Astronomique*, Vol. IV. page 181. He was prevented by clouds from observing the formation of the annulus, but, of its dissolution he speaks in the following terms. “ Le spectacle le plus beau était la fin de l’éclipse annulaire, ou lorsque l’anneau s’est fermé. Les montagnes de la lune se montraient très distinctement ; le bord de cet astre parut tout *dentellé* ; et sur le point de toucher celui du soleil *il parut comme un peigne, ou une scie, qui mordait sur ce bord.* Avant que l’attouchement parfait des deux bords fut effectué, on voyait non pas un filet continu de lumière, mais *des petits points lumineux, comme autant de grains brillans dans une file de perles, séparés par des interstices obscurs.* Ce beau phénomène n’a duré qu’un instant ; car le contact des bords et la disparition totale du dernier trait de lumière était instantanée.”

Now, it is somewhat extraordinary that in all these accounts, the description of the phenomenon (with one single exception already mentioned, and to which I shall presently allude again) is restricted to the very commencement of the annulus, or to the formation of the string of luminous points which on a sudden are seen to surround that portion of the moon’s limb about to enter on the sun’s disc : and no notice whatever is taken of that still more remarkable appearance, the existence of the long, dark, parallel lines which in a subsequent stage of the process are observed to connect together the limbs of the sun and moon, and to be suddenly broken asunder. M. VAN SWINDEN is the only person that has ever yet distinctly placed on record this singular phenomenon (See page 15) ; although it was probably seen in that eclipse (as in former ones, and also in the recent one) by every attentive observer within the limits of the central path, that had an unclouded sky.

Before I quit this part of the subject, I wish here to place also on record the appearances which the body of the moon presented during the existence of the annulus. Previous to the formation of the ring, the face of the moon was perfectly black : but on looking at it, through the telescope, *during the annulus*, the circumference was tinged with a reddish purple colour, which extended over the whole disc, but increased in density of colour according to the proximity to the centre ; so as to be in that part nearly black. At the same time the globular form of the moon was very perceptible. Mr. VEITCH noticed the same circumstances ; and we both agreed that the

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moon had the appearance of a *globe* of purple velvet.* No coruscations were visible on the darker parts, as noticed on former occasions by different observers. During the annulus, being very near sighted, I could not perceive the moon on the face of the sun, with my naked eye: but to Mr. VEITCH and others it was distinctly visible.

How far any of these appearances may favour the hypothesis of a lunar atmosphere, or whether indeed they could be accounted for on such an assumption, I shall not here stop to discuss: but it may perhaps assist those who are disposed to enter on such an enquiry, if I were to lay before the Society the various accounts of a phenomenon similar to that of the dark lines, observed at the transits of *Venus* over the sun in the years 1761 and 1769. For on each of those occasions many astronomers remarked that, at the interior contact of *Venus* with the sun (both on its ingress and egress) there was formed a sort of *dark ligament* between the border of *Venus* and the border of the sun, which appeared like a protuberance from the planet, and which continued several seconds.* I shall however give the accounts in their own words. The several appearances of this dark ligament are represented in the accompanying plate.

M. BERGMAN, who observed the transit of 1761 at Upsal with a 19-foot telescope, remarks (*Phil. Trans.* for 1761, page 228) “ Circa contactum “ interiorem, seu dum limbus *Veneris* a solis interiore separaretur, hoc non “ momento evenit; sed haud aliter ac binæ guttæ aquæ, separandæ inter se, “ *ligamentum formant*, ita quoque è *Venere* ad marginem solis *tuberculum* “ *nigrum extendebatur*. Hoc vero ligamento tandem in medio rumpente, “ momento adparuit distantia limbi proximi *Veneris* à margine solis æqualis “ circiter octavæ parti diametri *Veneris*. Circa emersionem *eadem fere* “ *adparentia occurrebat*, quamvis non adeo distincte, et in contactu ultimo “ ligamento quasi soli *cohærebat Venus*.”

In the same volume, page 396, we find the account of the observation of the same transit by Mr. HIRST, at Madras, with a 2-foot reflecting telescope. “ At the total immersion the planet, instead of appearing truly circular, “ *resembled more the form of a bergamot pear*; or, as Governor PIGOT then

* Both Mr. VEITCH and myself made use of a dark *red* glass, to defend the eye from the sun's rays.

† See LALANDE'S *Astronomie*, Vol. II. page 510.

“ expressed it, looked like a nine-pin: yet the preceding limb of *Venus* “ was extremely well defined.” Again at the egress he says that “ though “ the planet was as black as ink, just before the beginning of the egress, yet “ it was no sooner in contact with the sun’s preceding limb than *it assumed* “ *the same figure as before* at the sun’s subsequent limb: the subsequent “ limb of *Venus* keeping well defined and truly circular.”*

M. MALLETT also observed the same transit at Upsal, with an 18-inch reflector by SHORT; and, in the *Phil. Trans.* for 1766, he has given an account not only of his own observations, but also those of M. STRÖMER made with a 20-foot refractor, and those of M. MELANDER with a 16-foot refractor. Of M. STRÖMER’s observations he says (page 75) “ Dein appropinquante “ planeta ad contactum interiorem, *Venus* quidem circularis apparuit, sed “ figuram excedens versus marginem solis, *eodem fere phenomeno ac guttula* “ *aquæ corpori adhæret*; et hoc eadem ex parte magis extensum præbet. “ Eadem excrescentia *Veneris* parva solis cornua distinguebat, quæ sub- “ rotunda erant: *Venus* quoque largius supra marginem solis extensa quam “ par credebatur huic adhærens immersionem tamen intra pauca momenta “ perficiendam ostendebat.” His own observations, and those of M. MELANDER, confirm this account.

With respect to the transit of 1769, the first account we find is that given by Dr. MASKELYNE, in *Phil. Trans.* for 1768, page 355; which has evidently been printed at the end of the volume for that year, for the purpose of affording to astronomers the earliest information on the subject. The instrument used by Dr. MASKELYNE was one of SHORT’s 2-foot reflectors; and he thus describes the phenomenon which is the subject of this paper. “ The regularity of *Venus’s* circular figure was disturbed, towards the place “ where the internal contact should happen, by the addition of a *protuberance*, “ dark like *Venus*, and projecting outwards, which occupied a space upon “ the sun’s circumference, which bore a considerable proportion to the “ diameter of *Venus*. Fifty-two seconds before the thread of light was “ formed, *Venus’s* regular circumference (supposed to be continued as it “ would have been without the protuberance) seemed to be in contact with “ the sun’s circumference, supposed also completed. Accordingly, from “ this time, *Venus’s* regular circumference (supposed defined in the manner

* See this description represented in fig. 6, in the accompanying plate.

“ just described) appeared wholly within the sun’s circumference : and it
 “ seemed therefore wonderful that the thread of light should be so long
 “ before it appeared, *the protuberance appearing in its stead*. At length,
 “ when a considerable part of the sun’s circumference (equal to one-third or
 “ one-fourth of the diameter of *Venus*) remained still obscured by the pro-
 “ tuberance, a fine stream of light flowed gently round it from each side,
 “ and completed the same in the space of three seconds of time ; and *Venus*
 “ appeared wholly within the sun’s lucid circumference. But the protu-
 “ berance, though diminished, was not taken away till about twenty seconds
 “ more ; when, after being gradually reduced, it disappeared, and *Venus’s*
 “ circular figure was restored.”

Six other well known observers were present on this occasion, furnished with powerful telescopes : and although it is not stated whether any of them witnessed this singular phenomenon, yet it is evident, from the results given by Dr. MASKELYNE, that three of them at least must have seen it and noted its duration.*

In the volume of the *Phil. Trans.* for 1769, there are a great number of papers by various persons, containing accounts of the observation of the transit of *Venus* in that year, at different places on the globe : and they all (with one exception) agree in noticing the remarkable phenomenon above alluded to, and many of them have given diagrams of the appearance of *Venus* when near the sun’s limb. Dr. HORNSBY says (page 176) that “ that part
 “ of the sun’s edge, where the ingress happened, was very sensibly obscured
 “ by a penumbra, and *the limbs appeared to be united by a kind of ligament*
 “ *of a considerable breadth*. This ligament became narrower and narrower,
 “ and was at length reduced to a point and actually broken.” Dr. HORSLEY also (page 184) noticed the same circumstances, and has given a drawing of the appearance of the planet ; which is similar to fig. 8, in the accompanying plate. Dr. BEVIS remarks (page 190) that “ the planet seemed
 “ quite entered upon the disk, her upper limb being tangential to that of
 “ the sun. But, instead of a thread of light, which I expected immediately
 “ to appear between them, I perceived *Venus to be still conjoined to the sun’s*
 “ *limb by a slender kind of tail*, nothing near so black as her disc, and *shaped*

* Mr. DUNN was one of those that were present, and his observations will be given in the sequel.

“like the neck of a Florence flask.* The said tail vanished at once; and “for a few seconds after, the limb of *Venus* to which it had been joined, “appeared more prominent than her lower part, somewhat like the lesser “end of an egg; but soon resumed its rotundity.”† The Rev. Mr. HIRST says (page 229) “the same phenomenon of a *protuberance*, which I observed “at Madras in 1761, at both internal contacts, I observed again at this last “transit. At both times the upper edge of *Venus* diminished nearly to a “point before the thread of light between the concave edge of the sun and “the convex edge [of *Venus*] was perfected, when the *protuberance* broke “off from the upper edge of the sun: but *Venus* did not assume its circular “form till it had descended into the solar disc some distance.” Mr. HIRST has annexed several diagrams of the appearance of *Venus* during the progress of her ingress: one of which, shewing her figure just after the moment of osculation of the two limbs, is nearly the same as fig. 5 in the accompanying plate, which is taken from one of Mr. DUNN’s drawings; and another just before the separation of the dark ligament from the limb of the sun, is the same as fig. 6. Mr. HIRST remarks that “the appearance of this protu- “berance, or ligament, must now be universally confirmed; especially by “all observers of the transit of the present year: at least by all such who “have viewed it through telescopes of sufficient magnifying powers, and “who have sense enough to believe their own eyes, or candour enough to “embrace and acknowledge conviction, *malgré* all prejudices and precon- “ceived opinions.” A just and proper reflection, which (as we shall presently see) was absolutely called for at that day. Mr. WILLIAM BAYLEY remarks (page 266) “that *Venus’s* outer limb seemed to be in contact with the sun’s “limb, but no light of that part of the sun’s limb could be seen, *Venus* “being apparently joined to the sun’s limb by a black ligament, which gradually “diminished in breadth; and at length the sun’s light broke through it, “and *Venus* and the sun were to appearance perfect, and the black ligament “contracted itself, so that *Venus* was considerably within the sun’s limb, “suppose one-twentieth of her diameter.” Mr. WRIGHT says (page 276) that at the time of the ingress “*Venus* appeared completely round to the eye,

* Represented by fig. 7, in the accompanying plate.

† Dr. BEVIS says that in the transit of 1761 he did not observe this appearance: the planet was then perfectly circular and well defined.

“and to appearance rather detached, but *joined by a small dark thread or ligament*, which prevented the rays of light from appearing:” soon after which the internal contact was formed. ANDREW MAYER states (page 285) that “*paulo ante contactum interiorem, fascia quasi margini solis alligata visa est, quæ subito soluta.*” Dr. SMITH in his account (page 315) remarks that “as to the internal contact, the thread of light, coming round from both sides of the sun’s limb, did not close instantaneously, but with an uncertainty of several seconds; *the points of the threads* darting into each other, and parting again, in a quivering manner, several times before they finally adhered.” M. PLANMAN, speaking of the total ingress of *Venus* on the disc of the sun, adds (page 329) “*eo enim momento rupta est subito fasciola, quæ huc usque solis et Veneris margines junxerat, et planetæ corpus lumine solis undique est circumfusum.*” M. STRÖMER noticed when the limbs of *Venus* and the sun osculated, but he adds (page 331) that it was thirty-four seconds afterwards when “*eos separatos et obscuram fasciolam eos jungentem ruptam demum vidit.*” MM. MELANDER, BERGMAN, PROSPERIN and SALENIUS, who were also present, and observing the transit, speak likewise of the “*fasciola atra margines jungens,*” and of its rupture soon after the planet had entered on the sun’s disc. The same phenomenon also was witnessed by MM. WARGENTIN, FERNER, and WILCKE (page 332). Dr. WILSON describes the appearance in the following words (page 335): “as the internal contact approached, *Venus appeared to us to adhere to the sun’s limb by a dark protuberance or neck*, both the length and breadth of which varied every moment by a constant undulation: neither did this neck break off instantaneously, but changed its colour from black to a dusky brown, till at last the interval betwixt *Venus* and the sun’s limb appeared quite clear.” Dr. LIND, who observed the transit in company with Lord ALEMOOR and Mr. JAMES HOY, says (page 340) “in the internal contact *we all observed the black ligament or protuberance*, which was not broke for some seconds after the regular circumference of *Venus* seemed to be within the sun.” M. FERNER says (page 405) “I hoped to see the internal contact with more certainty, but I was mistaken; for I found as great difficulties there, though of another kind. When I judged by means of the circular figure of the sun’s disc that *Venus* should be entirely within the sun, I could not yet see the luminous cusps of the sun join together behind *Venus*; who, on the contrary, *appeared to carry the limb of the sun along with her*, which

“ appeared to bend towards *Venus*, leaving a black cavity in his limb :* and “ a moment after, when I thought I saw the whole body of *Venus* in the “ sun, a little black column appeared to proceed from *Venus* towards the “ imaginary limb of the sun.” MESSRS. BIDDLE and BAYLEY remark (page 417) that “ at the time of the first internal contact, the eastern or external limb “ of *Venus* seemed to be united to the sun’s limb by a black protuberance or “ ligament.” Mr. HARRIS, in his account, does not specially notice this ligament, but he says (page 426) that “ *Venus* appeared remarkably pro- “ tuberant on her upper limb, both before and at the time of her internal “ contact, which went gradually off soon after.” MESSRS. WALES and DYMOND have the following remarks (page 482): “ We took for the instant of the “ first internal contact the time when the least visible thread of light appeared “ behind the subsequent limb of *Venus*: but before that time *Venus’s* limb “ seemed within that of the sun, and his limb appeared behind hers in two “ very obtuse points, seeming as if they would run together in a broad stream, “ like two drops of oil; but which nevertheless did not happen, but joined “ in a very fine thread, at some distance from the exterior limb of *Venus*.”

In the next volume of the *Phil. Trans.*, viz. that for the year 1770, we find other accounts confirmatory of what has been already stated. Mr. DUNN, who was one of those that observed with Dr. MASKELYNE at the Royal Observatory at Greenwich, and who has given diagrams of the successive appearances that *Venus* assumed at her ingress and egress in 1761 and 1769,† remarks (page 70) that “ he saw the planet held as it were to the “ sun’s limb by a ligament formed of many black cones, whose bases stood “ on the limb of *Venus*, and their vertexes pointing to the limb of the sun.” I shall however have occasion to refer again to Mr. DUNN’s account. Mr. PIGOTT says (page 262) “ I perceived that *Venus*, before she separated “ from the sun, was considerably stretched out towards his limb, which gave “ the planet nearly the form of a pear: and, even after the separation of “ the limbs, *Venus* was twelve or more seconds before she recovered her “ rotundity.” Another person who was at Mr. PIGOTT’s observatory remarks

* It is difficult to follow this description even in imagination: but if we invert the order, and suppose the border of *Venus* to be distorted, and carried up to the sun’s limb, the whole is intelligible.

† One of these drawings is fig. 5 mentioned in page 21. But, I shall add a more remarkable diagram, in the sequel.

(page 264) that soon after the apparent internal contact, the limb of *Venus* “seemed to stretch itself out, and to form a tail,” which tail decreased in breadth till the instant of separation.* Mr. MASON says (page 462) that “at the internal contact the limb of *Venus* seemed to cohere to the sun’s limb, by a protuberance that appeared like a dark shade; which seemed to prevent my seeing the thread of light for about forty seconds longer than I expected.”

In the *Mémoires de l’Acad. Roy. des Sciences* for 1770, page 406, M. LALANDE has also collected together a number of observations confirmatory of what has been above stated: and amongst others, that of M. VALLEROY, who has the following remarks: “Lorsque nous nous croyions près du moment où devoit se faire l’entrée totale, chacun de nous vit la petite partie du disque de la planète, qui paroissoit tenir encore au bord du soliel, s’allonger à mesure que la planète faisoit du progrès: cet allongement formoit comme une espèce de queue par laquelle le corps de la planète tenoit au bord du soliel.”

From all these various accounts it is evident that when this planet is near the border of the sun, its circular form is considerably distorted, and that that side of it which is next to the edge of the sun appears to adhere thereto, and assumes at first a bulging appearance as represented by fig. 5, in the accompanying plate: but, as the planet advances, this protuberance increases in length, tapering off gradually to a finer point at the extremity, which is variously described by different observers, according to the representations given in figs. 6, 7, and 8. At last, the light of the sun is seen beyond the terminating point, and this is the instant generally noted for the complete ingress of the planet, although at this moment the whole body of the planet is seen considerably advanced on the sun’s disc. *Venus* however does not immediately assume her circular form, since it appears that some additional seconds elapse before the protuberance wholly subsides.

The interval which elapses between the time when the disc of *Venus* osculates with the edge of the sun, and the rupture of the dark ligament above alluded to, has been variously estimated by the different observers, and varies from eight seconds to seventy-three seconds of time. In the 5th

* A diagram is given by Mr. PIGOTT, which is nearly the same as that represented by fig. 8 in the accompanying plate.

volume of the *Memoirs* of this Society, page 264, M. FERRER has given a table of these observed differences; and from which he deduces the mean interval to be rather more than thirty-four seconds of time.

There is however a singular circumstance connected with this subject, which should not be suppressed. Notwithstanding the multiplicity of evidence relative to the appearance of the dark ligament above mentioned, there are still some astronomers to whom it was not visible. Dr. HORSLEY states (*Phil. Trans.* for 1769, page 187) that his brother Mr. JOHN HORSLEY, who was at the Royal Observatory, and had an excellent refractor by DOLLOND, assured him that he did *not* see the ligament, though it was seen by Dr. MASKELYNE and others at Greenwich (See page 19). And M. PINGRÉ, who with MM. FLEURIEU, FILIERE, and DE TOURÉS went to St. Domingo to observe the transit in 1769, has the following remarkable passage in the account in *Phil. Trans.* for 1770, page 500. “At the exit of *Venus* in 1761, “the limbs being not yet in contact, and even sensibly distant asunder, I saw “as it were a dark spot detach itself from *Venus*, and gain the limb of the “sun;* at which instant I estimated the internal contact. Many have this “year seen the same phenomenon at the total entry of *Venus*. I was in “expectation of it; *but neither I nor my associates perceived any such thing.*”

I ought also to add that in the accounts of the transit of *Venus* in 1761, the recorded observations of this singular phenomenon are much less numerous than in those of 1769; although some of those accounts were written by persons who (as it is now well known) *did* observe the phenomenon in that year. See *Mémoires de l'Acad. Roy. des Sciences* for 1770, page 406. I cannot account for this omission (so similar to that of the suppression of any mention of the dark lines in annular eclipses) except from a dislike to be the first to promulgate the existence of a phenomenon so rare, so extraordinary, and so unexpected; and which might possibly raise a doubt as to their veracity: or from a prejudice, on the part of those who superintended the publication of such memoirs, not to insert any accounts that might militate against any preconceived notions.

That some feeling of this kind formerly existed is, I think, evident from

* When the ligament breaks, its motion, at the moment of separation, is so rapid that it is difficult to discern whether the broken part collapses to the planet or to the sun's edge. At least, this I found to be the case with respect to the moon, in the late annular eclipse; but in the case of *Venus* the subsidence is more gradual.

a manuscript in the possession of Professor RIGAUD of Oxford, and with the perusal of which I have been favoured since the preceding part of this paper was drawn up. It is entitled “*Observations of the transit of Venus in 1761 and 1769, faithfully described, by S. DUNN.*” It differs in some respects from the statement published in the *Phil. Trans.*: the drawings also appear to be much more expressive of the description, than those given in that work. But the passage to which I more particularly desire to call the attention of the meeting is the following: “Every necessary encouragement was granted by the English nation for observing this transit [1769] at proper places abroad; and myself was recommended to be employed as one of the observers: but this was soon over-ruled, and one half of the persons who received this encouragement were such as cannot pretend to the least discovery in the former transit. This disposal of things was occasioned by that honest and faithful account of the transit of 1761, which I gave to the Royal Society, describing an unexpected *ligament* that was formed between *Venus* and the limb of the sun at the internal contact: for, I heard some of those gentleman declare no such appearance could exist; and others that no such appearance should be published by their consent.” Mr. DUNN then proceeds to state that “the time of the transit drawing near, it was intimated to me by His Majesty’s Astronomer at Greenwich, that I might be there and observe it; but without any other advantage than a person unemployed.” He did observe it there, as already related in the preceding part of this memoir, with an achromatic telescope of $3\frac{1}{2}$ feet, magnifying 140 times. I shall here pass over the progressive steps of the transit, which will be found in sufficient detail in the *Phil. Trans.* for 1770, and come at once to the most important part of the description, bearing on the point in question, and which are there but partially recorded. Alluding to the commencement of the total ingress he says, “At this time a ligament began to be formed which appeared to link, or join the circumferences of *Venus* and the sun together, so as to prevent the thread of light between them from being formed. This ligament very visibly consisted of several small ligaments, each of them perfectly black; the broader part of each being the base of a sort of cone, standing on the circumference of *Venus.*” Drawings are then given of this remarkable appearance; which, as they differ materially from those published in the *Phil. Trans.*, I have inserted in the plate accompanying this paper; being fig. 9 and 10 there given.

When *Venus* was fairly on the face of the sun, it was remarked by many of the observers that she was surrounded by a penumbra, the extent of which was differently estimated, and which is considered to have been caused by her atmosphere.* To this atmosphere some persons have attributed the cause of that faint light, or aurora, which is seen to encircle that portion of the planet which is *off* the sun, at the time of ingress and egress: a phenomenon which has been also witnessed round a small portion of the circumference of the moon off the sun, in several annular eclipses.†

With respect to *Mercury* I cannot find that any distortion or other remarkable appearance has ever been observed, at the time of its transits over the sun. On the contrary, we have the direct evidence of Sir WILLIAM HERSCHEL (who examined *Mercury*, with that special object in view, at the transit on November 9, 1802) that he could not discover any thing out of the usual course. For, in the *Phil. Trans.* for 1803, page 216, we have the following statement. “Ten-feet reflector. The whole disc of *Mercury* is as sharply “defined as possible: there is not the least appearance of any atmospheric “ring, or different tinge of light, visible about the planet.” Again when viewing the planet as it approached the sun’s limb, at its egress, he says “no “kind of distortion either of the limb, or of the disc of *Mercury*, took place. “The appearance of the planet, during the whole time of its emerging from “the sun, remained well defined to the very last. The following limb of “*Mercury* remained sharp till it reached the very edge of the sun’s disc; and “vanished without occasioning the smallest distortion of the sun’s limb, in “going off, or suffering the least alteration in its own figure.” Further he remarks, “It will not be amiss to add that very often, during the transit, I “examined the appearance of *Mercury*, with a view to its figure, but could “not perceive the least deviation from a spherical form.”

From a review of all the circumstances here detailed, it will be evident that, whatever be the cause of the distortion of the limb of *Venus*, in its transit across the sun, the same may be considered as producing that singular optical deception on the limb of the moon which I have described in the first part of

* See *Philosophical Transactions* for 1769, Plate 15, where a representation of this appearance is given.

† See the account of MACLAURIN in page 11, of SHORT in page 13, of VAN SWINDEN in page 15, and of GREVE in page 16: and, since this was written, the account of BESSEL, alluded to in page 32.

this paper. And that it arises from something connected with the planet and the moon, and not dependent wholly on the sun, is also evident from the circumstance that *Mercury* is not similarly affected.

But, to whatever cause this singular phenomenon may be attributed, it is very evident that the appearance itself should be more specially attended to by the practical astronomer on all future occasions: and it is requisite that the observer should note most distinctly the time of the exact phase that occurs. At the transit of *Venus* in 1761, very few of the observers noted (or if noted, they did not record) the appearance of the dark ligament, and it is consequently uncertain whether the time of total ingress of the planet is to be assumed at the moment when the limb of *Venus* osculated with that of the sun, or at the moment when the dark ligament was broken. At the transit in 1769, a little more attention appears to have been given to the case, and both these phenomena are in most instances recorded: but, at some of the places, only one moment of time is recorded, without any statement as to *which* of the phenomena it is intended to allude; thus involving the observation in uncertainty and confusion.*

In the annular eclipses mentioned in the preceding part of this paper, the same state of confusion and uncertainty exists. It is not known at the present day whether, in the annular eclipses of 1736-7, 1748, and 1764, or even in the recent annular eclipse of May last, the times of the moon's total ingress on the sun's disc, be reckoned from the moment when the moon's circumference appears to osculate with that of the sun, or from the moment when the dark lines are seen to part asunder. I believe that most observers have assumed the latter as the most certain and best determined instant of time; although it seems to me not to be the correct moment of the astronomical phenomenon: the former is in my opinion as easily determined if the observer would prepare himself for noting it, and certainly approximates most nearly to the correct time. My own record of the formation and dissolution of the annulus, in page 3, refers to the point of time here alluded to; namely, when the limb of the moon osculated with that of the sun, as nearly as I could estimate and call to mind, amidst the rapid succession of interesting phenomena; and which I consider to be simultaneous with the formation of the

* See M. FERRER's paper "On the determination of the parallax of the sun, from the observations of the transit of *Venus* over its disc, June 3, 1769," in the 5th volume of the *Memoirs* of this Society, page 253.

luminous string of beads. Both instants, however, ought to be recorded, as in the case of the transits of *Venus*: and in future annular eclipses (as well as in total ones*) I trust that this will be attended to. But, the interposition of clouds will sometimes frustrate the best intentions.

This precaution will be the more necessary, since it is plain that the appearances will be different to different observers, according to their local position with respect to the central line of the moon's shadow; as I have already noticed in the preceding part of this paper. And I know some persons who did not notice the dark lines in the late eclipse, although furnished with good telescopes, and favourably situated. This brings me to another portion of the subject to which I have not yet alluded, namely the distortion of the moon's circular shape: for, hitherto I have considered the phenomenon as remarkable only for certain filaments or projections from the moon's limb, without supposing that the general circular form of the moon was disturbed. In the case of the transit of *Venus*, we have seen that the disc of the planet, next to the edge of the sun, was sensibly protuberant, and that the form of the planet was thus rendered more like that of an egg, than a circle. The same cause that produced this apparent distortion of *Venus's* disc, might also produce a similar distortion in that of the moon; but, by reason of the magnitude of the moon's disc, and the field of the telescope not embracing the whole, it would not be so easily perceptible. There was one circumstance, however, connected with this subject, which I noticed during the late eclipse, that induces me to think that such a distortion did take place on that occasion, and which I shall now proceed to describe.

If we examine the relative curvatures of the circles in fig. 3, which represent the discs of the sun and moon, and note their proximity to each other, it will be seen that there can be no very perceptible difference in the apparent length of the parallel lines, which there denote the dark ligaments so frequently alluded to in this paper, provided those curves truly represented the apparent discs. But, in fact, the outer lines immediately before their rupture seemed to be nearly twice the length of those in the middle; which could arise only from some distortion of the moon's apparent limb, and of a

* We have already seen (in page 11) that that excellent astronomer, Mr. JOACHIM FERRER, was rather puzzled and undecided in the *total* eclipse of June 16, 1806, as to which of the two phenomena he should consider as the moment of total obscurity, owing to the intrusion of what he is pleased to designate as the *lunar concavities*.

kind similar to that which had been observed in *Venus*. I have endeavoured to represent this appearance in fig. 4: and if my notion be correct, it will shew us that all measures of the moon's diameter, when she is passing over the sun's disc, must be taken with great caution, and with due attention to the proximity of the part measured to the edge of the sun's disc, where alone the distortion seems to take place.

This hypothesis of a distortion of the moon's circular form seems to receive confirmation from a circumstance attending her motion across the sun's disc, when she is *wholly* thereon, which has been noted in annular eclipses by several observers: namely, that at the time of ingress and egress,* her motion appears more rapid than at any other point. This apparent increase of motion would arise from the subsidence of the protuberance in the first instance, and from its projection in the latter case.

Another singular anomaly also may arise, from this view of the subject. It is possible that in a small annular eclipse (that is, an eclipse where the apparent diameter of the moon, as computed from the tables, is but a few seconds less than the apparent diameter of the sun) the observer may be so exactly placed on the central line, as to see the eclipse *total*, for a moment of time. For, as each portion of the moon's circumference would (at the instant that it was concentric with the sun's) protrude, and adhere to that of the sun, the spectator would witness a total eclipse *sine mora*, when in fact he ought only to see an annular one.

It is very probable that the accounts of the appearance of great lunar mountains and valleys which we so frequently hear of in the descriptions of solar eclipses, may be traced to the same cause, as that which produces the phenomena above alluded to. These prodigious elevations and depressions are seldom or never seen except at the commencement or termination of the eclipse, or in places near the solar cusps; that is, in those points only which are near the edge of the sun. Every other portion of the moon's circumference generally appears comparatively smooth and circular, except viewed with a very powerful telescope; whilst with a much inferior instrument we may frequently detect inequalities in those parts of the moon's circumference which successively come in contact with the sun's limb.

* The ingress and egress, here mentioned, alludes to her *total* ingress and egress: or, in other words, to the time of the formation and dissolution of the annulus.

This brings me to the consideration of another subject connected with the present inquiry. It has, I believe, been generally supposed that, in eclipses of the sun, the measurement of the distances of the solar *cusps* affords one of the best means of determining the beginning and ending of the eclipse: and, if those cusps always presented a finely pointed apex, this would undoubtedly be the case. But, it is frequently found that the cusps are rounded, or serrated, or broken into parts, and consequently that we cannot obtain the correct measures between the *true points* of the cusps.* For which reason we oftentimes meet with discordances in such measures, that have hitherto baffled all attempts at explanation; but which may be fairly attributed to the causes above alluded to. I do not wish however to be considered as objecting to this mode of determining the phases of an eclipse, which, after all, is probably one of the best: but merely as wishing to place the observer on his guard, and to enable him to trace the source of error, should he meet with any of the discordances above mentioned.

I ought to apologise for the extent of these remarks, to which I have been led by the singularity and importance of the phenomenon: a phenomenon indeed which does not appear to have been sufficiently attended to by the practical astronomer on former occasions; or (if attended to and observed) not to have been sufficiently and duly recorded. As a *total* eclipse of the sun will take place on July 8, 1842, the central line of which will pass over the south of France and the northern part of Italy, and as another *annular* eclipse will take place on October 9, 1847, the central line of which will pass over the south-western parts of England and a great portion of France, favourable opportunities will thus be afforded to astronomers in this part of the globe for verifying the several points here brought into discussion, and for making arrangements for carrying into effect such a system of observations in various places, as may best tend to elucidate the present inquiry. It has been principally with a view to this object, that I have thus ventured to address the Society so much at length: and I trust that, if any observations be made, they will, however extraordinary and unexpected, be

* Accounts of such distortions are so numerous that it is unnecessary to allude to them more particularly. But if the reader is desirous of perusing a circumstantial statement of the phenomenon, with diagrams of the appearances, he may consult Mr. ELLICOT'S paper, mentioned in page 10.

faithfully and honestly recorded, and not suppressed through fear of encountering the prejudices and preconceived opinions of the public.

Since the preceding paper was written, I have seen the *Astronomische Nachrichten*, No. 320, containing the interesting remarks of M. BESSEL on the late annular eclipse of May 15, 1836, which was observed by him at the observatory of Königsberg, under peculiar circumstances: and I consider it fortunate for astronomy that it was thus seen by an observer so exact and circumstantial in all his descriptions. M. BESSEL had ascertained, by a previous computation, that his observatory was situate so near to the northern limit of the moon's umbra, that it was doubtful whether or not the eclipse would be annular there. When the day arrived, therefore, he looked out, towards the middle of the eclipse, with great interest, for the actual determination of this point from observation. The result deduced by him is that the eclipse was *not* annular at the observatory: or, in other words, that the light of the sun did not *wholly* encircle the body of the moon. But, perhaps those, who take the same view of the subject as I have done in the preceding part of this paper, may be disposed to qualify this definition of an annular eclipse. However, I shall not stop here to discuss this point; but give M. BESSEL'S own statement, in order that the reader may form his own conclusion on the subject: and I would premise that I have here extracted only such portions of M. BESSEL'S memoir as relate to the question of the formation and dissolution of the annulus, and the appearances consequent thereon.

“ During the eclipse, the part of the moon's border on the sun exhibited, “ as usual, protuberances and cavities. The cusps, which at the time of the “ nearest approach of the centres were extremely fine, exhibited (so far as “ could be distinguished by the eye) on their outer side, the regular curvature “ of the sun's limb: but, on their inner side, the irregularity of the moon's “ border. They appeared also, when their extremities fell on a part of the “ moon's limb not particularly mountainous, to terminate in sharp prominent “ points: whereas, when the extremities fell on the slope of a mountain, they “ assumed a corresponding figure. There was no rounding of the points “ which could not apparently be ascribed to this circumstance. Nor was any

“ thing seen which could be considered as indicating an irradiation of the sun’s disc, in the telescope made use of.

“ At the time the cusps approached towards each other they terminated at a very rugged part of the moon’s limb ; and I expected, but in vain, to see some parts of the sun’s disc appear between the points. About twenty-five seconds, however, before the nearest approach, there appeared near the termination of the upper cusp, a point which, though far indeed from exhibiting the bright light of the sun, was sufficiently visible in the powerful telescope of the heliometer. As the cusps were then approaching very near to each other, I expected every instant to see the annulus formed. This however did not take place : but the point, just mentioned, became more luminous ; and *other luminous points*, besides it, appeared, which soon united, and in this manner *rendered visible the whole of the moon’s border between the points of the cusps*.* Still I expected the formation of the annulus itself : till, on the disappearance of some points on the moon’s border (which shewed that the eclipse had begun to decrease) I first remarked that it would not take place. Ten seconds afterwards, no trace of the moon’s limb was visible.”

It is evident, from this last expression, that M. BESSEL was considering only that portion of the moon’s limb which lay between the solar cusps : and that the other (by far the larger) portion of the moon’s circumference was not regarded by him as presenting any remarkable or extraordinary appearance. Now, it is to this fact that I wish to draw the attention of the reader, as confirmatory of my preceding remarks : for I have more than once stated that it is only at the proximity of the borders of the sun and moon that these singular and prodigious elevations and depressions in the moon’s border are seen. M. BESSEL says, “ I saw the whole portion of the moon’s limb, between the cusps, for about fifteen seconds : some points of it longer. I observed the inequalities of the border : the depressed parts in a stronger, and the protuberances in a feebler light.” Indeed, there is nothing in his account but what fully confirms the statements of all preceding observers, as to the *commencement* of this phenomenon : and it was only the *first stage* of the phenomenon that M. BESSEL had an opportunity of observing ; since he was situate

* This stage of the phenomenon I consider to be similar to the formation of the string of luminous beads, or spaces, mentioned by me in page 5 : the first appearance of which I have there considered as the true moment of the formation of the annulus.—F. B.

too near the northern limit of the moon's umbra to admit of his witnessing those further alterations and variations in the irregularities of the moon's border, and the formation of the dark ligaments, which he probably would have seen had he been situate a little more to the southward.*

A somewhat similar result, though not so fully detailed, is recorded by the Rev. Dr. ROBINSON, who observed the same eclipse at Armagh. It appears from Dr. ROBINSON'S account, which accompanied the particulars of his observation, † that the luminous cusps were connected by a thread of light, frequently *interrupted by lunar mountains*, at 2^h 42^m 24^s.04: that the maximum breadth of this occurred at 2^h 42^m 36^s.01, *intersected however by two or three lunar mountains*: and that the cusps were disconnected at 2^h 42^m 45^s.98. It would seem therefore that at no period was the annulus (according to the commonly received opinion) completely formed at Armagh: since there was always an interruption of the complete circle of light by those dark ligaments (or lunar mountains) so frequently alluded to in this paper. Dr. ROBINSON adds that the projections which intersected the annulus were sharp and well defined: but he remarks that he looked in vain for the indication of a lunar atmosphere, said to have been seen on similar occasions; and that not the slightest trace of the moon's circumference could be seen *off* the sun.

As Dr. ROBINSON does not take notice of the other (by far the largest) portion of the moon's circumference, that was projected on the sun's disc, we may naturally presume, as in the case of M. BESSEL, that it presented nothing very remarkable. Now, since it was the northern limb of the moon that was seen between the solar cusps by M. BESSEL, whilst it was the southern limb that was thus observed by Dr. ROBINSON, it would seem that whilst M. BESSEL was viewing the serrated appearance of the moon's *northern* limb, her *southern* limb was comparatively regular and uniform; whereas the reverse was the case with Dr. ROBINSON: which confirms the remark I have so frequently made—that it is only when the limb of the moon approaches the limb of the sun, that this singular phenomenon takes place. Dr. ROBINSON was placed

* M. BESSEL mentions that a friend of his, situate about an English mile towards the south-west from the observatory, believed that he saw the annulus complete: but it was observed only with the naked eye.

† See the preceding volume of the *Memoirs* of this Society, page 266. Some further details accompanied that communication, which were inadvertently omitted to be printed in their proper place: the whole therefore are now reprinted at the end of the present paper.

somewhat further within the line of the moon's umbra than M. BESSEL, since the duration of the annulus at Armagh was nearly twenty-two seconds.

In the annular eclipse of September 7, 1820, M. VAN SWINDEN was situate still further within the moon's umbra than either M. BESSEL or Dr. ROBINSON; the duration of the annulus being forty-four seconds. See page 16. And he noticed not only the existence and disappearance, but also the re-appearance and final disappearance of the *dark ligaments*. Yet he has omitted to record the existence of the *luminous points*, which is the first stage of the phenomenon. This omission however has been supplied by M. GREVE who observed the eclipse at the very same place, as already recorded in page 15: but, who on the other hand did not observe the dark ligaments. Thus, we have two observers at the same place recording two distinct parts of the same phenomenon; each apparently unconscious of what the other had seen. M. VAN SWINDEN'S omission may be readily accounted for, from his attention being taken up by the appearance of the *luminous arch* which at that moment was observed *off the sun* between the cusps, as already mentioned in page 15: a phenomenon which was likewise observed by M. BESSEL in the late eclipse, and of which he has given a very detailed account; but which was not seen by Dr. ROBINSON.

It is clear therefore that, before we can deduce the most accurate and accordant results from the observations of annular eclipses, we must have further information on these points; and we must agree on the particular stage of the phenomenon, when the annulus shall be considered as formed, or dissolved: and after all, there will probably still remain some discrepancies arising from the distortion of the moon's limb according to the geographical position of the spectator. The subject, however, is worthy the consideration of astronomers; and ought not to be neglected at any ensuing solar eclipse that may afford facilities for determining these points.

But it is not merely to the moment of the formation or dissolution of the annulus that we need restrict our inquiries; since it appears that, at the commencement of the general eclipse, or when the border of the moon makes the first impression on the sun's disc, certain phenomena take place which are very much allied to those which I have been describing, and which are worthy of a more minute attention. Sir W. HERSCHEL, at the solar eclipse of September 5, 1793, observed that the first impression on the sun's disc was made by the projection of two high mountains of the moon, having the

appearance of horns; which were distinctly visible in his 7-foot telescope, before the body of the moon appeared; *Phil. Trans.* 1794, page 39. In the solar eclipse of January 31, 1794, M. MÉCHAIN says that the projection of a mountain of the moon on the disc of the sun announced the commencement of the eclipse. *Con. des Temps.* An. IV. page 192. And in the late annular eclipse, which has been the subject of the present memoir, and which was observed at Ormskirk by the Rev. Mr. DAWES, he states that “the first impression was made by a lunar mountain, which projected on the disc, and suggested the idea of the point of a lead-pencil having been pushed on to the sun’s disc.” It is much to be regretted that the observations of these mountains are not followed up during the progress of the eclipse. I apprehend that they would vanish after the moon had proceeded some distance on the sun’s disc.

At the termination also of the general eclipse we find something of the same kind recorded. M. VAN SWINDEN (as I have already noticed in page 15) says that “at the *end* of the eclipse, some black threads were perceived again.” Dr. ROBINSON also in the recent eclipse states that the end was at 4^h 4^m 58^s.88; “but the point of ultimate contact is a high mountain.” And perhaps if the accounts of other eclipses were examined more minutely, we might obtain further evidence on these points. There is sufficient however on record to induce us, on any future occasion, to look after these several phenomena with more attention. That mountains may occasionally obtrude themselves to our view, there can be no question: but it requires further explanation why almost all the remarkable distortions take place when observed near the edge of the sun’s disc, and that as the moon advances thereon these prodigious elevations in a great measure disappear.

[Letter from Mr. HENDERSON to Mr. BAILY. See the note in page 8.]

MY DEAR SIR,

Observatory, Edinburgh, May 20, 1836.

THE weather during the solar eclipse on the 15th was as favourable as could reasonably be desired. The sky was unclouded except towards the end, when a few flying clouds passed over the sun's disc, but they did not interrupt the observations. The wind blew pretty strongly from the south-west, and sometimes made the telescope vibrate so as to render the observations at these times a little doubtful. The limbs of the sun and moon were at times remarkably well defined. At other times they were seen serrated and undulating. On the whole the atmospheric circumstances were as favourable as could be expected in this climate at the season and time of the day,

The telescope with which I observed the eclipse was that of the altitude and azimuth circle by TROUGHTON and SIMMS, fixed under the dome of the observatory. It is 51 inches in focal length, and the object-glass has 3·4 inches of aperture; but the aperture was limited to 1·6 inches, as the sun was seen better defined with the reduced than with the whole object-glass. The eye-glass employed gave a magnifying power of 68. The whole instrument was screened from the sun, except the part of the object-glass employed.

The observation of the beginning of the eclipse I lost from inadvertence. It was supposed that the eye-glass with the diagonal reflector would be more convenient for looking at the sun than the direct eye-glass; but it was not considered that the diagonal eye-glass shews the images of objects inverted only in one direction. A wrong point of the sun's limb was consequently watched, and before the mistake was discovered the eclipse had commenced. Mr. GALBRAITH being on the observatory grounds with an achromatic telescope by TULLEY of 49 inches focal length, $3\frac{1}{2}$ inches aperture, and a magnifying power of 50, observed the beginning at 5^h 6^m 25^s·4 sidereal time, or 1^h 33^m 10^s mean time.

Shortly before the formation of the annulus the cusps were seen to approach, and to be broken into several parts. When they were about 30° or 40° from each other, an arch of faint reddish light was seen extending betwixt them. This appearance lasted several seconds. Then there sud-

denly appeared betwixt the cusps small detached portions of the sun's limb, like a string of beads, with dark intervals. The luminous portions increased in magnitude, the dark intervals decreased, and the annulus was at length seen completely formed of sensible breadth at the narrowest point. This was at $6^{\text{h}} 30^{\text{m}} 50^{\text{s}},1$ sidereal time, or $2^{\text{h}} 57^{\text{m}} 20^{\text{s}},9$ mean time. The first appearance of the detached luminous portions was nine seconds earlier.

At the dissolution of the annulus similar appearances were noticed in a reverse order. The annulus decreasing, but being still of sensible breadth, it was suddenly broken in several places by dark spaces, leaving luminous portions betwixt them. The dark spaces increased in magnitude, the luminous portions decreased, and finally disappeared, and the sun's limb was interrupted by a continuous dark space extending betwixt the cusps. The first rupture of the annulus was at $6^{\text{h}} 34^{\text{m}} 33^{\text{s}},1$ sidereal time, or $3^{\text{h}} 1^{\text{m}} 3^{\text{s}},3$ mean time, and it was eleven seconds afterwards when the detached luminous portions completely disappeared. Being occupied in noting and writing down the times of these phenomena, I did not observe whether any faint arch appeared at the end of the annulus.

The end of the eclipse did not seem to me capable of being observed with much precision. The portions of the limbs which were last in contact were sensibly uneven, and I could not determine satisfactorily the precise moment when they separated. At $7^{\text{h}} 53^{\text{m}} 0^{\text{s}},8$ sidereal time, I doubted whether the eclipse was ended: seven seconds later I was certain that it was over. In placing the termination of the eclipse at $7^{\text{h}} 53^{\text{m}} 4^{\text{s}},3$ sidereal time, or $4^{\text{h}} 19^{\text{m}} 21^{\text{s}},6$ mean time, an error of two or three seconds may possibly be committed. To greater accuracy I cannot pretend.

During the whole duration of the eclipse I made a great many observations of the transits of the sun's and moon's limbs, and of the cusps, over the horizontal and vertical wires of the telescope of the circle. When these observations shall have been properly reduced, the corrections of the lunar tables will be obtained.

Although my attention was almost completely engaged by this work, it was impossible not to take notice of the considerable diminution of daylight which took place towards the middle of the eclipse, and of the unusual and unnatural colour which the sky assumed, inclining towards a purple hue. *Venus* was distinctly seen by most persons who looked in the proper quarter, or to whom it was pointed out. *Jupiter* being much fainter was not seen by

many. Mr. WALLACE, my assistant, first perceived it at 2^h 52^m mean time. *Sirius* passed the meridian soon after the dissolution of the annulus; but though he saw it very bright in the transit telescope, he was unable to see it with the naked eye. There was a haze in that part of the sky. He also looked for *Capella* without success; and I have not learned that any of the fixed stars were seen by any one with the naked eye.*

The state of the meteorological instruments of the observatory, which were occasionally examined, for being employed in the computations of refraction, were as follows:

Sidereal time.	Exterior thermometer.	Barometer.	Attached thermometer.
^h 3 ^m 29	56 ^o ·9	^{Inches.} 30·20	55 ^o ·7
5 59	57·6	30·19	56·7
6 53	54·8	30·19	56·2
8 0	55·9	30·18	56·2

These are the principal phenomena which I observed with regard to this remarkable eclipse. To it may be applied the words of MACLAURIN in his memoir on the annular eclipse of February 18th, 1736-7, also observed in this city: “The remembrance of the eclipse will be preserved by the curious “who observed it with great pleasure, and agree that it was the most enter-“taining spectacle of this kind they ever saw.”—*Philosophical Transactions*, Vol. XL. page 194.

I am,

My dear Sir,

Yours faithfully,

T. HENDERSON.

In a subsequent letter which I have recently received from Mr. HENDERSON, in reply to my having forwarded to him the first proof sheet of the present Memoir, for his perusal, he says, “It seems to me that, except in one particular, the appearances, as presented to me, were the same as those which “you saw. The particular in which our descriptions differ is that of the “*long, black, thick, parallel lines, joining the limbs of the sun and moon.* I

* *Sirius* was seen with the naked eye at SIR THOMAS BRISBANE’S observatory.—F. B.

“ will not venture to say that they might not have been perceived by me ;
“ for, during the formation and dissolution of the annulus (each of which
“ lasted only about ten seconds) I was a good deal startled by the unexpected
“ magnitude of the appearance, and eager to seize the exact moments of the
“ principal phenomena. The impression on my mind however is that the
“ *last* appearance of the dark spaces *before* the complete formation of the
“ annulus, and their *first* appearance *after* it was ruptured, were of a *more*
“ *irregular* description than that which you have represented in fig. 3.”

I have considered it right to add this supplementary testimony of Mr. HENDERSON ; as, in a question of evidence, the public should have the statement of a witness in his own words. Mr. HENDERSON does not here doubt the *existence* of the dark spaces, but seems to think that they did not, at any time, assume a shape so uniform and *regular* as those which I have represented by fig. 3 on the plate. My own view of the subject however, and my perfect recollection of all the circumstances have not experienced any alteration.

*Observation of the Solar Eclipse, May 15, 1836, at the Armagh Observatory.**By the Rev. Dr. ROBINSON. (See the Note in page 34).*

	Mean Time.
The first contact was observed at	1 ^h 14 ^m 4 ^s ,58
Limb undulating.	
The luminous cusps connected by a thread of light, frequently interrupted by } lunar mountains	2 42 24,04
Maximum breadth of this, which, however, is intersected by two or three mountains, at	2 42 36,01
Cusps disconnected at	2 42 45,98
Eclipse ends	4 4 58,88

But the point of ultimate contact is a high mountain.

These were observed with the telescope of TROUGHTON'S equatorial, $2\frac{3}{4}$ inches aperture, power 60.

A few spots were observed.

	Mean Time.
(1) Very near the west limb touched by the shadow at	1 ^h 18 ^m 31,87
covered	1 19 11,76
(2) A larger, solitary, touched	1 32 21,58
covered	1 32 49,50
(3) Another, touched	1 54 12,00
covered	1 55 12,84
(4) Largest on the sun, touched	2 4 26,30
covered	2 5 21,15
(2) or perhaps (3) reappears	3 14 53,71
uncovered	3 15 35,60
(4) Reappears	3 17 56,20
Uncovered	3 18 40,08

A few measures of cusps were taken before and after the mid-eclipse, with a divided object-glass micrometer, applied to a triple achromatic of $2\frac{3}{4}$ inches aperture. The scale was determined on the 15th and 16th by the sun's diameter; but one of the images is not so sharp as its fellow, from the semi-lens being out of adjustment. They give

At	1 ^h	25 ^m	56,45 ^s	.....	15'	11",1	At	3 ^h	24 ^m	11,13 ^s	.....	26'	55",9
	1	29	46,82	.....	17	7,5		3	26	6,71	.....	26	33,6
	1	36	2,79	.....	20	8,8		3	27	23,49	.....	26	14,5
	1	41	33,01	.....	22	18,5		3	28	24,34	.....	26	1,7
	1	43	41,54	.....	22	50,9		3	29	38,13	.....	25	45,8
	1	46	40,05	.....	23	42,5		3	30	47,94	.....	25	32,0
	1	48	14,79	.....	24	5,8		3	30	6,73	.....	25	6,4
	1	49	36,56	.....	24	36,2		3	33	23,52	.....	24	48,9

I looked in vain for the indications of a lunar atmosphere, said to have been seen on similar occasions ; not the slightest trace of the moon's circumference could be suspected *off* the sun ; and the projections that intersected the annulus were sharp and well defined. The annular thread seemed about 5" broad ; and the luminous cusps, before and after its formation, were perfectly defined.