here and there has one higher than its neighbours raised its crests to the level of the surface.

But we have a third class of formation, evidently of later origin than the two we have been considering, viz., the great majority of the craters and ring-plains upon the surfaces of the maria. These are of less size than the craters upon the brighter portions of the surface, and are conspicuous by their brilliance. We have examples in Aristarchus, Flamsteed, and many others. In a paper published lately in "Knowledge," Mr. Maunder considered that the dazzling brightness of Aristarchus was due to its comparatively recent orign, and it is characteristic of all such formations that they have a decidedly new look. The difference in size is, of course, explainable by the gradual decrease in volcanic force, and ages must have elapsed between the periods of their upheaval. I have indicated above that large numbers of formations of the older class might exist under the seas, and, if such be the case, many of these would necessarily be more or less destroyed—if the sea had not already done so to a certain extent—by volcanic action finding its way through them to the surface, to form the newer craters.

It would then seem very probable that, of the three classes considered, the bright parts of the surface are the oldest, the maria come next in order of origin, and the smaller bright craters and ring-plains situated thereon came last into existence.

This paper was written just before the publication of the October "Journal," in which will be found a report of the Lunar Section, containing a reference to these formations, and suggesting that Members of the Section should give the matter their attention. The foregoing remarks may, then, possibly serve as a kind of introduction, though a very inadequate one, to the subject, which is one of great interest and of considerable importance.

On Dark Meteors.

By Frits Hopman.

It has already been stated in the "Journal" of the British Astronomical Association (Vol. VII., No. 2), that Mr. A. M. du Celliée Muller, at Nimeguen (Holland) was the first astronomer, who ever observed a dark meteor passing before the moon. Other scientific men, however, have claimed for themselves the priority in the discovery, and I have, therefore, thought it my duty in writing this paper to closely investigate the right of the respective claimants. It seems that five astronomers have, in different parts of the world, and independently of each other, observed dark meteors. Their names, arranged according to the date of their observation, are as follows:—

April 4, 1892. A. M. du C. Muller, Nimeguen.
July 22, 1896. Prof. W. R. Brooks, Geneva.
August 22, 1896. Gathman, America.
September 28, 1896. Ph. Fauth, Landstuhl.
February 16, 1897. O. Hoffmann, Buda Pesth.

Mr. A. M. du Celliée Muller gives in the Dutch periodical "De Natuur" (of the 15th of January 1893) the following account of his discovery:—

"On the 4th of April 1892, observing the moon with a Molteni telescope, I have seen phenomena, which according to

Prof. H. G. van de Sande Bakhuyzen, have never been seen before by any astronomer. I observed little black specks or disks, which moved with great rapidity before the disk of the moon. The duration of these transits was about one-fifth of a second, and within 41 minutes seven transitions took place. When I observed similar phenomena again on the 2nd of December following, I came to the conclusion that the little specks observed by me were meteors, which, being outside our atmosphere, and consequently not incandescent, stood out black against the bright moon's disk."

Some information about Prof. Brooks's first observation of dark meteors is to be found in the "Scientific American" of the 1st of August 1896, and is to the following effect:—

"A despatch from Geneva, New York, dated July 22, says: 'Prof. William R. Brooks, Director of Smyth Observatory, while 'observing the moon last night, made a most interesting and 'unique discovery. A dark round object was seen to pass rather 'slowly across the moon in horizontal direction.' Prof. Brooks believes that it was the passage of a dark meteor between the earth and the moon, far beyond the earth's atmosphere, so that it remained non-luminous. The observation is new in astronomical records."

We have already seen that this was not the case.

In September 1896, Mr. du Celliée Muller having meanwhile made a series of observations of dark (or as he styles them) "cosmic" meteors, published these observations in the "Mittei-"lungen der Vereinigung von Freunden der Astronomie und "Kosmischen Physik," Jahrgang VI., Heft 8, whereupon in the next number (9) of that same periodical, Herr Ph. Fauth, at Landstuhl, Rheinpfalz, stated that he had himself seen the phenomena, which, for the first time, had been observed at Nimeguen. It seems to me though, both from Herr Fauth's own paper, and from his letter (to Mr. du Celliée Muller) that although he saw from their distance that the black specs were moving outside our atmospheric zone, he did not recognise them as meteors, and it was only in recording his observation of September 28, that he definitely named them as such; at any rate this was the first observation to that effect published by him.

Furthermore, as we have already stated, Mr. O. Hoffmann at Buda-Pesth announced that he had seen a dark meteor crossing the moon, but this occurrence, it will be remembered, took place five years after the published observations of the Dutch astronomer. Mr. du Celliée Muller's discovery was received both in Holland and abroad with a considerable amount of scepticism, which is the more remarkable as the two principal theories about meteors (those of Arago and Schiaparelli) assume the existence of numerous very small heavenly bodies, which pass through our solar system in all directions. And even Annexagoras (according to Theophrastus, Stob. Eclog. Phys., lib. I., p. 560), says, "Lower than the moon and between her and the earth "there are other dark bodies, which may also produce moon "eclipses." But some astronomers, and amongst them the late Prof. Krueger, of Kiel Observatory, were of opinion that

Mr. Muller had seen birds passing before the moon, and, indeed, not wholly without reason, for it is well known that the objects which Capocci and Nobile at Naples observed passing before the sun have been shown by the late Prof. Kaiser to have been birds. In our present instance, however, this was not the case, as will be shown hereafter. Others suggested the black specks to have been plant seeds, while a third body of scientific men were of opinion that the phenomenon must have been caused by particles of dust in the eye of the observer. Subsequent observations have proved beyond all doubt that neither of the suggestions were in conformity with the truth; at the time, however, the false theories had to be refuted.

First of all, Mr. du Celliée Muller had his right eye carefully examined by a specialist, Dr. Nicolaï, at Nimeguen, who stated in his testimonial that he found no dust particles in the eye. Later on the fact that Mr. Muller and Mr. van Dÿk watched the same meteor passing before the sun, the image of which was projected on paper in the well-known method, showed as clearly as possible that in this case "mouches volantes" were out of the question.

On the 2nd of March, while a strong southerly wind was blowing and the clouds were drifting towards the east, one of these black spots was seen moving in a perfectly vertical direction. Therefore the object must have been moving above the regions where the upperwind was blowing. Again, at that great distance the object must have been of a considerable dimension and consequently could not have been a plant seed.

The explanation of the phenomenon by the hypothesis of birds has been refuted, amongst others, by Mr. Gouka, who, while observing the moon with a magnifying power of 200, saw a meteor which appeared as the very smallest speck. Now even the smallest bird must have been at a distance of 20,000 meters at least, to appear when seen with such magnifying power as a point without a visible diameter. This distance implies a velocity of 186 meters and a height of 12,000 meters above sea level!

So the identity of the dark meteors was proved. But now the question arose, how it was possible that a phenomenon of this kind could have remained undiscovered for so long, and indeed it seemed strange considering that the moon is closely watched year after year by so many astronomers in all parts of the globe. Mr. Th. E. J. Kramers, at Schiedam, suggested that the meteors might belong to a swarm which the earth had only recently captured and which was now rotating round her. Dr. G. J. D. Mounier, at Utrecht, remarked that since the great telescopes allow only a comparatively small portion of the moon or the sun to be surveyed, the chance of observing the transit of a dark meteor is small in the same proportion and many may pass unnoticed. Finally, Dr. Nÿland is of opinion that the fact that dark meteors which formerly were never seen, are now observed in several countries, finds its cause in the turning of the lines of the nodes of the meteoric orbits, an explanation which Mr. Muller also adheres to.

It is clear that the new method of observing meteors has great advantages over the old one, which may be summarised as follows :—

1. It is possible to see the meteor itself and not only the light produced by its conflagration.
2. The direction of its motion is easily determined; especially its parallax and its distance from the earth may be ascertained with an exactness hitherto unknown, by means of corresponding observations of the meteor, while it is passing before the moon.
3. Its apparent diameter can be estimated by comparing it with the lunar objects.
4. The new method allows us to find the velocity of meteors, while they are still outside our atmosphere where they must needs be considerably retarded, an element till now absolutely unknown, and from which most interesting conclusions might be drawn with regard to the density of the air at a great height.

I now proceed to record the principal results of the observations of Mr. Muller, in co-operation with Mr. A. J. Gouka, jun., and Mr. G. J. van Dÿk.

The observations have, beyond all doubt, proved the *cosmic nature* of the phenomenon.

The dark meteors have been seen *passing before the sun* too, in a tolerably great number.

They appear like the "shooting stars," now *alone*, now *in showers*.

Their *diameters* differ widely in size; two bodies have been observed, of which the apparent diameter was about as big as that of the lunar crater Tycho, while others were very much smaller.

Their apparent *velocity*, too, is different for different meteors, the duration of the transition varying between three seconds and a fraction of a second.

The *shape* of all the greater bodies, which travelled slowly enough to reveal their forms, was always circular; furthermore, these small disks were of a black *tint* and their outlines stood out clearly on the light background, which made them visible, the meteor and the lunar craters being equally well defined.

On September 13th, 1893, a great meteoric shower took place and the meteors were observed at Nimeguen, while they were moving across the sun. The transits followed one another with such great rapidity, that is was hardly possible to note them all down.

Twenty-eight transitions were observed, which clearly showed one single direction. Some elements of this shower have been calculated by Prof. J. A. C. Oudemans, director of the Utrecht Observatory, who gives the following values:

$$\Omega = 351^\circ$$
$$i = 141^\circ \text{ or } 39^\circ \text{ in a retrograde sense.}$$

After this observation Prof. Oudemans had a screen fixed to the Frauenhofer refractor at Utrecht for the purpose of studying dark meteors.

On August 4, 1897, 13 meteors were observed, 10 of which proceeded in the same direction. From the observations of

Mr. A. J. Gouka, jun., Prof. Oudemans has calculated the following values:

$$\Omega = 132^\circ\ 13'{\cdot}5$$
$$i = 10^\circ.$$

Dr. Nyland has seen several dark meteors and declares them to be of a globular shape; he even thinks he observed a rotation in some of them.

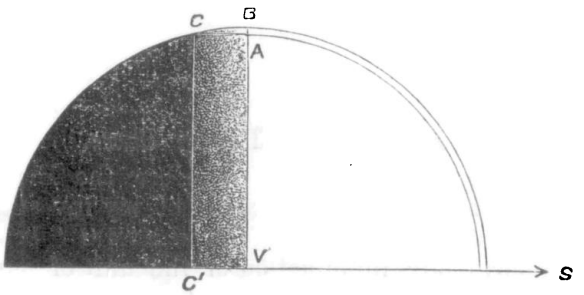
Finally I mention here a curious phenomenon, which some of the dark meteors reveal. Sometimes such a meteor appears before the disk of either sun or moon, and before it has reached the opposite edge suddenly disappears. The only explanation of the "fragmentary chords" (as Mr. Muller calls them) which has been given, is inserted in the paper on cosmic meteors, which appeared in "De Natuur." It is supposed that the meteor, while passing before the sun or moon, suddenly enters our atmosphere, becomes incandescent, and consequently ceases to be visible.

My object in writing this paper is to emphasise the facts and dates, which definitely prove that to Mr. du Celliée Muller is due the honour of having first discovered the existence of these dark meteors; and further by making the Members of the British Astronomical Association acquainted with some of the phenomena exhibited by these bodies to enlist their interest in this new and most important subdivision of physical astronomy. I hope that my short remarks may induce many astronomers in England to take up the study of cosmic meteors.

Correspondence.

The Cusps of Venus in Dichotomy.

Some time ago my friend M. Antoniadi had communicated me his theory on the atmospherical nature of the spots of Venus, which I consider as conclusive on the impossibility in which we are to pronounce ourselves on the rotation period of this planet.



Let V be the centre of Venus, VA its radius, S the direction of the Sun, and let AB represent the thickness of the planet's atmosphere, which we will consider as endowed with a great reflective power. The circle of theoretical illumination will be VA, but owing to the atmospherical transparency, it is obvious that the same circle is carried to CC', and the sun shines on the zone CBVC'. Such illumination, very intense near the theoretical