

XLIX. *Description of a Method of measuring Differences of Right Ascension and Declination, with Dollond's Micrometer, together with other new Applications of the same: By the Rev. Nevil Maskelyne, B. D. F. R. S. Astronomer Royal.*

Read Dec. 12, 1771. **T**HE divided object glass micrometer, as happily applied by the late Mr. John Dollond to the object end of a reflecting telescope, and now with equal advantage adapted by the present Mr. Dollond, his son, to the end of an achromatic telescope, is so easy of use, and affords so large a scale, that it is generally looked upon by astronomers as the most convenient and exact instrument for measuring small distances in the heavens. But, as the common wire micrometer is peculiarly adapted for measuring differences of right ascension and declination of celestial objects, and is not near so convenient or exact for measuring their absolute distances; so on the contrary the object glass micrometer is peculiarly fitted for measuring distances, and has, I believe, generally been supposed incapable of or unfit for measuring differences of right ascension and declination. Thus the two micrometers, as mutually supplying each other's defects, have been esteemed both

both equally necessary in their turn to be used by the practical Astronomer, and consequently to have a place in every well-furnished Observatory. Far be it from me to say any thing to the disparagement of either of these valuable instruments, or to envy it the place which it is so justly entitled to. Every Astronomer, who has time and inclination for making a variety of observations, would undoubtedly wish to be supplied with, and to make use of both. But, as every person desirous of making observations for his own amusement or public utility may not happen actually to be furnished with, nor chuse to be at the expence of providing himself with both, it is certainly a very desirable thing, if he could be enabled to make that use of the instrument he has, which might supply, in some measure at least, the want of the other which he has not. Therefore, as I find that the object-glass micrometer may be applied with little trouble and but small additional expence to the measuring differences of right ascension and declination, with an exactness little, if at all, inferior to what they can be obtained with the common micrometer, I propose to give here the directions necessary to be followed when it is used in this manner. I shall afterwards shew how differences of right ascension and declination between the limbs of the Sun and Venus or Mercury, and distances of the limbs both in lines parallel and perpendicular to the equator, may also be observed in the transits of these planets over the Sun. Examples of the second and third of these methods may be seen in the observations of the late transit of Venus at the North Cape, and in the South Seas, made according to these directions,

rections, which were previously communicated to the observers.

A small addition will be necessary to be made to the apparatus of the object-glass micrometer, to enable it to answer these purposes, viz. a cell, containing two wires intersecting each other at right angles, placed in the focus of the eye-glass of the telescope, and moveable round about, by the turning of a button. Let E N W S, TAB. XVI. Fig. 1. represent the field-bar of the telescope, E W and N S two wires intersecting each other at right angles at C, and moveable about the same as a center, in manner above-mentioned. Suppose it be required to measure the difference of right ascension and declination of two stars, whose difference of declination does not exceed the extent of the scale of the micrometer, and the distance of the meridians passing through the stars does not exceed C W, the semidiameter of the field of the telescope. Turn the wires E W, N S about, till one of the stars (the westernmost star will generally be best for this purpose) runs exactly along the wire E W, by the diurnal motion. Then separate the two segments of the divided object-glass to a convenient distance, and turn the micrometer round about, by means of the proper handle, till the two images of the same star, formed by the two segments of the object-glass, pass the horary wire N S at the same instant. Lastly, partly by separating the glasses, and partly by touching the rack-work screws of the stand of the telescope, cause the southernmost image of the northernmost star, and the northernmost image of the southernmost star, to appear both upon and run along the wire E W, as A, B. The numbers standing upon the scale
of

Fig. I.

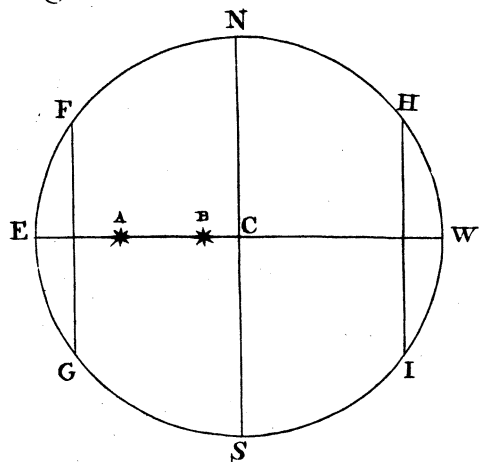


Fig. II.

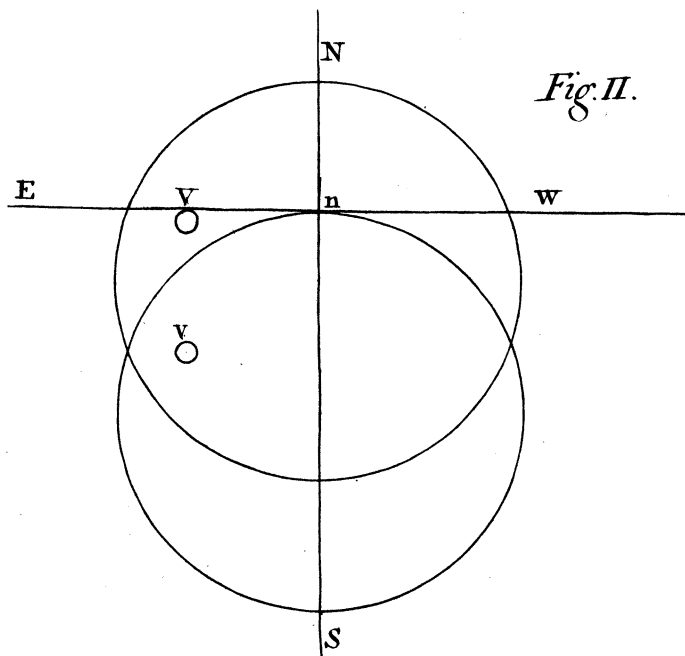


Fig. III.

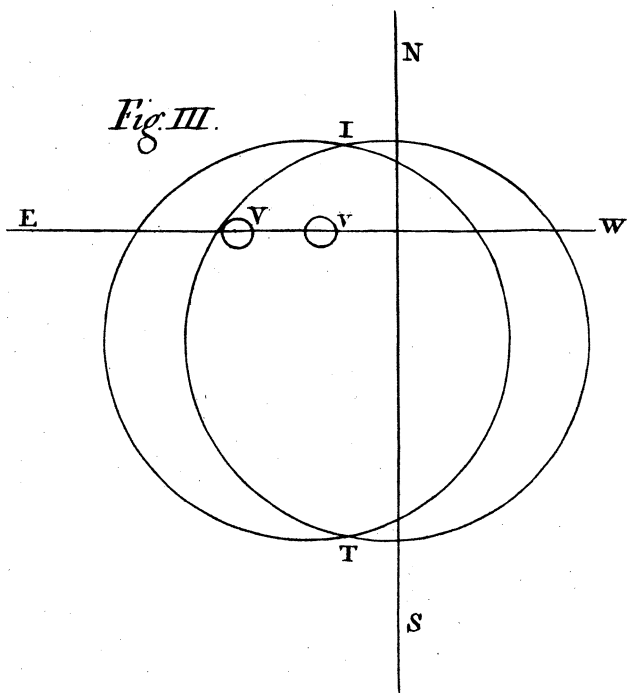
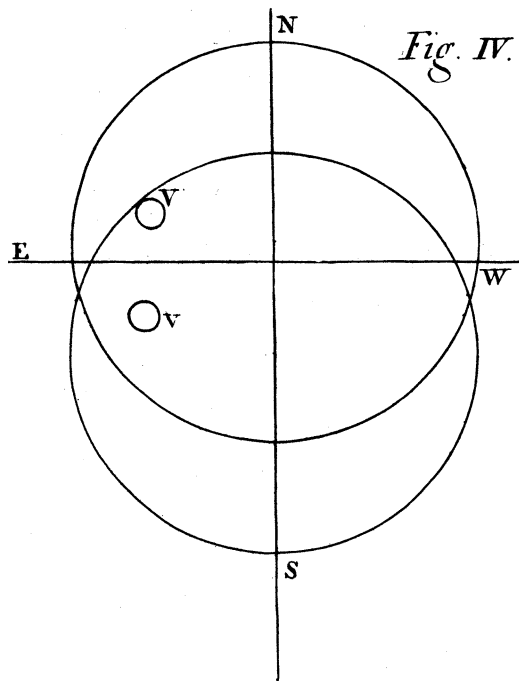


Fig. IV.



of the micrometer will shew the difference of declination of the stars ; and if the times be noted when they pass the horary wire N S the difference of the times will give the difference of their right ascension. For E W on account of the star's running along it, is parallel to the equator ; and consequently N S which is perpendicular to it, represents a meridian or horary circle. And because the two images of the same star pass the horary wire N S at the same instant, it follows that the centres of the two semicircular glasses lie in the same meridian, and consequently when A, B, the two contrary images of the two stars are brought to the same parallel of declination E W, the scale will shew the difference of their declinations. And, for the same reason, the times of the images of the two stars passing the meridian wire N S will not be affected by the separation of the glasses of the micrometer, and consequently the difference of the times will give the difference of their right ascension. It will be easily understood that in performing the operations above described, it will be necessary from time to time to turn the screws of the rack-work which move the whole telescope together. These operations will be much facilitated and rendered more exact, if the telescope be supported by and moveable on a polar axis ; for the wires and micrometer may be thereby more readily brought into the requisite positions, and the turning of the telescope about in order to follow the diurnal motion will not disturb those positions ; which will afford this farther advantage to the observer, of being able to repeat the observations without loss of time.

If two additional horary wires F G, H I parallel to N S be placed near E and W the two extremi-

ties of the wire, E W the adjustment of the wires and micrometer may be more readily performed, and the observation may be made on two stars, although their meridian distance from one another should be almost equal to E W the diameter of the field of the telescope. It is evident, that if two stars be thus observed whose difference of declination is well settled, the value of the scale of the micrometer may be thereby determined.

In the foregoing directions it has been supposed that the images of the two stars can be brought to appear within the field of the telescope on the wire E W at the same time ; but this is not absolutely necessary. For if the micrometer be set to the difference of declination nearly, and then the star which passes first through the telescope be made to run along the wire E W by touching one of the handles of the rack-work of the telescope, and afterwards the other star, when it comes into the telescope, be brought to the wire E W by altering the opening of the glasses of the micrometer, the difference of the declination will be had, by taking half the sum of the numbers shewn by the micrometer, at the two separate observations of the two stars on the wire E W. This will be true, in case it can be depended upon that the two semicircular glasses recede equally in contrary directions ; which may indeed be doubted, the work on which the motion of the glasses depends not being designed for such a purpose, and therefore probably not made sufficiently accurate for it.

The manner in which Mr. Dollond has contrived the motion of the glasses in his new improvement of the object-glass micrometer intirely obviates this difficulty,

difficulty, and the difference of right ascension and declination of any two stars or other points in the heavens may be thereby accurately measured, let the difference of right ascension be what it will, provided the difference of declination does not exceed the extent of the scale of the micrometer; and thus the object-glass micrometer is put pretty much on a footing with the common micrometer, even with respect to the measuring right ascensions and declinations.

The difference of right ascension and declination between Venus or Mercury and the Sun's limb, in their transits over the Sun, are to be observed nearly in the same manner as the difference of right ascension and declination of two stars. But the process will perhaps be rendered clearer by the following description.

1. Turn the moveable wires E W, N S, into such a position that the Sun's North limb *n* (see fig. II.) or the planets North limb V may run along the wire E W, which thereby becomes a tangent to the peripheries of their discs.

2. The semicircular glasses being separated to a convenient distance, turn the micrometer about, till the two images of the planet V, *v*, pass over the horary wire N S at the same instant.

3. Separate the glasses of the micrometer to that distance, that the North limb V of the Northernmost image of the planet may touch the wire E W at the same time that the Northernmost limb *n* of the Southernmost image of the Sun touches the same wire; and the scale of the micrometer will shew the difference of declination of the Northern limbs of the

the Sun and planet. In like manner, if the glasses of the micrometer be opened to a greater or less distance (according as the planet is nearer the North or South limb of the Sun) every thing else remaining unmoved, the difference of declination of the Southern limbs of the Sun and planet may be observed, by bringing the Southernmost limb of the Southernmost image of the planet to run along the wire EW, at the same time that the Southernmost limb of the Northernmost image of the Sun runs along the same. Half the difference of these two measures (if taken immediately after one another) is equal to the difference of the declination of the centers of the Sun and planet at the intermediate time, without any regard to the quantities of the diameters of the Sun or planet, or the error of adjustment of the micrometer.

The difference of the transits of the Eastern or Western limbs of the Sun and planet will give the difference of right ascension, as in the common micrometer.

Instead of differences of right ascension, distances of the planet from the Sun's limb in lines parallel to the equator may be more accurately observed as follows.

The glasses being separated to a convenient distance, turn both the wires and micrometer about, so that the two images of the planet may both run along the wire EW (see Fig. III.) and separate the glasses, so that V one of the images of the planet may touch the limb of the Sun to the East or West, or rather both alternately. Or perhaps the following method may be preferable : separate the two images of the Sun to any convenient distance, so as to produce a considerable angle of intersection of the circumferences at I and T;

Turn the wires about, so that the planet's centre, North, or South limb, may run along the wire EW; Then turn the micrometer about till the two intersections IT pass the horary wire NS at the same instant, and the micrometer will be in a proper position for measuring distances in a line parallel to the equator; and the distance of the planet from the Sun's limb in a line parallel to the equator will be obtained by only bringing the glasses nearer together, or separating them farther, till the planet's limb is in contact with the Sun's limb. If distances of the planet's near limb from the Sun's limb be thus taken to the East and West alternately, and reduced to a given time, by allowing for the motion of the planet by calculation, half the difference of the two reduced measures will be the distance of the planet's centre from the middle of the chord of the Sun's disc passing through the planet's centre parallel to the equator at the given time, without any regard to the quantities of the diameters of the Sun or planet, or the error of the adjustment of the micrometer. It may be proper to remark, that when the planet is brought to touch the Sun's limb, the point of contact will be North or South of the planet's centre according as the planet itself is North or South of the Sun's centre.

In like manner, distances of Venus or Mercury from the Sun's limb may be measured in lines perpendicular to the equator, see Fig. IV. (the micrometer being brought into the proper position, in the very same manner as for measuring the difference of declination from the Sun's north or south limb, before described); and if the planet be brought into contact with

with the Sun's limb to the north and south alternately, half the difference of the two measures, reduced to a given time by allowing for the motion of the planet by calculation, will be the difference of declination of the centers of the Sun and planet at that time, without any regard to the diameters of the Sun or planet, or the error of adjustment of the micrometer. And this would be a better observation than measuring the difference of declination of the limbs of the Sun and planet by bringing them both in contact with the same wire parallel to the equator described above; as the measuring distances from the Sun's east or west limb in lines parallel to the equator is a better observation than measuring differences of right ascension of the limbs by time.

By these two observations of distances of an inferior planet from the Sun's limb in lines parallel and perpendicular to the equator, its true place with respect to the Sun's center may be accurately ascertained during any part of its transit over the Sun's disk; and consequently its nearest approach to the Sun's center and the time of the ecliptic conjunction may be deduced with great exactness, although the middle of the transit should not be seen, and the Sun should be visible only for a small space of time sufficient for taking these observations.

The following order of making the several observations with Dollond's micrometer in the late transit of Venus was recommended to the observers who went on the part of the Royal Society to the North Cape and to the South Sea, which may serve to elucidate their observations. See Phil. Trans. Vol. LIX. p. 266, 267. and this Vol. LXI. p. 397, 418
Instructions

Instructions to the like effect were also given to the other observers, sent by the Royal Society to Hudson's Bay and the North of Ireland, on the same occasion. See Phil. Transf. Vol. LIX. p. 480—482. and Vol. LX. p. 488.

- “ 1st, Immediately after the first internal contact,
 - “ you are to observe several diameters of Venus
 - “ (suppose 12) with 0 of the vernier placed alternately to the right and left hand of the beginning of the divisions of the scale.
 - “ 2dly, You are to observe several differences of declination of the northern limbs of the Sun and Venus, and the southern limbs of the Sun and Venus alternately.
 - “ 3dly, If there be considerable time left before the middle of the transit, you are to observe distances of Venus from the Sun's limb to the east and west alternately, in lines parallel to the equator.
 - “ 4thly, If there still remain considerable time before the middle of the transit, you are to observe several times the horizontal diameter of the Sun.
 - “ 5thly, You are to begin at least half an hour (an hour would be better) before the middle of the transit, to measure the nearest distance of Venus from the Sun's limb, and the farthest distance of Venus from the Sun's limb, alternately.
 - “ N. B. The same position of the micrometer will serve for both, without turning it about. These observations are to be continued till the very middle of the transit,
- Vol. LXI. 4 A “ when

- “ when the distance will continue the same
- “ for a little space of time ; but it will be
- “ better to continue them for some time
- “ longer.
- “ 6thly, The same observations which were taken
- “ before the middle of the transit, or such as could
- “ not, through some impediment, be observed
- “ before, may be proper to be observed after the
- “ middle of the transit.
- “ 7thly, It will be adviseable to practise observations
- “ similar to those here recommended, previous to
- “ the transit of Venus, by means of spots in the
- “ Sun.”