Rev. W. R. Dawes, on the Measurement of Position-Angles

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<tr>
<td>Jan. 4</td>
<td>9h 31m 55s</td>
<td>23 42 30'30'</td>
<td>+ 39 41 9'1</td>
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<tr>
<td>Jan. 7</td>
<td>7h 21m 14'9</td>
<td>23 55 45'43'</td>
<td>+ 37 3 33'2</td>
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<tr>
<td>Jan. 8</td>
<td>7h 18m 23'6</td>
<td>0 0 16'58'</td>
<td>+ 3 6 47'0</td>
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Observatory of Harvard College, Cambridge, U.S.
Jan. 11th, 1858.

Previous to the arrival of the intelligence of Mr. Tuttle's discovery in Europe, the comet was discovered by Dr. Bruhns at Berlin on the 11th of January.

The following approximate position was obtained:—

9h 2cm M.T. Berlin.
R.A. 6h 53m N.P.D. 64° 40'


The usual method of measuring the position-angle of a double-star with a double-image micrometer, is by bringing the four stars composing the two images into a line, the components being placed at equal distances, whereby the double distance and the reading for position are obtained at the same time. The angle may thus be measured with considerable accuracy, provided the images are round and well defined, as in the double-image crystal micrometer, where the separation of the images is produced by the principle of double refraction in the crystal. Yet even in this, I believe that a more certain mode may be employed. But where the duplicity of the image is produced by the division of a lens, and, consequently, each of the images is formed by only one-half of the object-glass, the distortion of the image is so great (increased in bright stars by the coloured fringes in opposite directions) that, lying as it does at right angles to the direction of separation, a really accurate measure of the position-angle is impossible; and nearly all that can be hoped for is to place the images with sufficient correctness for measuring the double distance. This forms so serious a drawback to the use of such an instrument in double-star observations, that a statement of a method of observation by which the difficulty may be completely removed, and which I have satisfactorily employed for more than two years, will not, I trust, be unacceptable to the Society.

My plan is this: Two very fine wires, or very stout spider's webs, are placed parallel to each other, with their interior edges at a convenient distance apart (about eight or ten seconds) in the focus of the eye-glass or positive eye-piece. These are intended for the measurement of position-angles, by placing the stars...
of Double-Stars with Divided-glass Double-image Micrometer. 59

between them. They are either fixed by the maker at right angles to the direction in which the images are separated by the micrometer; or the eye-piece is so arranged that they may be brought into that position by the observer. Their direction is then parallel to that of the elongation of the images by diffraction.

In the application of these parallel wires to the measurement of position, the image is to be made single, by placing the index of distance at the zero-point, which may be known precisely if the distance has been first measured. This single image is then placed between the parallel wires for the measurement of the position-angle; the zero of position being obtained by causing the star to run along one of the wires.

If the star is bright, even the single image will not be free from appendages which would be annoying, and seriously detrimental to the accuracy of the observation, were the wires in any other relative position than that above described. But when they are so placed, the bright ray which crosses the image of a bright star is precisely parallel to the wires; and when, by turning the position-circle, their direction is brought to coincide with the position of the double star, the ray is not only parallel to the wires, but also passes through the centres of the two stars, and therefore in no degree prejudices the judgment of the eye in the measurement of the position. From numerous measures thus obtained, my conclusion is, that the results are equal in accuracy to those with the ordinary parallel-wire micrometer.

As it is of some importance that the double webs or wires should be pretty exactly at right angles to the direction of the separation of the images, it may not be superfluous to mention a process by which this may be readily accomplished by the observer. The parallel wires should be attached to a diaphragm turning along with the eye-lens in a four-glass eye-piece, or with the double eye-piece in the Amican form, and also fixable in the required position by a tightening screw or clamp. The rule will then be: Separate to a considerable distance the two images of any star of suitable magnitude (which may conveniently be pretty near the equator), and turn the wires in the eye-piece till the two images of the star are threaded upon one of them. Then turn the whole micrometer on the position-circle till the images run along the wire by the diurnal motion. Note the reading of the position circle, and then alter it 90° either way; also bring the two images into one. Turn the wires in the eye-piece, without altering the reading of the position-circle, till the single image is again carried along one of the wires by the diurnal motion; and the direction of the wires will then be at right angles to the direction of the separation of the images. The wires being clamped in that position will remain ready for use in this mode of observing.

In the directions above given, it is assumed that the two images pass each other centrally. If they do not, they should be made to do so by a slight alteration of the focal adjustment. The correctness of the adjustment for this purpose may be judged of
by noting whether both images of a single star continue to be threaded on one of the wires, while one image is carried across the other; the separation on either side being considerable for greater accuracy. This adjustment should be attended to before entering on the process above described for placing the wires perpendicular to the direction of separation.

If, however, the observer would rather have round images to deal with, they may be obtained by a very simple process. A piece of card-board is to be prepared, in which have been cut two circular apertures, the diameter of each being equal to the radius of the object-glass. They consequently touch in the centre. Place this before the object-glass. Then, the imaginary line joining their centres being placed nearly at right angles to the approximately known position of a double star, the images will be perfectly round when brought into a line for the measurement of the double distance. The position-angle may therefore be observed at the same time by thus placing the stars, or by bringing them between the parallel wires, which should be fixed, for this mode of observing, in the direction of the separation. A comparison of the results obtained by these two very different modes of measuring the position-angle is not without interest. Having for many years practised both methods with the double-refracting crystal micrometer, in which the images are free from distortion, I have come to the conclusion that the most correct results are obtained by the parallel wires; and my observations with the Amician double-image micrometer, in the mode last described, look the same way. This is especially the case where the components of a double star are very unequal in magnitude.

It is obvious that the use of the two circular apertures diminishes the light from each section of the object-glass by one-half. If, however, the object-glass is of considerable size, the objection will not apply to the brighter double stars, and it is in these especially that the distortion and colour are annoying and productive of uncertainty. Where the object is too faint to permit this sacrifice of light, the first method proposed will be more advantageously applicable than the second.

An effect very similar to that produced by the two circular apertures, attends the use of an elliptic aperture, the major axis being equal to the diameter, and the minor axis to the radius, of the object-glass. The major axis being placed perpendicular to the direction of separation, the disks in each image will be sensibly round. In this case also the area in use is equal to half the area of the object-glass; and I am not aware that it possesses any advantage over the two circular apertures.

As a specimen of the results which may be procured by thus using the divided-glass double-image micrometer, I here subjoin the observations of $\gamma$ Virginis, which I obtained with it during the last apparition, and also the results separately of each mode of varying the aperture; and, for comparison, add also those procured with the parallel-wire micrometer.
of Double-Stars with Divided-glass Double-image Micrometer. 61

Measurements of γ Virginis with the Amici double-image micrometer.

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<tbody>
<tr>
<td>1857'297</td>
<td>170'77</td>
<td>10</td>
<td>48</td>
<td>3'646</td>
<td>10</td>
<td>48</td>
<td>431</td>
<td>0'9</td>
</tr>
<tr>
<td>'338</td>
<td>170'48</td>
<td>5</td>
<td>27</td>
<td>3'560</td>
<td>10</td>
<td>42</td>
<td>431</td>
<td>0'6</td>
</tr>
<tr>
<td>'349</td>
<td>170'32</td>
<td>5</td>
<td>28</td>
<td>3'596</td>
<td>10</td>
<td>51</td>
<td>431</td>
<td>0'6</td>
</tr>
<tr>
<td>'351</td>
<td>169'36</td>
<td>5</td>
<td>32</td>
<td>3'601</td>
<td>10</td>
<td>61</td>
<td>252</td>
<td>0'4</td>
</tr>
<tr>
<td>'365</td>
<td>170'04</td>
<td>5</td>
<td>26</td>
<td>3'560</td>
<td>10</td>
<td>41</td>
<td>252</td>
<td>0'4</td>
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<tr>
<td>'371</td>
<td>169'98</td>
<td>5</td>
<td>40</td>
<td>3'549</td>
<td>10</td>
<td>44</td>
<td>252</td>
<td>0'5</td>
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<tr>
<td>'373</td>
<td>169'80</td>
<td>10</td>
<td>76</td>
<td>3'575</td>
<td>10</td>
<td>55</td>
<td>252</td>
<td>0'9</td>
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Remarks.

1857'297. Whole aperture. Air tolerably good.
'349. " Air bad.

The mean result of the whole is,

1857'35; P = 170°.08; obs. 45; wt. 277 on 7 nights:
D = 3".586; obs. 70; wt. 342; on 7 nights.

The mean result of the observations in which the whole aperture was employed, is—

1857'32; P = 170°.57; obs. 20; wt. 103; on 3 nights:
D = 3".600; obs. 30; wt. 141; on 3 nights.

With the double circular aperture, the mean result is—

1857'37; P = 169°.78; obs. 20; wt. 148; on 3 nights:
D = 3".583; obs. 20; wt. 105; on 2 nights.

With the elliptic aperture, the result is—

1857'36; P = 170°.04; obs. 5; wt. 26; on 1 night:
D = 3".569; obs. 20; wt. 96; on 2 nights.

This analysis of the results seems to show that the different kinds of aperture employed are not likely to introduce any perceptible difference in the measurement of either the angle of position or the distance.
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The following results, procured with the parallel-wire micrometer, furnish an interesting comparison:

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<tbody>
<tr>
<td>1837'288</td>
<td>170°08</td>
<td>10</td>
<td>34</td>
<td>3°543</td>
<td>6</td>
<td>15</td>
<td>411</td>
<td>1°58</td>
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<tr>
<td>'294</td>
<td>169°85</td>
<td>10</td>
<td>40</td>
<td>3°613</td>
<td>6</td>
<td>18</td>
<td>411</td>
<td>0°85</td>
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<td>169°99</td>
<td>10</td>
<td>85</td>
<td>3°591</td>
<td>10</td>
<td>84</td>
<td>411</td>
<td>0°84</td>
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<tr>
<td>'445</td>
<td>169°91</td>
<td>10</td>
<td>69</td>
<td>3°581</td>
<td>10</td>
<td>45</td>
<td>411</td>
<td>0°35</td>
</tr>
<tr>
<td>'472</td>
<td>169°76</td>
<td>10</td>
<td>89</td>
<td>3°533</td>
<td>10</td>
<td>93</td>
<td>411</td>
<td>0°63</td>
</tr>
<tr>
<td>'477</td>
<td>170°04</td>
<td>10</td>
<td>77</td>
<td>3°541</td>
<td>10</td>
<td>72</td>
<td>526</td>
<td>0°52</td>
</tr>
<tr>
<td>Mean = 1857'42</td>
<td>169°93</td>
<td>60</td>
<td>394</td>
<td>3°561</td>
<td>52</td>
<td>327</td>
<td>On 6 nights.</td>
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Remarks.


'294. Ditto.

'401. Air very fine.


'472. Air very fine.

'477. Air pretty good.

From a comparison of the numbers in the last columns of the two series of observations, it appears that the extreme differences among the angles measured on each night with the double-image micrometer, are not greater than those which occurred with the parallel-wire micrometer. But the extreme difference among the mean results with the double-image amounts to 1°41; while with the parallel-wire it is only 0°32: which may, perhaps, arise principally from the fact, that the sets taken with the latter consisted uniformly of ten observations, but with the former of only five on five nights out of the seven; and also that the state of the atmosphere was usually much more favourable on the nights when the parallel-wire micrometer was employed.

It is obvious that the same effect which is produced by a double circular, or figure-of-eight, aperture placed in front of the object-glass, may be secured by prefixing a diaphragm before the micrometer, and attached to it, so that it may turn with it in position. If a diaphragm so placed has two circular apertures whose circumferences touch each other in a point coinciding with the line of collimation of the telescope, and the diameter of each aperture is exactly equal to the semi-diameter of the cone of rays at the distance of the diaphragm from the focal point of the object-glass, the same quantity of light will reach the eye, and the images will be round and neat. This plan has the advantage that the line joining the centres of the two apertures, when once set perpendicular to the line of separation of the images, preserves that position by turning with the micrometer; while the apertures placed in front of the object-glass would require to be altered to a
of Double-Stars with Divided-glass Double-image Micrometer. 63

position perpendicular to that of each double star observed, before
the observations are begun. But, on the other hand, the diameter
of the apertures in the small diaphragm prefixed to the micro-
meter ought to be very accurately proportioned, and the object
must be kept very exactly in the centre of the field; otherwise, a
portion of the light from the object-glass will be lost, and the
images will not be perfectly round. Moreover, if the wires in the
field are employed for measuring the angle of position, it will be
found difficult pleasantly to illuminate them by the ordinary mode
of reflection from a diagonal plate in the telescope.

It would not be difficult to arrange a revolving aperture-plate
within a brass dew-cap, the edge of the plate being toothed, and a
pinion working in it; and a long light handle extending down the
telescope tube would enable the observer to turn it at pleasure.
The eyepiece being removed, the position of the apertures in the
plate can be seen from the eye-end.

As it is often essential, in the measurement of delicate double
stars (especially of close and very unequal ones, such as ζ Herculis
and δ Cygni) to have a very accurate adjustment of the focus, I
prefer securing this advantage, even though in so doing the
central passing of the images should be somewhat disturbed.
When this is the case, however, the readings of the position circle
should be noted at which the two images are brought into a line
on each side of the zero of distance, and the observed double dis-
tance must be multiplied by the secant of half the difference of the
two readings.

As the double-image micrometer contrived by Professor Amici
is not, I believe, much known in this country, it may be well to
state, that in it the rays from the object-glass are received by the
divided concave glass of the micrometer before they meet at the
focal point.

Haddenham, Thame, September, 1857.

At the close of the reading of Mr. Dawes’ paper, Mr. Main, at
the request of the President, made a few remarks on the use of the
double-image micrometer, and a conversation on the same subject
afterwards ensued, in which Mr. De La Rue and Mr. Carrington
took part.

New Planet.

A communication has been received from the Imperial Observ-
atory, Paris, containing the announcement of the discovery of a
new minor planet (the 51st of the group) on the 22d of January, by
M. Laurent, at the Observatory of Nismes.

On the 22d of January, at 14 hours, it had the same right
ascension as the star 22646 of Lalande, and was estimated to be
15’ further south, whence it would have a right ascension of