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COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

On the reliability of interferometer and photographic measures of double stars,

by *W. H. van den Bos.*

The measurement of close double stars has long been the domain of the micrometer observer, but recently the interferometer and the photographic method have come to the front from opposite sides of the field. The micrometer observer, in dealing with the results from these rival methods, though keenly appreciating their special advantages, should be on his guard against unforeseen errors, which are always likely to be introduced by new methods.

The interferometer is more powerful in separating close pairs than the visual observer, but cannot deal equally successfully with fainter objects and larger differences in the magnitudes, though MAGGINI's lists contain some examples of rather faint stars as well as differences of as much as $3\frac{1}{2}$ magnitudes.

The photographic method, if properly handled, attains a degree of accuracy and freedom of systematic errors in the measures of wider pairs which cannot be approached by the visual observer.

Against this, the orbit computer in using the results of the interferometer is likely to be misled by an internal agreement which is not a safe measure of the reliability of the mean result. The interferometer seems to be in danger of recording spurious elongations just as much as the micrometer observer. Two examples from MAGGINI's observations will prove this. The star 15 Eridani, *Bu GC* 1659 ($3^h13^m - 23°$) was measured on two nights, the mean of the closely accordant measures being 180°.7, 0".43. This result is probably an atmospheric effect, as the actual position is 240°, 0".2. The star 54 Eridani, *Bu GC* 2314 ($4^h35^m - 20°$) was measured on five nights, 161°.6, 0".39. It had been discovered by STONE with an 11-inch and measured by DEMBOWSKI with a 7-inch, but has always been found single by BURNHAM and the writer using telescopes in which it should have been an easy pair. In using these results some caution seems advisable.

The possibilities of the photographic method, as well as the precautions to be observed in using it, have been most fully discussed by HERTZSPRUNG (*Potsdam Publicationen*, 75). The rotating sector, or for closer pairs the use of suitable objective gratings, will keep the magnitude equation within reasonably small limits. The combination of a visual refractor and yellow filter will minimize the effect of different colours of the components; if a photographic refractor is used pairs with equal colours should be observed or the programme be restricted to objects near the zenith. A far more troublesome source of errors appears in the measures of close pairs and is due to photographic effects. Exhaustion of the developer may give a large distance, whereas the addition of scattered light from both components in the region between the two may cause a small distance. The latter effect is much more frequent in close pairs, unless the images have been overexposed.

Using a visual refractor of 50 cm aperture and $12\frac{1}{2}$ m focal length, HERTZSPRUNG found distinct traces of these effects at distances slightly exceeding 2". However, if the exposures are well timed and close pairs observed under good atmospheric conditions only, the observer may safely go below this distance. Blended or blurred images should be excluded from the measurement, as they will never give reliable results.

The writer, using a 33 cm photographic refractor of $5\frac{1}{4}$ m focal length, found these effects at distances under 4" (*B. A. N.* 34). This is in good agreement with HERTZSPRUNG's result, as this limit of reliable measurement (which of course has to be increased for unequal pairs) will depend primarily on the focal length, though influenced by the brand of plate, method of development, use of a visual or a photographic telescope, etc. Obviously this limit of reliability does not mean that measures of closer pairs must necessarily be erroneous. *) This seems to have been the impression of Dr. OLIVIER, who questions the above results in

*) In later work the writer restricted his programme to distances exceeding 4", believing that the observation of closer objects could better be left to longer telescopes or the visual observer.

a recent publication (*Leander McCormick*, Vol. IV), pointing out that his results for the double stars *Bu GC* 5407, 8750, 13477 and 13646, all of which are under 2″, are in good agreement with visual observations. He fully expects to obtain measures of nearly equal pairs under good conditions down to 1″.4 free from any but accidental errors.

Whilst, of course, there would only be reason to rejoice if Dr. OLIVIER's hopes were fulfilled, still it appears desirable to urge special caution in dealing with pairs under 2″, or in special circumstances even for much wider pairs. As an example of the latter case we may take *Bu GC* 11779, for which OLIVIER compares his result with HERTZSPRUNG's. From 61 exposures on two plates HERTZSPRUNG derives a distance of 4″.623 (m. e. ± ″.009), whereas OLIVIER from 7 exposures on three parallax plates finds 5″.00. He remarks: „If the components are fixed, the Potsdam measures are correct; if there is motion, those made here. Despite BURNHAM's note (fixed), the three measures published in his *G. C.* do indicate increasing distance (1869, 4″.50, 5n, Dem; 1894, 4″.71, 2n, Glp; 1902, 4″.78, 2n, Hu), which the measures here tend to confirm." Now it would indeed be surprising, if HERTZSPRUNG's result based on 61 well timed exposures were wrong, and OLIVIER's 7 overexposed (his note: blended) correct *). But obviously OLIVIER overlooked the fact that BURNHAM's note is based also on the measures in *G. C.* I (1832, 4″.69, 3n, Σ), and if we refer to the more complete list in LEWIS' *Struve stars*, no trace of an increase in the distance remains. My conclusion would be that HERTZSPRUNG is correct, and that the same effect which, using the ordinary developers, causes the border of a square of constant intensity to look darker on the photographic negative than the centre (EBERHARD, *Potsdam Publ.* nr. 84, p. 53), has increased the separation of the spots of maximum density in the blended image. Hence I maintain the above statement, that measurement of overexposed images of close pairs, even if separated, and a fortiori of blended images, may lead to erroneous results. The effect being purely a developement effect is most systematic, and an excellent internal agreement may give a bad mean value (*B. A. N.* 34, p. 195: *G. C.* 4122; the distance is at least 0″.20 too large, its mean error from internal agreement is about ± 0″.03).

As to the opposite case, where the photographic distance is too small, there is sufficient evidence of it in Dr. OLIVIER's measures. The number of exposures measured by him for any individual pair is far too small to permit an internal discussion similar to that made by HERTZSPRUNG, the accidental errors not being sufficiently reduced. Therefore I have taken from his list those pairs for which the distance did not exceed 5″, the difference of magnitude not exceeding $1^m.0$, and compaired his results with visual observations, *Bu. G. C.* being supplemented by recent measures at the Greenwich, Lick, Dearborn, Flower, Minnesota and Leiden observatories. Whereas for pairs above 2″ there are no discordances of a serious or systematic character, at least for the well timed special double star plates, the following pairs under 2″ show the effect well enough.

Bu. G.C. 8750. Visual measures 1877—1913 by 5 observers on 10 nights show no change in distance, range 1″.69—2″.03, mean value 1″.82. OLIVIER has 1″.46.

11525. Visual measures 1897—1926 by 5 observers on 15 nights show no change in distance, range 1″.66—1″.81, mean value 1″.72. OLIVIER has 1″.06. If an error of this amount already occurs at 1″.7, the limit of 2″ cannot be much too conservative.

The other cases cited by OLIVIER, *Bu GC* 5407, 13477 and 13646, agree well with the visual measures known to me, but the range in the angles for the last two (10° and 15° respectively, corresponding to ″.27 and ″.45) seems too large to call these measures reliable; at least the micrometer observer will never find such a range in his single settings on pairs of this class.

The same volume contains a list of photographic measures of so called proper motion-pairs by Dr. VYSSOTSKY, and inspection of his results may well discourage the micrometer observer who spends (or in my opinion wastes) his time in making observations of these objects and tends to confirm my conclusion in *B. A. N.* 26, that this work may better be left to the photographic observer.

*) In the case of *Bu GC* 2821 the Potsdam distance 3″.345 is obviously a misprint for 4″.345, as may be seen from the rectangular coordinates on p. 39. The measure of *Bu GC* 2726 given in Olivier's list, 4″.39, is probably a misprint for 3″.39.