

On the accuracy of measures made by the principal double-star observers.

By *W. Doberck.*

The following results have been obtained from a discussion of differences between observations and positions calculated from the orbits of thirty double stars lately determined by the writer, and are therefore to some extent vitiated by possible defects in the elements of these orbits. On the other hand it may not always be feasible to represent the present observations as closely in future, when a larger number of observations have to be also represented.

If the companion in a binary system should happen to be itself a very close double star, the attraction of the main star must cause the components of the companion to recede from each other at the time of peri-astron passage, if the orbit is, as usual, very excentric, and may thereby cause noticeable perturbations near the peri-astron. Such is probably the fact in case of α Centauri, but not in case of γ Virginis. The more or less regular waves noticed in the observed positions of many binaries are ascribed by Burnham to chance, and I believe this explanation to be generally sufficient. I should for instance attribute the undulations in case of λ Ophiuchi and ζ Aquarii to chance until it is found that the waves either continue regularly for a long time, uninfluenced by improvements in apparatus, or that they increase upon the approach of the components of the binary star.

By a certain observer's »constant error of distance« is meant the mean of the errors of the distances between the two components of a certain double star measured by that observer. This »constant error« is different in case of different objects measured by the same observer. By »accidental errors« are meant the errors left after correction for »constant error«, this correction being different in case of different objects.

The data used in the present investigation are not sufficient for examining the effects of differences of colour (spectrum). This effect must be considerable and I expect to be able to investigate it on the basis of different data.

Aitken. Angle P.E. $\pm 0''.019$ at $0''.6$, and $\pm 0''.023$ at $1''.5$ if components equal, and $0''.015$ larger if difference 5 magnitudes. No tendency to observe distances systematically wrong. Average constant error without regard to sign $\pm 0''.042$. After correction of constant error P.E. of distance $\pm 0''.032$ if components equal, and $\pm 0''.074$ if difference 5 magnitudes.

Barnard. Data insufficient. Probably similar to Aitken.

Bigourdan. Angle P.E. $\pm 0''.019$ within $1''$, and $\pm 0''.025$ at $1''.5$, if components equal. Within $1''$ but differing 3 magnitudes $\pm 0''.030$. Distances on an average $0''.066$

too large. It appears that very bright pairs are measured correctly. When the average magnitude is 5 the distance is $0''.05$ too great, and when the magnitude is $6\frac{1}{2}$ it is $0''.08$ too great. After correction for constant error P.E. of distance $\pm 0''.073$.

Bowyer. Angle P.E. $\pm 0''.025$. Distances $0''.075$ too small. P.E. of distance $\pm 0''.041$ at $1''$. It increases with the distance.

Bryant. Angle P.E. $\pm 0''.030$. Distances $0''.036$ too small. P.E. $\pm 0''.078$.

Burnham. Angle P.E. $\pm 0''.018$ if distance below $1''$ and components equal. If they differ 4 magnitudes $\pm 0''.030$. If distance above $1''$ and components equal $\pm 0''.025$. No tendency to observe distances systematically wrong. Average constant error without regard to sign $\pm 0''.067$. P.E. $\pm 0''.042$ if distance below $1''$, and $\pm 0''.059$ above $1''$. If magnitudes differ by 3 it rises to $\pm 0''.067$.

Collins. Angle P.E. $\pm 0''.051$. Distances $0''.088$ too great. P.E. $\pm 0''.067$.

Comstock. Angle P.E. for equal components $\pm 0''.015$ at $0''.6$, $\pm 0''.029$ at $1''.2$, and $\pm 0''.055$ at $4''$. When the components differ 4 magnitudes it is $\pm 0''.050$ at $0''.6$. The distances are on an average $0''.082$ too small. P.E. $\pm 0''.024$ below $1''$, and $\pm 0''.060$ above $1''$. If magnitudes differ by 4 the latter rises to $\pm 0''.069$.

Dawes. Angle P.E. $\pm 0''.026$ below $1''$, and $\pm 0''.043$ at $5''.5$, when components equal. When they differ by 3 they are only $0''.010$ larger, as Dawes used a prism before the eyepiece. The distances are $0''.055$ too large. Distances are as a rule measured too large in very small telescopes. P.E. $\pm 0''.046$ at $0''.7$, $\pm 0''.068$ at $1''.3$, and $\pm 0''.088$ at $5''.5$. I find no effect from difference of magnitude.

Dembowski. Angle P.E. $\pm 0''.019$ if within $1''.5$, and $\pm 0''.037$ at $4''.6$ for equal components. When they differ by 3 the P.E. is increased by $0''.010$. The distances are measured perhaps more often too small than too large, the average constant error being $\pm 0''.040$. P.E. $\pm 0''.055$ below $1''$, and $\pm 0''.073$ above $1''$. Differences in the magnitudes of the components appear to have no influence on the accidental errors. Dembowski had the use of instruments of successively better quality. His later results are therefore somewhat superior to former results. He observed distances larger in the beginning than later. The average of all the time is given here.

Doberck. Angle P.E. $\pm 0''.034$ at $0''.7$, $\pm 0''.039$ at $1''.5$, and $\pm 0''.062$ at $4''.5$. The distances are $0''.031$ too

large on an average. The mean of the constant errors without regard to sign is ± 0.049 . P.E. of distance ± 0.056 at 0.7 , ± 0.085 at 1.5 , and ± 0.112 at 4.5 . This rapid increase in the P.E., when the distance increases, is due to the inferiority of the clockworks I used at Markree and at Hongkong. The average of all the measures is discussed here. The P.E. at Hongkong was three times as great as at Columbus, O., or at Copenhagen (Comp. A. N. 3798). Differences in the magnitudes of the components appear to have no effect on either the angle or distance.

Doolittle. Angle P.E. ± 0.022 at 0.8 when components are equal. Distances about 0.061 too large. P.E. ± 0.085 .

Dunér. Angle P.E. ± 0.032 at all distances if components equal. If they differ by 3 the P.E. is 0.010 larger. Distances on an average 0.163 too small. P.E. ± 0.068 at 0.6 , ± 0.058 at 1 , and ± 0.050 at 4.5 . Difference of magnitude has no effect.

Encke. Angle P.E. ± 0.090 . Distances 0.310 too great. P.E. ± 0.172 .

Engelmann. Angle P.E. ± 0.040 at 0.6 , and ± 0.064 at 4 when components equal. When they differ by 3 the P.E. is 0.010 larger. Distances on an average 0.065 too large. P.E. ± 0.045 at 0.6 , and ± 0.090 above 1 .

Fletcher. Angle P.E. ± 0.043 . Average constant error of distance ± 0.121 . P.E. ± 0.052 .

Glasenapp. Angle P.E. ± 0.058 . Average constant error of distance ± 0.286 . P.E. ± 0.194 .

Gledhill. Angle P.E. ± 0.025 at 0.7 , ± 0.033 at 1.5 , and ± 0.049 at 4.5 when components equal. When they differ by 3 the P.E. is nearly 0.010 larger. The distances are not systematically wrong. The average constant error is ± 0.063 . P.E. ± 0.055 at 0.7 , and ± 0.121 above 1 .

Asaph Hall. Angle P.E. ± 0.019 at 0.6 , ± 0.022 at 1.5 , and ± 0.054 at 4 , when the components are equal. When they differ by 4 the P.E. is 0.025 larger. The average constant error of distance is ± 0.047 . P.E. ± 0.040 at 0.6 , and ± 0.051 above 1 . Difference of magnitude seems to have no effect.

Sir John Herschel. Angle P.E. ± 0.056 at 1 , ± 0.074 at 4 , and ± 0.143 at 17 . The distances are on an average 0.142 too great. P.E. ± 0.240 .

Sir William Herschel. Angle P.E. ± 0.055 at 1.5 , and ± 0.270 at 4.5 . I am at present investigating the distances observed by Sir William Herschel with the view of making them available. Sir John Herschel investigated the angles measured by his father, but had not at his disposal the data necessary for dealing with the distances, and he therefore rejected them.

Highton. Angle P.E. ± 0.081 . Average constant error of distance ± 0.202 . P.E. ± 0.172 .

Hough. Angle P.E. ± 0.041 at 1 , ± 0.115 at 6 . Constant error of distance ± 0.142 . P.E. ± 0.053 at 1 , and much larger at greater distances.

Jacob. Angle P.E. ± 0.036 at 0.75 , and ± 0.048 at 5 for equal components. The average constant error of distance is ± 0.073 . P.E. ± 0.063 at 0.75 , and ± 0.136 at 5 .

Jedrzejewicz. Angle P.E. ± 0.028 at 1.5 , and ± 0.046 at 4.5 for equal components. When the components differ by 3 the P.E. appears to be 0.030 greater. The distances are on an average 0.045 too great. The average constant error is ± 0.082 . P.E. ± 0.048 at 1 , and ± 0.096 at 4.5 .

Kaiser. Angle P.E. ± 0.039 at 2 , and ± 0.095 at 5 . Average constant error of distance ± 0.111 . P.E. ± 0.081 .

Knott. Angle P.E. ± 0.040 at 1 , and ± 0.059 at 4 . Distances on an average 0.028 too small. P.E. ± 0.037 at 1 , and ± 0.107 at 4 .

Lewis. Angle P.E. ± 0.027 below 1 , and ± 0.053 at 3.5 when the components are equal, but when they differ by one magnitude the P.E. is 0.013 larger, when they differ by 3, 0.039 larger, and when they differ by 5 magnitudes, it is 0.050 larger. The distances appear to be on an average 0.120 too large when both components are brighter than the 6th magnitude. When they are fainter the distances are too small by, on an average, 0.088 . P.E. ± 0.050 at 0.7 , ± 0.087 at 1 , ± 0.134 at 3.5 when the components are equal. When they differ by 5 the P.E. is 0.029 larger.

Mädler. Angle P.E. ± 0.029 at 0.6 , ± 0.036 at 1 , ± 0.040 at 5 when the components are equal. When they differ by 3 the P.E. is 0.022 larger. The distances are on an average 0.026 too small, but the mean of the constant errors without regard to sign is ± 0.102 . P.E. ± 0.061 below 1 , and ± 0.104 above 1 . The magnitudes do not seem to make any difference.

Main. Angle P.E. ± 0.105 . The distances are 0.098 too large. P.E. ± 0.101 .

Maw. Angle P.E. ± 0.016 at 0.9 , ± 0.031 at 1.7 , and ± 0.064 at 5 . The distances are on an average 0.045 too small. Average constant error of distance ± 0.076 . P.E. ± 0.048 at 0.9 , ± 0.062 at 1.7 , and ± 0.075 at 5 .

Mitchell. Angle P.E. ± 0.021 . The distances are 0.133 too great. P.E. ± 0.390 .

Morton. Angle P.E. ± 0.078 . The distances are 0.078 too large. P.E. ± 0.108 .

Perrotin. Angle P.E. ± 0.023 at 0.6 and ± 0.032 at 2 when the components are equal. When they differ by 3 the P.E. is 0.018 larger. When the main star is above the 5th magnitude the distances are on an average 0.015 too small. When below the 5th magnitude they are 0.052 too large. Average constant error without regard to sign ± 0.063 . P.E. ± 0.026 throughout.

Powell. Angle P.E. ± 0.060 at 5 . Average constant error of distance ± 0.159 . P.E. ± 0.073 .

Schiaparelli. Angle P.E. ± 0.015 at 0.6 , and ± 0.026 between 1 and 6 , when the components are equal. When they differ by 4 the P.E. is 0.030 larger. The distances are on an average 0.023 too small. The average constant error without regard to sign is ± 0.045 . P.E. ± 0.043 at all distances. The magnitudes appear to make no difference.

J. L. Scott. Angle P.E. ± 0.046 at 3 . The distances appear to be about 0.034 too large. P.E. ± 0.040 at 3 . These observations are made with a 5 inch equatoreal at Shanghai.

Seabroke. Angle P.E. $\pm 0''.034$ at $0''.7$, $\pm 0''.048$ at $3''.5$, and $\pm 0''.059$ at $4''.5$. Average constant error of distance $\pm 0''.131$. P.E. $\pm 0''.085$ at $0''.7$, $\pm 0''.130$ at $3''.7$, and $\pm 0''.139$ at $4''.5$. The magnitudes of the components appear to make no difference (Comp. Wilson and Seabroke).

Secchi. Angle P.E. $\pm 0''.019$ at $0''.7$, $\pm 0''.033$ at $1''.7$, and $\pm 0''.047$ at $4''$. Magnitudes make no difference. The distances are on an average $0''.062$ too small. The average constant error without regard to sign $\pm 0''.100$. P.E. $\pm 0''.072$.

Smyth. Angle P.E. $\pm 0''.031$ below $3''$, and $\pm 0''.049$ above $3''$. It is not certain whether the magnitudes have any influence. There is no systematic error in the distance. The average constant error is $\pm 0''.073$. P.E. $\pm 0''.095$. These observations are of very great value.

H. Struve. Angle P.E. $\pm 0''.013$ at $0''.5$, when components are equal. The magnitude coefficient is probably considerable, and the P.E. increases with the distance. Constant error of distance $\pm 0''.045$. P.E. $\pm 0''.051$.

O. Struve. Angle P.E. $\pm 0''.025$ at $0''.6$, $\pm 0''.042$ at $1''.3$, and $\pm 0''.067$ at $4''.5$ for equal components. When the magnitudes differ by 4 the P.E. is $0''.025$ larger. The average constant error of distance is $\pm 0''.055$. P.E. $\pm 0''.044$ below

$1''$, and $\pm 0''.071$ above $1''$ for equal components. When the magnitudes differ by $4\frac{1}{2}$ the P.E. is $0''.029$ greater.

W. Struve. Angle P.E. $\pm 0''.034$ below $3''$, and $\pm 0''.074$ above $4''$. The average constant error of distance $\pm 0''.058$. P.E. $\pm 0''.056$ below $3''$, and $\pm 0''.083$ above $4''$. The magnitudes do not appear to make any difference.

Talmage. Angle P.E. $\pm 0''.060$ at $1''$, and $\pm 0''.184$ at $4''.5$. The average constant error of distance is $\pm 0''.185$. P.E. $\pm 0''.253$.

Tarrant. Angle P.E. $\pm 0''.024$ at $0''.6$, and $\pm 0''.054$ at $2''$. The average constant error of distance is $\pm 0''.031$. P.E. $\pm 0''.051$.

Tebbutt. Angle P.E. $\pm 0''.067$ at $6''$. The distances are on an average $0''.114$ too great. P.E. $\pm 0''.110$.

Wilson and Seabroke. Angle P.E. $\pm 0''.034$ at $1''$ and $\pm 0''.075$ at $4''.5$. Average constant error of distance $\pm 0''.111$. P.E. $\pm 0''.095$ at $1''$, and $\pm 0''.178$ at $4''.5$. The magnitudes seem to have no influence.

H. C. Wilson. Angle P.E. $\pm 0''.063$ at $4''$. The distances are on an average $0''.177$ too great. P.E. $\pm 0''.165$.

Winnecke. Angle P.E. $\pm 0''.030$ at $0''.8$, and $\pm 0''.133$ at $4''$. The distances are on an average $0''.060$ too great. P.E. $\pm 0''.112$.

Kowloon, Elgin Road, Sutton, Surrey, 30th December 1907.

W. Doberck.

Mitteilungen über Veränderliche.

Von E. Hartwig.

Der Algolstern RZ Ophiuchi.

Dieser merkwürdigste Veränderliche unter den Algolsternen hat von diesen die längste Periode von nahe 9 Monaten, nachdem die Überwachung des Sterns in Hamburg und auf dem Yerkes Observatory (A. N. 4128) im August 1906 und in Bamberg 1907 Mai mit Sicherheit den Beweis geliefert hat, daß eine Halbierung der Periode nicht zulässig ist. Im September dieses Jahres, für welchen Monat die Ephemeride in der V. J. S. ein Minimum angekündigt hat, machte mich Dr. Praška auf diesen Umstand aufmerksam, und es wurde für den Abend des 25. September bereits seine Beobachtung vorgesehen, als eine Depesche von Ceraski aus Moskau mir mitteilte, daß der Stern sich im Minimum befinde und noch 6 Tage darin verweilen werde. Der Stern konnte mit Ausnahme des 29. September Abend für Abend nachgesehen und in seinem Lichtaufstieg am 1. und 2. Oktober beobachtet werden. Die wiederholten Helligkeitsschätzungen in diesen Nächten ergeben den Verlauf des Aufstiegs, der $2\frac{2}{3}$ Tage dauert, sehr sicher. Nach der Mitteilung von Dr. Graff (A. N. 4205) hat der Abstieg am 21. September stattgefunden. Nach meiner Lichtkurve des Aufstiegs muß bereits am 20. Sept. eine kleine Schwächung des Lichtes bemerkbar gewesen sein. Das Minimum dauert danach $8\frac{1}{3}$ Tage, und die Periode ist nach den Mitteilungen von Ceraski in A. N. 4046 über das Minimum von 1905 August, dessen Mitte Aug. 2 gewesen sein muß, 261.7 Tage, genau übereinstimmend mit dem von Blažko in A. N. 4108 angezeigten Werte 261.8.

Ein neuer Veränderlicher 182.1907 Draconis.

In einer kürzlich erschienenen eingehenden Abhandlung über den Antalgolveränderlichen RW Draconis, die zur Veröffentlichung in den Berichten der Naturforschenden Gesellschaft Bamberg allgemeinverständlich abgefaßt wurde, ist ein Vergleichstern ϵ erwähnt, der im Laufe der Beobachtungen in etwa Jahresfrist immer heller geworden ist und um eine Größenklasse zugenommen hat. In der Bonner Durchmusterung scheint er nicht beobachtet zu sein und hat jetzt, 1907 Dezember, die Helligkeit 8^m.7. Seinen Ort bestimmte ich am Heliometer im Anschluß an BD 58°1650 (AG Hells 8895) zu:

$$\begin{array}{rcl} 1855 & 16^h 32^m 59^s.15 & +57^\circ 53' 48''.5 \\ 1900 & 16 \ 33 \ 47.59 & +57 \ 48 \ 15.4 \end{array}$$

Der Stern hat offenbar eine sehr lange Periode.

Die der Abhandlung beigegebene, nach einer photographischen Aufnahme mit einem fünfzölligen Hermagisobjektiv in dreimal größerem Maßstab als die Bonner Karte hergestellte Sternkarte möchte wohl auf den ersten Blick den Anschein erwecken, als ob der Stern nicht mit BD 57°1691 identisch ist, auf den der auf der Karte mit d bezeichnete Stern besser zu passen scheint. Die Größe 10^m.0 von d macht das aber nicht wahrscheinlich, während andererseits die Abweichung in Deklination von 3.8 zwischen ϵ und 57°1691 auch etwas groß erscheint.

Die der Abhandlung beigegebene Ephemeride von RW Draconis, die sich auf die aus meinen Beobachtungen abgeleiteten Elemente: