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Astronomy. — *"Contributions towards the determination of geographical positions on the West coast of Africa"* *IV.* By C. SANDERS. (Communicated by Prof. E. F. VAN DE SANDE BAKHUYZEN).

(Communicated in the meeting of June 24, 1916).

1. *Introduction.*

My last paper [1]) on my determinations of geographical positions on the West coast of Africa dates from 1908; I describe there what I did in that direction in the years 1903—1906. In 1906 I was in Europe for some time, but in May 1907 I had returned to Chiloango, while in the mean time my stock of instruments had been augmented by a ZEISS telescope of 80 mm. aperture and 120 cm. focal distance. The principal purpose for which I had obtained this telescope was to be able to observe occultations of stars by the moon, in order in this way to improve my results for the absolute longitude of Chiloango, which I had previously determined by means of lunar altitudes. At the same time I wished to try to make other observations, which might be of use scientifically, my especial aim being the observations of eclipses and other phenomena of the satellites of Jupiter; while, when the telescope had only been in my possession for a short time, I had an opportunity of observing the transit of Mercury on Nov. 14th 1907, at least partially. I published the result of these observations in 1908 [2]). At the same time, some of the observations, especially those of the reappearance in occultations, were made very difficult by the circumstance that my telescope had provisionally been provided with an azimuthal mounting, which was to be replaced later by a parallactic one. This proved, however, to be difficult to accomplish and finally I ordered a second telescope exactly the same as the first, but mounted parallactically.

[1]) C. SANDERS. Bijdragen tot de astronomische plaatsbepaling op de Westkust van Afrika. (III). Versl. Akad. Amst. **17**, 66—84. 1908. (Proceedings XI. p. 88).

[2]) C. SANDERS. Waarneming van den overgang van Mercurius . . . . Versl. Akad. Amst. **17**, 84—85. 1908. (Proceedings XI. p. 108).

With this telescope, which I received in July 1909 and to which a ring-micrometer was added, I then continued my observations, principally of occultations and of phenomena of the satellites of Jupiter, while I succeeded in 1910 in obtaining some observations of HALLEY's comet. All this time, however, I had constant trouble from the weather conditions, as the sky usually became clouded over in the evening, and moreover in the years which followed, my astronomical work was more and more interrupted by my other occupations, so that at the end of 1910 I was obliged to temporarily close my observations of occultations In the last three years I had been able to obtain 24 observations, although almost exclusively of disappearances. Of these observations 10 concerned known stars, for the occultations of which I could make the necessary preparations, while 14 were of unknown stars, which had to be first identified by diagrams which I made for the purpose and had subsequently to be accurately observed in the meridian.

The occultations of the known stars I soon afterwards calculated and made use of for the determination of the longitude For these calculations I used both BESSEL's method and an approximation method given by OUDEMANS and refined still more by E. F. VAN DE SANDE BAKHUYZEN, which in most cases yielded sufficiently accurate results.

Of course at the moment I could only make use of approximate elements, especially as regards the places of the moon, and although that might now be corrected, it appears to me preferable to wait with my final calculations, until I have at my disposal sufficiently accurate positions for all the stars observed.

For only 7 observations I made calculations with provisionally corrected elements, in which (1) I introduced a general correction to the R A. of the moon of $+ 0^s40$, and corrected the declination in accordance with this, (2) I assumed the lunar parallax according to NEWCOMB, and (3) for the semidiameter of the moon I used the value 15′32″68, which was deduced by Prof. BAKHUYZEN from occultations and heliometer-observations

Thus I obtained as results for the longitude of my place of observation

1908	June 16	P XIX 369	Reapp.	$-48^m 31^s2$
	Sept. 30	ψ Ophiuchi	Disapp.	25.0
	Nov. 6	ν Piscium	,,	31.2
1909	March 28	ε Geminorum	,,	30.8
1910	March 16	υ_1 Tauri	,,	30.1
	,, 20	υ_2 Cancri	,,	30.0
	May 20	l_2 Virginis	,,	28.7

Taking into consideration that the 2nd result has less weight, the mutual agreement may be considered satisfactory. When we give the 2nd result a weight of 0.5, the mean result becomes

$$-48^m29^s9$$

while formerly from the observation of altitudes of the moon

$$-49^m32^s3 \pm 1^s0.$$

was found.

Probably in a final calculation, as the correction of the mean longitude of the moon for the mean epoch of my observations was about $+0^s47$, a somewhat greater eastern geographical longitude will be found, and the new result, even from these seven stars alone, will come somewhat nearer to the earlier one.

In the years 1911 and 1912 I was obliged to restrict myself to the absolutely necessary time determinations My supply of chronometers was in the mean time augmented in August 1909 by one from DENT, which was regulated to sidereal time, and as both my other chronometers by HEWITT and HOHWU began to shown signs of old age, I ordered in 1910 another chronometer from A. DE CASSERES in Amsterdam, which I received in February 1911. This chronometer DE C. 769 had shown a very regular rate in a six months test by Mr. ROOSENBURG at the Amsterdam branch of the Dutch Meteor. Institute. It preserved this quality in Africa, so that I was able to use it as a standard instrument. This was of value to me, not only for the accuracy of my observations, but also because in connection with the official introduction on Jan. 1st 1912 of the time of the 15th meridian east of Greenwich (= Middle European time) I was requested by the Portuguese Government to determine the time, and to distribute it telegraphically or telephonically in the district, for which purpose my HOHWU chronometer was deposited at Cabinda, the capital of the district.

My hope of being able in these years to carry out my long cherished plan of making determinations of geographical position for one or two points on the Lukula river, unfortunately came to nothing, but a more favourable time began again for my observations after I definitely changed my place of residence from Chiloango te Matuba, in 1913. In the following year I was able to make a determination of the geographical coordinates of my new domicile and also of the capital Cabinda.

This was the last of my observations with the old Universal

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Instrument, as in the mean time I had ordered a new and larger instrument from the firm of SARTORIUS in Göttingen. At the end of 1914 I again went to Europe for six months, and on my return in the summer of 1915 I was able to take the new instrument with me, after it had been subjected to a first examination at the observatory in Leiden.

Although I have since made a considerable number of observations with this instrument, it will be better to discuss these in later papers. The publication of my occasional observations with the ZEISS-telescope, in so far as these may prove to be of scientific value, will also be better delayed till that of the final discussion of my occultations In the following paper I shall therefore confine myself to the determinations of the coordinates of Matuba and Cabinda.

2. *Determination of the latitude of Matuba.*

In July 1913 I made a first determination of the latitude of Matuba by meridian-zenith-distances, and I afterwards repeated it in Febr. and March 1914. A short description of my installation there may here be given.

Matuba is about 400 meters from the coast, and lies more than 100 meters above sea level. My observatory consists of three apartments, of which the two outer ones are provided with moveable roofs. In these my universal instrument and the equatorial ZEISS telescope are mounted upon solid piers. Here on the firm ground a much greater stability is obtained than at Chiloango. In the inner room, which is arranged as a study, stand the chronometers in a closed cupboard, which is kept dry by calcium chloride. The observatory stands free from my house, but is connected with it by a covered passage.

The first determination of the latitude of my observatory was made in 1913 from July 6th to July 22nd, and I proceeded in exactly the same way as before in my second determination of the latitude of Chiloanga [1]), i.e. that observations were made exactly in the meridian, so that only one pointing could be obtained of each star. In order to eliminate as far as possible the systematic division errors and the flexure of the telescope, the observations were made in six different positions of the vertical circle, namely with the zenith point

[1]) Versl. Akad. Amsterdam **17** 73—78 ; Proc. **11** (95—101) 1908.

brought successively to 0°, 30°, 60°, 90°. 120° and 150°, and each time I observed two stars which culminated to the north and two which culminated to the south of the zenith, as far as possible at the same zenith-distance. In order to eliminate the zenith-point one star was each time observed in each position of the instrument. Comparing the differences thus obtained in the six positions between the latitude found by the northern and the southern stars $\varphi_N - \varphi_S$; with the corresponding differences formerly obtained at Chiloango (the mean zenith-distance in the Chiloango and the Matuba observations do not differ much, and in the 2nd determination at Chiloango observations were made in the same 6 positions of the circle) I found a considerable abnormality in one of the positions of the circle which rendered the course of the results less simple than in the previous series. This made me suspect that the vertical circle might have become slightly deformed during the transport, a few local injuries were plainly visible, and it was possible that these might have been accompanied by a very slight general deformation.

In order to arrive at a greater certainty on this point, and as in any case it was desirable to check the results obtained by a new series of observations, I decided to undertake a second determination, and I accomplished this plan in 1914, from Febr. 22nd to March 14th. In this observations were again made in 6 positions of the circle, but this time the zenith point was brought to 15°, 45°, 75°, 105°, 135° and 165°, and the number of observations in each position was doubled. Of the 8 observations 4 now concern northern, and 4 southern stars, of which two were each time made in each position of the instrument. Each evening (i.e. in each position of the circle) the same 8 stars were observed.

The results from both these series of observations are given below. For the sake of brevity I leave out the original readings of circle and level and the different reductions applied to them and give only the latitude φ according to each observation and thereby for each position of the circle the mean results from the 2 or 4 north and south stars φ_N and φ_S respectively, and also their differences and half sums $\varphi_N - \varphi_S$ and $\frac{1}{2}(\varphi_N + \varphi_S)$. The positions of the instrument are indicated in column P by the letters R = circle right of observer and L = circle left of observer. This was the simplest way of noting the observations at the time, but it leads to the same letter indicating a different position of the axis for a north and for a south star, and also NR and SL and similarly NL and SR referring to the same position of the axis. Column Z contains the zenith distance in full degrees, with the letters N (North) and S (South).

DETERMINATION OF THE LATITUDE OF MATUBA 1ST SERIES.

Date Zenith point	Star	Z	P	φ_N	φ_S	$\varphi_N - \varphi_S$	$\frac{\varphi_N + \varphi_S}{2}$
1913				−5°16′			−5°16′
July 19, 20	η Ursae maj.	55°N	R	61″63			
0°	β Centauri	55 S	L		54″40		
	γ Bootis	44 N	L	62.71			
	α Lupi	42 S	R		53.30		
	Mean			**62.17**	**53.85**	**−8″32**	**58″01**
July 22	β Centauri	55 S	R		54.45		
0°	α Lupi	42 S	L		57.34		
	α Bootis	25 N	L	63.35			
	γ Bootis	44 N	R	60.44			
	Mean			**61.90**	**55.90**	**−6.00**	**58.90**
July 17	η Ursae maj.	55 N	R	59.53			
30°	α Bootis	25 N	L	56.59			
	β Centauri	55 S	L		59.61		
	α^2 Centauri	55 S	R		62.57		
	Mean			**58.06**	**61.09**	**+3.03**	**59.58**
July 6	γ Crucis	51 S	R		60.16		
60°	β Crucis	54 S	L		60.56		
	ε Ursae maj.	62 N	R	58.30			
	ζ^1 Ursae maj.	61 N	L	58.72			
	Mean			**58.51**	**60.36**	**+1.85**	**59.44**
July 7	β Crucis	54 S	R		61.07		
90°	ε Centauri	48 S	L		61.70		
	ε Ursae maj.	62 N	L	53.96			
	ζ^1 Ursae maj.	61 N	R	53.33			
	Mean			**53.65**	**61.39**	**+7.74**	**57.52**
July 9	δ Crucis	54 S	R		57.38		
120°	ε Ursae maj.	62 N	L	[57.20]			
	ζ^1 Ursae maj.	61 N	R	55.25			
	ε Centauri	48 S	L		60.47		
	η Ursae maj.	55 N	L	58.34			
	Mean			**56.80**	**58.93**	**+2.13**	**57.87**
July 10	ζ^1 Ursae maj.	61 N	R	66.14			
150°	ε Centauri	48 S	L		57.02		
	η Ursae maj.	55 N	L	65.00			
	ζ Centauri	42 S	R		58.17		
	Mean			**65.57**	**57.60**	**−7.97**	**61.59**

DETERMINATION OF THE LATITUDE OF MATUBA. 2ND SERIES.

Date Zenith point	Star	Z	P	φ_N	φ_S	$\varphi_N - \varphi_S$	$\frac{\varphi_N + \varphi_S}{2}$
1914				−5°16′			−5°16′
Febr. 22	α Columbae	29°S	R		56″79		
15°	β Columbae	31 S	L		58.81		
	γ Geminorum	28 N	R	58″67			
	ζ Canis maj.	25 S	L		60.30		
	ν Geminorum	26 N	L	59.67			
	ν Argus	38 S	R		61.15		
	ε Geminorum	31 N	L	60.49			
	κ_2 Geminorum	37 N	R	60.18			
	Mean			**59.75**	**59.26**	**−0″49**	**59″51**
Febr. 25	α Columbae	29 S	R		64.06		
45°	β Columbae	31 S	L		62.54		
	γ Geminorum	28 N	R	57.08			
	ζ Canis maj.	25 S	L		[69.79][1])		
	ν Geminorum	26 N	L	55.71			
	ν Argus	38 S	R		62.20		
	ε Geminorum	31 N	L	57.66			
	κ_2 Geminorum	37 N	R	57.52			
	Mean			**56.99**	**62.93**	**+5.94**	**59.96**
March 9	α Columbae	29 S	R		65.80		
75°	β Columbae	31 S	L		67.18		
	γ Geminorum	28 N	R	51.34			
	ζ Canis maj.	25 S	L		66.12		
	ν Geminorum	26 N	L	56.93			
	ν Argus	38 S	R		63.88		
	ε Geminorum	31 N	L	52.02			
	κ_2 Geminorum	37 N	R	54.01			
	Mean			**53.57**	**65.74**	**+12.17**	**59.66**

[1]) Probably an error in the reading.

DETERMINATION OF THE LATITUDE OF MATUBA. 2ND SERIES. (Continued).

Date Zenith point	Star	Z	P	φ_N	φ_S	$\varphi_N-\varphi_S$	$\frac{\varphi_N+\varphi_S}{2}$
				−5°16′			−5° 16′
March 12	α Columbae	29°S	R		63″59		
105°	β Columbae	31 S	L		64.82		
	η Geminorum	28 N	R	53″13			
	ζ Canis maj.	25 S	L		64.41		
	ν Geminorum	26 N	L	55.56			
	ν Argus	38 S	R		64.52		
	ε Geminorum	31 N	L	50.78			
	α₂ Geminorum	37 N	R	52.12			
	Mean			**52.90**	**64.34**	**+11″44**	**58″62**
March 13	α Columbae	29 S	R		58.06		
135°	β Columbae	31 S	L		58.58		
	η Geminorum	28 N	R	56.95			
	ζ Canis maj.	25 S	L		60.73		
	ν Geminorum	26 N	L	56.81			
	Argus	38 S	R		60.34		
	ε Geminorum	31 N	L	58.40			
	α₂ Geminorum	37 N	R	57.33			
	Mean			**57.37**	**59.43**	**+2.06**	**58.40**
March 14	α Columbae	29 S	R		60.71		
165°	β Columbae	31 S	L		58.42		
	η Geminorum	28 N	R	57.40			
	Canis maj.	25 S	L		59.42		
	ν Geminorum	26 N	L	59.57			
	ν Argus	38 S	R		56.72		
	ε Geminorum	31 N	L	57.52			
	α₂ Geminorum	37 N	R	59.23			
	Mean			**58.43**	**58.82**	**+0.39**	**58.63**

The refraction was calculated by the tables given by ALBRECHT; the declinations were taken from the Nautical Almanac, i.e. from NEWCOMB's fundamental catalogue. From all the observations of the same evening one zenith point was deduced which satisfied all of them in the best manner comparing the φ_R and φ_L, i.e. so that

$$\varphi_{NL} - \varphi_{NR} + \varphi_{SR} - \varphi_{SL} = 0\,;$$

the mean results are, however, independent of this. On July 19 and July 20 the observations were incomplete, but they supplement each other; from both days together follows as zenith point 48″40, while on July 22[nd], when another series of observations was made with the same position of the circle, 49″18 was found (see preceding tables).

Where in the observations in each position of the circle the mean zenith distance of the north and the south stars was the same, the influence of systematic division errors and of flexure becomes eliminated in the half sum $\frac{1}{2}(\varphi_N + \varphi_S)$ for each position, and in that case it is certainly best to regard the mean of the 6 results as our final result. My second series of observations answered very perfectly to these requirements. In that series the same 8 stars were observed each evening and the mean zenith distance was for the northern stars 30°.3, for the southern ones 30°,5. (R.N. 33°, R.S. 33°, L.N. 28°, L.S. 28°). In the first series the zenith distances differ more; the mean differences $z_N - z_S$ lie for the various positions of the circle between $-15°$ and $+13°$ and their mean value is $+3°$ (the mean values of z themselves were $z_N = 54°$, $z_S = 50°.5$, mean $z = 52°$). But even in this case the method mentioned above will probably give the best results possible. We thus get:

	1[st] Series	2[nd] Series
	— 5° 16′ 58″46	— 5° 16′ 59″51
	59.58	59.96
	59.44	59.66
	57.52	58.62
	57.87	58.40
	61.59	58.63
Mean	— 5° 16′ 59″08±0″60	— 5° 16′ 59″13±0″27

The mean errors added to the final results were deduced from the mutual agreement of the 6 partial results. Of the latter themselves the mean errors are ± 1″48 and ± 0″66. Judged by this, the 2[nd] series proves to be much more accurate than the 1[st]. This is undoubtedly partly due to the fact that in the 2[nd] series twice as many observations were made as in the 1st, but this can only partially explain the great difference. Our results give as the mean error for the mean of 2 pointings L, R, *after* correction for division errors and flexure, for the two series $\pm 2''09$ and $\pm 1''32$ respectively and it is not probable that the *actual* accidental errors would differ so much. Presumably, therefore, the somewhat great differences $z_N - z_S$ have caused an insufficient elimination of the systematic errors in the mean results for the single positions.

In the same way as previously (these Proceedings 4, p. 274, 1901) I deduced the correction-formulae for systematic division errors and flexure for both series from the values for $\varphi_N - \varphi_S$. For the former I found

1st series $+ 3''69 \sin (2a—154°5)$
2nd „ $+ 3''98 \sin (2a—169°3)$.

The two formulae agree sufficiently, but, as I mentioned before, the first formula does not agree well with the results of observation, which suggested to me a possible deformation of the circle; for a proper agreement another term dependent upon 4α with a coefficient $3''13$ was necessary. but such a term can have little real significance. As, however, the formula for the 2nd series undertaken a year later agrees very well with the observations, and at the same time differs very little from those deduced from previous observations, my fear of a deformation of the circle must be regarded as unfounded. Probably the inequality, of the zenith distances is the principal cause of the anomaly.

For the flexure assumed to be proportional to $\sin z$

1st series $z = - 0''04 \sin z$
2nd series $+ 5.20 \sin z$

was found.

The two values are very discordant, and the result from the more accurate second series seems also to deviate very greatly from the earlier results; the divergence becomes less striking, if we do not assume that the influence of flexure must be proportional to $\sin z$. I shall return to this and in general to the systematic errors of my instrument in section 4.

In conclusion the most probable final result for the latitude of Matuba may be established. The 2nd series of observations I also calculated in a different manner, correcting the single results according to my formulae and then taking the mean value from them. My final result now became $-5°16'\,59''13$, exactly the same as that deduced above, a new proof that this time I had succeeded in arranging my observations in every way symmetrically. As m.E. for one pair of observations L., R. ± 1″20 was now found, from which ± 0″25 would follow for my final result.

In every way, therefore, the much greater reliability of the 2nd series is shown. However, the result of the 1st series happens to agree practically completely with that of the 2nd and it is therefore of no importance what relative weight we attach to each.

As my final result I accept:

Latitude of Matuba Observ.-Pier. —5° 16′ 59″1 ± 0″3.

3. *Determination of the latitude of Cabinda.*

For the purpose of the determination of the geographical position of Cabinda, which I undertook at the request of the Governor of the district, a concrete pier was built at a short distance from the meteorological post.

For the determination of the latitude I observed zenith-distances in the meridian, and I contented myself this time with 4 positions of the circle. But even with this restriction I was not able to carry out my programme (8 stars each time) completely in the short time at my disposal. For the determination of the time my Hohwü-chronometer stationed at Cabinda served. On Sept. 29th and 30th 1 and 2 observations respectively in position R were failures; the corresponding observations in position L are therefore omitted also. (See following table).

Very striking in these results is the rather marked deviation always in the same sense of 61[1] Cygni, and if we should assume that I had not pointed the telescope on 61[1] Cygni, but on a point nearer to the centre of gravity of the two stars, the deviation would become even greater. I considered, therefore, that I should not be justified in excluding these results.

Although the number of observations obtained in the various positions of the circle is very different, I think it is best to assume the simple mean value of the 4 partial results as my final result, and to deduce the m.e. from their mutual agreement. The observations clearly are less accurate than those at Matuba, due perhaps partly to a lesser stability of the pier.

I assume, therefore, retaining 61 Cygni.

Latitude Cabinda Observation-pier. —5° 33′ 22″3 ± 0″6.

If 61 Cygni is excluded, the results of the 4 days receive the corrections + 1″02, + 0″54, + 1″90 and + 1″09 and the mean result becomes — **5° 33′ 21″2.**

Determination of the latitude of Cabinda.

Date Zenith point	Star	Z	P	φ_N	φ_S	$\varphi_N - \varphi_S$	$\frac{\varphi_N + \varphi_S}{2}$
1913				-5°33′			—5° 33′
Septemb. 27	α Pavonis	51°S	R		23″66		
0°	γ Indi	42 S	L		21.29		
	γ Cygni	51 N	R	20″35			
	61¹ Cygni	44 N	L	25.75			
	ζ Cygni	35 N	R	23.21			
	γ Pavonis	60 S	L		23.03		
	γ Gruis	32 S	R		20.88		
	ι Pegasi	30 N	L	17.56			
	Mean			**21.72**	**22.22**	**+0″50**	**21″97**
Septemb. 29	61¹ Cygni	44 N	L	19.53			
90°	ζ Cygni	35 N	R	14.97			
	γ Pavonis	60 S	L		28.26		
	γ Gruis	32 S	R		25.10		
	ι Pegasi	30 N	L	15.27			
	ζ Cephei	63 N	R	14.35			
	Mean			**16.03**	**26.68**	**+10.65**	**21.36**
Septemb. 30	61¹ Cygni	44 N	L	23.79			
45°	ζ Cygni	35 N	R	19.76			
	γ Pavonis	60 S	L		25.10		
	γ Gruis	32 S	R		18.83		
	Mean			**21.78**	**21.97**	**+0.19**	**21.87**
October 1	61¹ Cygni	44 N	L	29.64			
135°	ζ Cygni	35 N	R	22.60			
	γ Pavonis	60 S	L		23.72		
	γ Gruis	32 S	R		22 81		
	ι Pegasi	30 N	L	20.95			
	ζ Cephei	63 N	R	25.44			
	γ Toucani	55 S	L		23.89		
	β Gruis	42 S	R		22.63		
	Mean			**24.66**	**23.26**	**—1.40**	**23.96**

4 *Systematic errors of the universal instrument.*

a. Division errors.

I put together below the formulae found in the different series of observations for the correction which must be applied to the readings α of the vertical circle of my instrument on account of the systematic division-errors. I confine myself everywhere to the terms in 2α.

Chiloango	1900—01	$\Delta\alpha = + 4''74 \sin (2\alpha - 169°2)$
,,	1903	$+ 5.15 \sin (2\alpha - 175.4)$
Matuba	1913	$+ 3.69 \sin (2\alpha - 154.5)$
Cabinda	1913	$+ 2.57 \sin (2\alpha - 171\ \ )$
Matuba	1914	$+ 3.98 \sin (2\alpha - 169.3)$

If we take into consideration the lesser accuracy of the results of the 1st series at Matuba and of the observations at Cabinda, the agreement of the 5 formulae may be considered satisfactory. That in the division errors a term occurs of the assumed form with a coefficient of about 4″ may be considered as proved and there is no reason to suspect any change with the time. That these errors are fairly large, is not surprising either, when we consider that the radius of the circle is only 70 mm.

Of course the values calculated from this will not represent the full amount of the division errors. At the same time the results of the most accurate series Matuba II do not point to large residual values. Whereas a comparison of the mean results for each position $\frac{1}{2}(\varphi_N + \varphi_S)$ with their mean value here leads to a m.e. of $\pm 0''66$, the m.e. is $\pm 0''82$ according to a comparison of the $\frac{1}{2}(\varphi_N - \varphi_S)$ with the formula including the flexure.

b. Flexure of the telescope.

In the table below are given, instead of the previously deduced coefficients of *sin z,* the values of the flexure of the straight telescope (which thus represent the differences of the flexure of the objective and ocular halves) directly determined for the mean zenith distance of the series.

Chiloango	1900—01	$z = 53°$	$\Delta z = -0''48$
,,	1903	49	-1.33
Matuba	1913	52	-0.04
Cabinda	1913	44	$+1.24$
Matuba	1914	30	$+2.62$

Whereas the deviation from the previous results of those obtained in Cabinda might be explained by their smaller accuracy, the great deviation of the more accurate series Matuba II is very striking, and it becomes much more so, if the flexure is represented by $c \sin z$, and the coefficients c are compared. This cannot be attributed to accidental errors, (cf. the m. e. ± 0″82 found above as against ± 0″66) and there seem to be only two explanations possible, either we must assume a change with the time, or suppose that the flexure may even change its sign with the zenith distance. The latter was namely in the last series noticeably smaller than in all the previous ones.

At any rate it is necessary for each series to use the flexure deduced from it

5. *Determination of the longitude of Matuba and Cabinda.* —

The difference of longitude between Matuba and Chiloango, and later that between Cabinda and Matuba, was determined geodetically, which in the given circumstances seemed preferable.

a. Determination of the geographical position of Matuba with respect to Chiloango.

As early as 1901, I had connected my observation-pier at Chiloango with the flag staff of the Residency at Landana and in 1910 I connected my new observation place at Matuba with it also, by a tacheometric measurement of the road between the two places. I determined their relative magnetic coordinates, and, in order to be able to reduce these to astronomical ones, I made at the same time some determinations of the magnetic declination in Chiloango, in which the already determined azimuth of the harbour light provided me with the absolute orientation (once the sun was observed directly).

For the magnetic declination I obtained, with a needle of 86 mm. length

1910 Oct.	8	p. m.	14° 40′ 35″	West
„	28	a. m.	39 31	
Nov.	2	p. m.	43 53	
„	3	a. m.	38 2	
„	3	p. m.	52 55	
„	4	a. m.	35 33	
„	4	p. m.	50 22	
		Mean	14° 42′7	West

The values found for the magnetic coordinates of Matuba observ.-pier with respect to Landana flag staff follow here, and subjoined the astronomical coordinates calculated from them by means of the magnetic declination.

Matuba with respect to Landana

$$\Delta X_{magn} = + 1290^{m}03, \qquad \Delta Y_{magn} = - 7261^{m}03$$

$$\Delta X_{astr} = + 3091^{m}64 \qquad \Delta Y_{astr} = - 6695^{m}41$$

Adding to the latter the coordinates of Landana with respect to Chiloango observation-pier and taking the latter point as the zero point of coordinates we obtain

Landana flag staff $X = + 686^{m}29$ $Y = - 2308^{m}52$

Matuba observ. p. $X = + 3777.93$ $Y = - 9003.93$

If these are reduced to seconds of arc with the reducing factors:

1″ in the direction of the meridian $= 30^{m}714$

1″ „ „ „ „ „ parallel $= 30.789$

we find for the difference of latitude and longitude between Matuba and Chiloango and by means of these for the geographic coordinates of Matuba:

Matuba—Chiloango $\Delta\varphi = - 4' 53''15$ $\Delta\lambda = - 2' 2''7$

Chiloango $\varphi = - 5°12' 4''20$ $\lambda = - 12° 8' 4''5$

Matuba Obs. pier $\varphi = - 5°16' 57''4$ $\lambda = - 12°10' 7''2$

The latitude of Matuba derived from that of Chiloango thus differs by 1″7 from the value as directly determined. This difference may be explained by accidental errors, in the first place by those made in the tacheometric measurement. It is also possible that in this case local attractions played a part. Not long ago (May 1913) at Matuba a few hundred metres to the south of my observation-pier considerable land slides took place.

However this may be, according to the above calculation we may assume

Longitude of Matuba Obs. P $= - 12° 10' 7''.2$
$= - 0^{h}48^{m}40^{s}.48$.

b. Determination of the Longitude of Cabinda.

As regards the determination of the difference of longitude between Cabinda and Matuba, it seemed to me most suitable to deduce this from the difference of latitude and an azimuth determination.

For this purpose I placed at Matuba at a distance of about 200 m. from my observation-pier a signal on a tripod, which was visible from Cabinda and was lighted at night by an acetylene lamp with reflector.

For the coordinates of the signal with respect to the observation-pier I found by the measurement of azimuth and distance

$$\Delta\varphi = -\quad 7''.14 \qquad \Delta\lambda = -\quad 0''.24$$

thus Signal Matuba $\varphi = -5^\circ 17' 6''.2 \qquad \lambda = -12^\circ 10' 7''.4$

On Sept. 25, 1913 at Cabinda I made a time-determination by means of β Ceti in the east and α Ophiuchi in the west. The telescope was twice pointed on each star in each position of the instrument, at mean zenith distances of 59° and 57° respectively. As correction of the Hohwü chronometer I found:

by β Ceti	$+ 0^h54^m35^s19$
α Ophiuchi	35.46
Mean	$+ 0^h54^m35^s33$

On Sept 27 I then determined the azimuth of the signal by means of the greatest digression of ν Ophiuchi (the observation of that of θ Ceti failed) and found, counting from the north through the east etc.

Azimuth Signal Matuba $A = 353^\circ 55' 26''.1$.

From this and from $\varphi' - \varphi = -16' 16''1$ I calculated from Albrecht and from Schols in complete agreement:

$$\lambda' - \lambda = -1' 43''.65$$

from which

Longitude Cabinda Obs. P. $= -12^\circ 11' 51''.1 = -0^h48^m47^s.4$.

An error of 30″ in the azimuth causes in the longitude one of 0″14 only.

Physics. — *"Note on the model of the hydrogen-molecule of* Bohr *and* Debije". By J. M. Burgers. (Communicated by Prof. H. A. Lorentz).

(Communicated in the meeting of June 24, 1916.)

Miss H. J. van Leeuwen has recently published a paper containing some notes on Debije's calculation of the dispersion formula of hydrogen, which calculationis founded on the well-known model of the H_2-molecule [1]). In that paper it is demonstrated that some of the vibrations which occur in Debije's calculations are unstable, and methods are discussed by which the stability of the model may be ensured.

[1]) These Proc (1916) Vol. XVIII, p. 1071.