On the Distribution of the Stars of the 11th Magnitude.

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(*Communicated by Professor W. de Sitter, Assoc. R.A.S.*)

1. In the October number of the *Monthly Notices* (**78**, 668) Mr. Plummer published some results on the distribution of the stars, based on Dr. Nort's reduction of the Harvard Map of the Sky. These results need some corrections, as the data used are not homogeneous.

The Harvard charts have been counted by Mr. Henie at Lund, who also determined the two principal elements for reducing the counted numbers to homogeneous densities, viz. the limiting magnitude for each chart and the decrease of star density with increasing distance from the centre. But, as Dr. Nort in his new reduction of these star counts pointed out, both determinations are unsatisfactory. To find the limiting magnitude—or the reduction of the star densities to the same limiting magnitude,—Mr. Henie made use of the series of comparison stars for variables from Hagen's Atlas; but he used only a part of them, and for most charts the limiting magnitude rests on 3, 2, or 1 series of stars only. The reduction to centre was deduced from the decrease of star density from the centre to the margins. As the Harvard charts extend over 30°, the decrease must be found too great for the charts with great density, having their centre in the Milky Way. A better and indeed sufficient determination of the reduction to centre could be obtained by counting a second set of plates with the centres at the edges of the charts used. With the materials at hand it is, however, not possible to find much better values now; so we must adopt this reduction as computed by Dr. Nort.

For a study of the distribution of the stars over the sky as a whole, the other element, the limiting magnitude for every chart, is much more important. That in this respect the results of Dr. Nort are far from homogeneous may be seen at once when we plot them on a celestial map. The reduced star densities of adjacents charts show, in their overlapping parts, considerable systematic differences. Before using them for statistical studies it is therefore necessary to make them homogeneous.

2. As a first, and for our purpose sufficient, approximation we suppose that the star densities of Dr. Nort can be reduced to a homogeneous system by multiplying them by factors C that are constant for each Harvard chart. These factors may be found from the overlapping parts of the adjacent charts. If d_1 and d_2 are the mean densities on charts a and b in the region they have in common (usually containing 5–15 counted fields), then

$$\log d_1 - \log d_2 = \log C_b - \log C_a.$$

Each chart is in this way connected with all the surrounding charts (at least 4), and from the whole of these equations (there are 118 of them) we may find log C for the 55 charts by a process of successive approximations that makes their sum zero. As the mean error of a result for log C is 0·05, and as 35 out of 55 values are 0·10 or more and 10 values are 0·20 or more, the reality of the majority of these corrections stands beyond doubt. The coefficients thus found are contained in Table I.

TABLE I.

Coefficients by which the Star Densities of Dr. Nort must be multiplied.

Chart.	Centre.		Coefficient.	Chart.	Centre.		Coefficient.
1	...°	+90°	1·05	29	210°	0°	1·38
2	0	+60	0·76	30	240	,,	0·69
3	45	,,	2·19	31	270	,,	0·60
4	90	,,	1·41	32	300	,,	1·23
5	135	,,	1·02	33	330	,,	0·81
6	180	,,	1·35	34	0	−30	0·74
7	225	,,	1·26	35	30	,,	0·65
8	270	,,	1·35	36	60	,,	0·93
9	315	,,	1·38	37	90	,,	0·78
10	0	+30	0·83	38	120	,,	1·26
11	30	,,	0·81	39	150	,,	1·38
12	60	,,	0·98	40	180	,,	1·02
13	90	,,	0·69	41	210	,,	0·85
14	120	,,	0·48	42	240	,,	0·69
15	150	,,	0·63	43	270	,,	0·81
16	180	,,	1·29	44	300	,,	0·56
17	210	,,	1·10	45	330	,,	0·93
18	240	,,	1·20	46	0	−60	0·55
19	270	,,	1·02	47	45	,,	0·65
20	300	,,	1·29	48	90	,,	0·68
21	330	,,	0·74	49	135	,,	0·76
22	0	0	0·66	50	180	,,	0·66
23	30	,,	1·07	51	225	,,	0·63
24	60	,,	1·05	52	270	,,	1·17
25	90	,,	0·79	53	315	,,	0·66
26	120	,,	1·17	54	0	−85	0·55
27	150	,,	1·70	55	210	−75	0·52
28	180	,,	1·51				

The changes that are brought about by these coefficients in the star densities are rather considerable. This means, that without these corrections the numbers of Dr. Nort must give a false representation of the general distribution of the stars. So the exceedingly high density he found for the most southern part of the Galaxy, in the Southern Cross, which makes these regions the richest of the sky, is not real, but chiefly a consequence of the great density and the low limiting magnitude of charts 50 and 55. In the same way most of the conclusions based on his numbers must be revised.

3. By application of the corrections here found, however, we obtain values for the star density that are fairly homogeneous over the whole sky. They are therefore the best material we possess at this moment to study the distribution of these stars, better indeed than the catalogue plates of the Carte du Ciel, that extend to a somewhat lower limiting magnitude.

For this purpose each chart has been divided into four quadrants (of 15° square), and for every quadrant the mean corrected density (usually from 25 fields) was computed. For the centre of each quadrant the galactic longitude and latitude were read from the abacus in Dr. Nort's memoir (a rather rough method, as errors of 1° or perhaps more may occur, but for our purpose it is sufficient). In Table II. is given a catalogue of these mean densities; the first two columns give the galactic co-ordinates of the centre, the third column gives the number of the chart, the fourth the star density per square degree.

TABLE II.

Mean Star Densities arranged in order of Galactic Longitudes.

Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.	Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.
1°	−59°	45	15·4	+15	34°	+64°	17	10·8	+02
2	+53	18	13·3	+05	35	+18	19	37·7	+12
6	+ 6	31	29·6	−09	39	+11	20	62·2	+26
6	−28	32	25·9	+08	41	−22	21	37·0	+16
8	+38	18	22·6	+14	42	−63	22	14·7	+15
12	+26	19	30·4	+13	43	−43	33	18·5	+11
12	−72	34	12·2	+12	45	+36	8	25·9	+18
13	− 6	32	43·3	+07	47	+47	7	17·9	+13
13	−40	33	23·6	+19	47	− 3	20	59·5	+20
19	+12	19	44·0	+12	48	+19	8	28·3	+01
21	−20	32	34·1	+10	52	− 8	21	52·0	+16
24	0	20	43·0	+05	53	+ 8	9	50·5	+15
26	−54	33	17·1	+17	54	−32	21	31·6	+22
29	−30	33	24·9	+09	59	−51	22	13·1	+03
30	+56	18	12·1	+03	60	−85	34	10·6	+09
30	+40	18	19·9	+11	61	+76	17	10·3	+06
30	+33	19	22·2	+08	62	+62	7	13·0	+09
31	−10	20	38·3	+04	64	− 3	9	88·6	+37

TABLE II.—*continued.*

Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.	Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.
65°	−18°	21	32·9	+06	120°	−14°	12	17·3	−27
67	+38	7	17·5	+03	120	−34	11	9·5	−28
67	+37	8	15·8	−02	120	−68	23	13·4	+14
67	+21	8	28·1	+03	126	+ 7	4	27·2	−13
67	+20	9	31·9	+07	131	−46	23	16·3	+08
67	−37	10	19·4	+07	132	+50	5	7·2	−24
73	−21	10	33·1	+10	132	− 3	12	18·4	−31
75	− 9	2	43·2	+09	133	+21	4	22·0	−08
77	+ 8	9	46·6	+11	133	−26	12	10·6	−33
78	+ 7	2	41·4	+05	136	+34	5	10·2	−25
80	+20	1	18·9	−16	137	+ 2	13	24·8	−18
82	+48	7	10·7	−08	140	+68	16	10·0	+01
82	+37	1	13·0	−11	144	+16	13	15·9	−28
82	−71	22	13·2	+15	144	−16	12	9·3	−51
84	+48	6	11·2	−06	145	−37	24	15·4	−03
84	+ 5	2	34·4	−04	147	+62	15	10·1	−02
85	+66	6	10·3	+01	147	+23	14	12·7	−29
86	+ 6	3	37·9	+01	150	+46	15	9·5	−15
86	−55	22	11·0	−02	150	+38	14	11·2	−16
87	−41	10	14·3	−02	150	−58	23	12·4	+05
89	−23	10	20·3	−09	152	− 6	13	21·5	−23
91	−12	2	26·8	−10	156	−24	24	12·0	−30
94	+78	16	9·2	+01	158	+ 7	13	25·9	−15
96	+17	1	32·5	+04	158	−79	35	8·7	−01
98	−23	11	23·7	−02	162	−47	24	13·3	00
102	+34	1	14·7	−09	164	+19	14	17·3	−21
103	−40	11	13·1	−07	164	−13	25	19·0	−23
107	+45	6	9·9	14	170	+33	14	13·5	−14
108	+44	5	11·5	−09	171	+ 1	25	28·7	−12
108	+13	3	22·8	−16	172	−33	24	21·3	+06
108	−53	23	14·7	+09	175	+45	15	13·7	00
109	+14	4	25·5	−10	176	−65	35	11·8	+07
113	−10	3	40·1	+06	177	+13	26	32·5	00
113	−18	11	19·7	−16	179	−20	25	18·3	−17
115	+30	5	12·6	−20	181	+59	15	11·0	00
115	+28	4	17 3	−09	182	−26	37	12·6	−25
118	− 2	3	36·6	−02	182	−53	36	17·4	+17
120	+60	6	10·4	−02	186	+28	26	15·3	−14

TABLE II.—*continued.*

Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.
186°	− 6°	25	34·8	−02
188	−38	36	13·5	−08
192	+72	16	10·7	+06
193	+40	27	17·7	+06
193	+ 6	26	35·8	−01
199	−12	37	25·8	−11
201	+20	26	20·2	−13
204	0	38	28·8	−12
206	+54	27	14·4	+09
209	+30	27	19·2	−02
210	−33	37	13·7	−13
210	−40	36	18·5	+08
210	−56	36	19·3	+23
212	+12	38	29·0	−06
214	−64	35	15·9	+19
215	−18	37	23·3	−09
219	−11	38	19·3	−25
221	+22	39	27·7	+03
222	+63	28	16·5	+21
223	+43	27	16·5	+06
225	−36	48	18·3	+03
227	+ 3	38	46·5	+09
227	−47	47	15·9	+08
228	−19	48	19·9	−15
232	+ 8	39	35·0	−01
233	− 8	49	37·2	+02
234	+32	39	23·0	+08
239	+51	28	12·2	00
240	+85	16	9·0	+02
241	−76	35	11·1	+09
242	−62	47	15·1	+16
244	+ 3	49	44·6	+07
245	+18	39	37·1	+11
247	+37	40	17·6	+03
247	−20	49	21·5	−10
247	−21	48	20·5	−11
247	−37	48	18·7	+05
247	−38	47	15·1	−03
253°	+21°	40	28·0	+02
255	+ 9	50	25·1	−15
257	− 8	49	51·5	+16
258	− 7	50	63·0	+24
262	+71	28	15·6	+22
262	−25	54	28·6	+09
262	−48	47	12·1	−03
263	−42	54	12·3	−08
264	− 5	50	64·5	+24
264	−48	46	14·8	+06
265	−15	55	21·1	−17
265	−66	46	13·4	+13
266	+55	28	13·9	+08
266	− 6	51	61·0	+22
267	+41	40	15·6	+02
269	+23	40	25·1	00
270	− 3	55	59·1	+20
271	+12	50	26·6	−10
274	−78	34	11·4	+11
277	−24	54	35·9	+17
278	+23	41	24·1	−01
280	−23	55	40·0	+21
282	−37	54	17·0	+01
283	+40	41	16·2	+02
284	− 8	55	53·2	+17
287	−45	46	13·9	+01
288	+53	29	17·5	+17
288	−13	51	43·2	+12
288	−44	53	15·8	+05
289	−14	52	35·2	+04
293	+18	41	31·1	+03
293	+10	51	51·7	+17
295	−28	52	28·6	+13
295	−30	53	19·6	−01
298	+ 2	51	45·7	+08
300	+68	29	16·1	+22
300	+34	41	15·7	−06
300	+14	42	27·3	−07

TABLE II.—*continued.*

Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.	Galactic Long.	Galactic Lat.	Chart Number.	Stars per Sq. Deg.	Logarithmic Deviation, unit 0·01.
300°	−60°	46	13·4	+09	330°	−38°	44	14·0	−06
306	− 7	52	44·9	+09	330	−46	45	16·3	+08
311	+46	29	16·0	+08	332	+ 6	43	28·8	−11
312	+ 3	42	30·6	−09	336	+24	30	10·1	−38
312	−50	53	11·5	−03	338	+79	17	9·1	+01
313	+26	42	18·0	−10	338	− 7	43	25·4	−16
313	−21	52	33·5	+10	342	+47	30	14·3	+04
316	−34	53	20·7	+06	344	+13	31	17·2	−28
317	− 2	43	36·4	−02	344	−19	44	17·7	−20
320	−68	34	16·1	+22	350	−33	44	18·5	00
324	+16	42	17·2	−25	351	− 1	31	29·8	−11
324	−16	43	25·3	−08	352	+33	30	15·2	−08
325	+37	30	14·0	−08	355	−45	45	18·7	+13
327	−23	44	10·6	−37	356	+65	17	10·9	+03
327	−62	45	14·2	+13	357	−13	32	19·8	−22
330	+58	29	14·8	+13	359	+20	31	20·2	−13

4. The distribution of the star densities over the sky may be studied in two different ways: by expressing it by numerical formulæ — this is the way followed by Mr. Plummer — or by plotting them on a map. In the first case we try to express the density as a function of galactic latitude and longitude. To find the decrease with galactic latitude the logarithms of the densities were condensed into the following mean values :—

Mean Lat.	Log N.	*n*.	*m*.
2°·6	1·594	18	11·42
7·5	1·587	25	11·46
12·8	1·429	18	11·18
19·8	1·370	37	11·23
29·8	1·250	29	11·24
39·1	1·209	29	11·40
49·1	1·132	28	11·41
61·0	1·121	18	11·65
73·7	1·059	18	11·65

Using the table of Van Rhijn,* we find from these log N the limiting magnitudes given in the fourth column; their weighted

* Dr. P. J. van Rhijn, "On the Number of Stars of each Photographic Magnitude in different Galactic Latitudes," table iv. (*Public. Groningen*, No. 27, p. 62).

mean 11·38 may be considered as the limiting photographic magnitude belonging to the Harvard Map reduced in this manner.

The dependence of density on galactic longitude has a meaning for the lower galactic latitudes only. For different zones between ± 40° the densities were plotted in a diagram and curves were drawn through them. They all show the same character: two maxima of density in the first and third, two minima in the second and fourth quadrant of longitude. They may be represented by the formulæ—

Zone	log N =	cos λ	sin λ	cos 2λ	sin 2λ	cos 3λ	sin 3λ
+40° to +21°(32)	1·245 + ·028	− ·045	− ·053	+ ·130	− 000	+ ·030	
+20 „ +11(20)	1·424 + ·020	− ·020	− ·048	+ ·134	− 020	+ ·028	
+10 „ −10(43)	1·575 + ·052	− ·035	− ·117	+ ·075	− 027	+ ·015	
−11 „ −20(19)	1·374 + ·099	− ·055	− ·117	+ ·082	− 053	+ ·018	
−21 „ −40(34)	1·285 + ·099	− ·032	− ·077	+ ·107	− 037	+ ·053	

The terms of the first and second order may also be written—

$1·245 + ·053 \cos(\lambda - 302°)$		$+ ·140 \cos 2(\lambda - 56°)$	
1·424 + ·027	315	·142	55
1·575 + ·063	326	·139	74
1·374 + ·113	331	·143	72
1·285 + ·104	342	·132	63

All these zones show a great resemblance in their formulæ. If we take their weighted mean, we obtain a formula that represents the general distribution of the 11th magnitude stars along the galactic zone.

$$\log N = 1·389 + ·059 \cos\lambda - ·037 \sin\lambda - ·085 \cos 2\lambda + ·103 \sin 2\lambda - ·026 \cos 3\lambda + ·029 \sin 3\lambda$$
$$= 1·389 + ·070 \cos(\lambda - 328°) + ·134 \cos 2(\lambda - 65°) + ·039 \cos 3(\lambda - 44°)$$

The first term may be explained by an eccentric place of the sun in this star system (the centre of the system lying towards $\lambda = 328°$). The second term means a greater density along the axis 65° − 245°, a smaller density in a direction perpendicular to it, thus making the figure of our star system a three-axial ellipsoid with densities 8·6, 18, and 33 along the three axes. The higher terms are small; they may be real—the coefficients of cos 3λ and sin 3λ have the same sign in all the zones—but they have no physical meaning: the excess of stars at λ = 44°, 164°, and 284°, and the lack of stars at λ104°, 224°, and 344°, all together expressed by the third term, have no organic connection with each other. The irregularities these higher terms represent are local; they are connected with the star clouds and the void spaces of the Milky Way itself, and therefore they are not aptly represented by a formula. Perhaps the same may be said of the first term, as it expresses only the fact that the minimum density at λ150° is lower than the minimum at λ330°.

The results here found are very different from Mr. Plummer's; this is not astonishing, as the foundations of his calculations need large corrections. We have not pursued further our research in this direction, because periodic functions, spherical harmonics, or other formulæ are inadequate to represent the irregularities of the star distribution.

5. The special features of the distribution of the stars show themselves at once when we plot the densities on a map or a globe. Next to the general decrease from the Milky Way to its poles, we detect by this method immediately, by mere inspection, all the irregularities in the distribution. Two regions of greatest density in the galactic zone appear, nearly opposite to each other, one in Cygnus and Lacerta, the other extending from α and β Centauri, on the southern side of the Cross, to β and ϵ Carinæ. Between them we find the poorest parts of the Milky Way in Auriga and Gemini, and on the other side between Aquila and the sting of the Scorpion. This distribution of the stars to the 11th magnitude does not correspond to the distribution of light in the Milky Way; this light is feeblest in Perseus and becomes brighter in Auriga, and on the other side the bright patches in Aquila, Scutum, and Sagittarius shine through the thin layer of 11th magnitude stars. Where the density in the galactic zone is least the void spaces around the galactic poles reach farthest to the Milky Way; on the northern side a region with density < 10 extends from Arcturus to the forelegs of Ursa Major, and on the southern side a most curious isolated void space lies in Taurus and Aries immediately on the western border of the Milky Way. On the opposite side, in Sagittarius and Ophiuchus, this phenomenon is less clearly indicated.

We get a still better picture of the peculiarities in the distribution of the stars if we eliminate the decrease to the galactic poles by comparing the observed densities not with an equal distribution but with a spheroidal star system, where the density depends only on magnitude and galactic latitude. With the limiting magnitude 11·38 we take from Van Rhijn's table iv. the normal density (log N) for each latitude; the deviations of the logarithms of the real densities from these normal log N are inserted in Table II. in the last column. The distribution of these numbers over the sky show the anomalies in the real distribution of the stars, compared with the typical oblate star system.

If we plot them on a globe and draw isanomalous lines (see fig. 1) we find two opposite regions of deficiency, one greater, extending from the celestial North Pole over Orion and Argo to the South Pole, the other smaller, covering Ophiuchus, Aquila, Sagittarius, Scorpio, and Lupus. They are separated by a zone of surplus density; in it the regions of greatest excess lie, of course, in the Milky Way, one in Cygnus-Lacerta, the other on the other side, south of the Cross and in Musca. Other less-marked regions of excess lie in Virgo, near Fomalhaut, and in the southern part of Eridanus. In each of the regions of deficiency lies a centre of greatest defect, one in Taurus ($\alpha = 65°$, $\delta = +25°$), the other in Ophiuchus ($\alpha = 250°$, $\delta = -10°$), nearly opposite to each other. The first is the remarkable region at the border of the Milky Way,

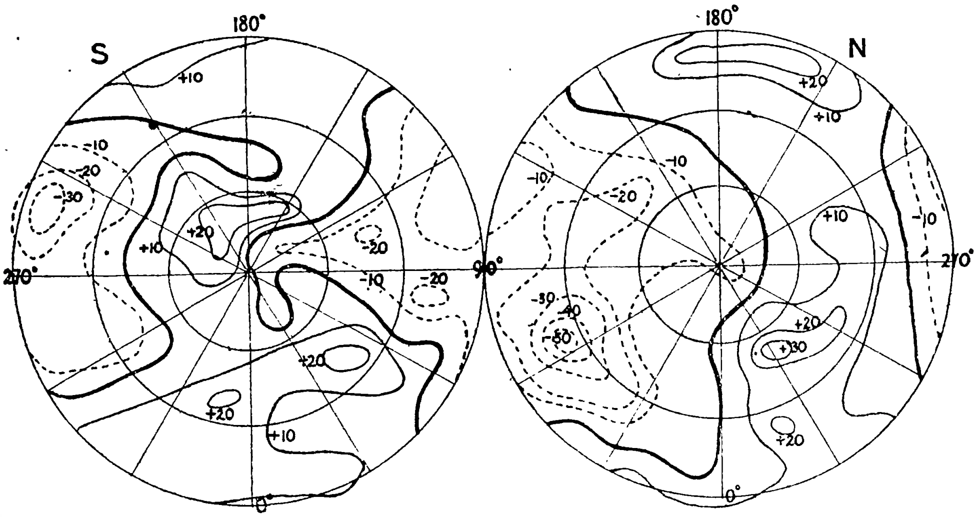

Fig. 1.

already noted above, where the density is only $\frac{1}{3}$ of what it should be in a regular universe; the other is somewhat less deep.* They appear like funnel-shaped pits in the flattened star mass. If we represent the distribution of these stars by the irregular surface

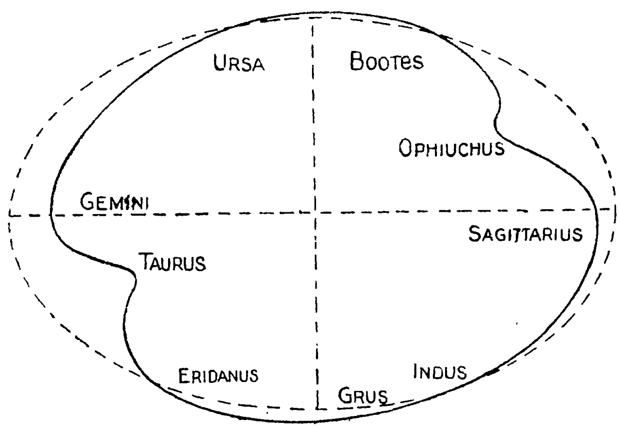

Fig. 2.

of a star cloud with equal volume-density throughout—thus making each radius proportional to the cube root of the number of stars,—its cross-section takes the shape of fig. 2.

* Both are also clearly indicated on the Catalogue plates of the Carte du Ciel, *cf.* Frederick Seares, "The Galactic Condensation," table vi. and fig. 2 (*Ap. J.*, **46**, 131–133). From a separate count we found afterwards the centre of the first to be at $\alpha = 68°$ $\delta = +27°$, with a star density only one-eighth of the normal density.

It is clear that this distribution cannot in any way be represented by a three-axial ellipsoid; the deviations from the oblate star spheroid bear quite another character. We need not take account here of the maxima of excess, for they are local features and are connected with the remote star clouds of the Milky Way itself. After the oblateness along the galactic plane as the first great deviation from equal distribution there remain, as the second systematic deviation, the two opposite regions of paucity, that arrange themselves around the funnel-shaped pits in Taurus and Ophiuchus as their cores. From these cores the lack of stars spreads itself wide around, and causes the small star density in the neighbouring parts of the Milky Way, which appeared in the formulæ above as the terms with 2λ. Their influence is not symmetrical on all sides: the variation is steep and sudden at

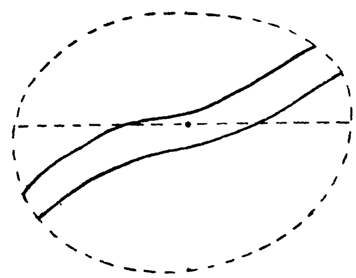

Fig. 3.

the western side, away from the Milky Way; on the other side it is gradual, and extends far across the Milky Way.

6. To explain this remarkable anomaly in the regular distribution of the stars, we may connect the Taurus pit with the nebulosities revealed by photography in the region of the Pleiades. We must then assume that in Taurus extensive dark nebulous matter, of which the brightest luminous parts are visible around the stars of the Pleiades, obscures the far removed stars; these absorbing masses must stretch themselves, gradually thinning out, across the Milky Way, over a great part of the sky from pole to pole, thus causing a general lack of stars in these regions. Then we must assume the same for the Ophiuchus pit, and perhaps the remarkable bright and dark nebulosities photographed by Barnard in Scorpio are the densest outlying parts of this nebulous matter. In this explanation it is mere accident that the two strongest darkened regions lie opposite to each other; they have no physical connection. Another difficulty lies in the fact that we find the brightest clouds and patches of the Milky Way just in the regions of Scutum and Sagittarius that should be obscured by near absorbing nebulosity.

Another explanation may be found in the supposition that a dark lane, a channel with small star density, pierces the star cloud around our sun in the direction of these pits. Then we will see a lack of stars in two opposite directions. By assuming the channel somewhat curved and the sun out of its axis (as in fig. 3), we may explain why the funnels lie unsymmetrically in the regions of deficiency and are not exactly opposite to each other. But it is useless to go into such details before the results of the Harvard Map are either confirmed or corrected by other data.

Summary.

1. The star densities given by Dr. Nort in his memoir and used by Mr. Plummer are not homogeneous.

2. By multiplying them by the coefficients given in Table I. they are reduced to a homogeneous system that affords the best material now available to study the distribution of the stars to the 11th magnitude.

3. Next to the regular decrease with galactic latitude the mathematical analysis shows a variation with the galactic longitude, especially a term with 2λ, which indicates a three-axial ellipsoid as the figure of our star system.

4. By plotting the logarithmic deviations from a star density regularly decreasing with galactic latitude, the cause of this variation becomes manifest. Two regions of deficiency are shown, arranged around two opposite spots in Taurus and Ophiuchus, where the star density is only $\frac{1}{3}$ of the normal density or still less. They may be explained by extensive absorbing nebulosities or by a dark channel traversing our star system.

Preliminary Note on the Application of Photoelectric Photometry to Astronomy. By A. F. and F. A. Lindemann.

Some ten years ago Elster and Geitel suggested that photoelectric phenomena would form a useful means of comparing the light received from different sources. This suggestion was first put into practice for astronomical purposes by Rosenhain and Meyer at Tübingen, and by Guthnick at the Babelsberg Observatory. Since no details of their work are to hand, a description of the methods which had been developed successfully at the Sidholme Observatory may prove of interest to astronomers, even though the weather has prevented the taking of more than a few preliminary observations. There are a number of problems of considerable interest which cannot be adequately studied by the usual photometric arrangements. The photoelectric method combines comparatively high accuracy with the advantage of being applicable to most diverse conditions. Since it does not necessitate a very good lens or mirror or a very accurate clock, it is hoped that it will be widely adopted once its simplicity and reliability are realised.