of field. That field consists of forces touching concentric circles and great $\frac{1}{\sin r}$.

P o s t s c r i p t. In the formula for vector fields in hyperbolic spaces:

$$Pot.\ X = \int \frac{\overline{\nabla}^2 X}{k_n} F_1(r)\, d\tau + \int \frac{\overline{\nabla}^1 X}{k_n} F_2(r)\, d\tau$$

nothing for the moment results from the deduction but that to $\overline{\nabla}^2 X$ and $\overline{\nabla}^1 X$ also must be counted the contributions furnished by infinity. From the field property ensues, however, immediately that the effect of these contributions disappears in finite, so that under the integral sign we have but to read $\overline{\nabla}^2 X$ and $\overline{\nabla}^1 X$ in finite..

For the $\overline{\nabla}^1$ at infinity pro surface-unity of the infinitely great sphere is $<$ order e^{-r}; the potential-effect of this in finite becomes $<$ order $re^{-(n-2)r} \times e^{-r} = re^{-(n-1)r}$; so the force-effect $<$ order $e^{-(n-1)r}$; so the force-effect of the entire infinitely great spherical surface is infinitesimal.

And the $\overline{\nabla}^2$ at infinity pro surface-unity is $<$ order $\frac{1}{r}$; it furnishes a potential-effect in finite $<$ order $e^{-(n-1)r} \cdot \frac{1}{r}$, thus a force-effect $<$ order $e^{-(n-1)r} \cdot \frac{1}{r^2}$; so the force-effect, caused by the infinite, remains $<$ order $\frac{1}{r^2}$.

The reasoning does not hold for the force field of the hyperbolical Sp_2 in the second interpretation (see under B § VIII), but it is in the nature of that interpretation itself that the derivatives at infinity are indicated as such, therefore also counted.

Meteorology. — "*On Magnetic Disturbances as recorded at Batavia.*" By Dr. W. VAN BEMMELEN.

(Communicated in the meeting of September 29, 1906).

Some months ago Mr. MAUNDER of the Greenwich-Observatory addressed a request to the Batavia Observatory to provide him with a list of magnetic storms recorded at Batavia with a view of testing his results as to the influence of the synodic rotation of the sun to the occurrence of disturbances.

Mr. MAUNDER concludes from an inspection of the disturbances recorded at Greenwich (and also at Toronto) that they show a tendency to recur after a synodic rotation of the sun and that sometimes even two and more returns occur. His conclusion is:

"Our magnetic disturbances have their origin in the sun. The solar "action which gives rise to them does not act equally in all directions, "but along narrow, well defined streams, not necessarily truly radial. "These streams arise from active areas of limited extent. These active "areas are not only the source of our magnetic disturbances, but "are also the seats of the formation of sun-spots."

As soon as I could find the necessary leisure I prepared a list for the period 1880—1899, containing 1149 disturbances and immediately after made some statistical calculations based on them.

A discussion of such statistical results is always better made by the author of the list, than by another person for whom it is impossible to consult the original sheets.

Though intending to publish the list, statistics and some reproductions in full, I wish to give a preliminary account of my results, because these questions are now of actual importance.

Rules followed in preparing the list.

An exact definition of what is understood by the expression "magnetic storm" has never been given; certain features however are characteristic to it, viz:

1. The sudden commencement.
2. The postturbation.
3. The increased agitation.

Concerning the second, which I called the postturbation [1]), the well known fact may be remarked, that during a storm the *mean* level of the components of the force changes, till a maximum digression is reached, and afterwards returns slowly to its old value.

In 1895 I called attention to this phenomenon and investigated its distribution over the earth.

This research enabled me to give the following description of the postturbation.

During a magnetic storm a force appears contrary to the earth's ordinary magnetic force, with this difference, that its horizontal component is directed along the meridians of the regular part of the earth's magnetism, consequently not pointing to the magnetic pole, but to the mean magnetic axis of the earth.

[1]) Cf. Meteorologische Zeitschrift 1895, p. 321. Terrestrisch Magnetisme I p. 95, II 115, V 123, VIII 153.

In accordance with this description, during the earlier part of a storm the horizontal force diminishes, the vertical force increases, and during the latter part these forces resume slowly their original values. The characteristic features sub 1 and 2 either do not necessarily attend every storm, or if so, they do not show themselves clearly enough to enable us to decide definitely whether a succession of waves in a curve must be considered as a storm or not.

On the contrary the increased agitation is an essential feature and has therefore been adopted by me as a criterion.

Unfortunately it is impossible to establish the lowest level above which the never absent agitation may be called a storm, because the agitation is not only determined by the amplitude of the waves, but also by their steepness and frequency.

To eliminate as much as possible the bad consequences which necessarily attend a personal judgment, the list has been prepared:

1. by one person;
2. in as short a time as possible;
3. from the aspect of the curves for one component only (in casu the horizontal intensity, which in Batavia is most liable to disturbance);
4. for a period with nearly constant scale-value of the curves (1 mm. = ± 0,00005 C.G.S.);

For each storm has been noted:

1. the hour of commencement;
2. „ „ „ expiration;
3. „ „ „ maximum;
4. the intensity.

Mr. MAUNDER calls a storm with a sudden start an S-storm; analogously I will call one with a gradual beginning a G-storm. In the case of a sudden impulse the time of beginning is given to the tenth of an hour; in that of gradual increase of agitation only by entire hours.

The hour of beginning of a G-storm is not easy to fix. I have chosen for it the time of the very beginning of the increased agitation, and not the moment in which the agitation begins to show an unmistakable disturbance character.

Afterwards it became clear I had shown a decided preference for the even hours, which may be accounted for by the fact that only the even hours are marked on the diagrams.

To eliminate this discordance I have added the numbers of G-storms commencing at the odd hours for one half to the preceding and for the other half to the following hour.

Because a storm as a rule expires gradually, it is often impossible to give the exact moment it is past. If doubtful I have always taken the longest time for its duration; hence many days following a great storm are reckoned as being disturbed, which otherwise would have passed as undisturbed.

For the time of the maximum I have taken the moment of maximum agitation, which does not always correspond with the hour of maximum postturbation.

I believe the hour at which the mean H-force reaches its lowest level is a better time-measure for the storm-maximum, but to determine it a large amount of measuring and calculating is required, the change in level being often entirely hidden by the ordinary solar-diurnal variation.

The intensity of the storm has been given after a scale of four degrees: 1 = small; 2 = moderate; 3 = active; 4 = very active.

It is not possible to give a definition of this scale of intensity in words, the reproduction of typical cases would be required for this.

Hourly distribution of the beginning of storms.

It is a known fact, that the starting impulse is felt simultaneously all over the earth. The Greenwich and Batavia lists furnished me with 53 cases of corresponding impulses, which, if the simultaneity is perfect, must enable us to derive the difference in longitude of the two observatories.

I find in	6	cases	$7^h 12^m$
„	19	„	7 0
„	28	„	7 6
		Mean	$7^h\ 7^m 15^s$

True difference $7^h 7^m 19^s$.

It it very remarkable indeed to derive so large a difference of longitude with an error of 4 seconds only, from 53 cases measured roughly to 0.1 hour.

The simultaneity should involve an equal hourly distribution if every *S*-impulse were felt over the whole earth. As this is not the case, which is proved by the lists of Greenwich and Batavia, it is easy to understand that the Batavia-impulses show indeed an unequal hourly distribution. We find them more frequent at 6^h and 10^h a. m. and 7^h p. m.

Hourly distribution of *S*-impulses.

Hour	Number in %	Hour	Number in %
0 a. m.	4.1	noon 12	4.7
1	2.5	13	5.0
2	3.0	14	3.3
3	2.2	15	3.9
4	4.1	16	4.4
5	3.9	17	3.6
6	6.3	18	4.1
7	4.5	19	5.5
8	5.1	20	3.6
9	5.8	21	3.9
10	6.1	22	3.6
11	5.0	23	3.3

This same distribution we find again in the case of the *G*-storms, but much more pronounced; a principal maximum at about 8^h a. m., and a secondary one at 6^h p. m.

Accordingly the hour of commencement of the *G*-disturbances is dependent upon the position of the station with respect to the sun, and it seems, that the hours most appropriate for the development of a *G*-disturbance also favour the development of an *S*-impulse.

Hourly distribution of the commencement of G-storms (in %).

Hour	0	2	4	6	8	10	noon 12	14	16	18	20	22
Intensity: 1	6.0	6.0	5.1	6.7	18.7	17.9	7.4	4.7	6.0	8.0	6.5	7.1
» 2	4.5	4.9	4.2	5.7	20.8	16.4	7.3	5.6	5.4	9.2	8.4	7.6
» 3 and 4	7.1	3.5	4.3	7.5	18.5	13.4	3.9	5.5	5.1	9.1	11.8	10.2
All	5.4	5.1	4.6	6.3	19.7	16.5	6.8	5.2	5.6	8.7	8.3	7.8

Hourly distribrution of the maximum (in °/₀).

	Hour	0	2	4	6	8	10	noon 12	14	16	18	20	22
S-storms.	Intensity 1	11.5	6 7	5.5	1.8	4.7	12.8	12.6	5.3	6.1	6.1	10.9	16.2
	» 2	16.9	9.1	5.9	1.2	1.4	7.3	7.6	3.9	7.6	10.8	13.5	15.2
	» 3 and 4	11.2	4.0	2.4	1.6	0.8	4.0	7.2	6.8	12.0	13.6	17.2	19.2
	All	14.1	7.4	4.9	1.5	2.4	8.6	9 2	4 8	7.8	9.7	13 3	16.3
G-storms.	Intensity 1	12.3	16 7	10.9	5.8	4.3	13.8	5 8	2.9	2.9	5.1	10.1	9.4
	» 2	11.3	7.7	3.6	5.6	3.3	8.5	11.3	8.5	6.1	5.2	14.1	14.9
	» 3 and 4	12.2	9.3	5.8	3.2	3.5	7.7	9.0	6.4	8.0	7.7	10.3	17.0
	All	11.9	10.2	6 0	4.6	3.6	9.2	9 2	6.5	6 3	6.3	11.6	14.8

These hourly numbers show for each intensity, and for both kinds of storms the same, strongly marked distribution over the hours of the day.

Thus the development of agitation during a storm is dependent on the position of the sun relatively to the station in a manner which is the same for S- and G-storms.

The period has a principal maximum at 10^h p. m. and a secondary one at noon; and being compared to the diurnal periodicity of the commencement of G-storms, it is evident, that: *On the hours when the chance for a maximum-agitation begins to increase, we may expect most storms to take a start.*

Hence we may come to the following supposition.

The susceptibility of the earth's magnetic field to magnetic agitation is liable to a diurnal and semidiurnal periodicity. Whatever may be the origin of the increase of agitation, sudden or gradual, this periodicity remains the same.

This was the same thing, that was revealed to me by the inspection of the hundreds of curves in preparing the list.

The agitation rises at about 8^h a. m. after some hours of great calm and reaches a maximum at about noon. A second period of calm, less quiet however than in the early morning, is reached in the afternoon, and a second rise follows till a maximum is attained shortly before midnight.

The day-waves however are smaller and shorter, the night-waves larger and longer and also more regular in shape. These regular night-waves are often restricted to one large wave, very suitable for the study of these waves.

Hourly distribution of the end of the storm.

Hour	Number of cases	Hour	Number of cases
0 a. m.	163	12	66
2	172	14	60
4	204	16	43
6	140	18	50
8	60	20	46
10	36	22	49

Quite in agreement with the above mentioned conclusions, the curve representing the diurnal periodicity of the final-hour is nearly the reverse of that for the maximum.

Evidently the hour 0 (the end of the day) has been strongly favoured.

Resuming we may according to the Batavia disturbance-record draw the following conclusions:

1st. *the origin of* S-*storms is cosmical*;

2nd. *the origin of* G-*storms may be also cosmical, but the commencement is dependent on the local hour;*

3rd. *the development of all storms, concerning the agitation, is in the same way dependent on the local hour.*

Storms and sunspots.

In the following table the year has been reckoned from April 1s till April 1st of the following year, with the exception of 1882, the diagrams for the months Dec. '82, Jan.—March '83 missing. For 1880—'83 the yearly numbers have been increased in proportion to the number of missing record days.

Numbers in °/₀.

Year	Sunspot number	Intensity							
		1		2		3 and 4		All	
		S	G	S	G	S	G	S	G
1880/81	37.5	2.7	4.2	1.5	6.6	1.2	2.3	1.6	5.1
81/82	56.9	1.4	6.7	0.0	5.9	1.2	2.3	0.8	5.6
82	70.8	1.4	2.8	5.3	6.6	13 0	6.1	7.9	5.2
83/84	68.8	6.8	7.8	7.5	5.4	6 9	5.3	7.1	6.2
84/85	59.5	2.7	4.6	9.8	6.4	9.3	6.1	8.2	5.7
85/86	45.7	4.1	1.4	9.8	4.1	10.6	6.9	9.0	3.6
86/87	19.6	0.0	1.1	2.3	5.9	1.9	7.6	1.6	4.5
87/88	11.6	2.7	7.8	3.0	4.3	3.7	4.6	3.3	5.6
88/89	6.4	5.4	5.7	4.5	4.1	2.5	3.1	3.8	4.5
89/90	5.9	10.8	4.9	5.3	3.3	1.2	4.6	4.6	4.1
90/91	13.0	13.5	8.1	2.3	3.8	0.6	3.1	3.8	5.2
91/92	47.4	6.8	4 6	5.3	5.1	6.9	8.4	4.7	5.5
92/93	74.5	9.5	6.4	8.3	3.3	12.4	4.6	10.3	4.6
93/94	85.2	9.5	6.0	9.0	3.8	11.8	5.3	10.3	4.8
94/95	74.2	5.4	4.6	8.3	7.7	3 7	6.9	5.7	6.5
95/96	57.4	6.8	5.3	5.3	6.9	5.0	8.4	5.4	6.6
96/97	38.7	4.1	4.2	5.3	5.4	2.5	3.1	3.8	4.6
97/98	26.5	4.1	5.3	3.0	5.4	3.7	7.6	3.5	5.7
98/99	22.9	2.7	8.5	4.5	5.9	1.9	3.8	3.0	6.5

From these numbers it appears that those for the G-storms show no correspondence with the sunspot-numbers, also that those for the S-storms show a correspondence which is emphasised according as the intensity increases, and finally that the S-storms show a maximum when the G-storms have a minimum and the reverse.

This latter fact is apparently caused by the circumstance of the storms hiding each other, the G-storms being eclipsed by the S-storms in a higher degree during greater activity of the sun, than the S-storms by the G-storms. Indeed a simple inspection of the diagrams shows that the agitation of G-storms is greater during a sunspot maximum, than in minimum-years. Also in maximum-years the S-storms of intensity 1, are hidden by their stronger brothers to such an extent, that the eleven-yearly periodicity is nearly the reverse for them.

Annual distribution of S- and G-storms.
(Only the uninterrupted period April 1, 1883—April 1, 1899 has been considered).

Month	Numbers	
	S.	G.
January	31	54
February	31	53
March	29	60
April	24	57
May	24	61
June	27	51
July	31	61
August	29	47
September	32	55
October	31	64
November	22	58
December	18	58

A strong difference in behaviour between G- and S-storms can be noticed. The G-storms have no annual periodicity as to their frequency, whereas the S-storms show a strong one.

This points, just like the daily periodicity of commencement, either to a different origin, or to a changing tendency of the development of the S-impulse during the day and year.

Comparison with Greenwich-storms.

MAUNDER derives from the reproduction of storms published in the volumes of the Greenwich Observations a maximum at 6^h p. m. and from the original recording-sheets on the contrary at 1^h p. m. The cause of this discrepancy he finds in the manner he looked for the commencement. He writes: "the times when the phases of diurnal disturbance are most strongly marked are naturally most often taken as the times of commencement."

At Greenwich these phases of agitation are most prominent at 1^h p. m. and 6^h p. m.

As I assumed for the hour of beginning the first increase of agitation it is clear my times of beginning are on an average much earlier.

Thus the difference shown by the hourly distribution of commencement between the Greenwich- and the Batavia-list, may be ascribed chiefly to difference of interpretation.

As appears from the figures given above, compared with those for Greenwich the annual periodicity is quite the same for both the northerly and the equatorial stations, which differ no less than 60 degrees in latitude. But the Greenwich dates, quoted from a complete magnetic calendar, prepared by Mr. Ellis and extending from 1848 to 1902 give no separation of G- and S-storms. Thus it is not possible to decide whether at Greenwich the G-storms lack an annual periodicity in their frequency.

The impulse at the start.

The material at present at my disposal for investigating the features of this phenomenon in other places on earth, is very small.

Notwithstanding this I may conclude: *that this phenomenon is of great constancy in features all over the earth, and consequently a phenomenon of great interest, which might teach us much about the manner the S-storms reach the earth.*

Description of its features for some places.

Greenwich. According to the reduced reproductions of disturbance-curves published in the volumes of the Greenwich-Observations, the impulse consists of a sudden movement in H, D and Z, instantly followed by the reversed movement, the latter being considerably greater. The direction of the movement is always the same.

I have measured 34 cases and have found on an average:

H Δ D	Δ H	Δ Z	
25 γ W	$+ 77\,\gamma$	$+ 39\,\gamma$	($1\,\gamma = 0.00001$ C.G.S.).

Batavia. The preceding impulse is missing for H and Z, only for D it is often present.

Here also the direction of the movement is constant.

35 cases for the years 1891 and '92 gave on an average for the magnitude of digression $H\Delta D = 9\gamma W$; $\Delta H = +45\gamma$; $\Delta Z = -16\gamma$.
duration „ „ 3.5 min.; 5 min.; 12 min.

Though the movement of H and D are not sudden in absolute sense, that for Z is too gradual to justify the application of the word sudden to it.

The reproductions of disturbance-curves for Potsdam and Zi Ka Wei also show some cases of the preceding impulse. At both stations the direction of the movement is remarkably constant. In the publications of the Cape Hoorn observations (1882/83) I found three cases exposing also a constant direction.

Summarizing them, we have:

Station	H	D	Z
Potsdam	+	W	—
Greenwich	+	W	+
Zi Ka Wei	+	E	—
Batavia	+	W	—
Cape Hoorn	+	W	—

Consequently with one exception for D and one for Z we find that: *the commencing impulse of the S-storms is the reverse of the vector of postturbation, being deflected however to the West of it.*

Suppositions concerning the origin of disturbance.

The hypothesis on the existence of defined conical streams of electric energy, which strike the earth, though not quite new, has obtained increased plausibility by MAUNDER's results. From the statistics based on the record of disturbances at Batavia it might be concluded that it is chiefly the S-storms that find their origin in the sudden encounter of the earth with such a stream.

And as the earth is first struck at its sunset-arc, it is not impossible that the G-storms, which begin by preference shortly after sunrise and have no annual periodicity in their frequency as the S-storms have, are only partly caused by these encounters.

When in the case of the streams we admit that energy progresses from the sun in the form of negative electrons, we might think the G-storms find their origin by electrified particles being propagated by the light-pressure according to the theory set forth by Sv. ARRHENIUS.

Further we may suppose, that when the earth has received a charge the following development of the storm is the same as it is dependent on the local hour only. ARRHENIUS has already given an explanation of the nocturnal maximum.

In recent times it has often been attempted to explain magnetic fluctuations by the movement of electric charge through the higher layers of the atmosphere. (SCHUSTER, VAN BEZOLD, SCHMIDT, BIGELOW).

The remarkable analogies which are met with in many cases between the streamfield of atmospherical circulations and the fields of magnetic fluctuations, lead to such speculations.

I believe it is allowed to hazard analogous speculations concerning the cause of the beginning of impulse and postturbation.

We may suppose the streams to contain negative electrons. When they strike the earth the outer layers will be charged with negative electricity. These outer layers do not rotate in 24 hours, but in a longer time increasing with their height.

So a countercurrent of E—W direction charged with negative electrons will originate, causing an increase of H and a decrease of Z. The electrons, however, on entering the magnetic field of the earth, will follow the lines of force towards the magnetic south pole (the positive pole). The movement of negative electrons along the lines of force has been fairly well proved, as is well known, by the auroraravs.

By this movement, the current of electricity will become NE—SW and a westerly deflecting S-impulse will be the consequence.

The sudden charge of the extreme layers of the atmosphere with negative electricity, will attract the positive ions, with which the high layers may be supposed to be charged, to still higher layers.

These positive ions will thus enter into a faster moving counter current, and a positive charged counter current will be the consequence.

These ions will move along the lines of force towards the north, but much slower than the negative electrons, and therefore the resulting deflection of the magnetic force caused by such a + current viz. a force contrary to the ordinary one, will be of no appreciable magnitude. It is conceivable that the effect, which accordingly is in the same sense as the postturbation, will develop in a more gradual manner than the commencing impulse of the S-storms; moreover we may understand that it disappears still more gradually in proportion as the negative electrons again leave the earth or are neutralised by positive ions.

Only we should expect the current to follow the latitude-parallels and accordingly the vectors of postturbation to point to the true south and not to the southerly end of the earth's mean magnetic axis.

Perhaps we may find an explanation for this fact in the influence no doubt exerted by the earth's mean magnetic field and the distribution of positive ions in the atmosphere.

These speculations are indeed very rough, but they have one great advantage, viz. to avoid the difficulty, raised by Lord KELVIN, of allowing an expenditure of the sun's energy causing magnetic disturbances, much too great to be admitted.

CHREE (Terr. Magnet. X, p. 9) points to the fact, that also MAUNDER's defined streams require far too great an expenditure of energy.

According to my opinion we have only to deal with the charge received at the moment of the impulse, and by accepting an intermittent emission of the sun's energy, it is not necessary to integrate it over the entire time between one or more returns of the stream.

Part of the energy is also supplied by the rotation-energy of the earth; and it is curious to remark, that by such an influence the rotation of the earth would be lengthened for a minute fraction during a magnetic storm.

Chemistry. — *"Nitration of meta-substituted phenols"*. By Dr. J. J. BLANKSMA. (Communicated by Prof. HOLLEMAN).

(Communicated in the meeting of September 30, 1906).

Some years ago[1]) I pointed out that by nitration of meta-nitrophenol and of 3-5-dinitrophenol tetra- and pentanitrophenol are formed. This showed that the NO_2-groups in the m-position do not prevent the further substitution of the H-atoms in the o- and p-position by other groups. I have now endeavoured to increase these two cases by a few more and have therefore examined the behaviour of some m-substituted phenols which contain, besides a NO_2-group in the m-position, a second group in the m-position, namely of

$$C_6H_3 . OH . NO_2 . (CH_3,OH,OCH_3,OC_2H_5,Cl,Br) \ 1 . 3 . 5.$$

Of these phenols the 5-nitro-m-cresol[2]) and the monomethylether of 5-nitroresorcinol[3]) were known. The still unknown phenols were made as follows:

The 5-nitroresorcinol (m.p. 158°) from its above cited monomethylether by heating for five hours at 160° with (30°/₀) HCl, or by reduction of 3-5-dinitrophenol with ammonium sulphide to 5-nitro-

1) These Proc. Febr. 22, 1902. Rec. **21**. 241.

2) NEVILE en WINTHER Ber. **15**. 2986.

3) H. VERMEULEN Rec. **25**. 26.