an equal pull with that of the Sun, but only a pull equal to the difference of the amount of the Sun's pull upon Earth and Moon at the moment, and this difference of the Sun's pulls is always much less than the whole attraction which the Earth is able to exert upon the Moon. Both Earth and Moon fall towards the Sun together, this falling motion, of course, being combined with any other intrinsic motions which Earth and Moon may possess at the time. When it is New Moon, she is $\frac{1}{389}$th nearer the Sun than is the Earth. The Sun's disturbing influence then makes the Moon fall towards himself slightly faster than the Earth, the Earth's attraction on the Moon is thus diminished for the time being, and the Moon's curvature towards the Earth is diminished, and increased towards the Sun. At half Moon or quadratures, when Earth and Moon are at equal distances from the Sun, the Sun is pulling the Earth and Moon towards himself with equal force indeed but on converging lines, and thereby reinforcing the Earth's attraction on the Moon, rendering the Moon's orbit at quadratures rather more curved towards the Earth, than it would have been if there were no Sun disturbing her true elliptical orbit. The Earth's attraction on the Moon is thus weakened at Syzygies and reinforced at Quadratures, much in the same way as the tides are drawn away from the centre of the Earth, when in a line with the Moon's attraction (disregarding the effects of friction), and pulled towards the Earth's centre when at right angles to the line of the Moon's attraction. The force is directed away from the Earth, or the Earth's attraction is diminished at Full Moon as well as New Moon, because the Sun then attracts the Earth a little more than he attracts the Moon, thereby tending to separate them. Whilst the Sun is the only body which is able sensibly to disturb the Moon's elliptical motion by his direct action the planets do so indirectly, by disturbing the Earth's orbit and therefore slightly modifying the ratios of the distance of Sun, Earth and Moon. But before we enquire into the effects of the planets' attraction upon the Moon's orbital motions, we will first give our attention to the disturbances caused by the Sun alone. [*To be continued.*]

Extracts from Publications.

Planet M. T.

The mean distance of Eros from the Sun is 1,458, that of Mars 1,524, the mean distance of the Earth from the Sun being unity. When the small planet M. T. was discovered, in 1911, it was seen that an orbit with the same perihelion distance as Eros and a slightly greater eccentricity, would satisfy the observations; but the observations have been so scanty that no satisfactory orbit has been determined. In the number of the Pub. Ast. Soc. Pac., from which the above paragraph is quoted, there happens to be an article by Mr. Haynes, also of California, who after describing the difficulties experienced in making observations of the planet, and, therefore, in computing an ephemeris, writes:—

"A very unfavourable opposition of 1911 M. T., occurred some time early in the present year. The brightness was in the neighbourhood of the twentieth magnitude. Dr. Curtis, of the Lick Observatory, kindly offered to make a search for the planet with the Crossley reflector, and ephemerides based upon the most probable orbit were furnished him. During the course of his observation he discovered three minute planets in the immediate neighbourhood of the positions indicated by one of the ephemerides. Enough observations of all three were secured to render it certain that none were identical with 1911 M. T. This failure to find the planet does not justify the rejection of the orbit upon which the search was based, because the predicted magnitude is very uncertain, and the planet may have been in the region photographed, but too dim to be reached even by the Crossley. A more favourable opposition will occur in 1915, and it is hoped that the planet may be recovered at that time."

[*English Mechanic and World of Science.—Oct. 31, 1913.*]

British Astronomical Association.

The President (Colonel Markwick) delivered the twenty-third presidential address at the annual meeting of the British Astronomical Association on October 29th at Sion College, taking for his subject the work of the observing sections since the foundation of the Association. Of these sections, now fourteen in number, the output for publication has filled seventy-five memoirs, containing more than 3,000 pages; but more than one-third has been filled by two sections—the Sun and Variable Stars—while just over another third has been contributed by Jupiter, Mars, and Meteors.

In view of Professor Pickering's dictum as to the small amount of valuable research open to the amateur with small instruments, Colonel Markwick drew special attention to several points on which further research is badly wanted. We still do not know the nature of sunspots, nor what the surface of the Moon is, nor the rotation periods of Mercury and Venus ; and for all these problems work can be done by the amateur, in addition to the field allowed him by Professor Pickering in photometry, specially of variable stars, and the attractive regions of comet-seeking and double star measures. The work of the Association is recognised as quite valuable by such an authority as Professor W. H. Pickering, at present working in Jamaica, who desires to collaborate with M. Antoniadi of Meudon Observatory, who is Director of the Mars Section of the British Astronomical Association. Work is required especially for the sections that have not yet produced much, such as that of Aurora and Zodiacal Light, and especially of Double Stars, many of Struve's wide pairs having been much neglected in consequence of the concentration of powerful telescopes on the closer pairs. The four eclipse expeditions of 1896, 1898, 1900 and 1905 give great hope of valuable work to be done or attempted at the forthcoming eclipse of 1914, August 20. In proposing a vote of thanks to the President, Mr. Knobel recalled, from personal experience, the abortive attempts at co-operation in observing the Sun, Moon and Jupiter in the years 1860 to 1880, before the foundation of the Association.

[*English Mechanic and World of Science.—Nov. 7, 1913.*]

The Annular Nebulæ in Lyra.

To " X " (586, p. 342). Mr. Burt Newkirk, of Minneapolis, in 1902, determined the parallax of the star at the centre of the Ring nebula in Lyra to be 0·10″, and found that it has a proper motion of 0·180″ per year in direction of positionable 303·7 degree. This was found from measures of the star with respect to a 12th-magnitude star outside the Ring made by Professor Burnham in 1891, by Professor Barnard in 1898, and by measures of photographs by Professor Leavenworth, supplemented by measures of this 12th-magnitude star with reference to stars around. A few years later Professor Barnard, to continue the investigation, repeated the measures of this central star with reference to the star outside, and these measures of 1903-04 did not verify the proper motion found by Mr. Newkirk, and as his determination of parallax depended on this proper motion, it seemed that the derived parallax must be fallacious. This was the opinion expressed by Professor Barnard in a paper in the "Monthly Notices" for 1906 January; but Mr. Newkirk replied later that his parallax determination was independent of the proper motion determination, and that he saw no reason to alter the value. It appears that the central star is considered to be part of, or rather the nucleus of, the nebula. I believe this is the only object of the class whose parallax has been determined; but I do not know on what grounds it is to be considered the nearest of the nebulæ.

[*English Mechanic and World of Science.—Nov. 14, 1913.*]

A Theory of Solar Phenomena.

The Sun is a liquid molten body, up to the level of spot nuclei, of a temperature between 6,000° and 7,000° absolute (compare my paper "The Constitution of the Sun," Astrophysical Journal, January 1909).

The liquid masses are of uniform density to great depth, which permits of an extended system of convection-current which are a necessity in every rotating fluid body contracting in consequence of cooling. In low latitudes, between 10° and 30°, the masses rise from the interior to the surface. A small portion turns against the Equator, there going down again; but the bulk streams, at the surface, to higher latitudes and is drawn in between 60° and the poles, returning to low latitudes in the depth. Superposed on this prime system are smaller convection-currents.

The Sun has an atmosphere as high as the highest prominences. The principal constituent of this atmosphere is coronium hydrogen, helium, and other gases and vapours forming but a small percentage.

The photospheric clouds, floating at a certain height above the liquid surface, and formed by the condensation of vapour rising from the liquid masses, just as terrestrial clouds are formed by the condensation of vapours rising from our oceans.

As to the density in the corona it has been asserted that there must be practically a vacuum, because comets had traversed that region without encountering there any resistance. That is an error. Comets 1843 I and 1881 I were discovered only after their perihelion, so that we cannot say whether they were disturbed or not. 1882 II was observed a week before perihelion, but here too we are unable to assert that it passed undisturbed for it had afterwards 3 nuclei, instead of 1 before. Further, 1843 I and 1882 II were visible on the day of perihelion (and only on that day) with the naked eye close to the Sun, a brilliancy quite unparalleled, which can only be explained by the assumption that the comets encountered there a resistance and blazed up as meteors do when entering our atmosphere.

Prominences are eruptions of coronium-gas, but not of hydrogen, helium and calcium, as they appear to be at first sight. A mass of gas, escaping from the liquid Sun, and entering the free atmosphere, must expand there, and is consequently cooling. But at the same time it must encounter in the atmosphere a certain resistance, which can be overcome only by compressing this atmosphere all round the expanding mass. Now compression of a gas makes its temperature rise.

The cooling by expansion or the heating by compression may be calculated from the formula :—

$$T_2 = T_1 \frac{(P_2)}{(P_1)} \frac{K-1}{K}$$

(K being 1 : 41 for gases like hydrogen).

It results, therefrom, that whenever the pressure diminished in the ratio 1 to 0·1 the absolute temperature falls in a ratio 1 to 0·51, or if the pressure increases the temperature goes up in the same ratio.

The coronium-gas, escaping from the liquid masses, expands and cools, and is surrounded by a zone of compression in the atmosphere ; this zone, therefore, is heated and thereby again becomes visible in the spectroscope in approximately the forms of the coronium-eruption, though the latter itself is not observed by us. We thus have an explanation why the spectra of the prominences and atmosphere are nearly identical. The cooling in the jets, which must originate under enormous pressure within the Sun, goes at great heights of the atmosphere very close to absolute zero.

Quiet prominences, which occur in all latitudes, are caused by the escape of gas over extended areas from small, but very numerous, bubbles. The eruptive prominences (jets, flames, or metallic prominences), only occurring in the spot-zones or near to them, are caused by the rapid emptying of very large bubbles, which, while still at a considerable depth below the surface, already have diameters of hundreds of kilometres.

One volume of water at 0° C. absorbs more than 1,000 volumes of ammonia-gas, thereby doubling its volume, and gives out the gas again at 100° C. Even under high pressure the volume of the free gas would exceed the volume of liquid water in which it had been absorbed. Moissan has shewn that molten iron in a similar way very strongly absorbs atmospheric gas, that on further heating this gas is again set free in a sort of effervescence, and that only after still further heating does the true boiling begin. Thus we may assume that the like process is possible at the still higher temperature of the liquid solar masses. Where these come up in low latitudes with the full temperature of the interior, absorption of the coronium will not take place. But the radiation causes a cooling, and now absorption takes place ; the masses become saturated with coronium-gas. The secondary similar convection-currents carry these masses now into the interior, where they become re-heated, and in consequence the absorbed gas is set free again.

With a density of only 1·1 in the outer layer, each metre exercises a pressure of 3 atm., 1,000 kilometres (only about $\frac{1}{700}$ths part of the radius) 3,000,000 atm., which great pressure in relatively small depths reduces the free gas to very minute bubbles, which remain nearly stationary in the surrounding liquid.

The setting free of absorbed gases is greatly facilitated by stirring or shaking the absorbing liquid. If the relatively feeble terrestrial earthquakes are often capable of causing an observable tremor of the entire globe, then we must conclude that, by the enormous eruptions which we often witness on the Sun, very extensive areas will suffer a shaking which causes the absorbed gas to be set free and (if not in too great depths) to rise to the surface, and there to cause quiet prominences. These masses thus become poor in absorbed gases, and, if they have wandered through the depth of the Sun, cannot cause prominence phenomena to a large extent on reaching the surface in low latitudes. Consequently there are few or no eruptions, the masses are not shaken and retain the absorbed gas, so that after due time large eruptions can take place again. In this way we may explain the periodicity of solar activity by means of the system of convection-currents.

When the free gas rises to the surface before it is drawn into the depth of the circulation, it cannot accumulate sufficiently into bubbles so large as we need to explain the great eruptions in the spot-zones. This accumulation, however, is possible when the gas is retained and has to go through the depth, and therefore the great eruptions or explosions, which are the cause (not a consequence) of spot-formation, only take place where the circulation comes to the surface, *i.e.*, in the spot-zones.

The pressure, which gives jets a velocity of hundreds of kilometres a second, must be enormous ; Zollner calculated it to be about 68 millions atm. for not excessive cases. In the great heights to which these eruptions are thrown up, the pressure will be but a fraction of an atmosphere. As these eruptions endure often only for a few minutes, the cooling of the expanding coronium goes very near to absolute zero ; the gas partly liquefies and even solidifies ; a fall of coronium-rain or snow pours down on the glowing ocean and causes there a sudden cooling of the liquid masses ; a spot is formed as a consequence of an eruption from the hot interior, but nevertheless as a product of cooling.

The spot—slag-island, as in Zollner's theory—lies imbedded below the photosphere, and a circulation commences above it, which goes outward below and inward at high levels.

The spots, floating on the liquid masses, must follow the drifts therein. Pursuing Carrington's researches in this respect, Sporer found for the period 1861 to 1880 the following latitude drifts of sun-spots :

Between	0° and 5°	...	0·00 km. per hour		Mean for both hemispheres.
,,	5° ,, 10°	...	5·27 ,, ,,		
,,	10° ,, 15°	...	0·75 ,, ,,		
,,	15° ,, 20°	...	3·58 ,, ,,		
,,	20° ,, 25°	...	11·86 ,, ,,		
Upwards of	25°	...	17·13 ,, ,,		

The mean length of a stream-line in the great convection-current may be estimated to be 2 million kilometres, and if a revolution lasts 11 years the mean velocity comes out about 2·0 kilometres an hour, much less than the above figures. Considering, however, that the velocity in the currents varies inversely as the widths of the cross-sections in its different parts, it is clear that the velocities must be less than the mean at the surface and greater in the depth.

The rotation-period of the Sun, increasing with the latitude, may be explained, firstly, by Faye's hypothesis; the masses are coming up from the depth, not in a perpendicular direction, but in an inclined one; and, secondly, in Zollner's view by a trade-wind-like circulation in the atmosphere. The temperature of the liquid globe being lower in high latitudes than it is near the Equator there must be such a circulation in the atmosphere increasing in intensity with the latitude. On the Sun there are no continents which interfere with the drifts originated by the trade winds, and they thus can develop far better than they do on the Earth.

Besides the actual drift of the spot-islands, there occurs also an apparent motion due to the trade-winds. As they are blowing strongest against the east shore with the full temperature of the normal surface, they must cause on this side a dissolution more rapid than that which takes place on the opposite side. The position of spots being deduced from their apparent centre only, the observer thus finds a greater displacement, after some time, than has actually occurred.

If a spot lasts for a longer time it is because it is renewed by subsequent eruptions. The accumulations of gas—the great bubbles—may be arranged at random, although on the average in a nearly straight line; they then will take place at the same locality as the first eruption. As, however, the spot has undergone a displacement in the meantime opposed to the rotation, it now suddenly jumps back to its former position—a fact which has been observed long ago.

20. That spot-formation of a new cycle always sets in at higher latitude is explained as follows:—Those masses, saturated with absorbed gas, which are drawn into the depth definitely already between 50° and 70° will rise again earlier, and in about 30° latitude, as compared with those which go to the interior only between 70° and 90°, and therefore reach the surface again later and in lower latitudes.

20. Absorption of the Sun's radiation can only take place at higher, and therefore cooler, levels. The higher levels therefore again must possess a greater content of energy than would correspond to the adiabatic curve. For this reason no cooling in low levels can be explained by descending currents; these would always arrive there hotter than their surrounding.

J. F. SHERM. SCHULZ.

Hamburg, October 1913.

[*The Observatory.—November 1913.*