about three feet thick, they retain for a long time the heat which they absorb during the day. The result is that there are layers of air of different temperature in the room at night." To improve fundamental astronomy, half a second of arc, he says, must be seriously taken into account, and this can only be done by employing a sound instrument and a properly-constructed observing-room, "and we have neither the one nor the other at the Cape nor at Greenwich. If we are going to fight for two-tenths or three-tenths of a second, we must set to work *de novo* with better instruments, better housed, for the determination of constant error."

THE LUNAR ATMOSPHERE.—Various are the methods that can be adopted for observing whether the moon has an atmosphere or not, but some of them, such as those that depend on solar eclipses, have been the least often attempted, since they are of an extremely delicate nature. In eclipses, whether partial or total, if the moon really had a moderately dense atmosphere, we should be able, by photographing the sun when partially covered by the moon, to note whether the delicate details on the solar surface in the region of the lunar limb had suffered any slight alterations in their forms. To note such variations it is needless to say that photography must be employed, and further that the photographs must be on a moderately large scale, for if indeed there be changes of form they will by no means be necessarily *very* apparent. For such observations as these no better scale could be used than that adopted by M. Janssen in those wonderful solar pictures that have done much to help us in extending our knowledge of the sun's surface. In fact M. Janssen, in *Comptes Rendus* for April 17 (No. 16) tells us that in order to try this method again several plates were exposed during the recent eclipse of the sun, but owing to the state of the sky the conditions were not very favourable, as these large photographs require a perfectly pure atmosphere. He mentions at the end of his note that he has already made some progress towards the solution of this question from the photographs that were taken at Marseilles during the partial eclipse of July, 1879.

GEOGRAPHICAL NOTES.

THE Berlin Geographical Society has awarded the Humboldt medal, the highest honour it can bestow, to Dr. John Murray, editor of the *Challenger* reports, in recognition of the great advances in physical geography which are associated with his name.

THE Paris Geographical Society has also awarded one of its gold medals to a foreigner, Dr. Fridjof Nansen. Other gold medals given by the Paris Society went to Captain Monteil, for his great journey to Lake Chad, M. Dybowski, for exploration on the Shari, and M. Lentheric for his monograph on the Rhone.

MR. GUY BOOTHBY has recently crossed Australia from north to south. He started from Normanton on the Gulf of Carpentaria in March, 1892, travelled leisurely on horseback or in a waggon to Bourke, and then descended the Darling in a boat, and later a river-steamer to Morgan, thence by rail to Adelaide. The journey occupied rather more than a year, and so far as appears little or no new country was traversed.

THE May number of the *Scottish Geographical Magazine* contains a paper on the people of the Lake Nyasa region, by Mr. D. J. Rankin, in which he makes some serious charges against Mr. H. H. Johnston, the British Commissioner. Mr. Rankin considers the rule of the commissioner to be too severe, and finds fault with his knowledge of the native tribes and their claims to the land.

MR. E. A. FLOYER has a long paper in the *Geographical Journal* on the Eastern Desert of Egypt, illustrated by some very characteristic pictures and a new map, the result of his surveys. The expedition of which he was the leader was sent out by the Egyptian Government in 1891, and surveyed 23,000 square miles of mountainous desert. The region is crossed by a ridge of high ground in the higher peaks of which a few shepherds find a precarious pasture for their flocks, which feed on the comparatively thick growth of acacias. The water-supply is in the form of natural reservoirs of rain, in many cases contained in limestone cavities which keep the wells supplied.

THE Columbus *fête* held in Paris on April 15, the 400th anniversary of the return of Columbus is reported at length in the current number of the *Revue de Géographie*, the main feature being an address by M. Ludovic Drapeyron, who presided. The novelty of such celebrations has passed, and it is difficult to see how the celebration of the fourth centenary of each episode of the life of Columbus after 1492 can be made serviceable to geography or of special interest to the public.

THE RECENT SOLAR ECLIPSE.

WE have already printed a number of telegrams relating to observations of the solar eclipse of April 16 in various parts of the world, and now reproduce from the *Nottingham Daily Guardian* of May 9 an article on the work of the British party in West Africa. This article is contributed by a special correspondent of that journal, who writes from H.M.S. *Blonde*, Las Palmas, April 28. It contains the first detailed information which has appeared on the subject. The writer says :—

The expedition left Liverpool on March 18 by the British and African Company's steamer *Teneriffe*, the company having most generously contracted to convey them to the Gambia at greatly reduced rates. Bathurst, near the mouth of the Gambia, was reached on March 31, when the observers and their instruments were at once transferred to H.M.S. *Alecto*, which had been kindly placed at the disposal of the expedition by the Admiralty. The *Alecto*, being specially designed for service on the West African rivers, was eminently adapted to the purposes of the observers, and, indeed, without some such aid the expedition would have been impracticable. On the afternoon of April 2 the *Alecto* proceeded with the observers to the Salum River, which lies some distance to the north of the Gambia, and Fundium was reached on the following morning. The village, by the way, is called Goundiougne by the French. The chief occupation in this part of Africa is the raising of ground nuts for export. On arrival it was found that M. Deslandres and a small staff from the Paris Observatory had already been at Fundium a fortnight, and had got most of their instruments into position. A neighbouring site, kindly offered to the British party by the Administrator, was at once accepted as satisfying all requirements. It had the advantage of being partially enclosed, and was quite near to one of the wharves, so that the instruments could be put ashore without difficulty. The land around Fundium is very flat, and a perfectly clear horizon was therefore obtained. The site having been selected, plans for the arrangement of the various instruments were at once drawn, and the concrete bases were laid down, the necessary cement having been brought from Liverpool. Huts for the instruments, which had likewise been brought from England, and the instruments themselves were also erected with the least possible delay. In this preliminary work Lieutenant-Commander Lang and his staff, with the readiness characteristic of the British Navy, gave the party all needful assistance.

As eclipse work was new to all the observers, with the exception of Prof. Thorpe, who was in charge of the expedition, the instrumental equipment was such as not to overtax any of them. Prof. Thorpe, assisted by Mr. P. L. Gray, was in charge of a 6-inch equatorial telescope, belonging to Greenwich Observatory, with the necessary accessories for determining the intensity of the light at different points of the corona. The photometer used was of the form in which the amount of light from a glow lamp necessary to cause the disappearance of a grease spot on a piece of paper was determined by measuring the strength of the electric current which illuminates it. A number of such spots were so arranged in the photometer that the image of the corona formed by the telescope fell upon them, while on the other side they were illuminated by a glow lamp, the whole, of course, being inside a dark box. I myself, representing Prof. Norman Lockyer, had the management of a 6-inch photographic telescope, provided with a large prism in front of the object glass for the purpose of determining the chemical constitution of the corona and prominences. With this method of work a separate image of each position of the corona or prominences is obtained corresponding to each kind of light which it emits, and this gives the clue to its chemical character. A duplex telescope for photographing the surroundings of the eclipsed sun was in charge of Sergeant J. Kearney, R.E., who has had the advantage of a long and varied experience in photographic matters.

The instrument was provided with two object glasses of 4-inch aperture, the tube carrying them having a partition down the middle. The image formed by one of the lenses was received directly on the photographic plate, but in the other case it was magnified about three times by one of Mr. Dallmeyer's new telephotographic lenses. The dark slides carrying the photographic plates were ingeniously arranged so that by a single operation two plates were exposed. Lieutenant Hills, R.E., one of the volunteer observers, was in charge of two spectroscopes of the ordinary form provided with slits. These were mounted on an equatorial stand, and were each provided with a 3-inch condensing lens. Here, again, photographic plates replaced the eye. A piece of apparatus for determining the total light of the corona was in the hands of Mr. Forbes, the other volunteer observer. Lieut.-Commander Lang undertook to make a drawing of the faint outlying parts of the corona by following the plan initiated by the American astronomer Newcombe in 1878. This consists in erecting a wooden disc in line with the eye and the eclipsed sun, and at such a distance that it appears to cover all the bright inner corona. The eclipse itself is thus eclipsed, and the observer has an opportunity of studying the more delicate parts of the corona, his eye being protected from the brighter light by the wooden disc.

The weather, fortunately, was magnificent during the whole tay of the observers at Fundium, and almost cloudless skies were experienced both day and night. By April 10 the instruments had all been carefully erected and adjusted by observations of the stars, and all was in readiness for the eclipse. Rehearsals of the operations which were to be gone through during the eclipse were now begun, and continued daily. It was arranged that the commencement of totality should be announced by pistol shot, Prof. Thorpe giving the signal to fire. Quartermaster Hallet was then to record in a loud voice the lapse of the 250 seconds of totality by reading the 15 seconds sandglass, which is so commonly used with the ship's log. Several rehearsals were gone through at dusk, when it was estimated that the light was about equal to that which might be expected during totality.

At last the day of the eclipse arrived, and everything was in complete order. The morning was a little more hazy than usual, but all felt confident of obtaining at least a moderate view of the eclipse. The observers themselves were at their posts soon after noon, and driving clocks and other details were attended to. At five minutes past one the moon was seen to have encroached on the south-western limb of the sun, and as it gradually passed over the disc the temperature of the air as gradually fell. At two o'clock the officers of the *Alecto*, who were kindly assisting the observers, also took their places. The light now waned very rapidly, and the breeze felt cold. In appearance the light of day at these stages very much resembled that which precedes an English thunderstorm. All the observers were now in perfect readiness for the pistol shot. "Five minutes" was announced by Prof. Thorpe, and I began my spectrum photographs, exposing six plates before totality. Amidst almost breathless silence the sound of the pistol shot was awaited. Eventually a similar pistol signal adopted in the French camp was clearly heard, and that moment the shadow of the moon went sweeping past. Prof. Thorpe's signal to fire, however, was not given until at least 10 seconds later. As the last trace of bright sunlight disappeared out flashed a magnificent corona of silvery light, together with numerous red and white prominences. The corona was very evenly distributed round the dark moon, that is to say, there were none of the great extensions along the Equator which were seen in 1878 and 1889. The light of the corona was very bright, and the lamps which had been provided for the use of the observers during totality were quite unnecessary—indeed, the sky light was so bright that no stars became visible at all, but Jupiter and Venus, which happened to be quite near the sun, shone out most distinctly. At Bathurst, however, the sky appears to have been clearer, and some of the brighter stars were also seen. The various observations were made and the photographs taken with no hitch whatever beyond the loss of about 10 seconds at the beginning of totality. This caused me to lose three exposures during totality, and reduced the number of Sergeant Kearney's photographs from 12 to 10. To err on the right side, Lieutenant Hills very fortunately closed his dark slides soon after "25 seconds" had been called by the quartermaster. In this case the slightest flash of sunlight would have been disastrous. Five minutes after totality was over I exposed my last plate, and the actual work of the expedition was at an end. What was more, all were confident of success.

Now, as to the results of the observations and photographs. Though it is much too early to attempt to state all that we may, except to learn from them, one point is clear. The general distribution of the corona is exactly what was expected, seeing that the sun is now in a very disturbed state. The sun spots, it is well known, have an eleven yearly period, and at the present time they are nearly at a maximum. This, in fact, made the recent eclipse one of the highest importance. It has been observed in previous eclipses that when the spots are at a minimum the corona is very much extended in the direction of the sun's equator, while, on the other hand, when the spots are at a maximum the corona is very much more evenly distributed. This supposed periodicity of the general form of the corona has received further confirmation by the recent observations. No unusual equatorial extension is shown on the excellent photographs taken by Sergeant Kearney, and none was observed by Lieut.-Commander Lang, who was specially looking for it. At Prof. Thorpe's suggestion Dr. Prout, the colonial surgeon at Bathurst, also erected a similar wooden disc, and his observations confirm those of Captain Lang. The prominences also follow the sun spots with regard to frequency, and, as already stated, a large number of them were seen. These are shown on Sergeant Kearney's photographs, and a complete record of the spectrum of each one is shown on the photographs taken by myself. The latter have the further advantage of showing the forms of the prominences as well as the spectra. Some of them chiefly show lines of hydrogen and calcium, while others again are almost crowded with lines of various metals. A complete record of the prominences has therefore been secured. With regard to the spectrum of the corona it seems doubtful at present whether our knowledge has made any great advance by the recent observations. The spectrum appears to have been very largely continuous, such as would be given by a mass of incandescent solid particles. One green line, which has previously been observed to be very prominent in the coronal spectrum, and the bright yellow line of the unknown substance, which is called helium, however, are shown in my photographs, and subsequent detailed examination may lead to the discovery of others. Lieut. Hill's photographs, which were specially exposed for the coronal spectrum, show a large proportion of continuous spectrum, and several lines which require further investigation. Much is to be hoped for, however, in another direction. The question of the constitution of the layers of the vapour which lie closest to the photosphere is one of the first importance to solar physicists. I had made arrangements to take two successive instantaneous spectrum photos as nearly as possible after the commencement of totality, but, as already stated, the opportunity was lost by reason of the lateness of the signal. The photos taken immediately after totality, however, promise to throw considerable light on the subject. Only two of these have been developed at present, and in addition to the ordinary spectrum of the uneclipsed part of the sun, they show large numbers of bright lines in the spectrum of those portions of the sun's atmosphere which were still left exposed by the moon. These, of course, also require a very detailed examination before any conclusion can be drawn. Of the thirty plates which I exposed only eleven have been developed so far, the facilities at Fundium not being very great. These were selected here and there from the whole series, and little doubt is entertained as to the good quality of the remaining plates. The photographic work was undertaken with the view of investigating the laws of variation in the brightness of the corona (1) according to the distance from the photosphere; (2) from one eclipse to another. Prof. Thorpe and Mr. Gray were successful in securing observations of the intensity of the light at sixteen different points of the corona, while Mr. Forbes made eleven measurements of the total light at as many different stages of the eclipse. All these observations were considered to be of a high degree of accuracy, but reduction to former standards and comparisons with measures at former eclipses have still to be made.

M. Deslandres' equipment consisted chiefly of spectroscopes of various forms, but in addition he was provided with instruments for photographing the eclipsed sun, one on a large and the other on a small scale. The haze somewhat interfered with his work, but he appears to have been fairly successful with such plates as were developed before the British expedition left.

The natives at Fundium were by no means alarmed during the eclipse, and there was fortunately no call for the guard of

bluejackets, which Captain Lang had taken the precaution to place in the immediate neighbourhood of the instruments; indeed both here and at Bathurst the natives were sufficiently well informed to watch the progress of the eclipse through smoked glass. The cause of the eclipse seems to have been ascribed to the Almighty, and not in any way associated with the presence of the astronomers. The members of the expedition themselves had no opportunity of studying the effect of the eclipse upon the brute creation, but trustworthy observers in Bathurst report that the usual state of alarm prevailed amongst fowls, cats, and other animals. Immediately after the eclipse the huts were partly dismantled, and the observers and their instruments were photographed by Prof. Thorpe, exactly as during the operations, the astonished natives meanwhile gathering in large numbers. After a short rest, the work of dismounting and packing the instruments was begun, and before sunset considerable progress had been made. By the evening of April 17, all was packed and safely aboard the *Alecto*, and the only material remnants of the expedition were waste paper and a slab of cement, prepared and inscribed by Lieutenant Hills, with the words, "British Eclipse Expedition, April 16, 1893." It is impossible to speak too highly of the assistance rendered to the expedition by the officers and men of the *Alecto*. As already stated, Lieutenant-Commander Lang made independent observations, with the assistance of Lieutenant Colbeck. Prof. Thorpe and Mr. Gray were assisted by Mr. Pym, and myself by Lieutenant Shipton and Chief Artificer Milligan, Lieutenant Hills by Dr. Moore, Sergeant Kearney by Sergeant Williams, and Mr. Collick and Mr. Forbes, by Mr. Willoughby, the engineer, and Mr. Murphy, one of the artificers.

The expedition left Fundium on April 18, and arrived at Bathurst on April 19, where H.M.S. *Blonde* was waiting under orders to convey the party to Grand Canary. Without this convenient arrangement, the expedition could not have left Bathurst before May 3 or 4. The homeward journey to England will be completed by a passage in the first available steamer.

THE ORIENTATION OF GREEK TEMPLES.[1]

THIS investigation is supplementary to Mr. Lockyer's examination of the orientation of the Egyptian temples, in the course of which he has cited passages translated from hieroglyphics, showing most distinctly that there was a connection between the foundation of those temples and certain stars. He has also shown that the structure of the temples demonstrates that the light from these stars must have been admitted at their rising or setting along the axis of the temples through the doorways, and that in certain temples the doorways have been altered in such a way as to follow the amplitude of the star as it changed, owing to the precession of the Equinoxes, and that in some cases a new temple had been founded alongside of an older one for the same purpose.

Although there does not seem to be any historical or epigraphical record of such a nature in Greece, the architectural evidence is not wanting. On the Acropolis of Athens there are two temples, both dedicated to Minerva, lying within a few yards of one another, both apparently oriented to the Pleiades, the older temple to an earlier position of the star group, and the other to a later one. At Rhamnus there are two temples almost touching one another, both following (and with accordant dates) the shifting places of Spica. In a temple at Ægina a doorway placed excentrically in the west wall of the cella was adapted for the observation of a setting star.

A clue is given for finding out the dates of the foundations of temples oriented to stars by means of the changes produced upon them by the precession of the Equinoxes; a movement which induces a divergence between the latitudes and longitudes of stars, and their places reckoned in declination and right ascension; so that after the lapse of 200 or 300 years a star which rose or set in the direction of the axis of a temple would have passed to a different amplitude, so as to be no more available for observation, as before, from the adytum.

In the earlier ages of Greek civilisation the only accurate measure of time by night was obtained by the rising or setting of stars, and these were more particularly observed when heliacal, or as nearly as possible to sunrise. For the purpose of temple worship, which was carried on almost exclusively at sunrise, the priests would naturally be very much dependent for their preparations on the heliacal stars as time warners.

The orientation of temples may be divided into two classes, solar and stellar. In the former the orientation lies within the solstitial limits; in the latter it exceeds them. In Greece there are comparatively few of the latter class.

In the lists of temples which follow, all the orientations were obtained from azimuths taken with a theodolite, either from the Sun or from the planet Venus. In almost every case two or more sights were observed, and occasionally also the performance of the instrument was tested by stars at night. The heights subtended by the visible horizon opposite to the axes of the temples were also observed.

The first list comprises twenty-seven intra-solstitial temples:

7	examples from	Athens.	1	example from	Sunium.
3	,,	Olympia.	1	,,	Corinth.
2	,,	Epidaurus.	1	,,	Bassæ.
2	,,	Rhamnus.	1	,,	Ephesus.
2	,,	Ægina.	1	,,	Platæa.
1	,,	Tegea.	1	,,	Lycosura.
1	,,	Nemea.	1	,,	Megalopolis.
1	,,	Corfu.	1	,,	Argos.

For all these the resulting solar and stellar elements are given, with the approximate dates of foundation, similarly to the following specimen, namely, that of the Temple of Jupiter at Olympia.

Olympia, lat. 37° 38′ *N.*

Temple of Jupiter	Orientation angle.		Stellar elements.	Solar elements.	Name of star.
	° ′ ″		° ′ ″	° ′ ″	
	262 37 46	Amplitude, star or sun	8 33 0 N.	7 22 14 N.	
		Corresponding altitude	3 0 0 E.	1 42 0 E.	
		Declination	+8 40 0	+6 52 22	
		Hour angles	$6^h\ 11^m\ 37^s$	$7^h\ 34^m\ 52^s$	
		Depression of sun	...	14° 12′ 0″	
		Right ascension	$23^h\ 40^m\ 0^s$	$1^h\ 3^m\ 5^s$	
		Approximate date	B.C. 740	Apr. 6.	

This example has been selected from the rest of the list because this temple has been chosen for the purpose of showing the method of procedure in working out the elements from the observations, those, namely, of the orientation angle, and of the height of the visible horizon.

A few general remarks, however, seem required respecting the Sun's and star's altitude, and the Sun's depression when the star is to be observed.

For a star to be seen heliacally, it is necessary that the Sun should be just sufficiently below the horizon for the star to be recognised. According to Biot, Ptolemy, speaking of Egypt, has recorded this to be about 11°. But where, as generally in Greece, there are mountains screening the glow which at such times skirts the true horizon, it seems fair at any rate for a first magnitude star to consider 10° as sufficient. I have myself seen Rigel in the same direction as the Sun when elevated 2° 40′ above the sea horizon, the Sun being less than 10° below. Obviously an observer looking from a dark chamber in a well known direction would be more favourably situated.

It is proper to allow about 3° of altitude for a star to be seen above low clouds and the hazy glow which skirts the horizon. The Sun's light, however,, seems to be very effective at a lower altitude, and when he appears over a mountain of 2° or 3° altitude the angle may properly be reduced by 20′ or 25′, partly for refraction, and partly because a small segment only of the disc is sufficient for illumination.

The method I have pursued in working out the example of the Temple of Jupiter at Olympia is as follows.

The orientation angle, measured from the south point round by way of west and north, is 262° 37′ 46″, which is equivalent to an amplitude of +7° 22′ 14″. The eastern mountain subtends an angle of 2° 4′. For reasons above given, the solar altitude

[1] Abstract of a paper (read before the Royal Society on April 27), "On the Results of an Examination of the Orientation of a number of Greek Temples, with a view to connect these Angles with the Amplitudes of certain Stars at the time these Temples were founded, and an endeavour to derive therefrom the Dates of their Foundation by consideration of the changes produced upon the Right Ascension and Declination of the Stars arising from the Precession of the Equinoxes." By F. C. Penrose, F.R.A.S. Communicated by Prof. J. Norman Lockyer, F.R.S.