THE OXFORD UNIVERSITY OBSERVATORY.—The twenty-third annual report of the visitors of the University Observatory appears in a recent number (June 14) of the *Oxford University Gazette*. The report refers to the period from June 1, 1897, to May 31, 1898, and exhibits the state of the observatory on the last-named day. One of the main points referred to by Prof. Turner in the report, is that of the necessity of completing the observatory by attaching to it a residence. This, he points out, is urgent, since it is most imperative that the official staff should be as near their work as possible when both routine observational work and students have to be dealt with. Prof. Turner refers to a very curious accident that occurred to the level belonging to the Barclay transit circle that is used for time determinations, which is well worth repeating. "The striding level, weighing 19 lbs., which was suspended over the instrument by means of a cord, pulley and counterpoise, fell (from its usual position when not in use near the roof) a distance of three or four feet on to the instrument, owing to the snapping of the cord. It was found the next morning standing upright, with its feet on the pivot covers as if in position for an observation. The blow had thus been received by the pivot covers, and no other part of the instrument had apparently been damaged or even struck. The brass tube of the level itself was shattered, but the glass-tube inside was not broken!" Surely this is quite a unique accident?

The measurement and reduction of the plates for the Astrographic Catalogue seem to be proceeding apace, an average of 3951 measures of the star positions and magnitudes being made every week, the total number for the year being 205,443. The main result of the year's work is that the prospects of achieving the object aimed at are brighter than previously: this was, as Prof. Turner states, that by the middle of 1901 we may be ready to furnish, or demand, the positions and magnitudes of the brighter stars in zones $+24°$ to $+32°$ to the number of something like a quarter of a million. The speed at which these measures can be made, can be gathered from the statement that "whereas at first thirty or forty star-measures an hour was thought fair work, the more skilful can now measure 150 per hour or more." The new photographic transit circle has involved much experimental work, and is proceeding satisfactorily.

THE SUPPOSED VARIABLE Y AQUILÆ.—In the series of measures to determine the light curves of variable stars of short period north of $-40°$ Declination with the meridian photometer, the curve of the star $+10°$ 3787 was not found to be smooth. This star had previously been catalogued by Chandler as varying from 5·3 to 5·7 in a period of 4·986 days. It was also suspected by Gould, confirmed by Chandler 1894, and also by Yendell. Mr. Wendell has recently made some observations (*Harvard College Observatory Circular*, No. 30) with the photometer attached to the 15-inch equatorial telescope, on six nights in May last, eighty sittings being made each night, the comparison star employed being $+10°$ 3784. The mean of the differences of magnitude showed very little variation, and, as Prof. Pickering states, fails to show any evidence of variation, since deviations of a tenth of a magnitude may be ascribed to errors of observation. Since it is "impossible to prove that the light of a star never changes, this star may still be an Algol variable with a short time of variation, or the period may be entirely wrong."

## COMPANIONS OF ARGON.[1]

FOR many months past we have been engaged in preparing a large quantity of argon from atmospheric air by absorbing the oxygen with red-hot copper, and the nitrogen with magnesium. The amount we have at our disposal is some 18 litres. It will be remembered that one of us, in conjunction with Dr. Norman Collie, attempted to separate argon into light and heavy portions by means of diffusion, and, although there was a slight difference[2] in density between the light and the heavy portions, yet we thought the difference too slight to warrant the conclusion that argon is a composite substance. But our experience with helium taught us that it is a matter of the greatest difficulty to separate a very small portion of a heavy gas from a large admixture of a light gas; and it therefore appeared advisable to re-investigate argon, with the view of ascertaining whether it is indeed complex.

In the meantime, Dr. Hampson had placed at our disposal his resources for preparing large quantities of liquid air, and it was a simple matter to liquefy the argon which we had obtained by causing the liquid air to boil under reduced pressure. By means of a two-way stopcock the argon was allowed to enter a small bulb, cooled by liquid air, after passing through purifying reagents. The two-way stopcock was connected with mercury gas-holders, as well as with a Töpler pump, by means of which any part of the apparatus could be thoroughly exhausted. The argon separated as a liquid, but at the same time a considerable quantity of solid was observed to separate, partially round the sides of the tube, and partially below the surface of the liquid. After about 13 or 14 litres of the argon had been condensed, the stopcock was closed, and the temperature was kept low for some minutes in order to establish a condition of equilibrium between the liquid and vapour. In the meantime the connecting tubes were exhausted, and two fractions of gas were taken off by lowering the mercury reservoirs, each fraction consisting of about 50 or 60 cubic cm. These fractions should contain the light gas. In a previous experiment of the same kind a small fraction of the light gas had been separated, and was found to have the density 17·2. The pressure of the air was now allowed to rise, and the argon distilled away into a separate gas-holder. The white solid which had condensed in the upper portion of the bulb did not appear to evaporate quickly, and that portion which had separated in the liquid did not perceptibly diminish in amount. Towards the end, when almost all the air had boiled away, the last portions of the liquid evaporated slowly, and when the remaining liquid was only sufficient to cover the solid, the bulb was placed in connection with the Töpler pump, and the exhaustion continued until the liquid had entirely disappeared. Only the solid now remained, and the pressure of the gas in the apparatus was only a few millimetres. The bulb was now placed in connection with mercury gas-holders, and the reservoirs were lowered. The solid volatilised very slowly, and was collected in two fractions, each of about 70 or 80 cubic cm. Before the second fraction had been taken off, the air had entirely volatilised, and the jacketing tube had been removed. After about a minute, on removing the coating of snow with the finger, the solid was seen to melt, and volatilise into the gas-holder.

The first fraction of gas was mixed with oxygen, and sparked over soda. After removal of the oxygen with phosphorus it was introduced into a vacuum-tube, and the spectrum examined. It was characterised by a number of bright red lines, among which one was particularly brilliant, and a brilliant yellow line, while the green and the blue lines were numerous, but comparatively inconspicuous. The wave-length of the yellow line, measured by Mr. Baly, was 5849·6, with a second-order grating spectrum. It is, therefore, not identical with those of sodium, helium, or krypton, all of which equal it in intensity. The wave-lengths of these lines are as follows:—

| | |
|---|---|
| Na ($D_1$) | 5895·0 |
| Na ($D_2$) | 5889·0 |
| He ($D_3$) | 5875·9 |
| Kr ($D_4$) | 5866·5 |
| Ne ($D_5$) | 5849·6 |

The density of this gas, which we propose to name "neon" (new), was next determined. A bulb of 32·35 cubic cm. capacity was filled with this sample of neon at 612·4 mm. pressure, and at a temperature of 19·92° it weighed 0·03184 gram.

Density of neon ... ... ... 14·67

This number approaches to what we had hoped to obtain. In order to bring neon into its position in the periodic table, a density of 10 or 11 is required. Assuming the density of argon to be 20, and that of pure neon 10, the sample contains 53·3 per cent. of the new gas. If the density of neon be taken as 11, there is 59·2 per cent. present in the sample. The fact that the density has decreased from 17·2 to 14·7 shows that there is a considerable likelihood that the gas can be further purified by fractionation.[1]

[1] "On the Companions of Argon." By William Ramsay, F.R.S., and Morris W. Travers. Paper read at the Royal Society, June 16.

[2] Density of lighter portion, 19·93; of heavier portion, 20·01 (Roy. Soc. *Proc.*, vol. 60, p. 206).

[1] June 21.—After a preliminary fractionation, the density has been still further reduced to 13·7.

That this gas is a new one is sufficiently proved, not merely by the novelty of its spectrum and by its low density, but also by its behaviour in a vacuum-tube. Unlike helium, argon, and krypton, it is rapidly absorbed by the red-hot aluminium electrodes of a vacuum-tube, and the appearance of the tube changes, as pressure falls, from carmine red to a most brilliant orange, which is seen in no other gas.

We now come to the gas obtained by the volatilisation of the white solid which remained after the liquid argon had boiled away.

When introduced into a vacuum-tube it showed a very complex spectrum, totally differing from that of argon, while resembling it in general character. With low dispersion it appeared to be a banded spectrum, but with a grating, single bright lines appear, about equidistant through the spectrum, the intermediate space being filled with many dim, yet well-defined lines. Mr. Baly has measured the bright lines, with the following results. The nearest argon lines, as measured by Sir William Crookes, are placed in brackets:—

| | | |
|---|---|---|
| Reds very feeble, not measured. | | |
| First green band, first bright line ... ... | 5632·5 | (5651 : 5619) |
| First green band, second bright line ... ... | 5583·0 | (5619 : 5567) |
| First green band, third bright line ... .. | 5537·0 | (5557 : 5320) |
| Second green band, first bright line ... ... | 5163·0 | (5165) |
| Second green band, second bright line ... | 5126·5 | (5165 : 5065) brilliant. |
| First blue band, first bright line ... ... | 4733·5 | (4879) |
| First blue band, second bright line ... ... | 4711·5 | (4701) |
| Second blue band, first bright line ... ... | 4604·5 | (4629 : 4594) |
| Third blue band (first order) ... ... ... | 4314·0 | (4333 : 4300) |
| Fourth blue band (second order) ... ... ... | 4213·5 | (4251 : 4201) |
| Fifth blue band (first order), about ... ... | 3878 | (3904 : 3835) |

The red pair of argon lines was faintly visible in the spectrum.

The density of this gas was determined with the following results:—A globe of 32·35 c.c. capacity, filled at a pressure of 765·0 mm., and at the temperature 17·43°, weighed 0·05442 grams. The density is therefore 19·87. A second determination, made after sparking, gave no different result. This density does not sensibly differ from that of argon.

Thinking that the gas might possibly prove to be diatomic, we proceeded to determine the ratio of specific heats:—

| | |
|---|---|
| Wave-length of sound in air ... ... | 34·18 |
| ,, ,, gas ... ... | 31·68 |
| Ratio for air ... ... ... ... | 1·408 |
| ,, gas ... ... ... ... | 1·660 |

The gas is therefore monatomic.

Inasmuch as this gas differs very markedly from argon in its spectrum, and in its behaviour at low temperatures, it must be regarded as a distinct elementary substance, and we therefore propose for it the name "metargon." It would appear to hold the position towards argon that nickel does to cobalt, having approximately the same atomic weight, yet different properties.

It must have been observed that krypton does not appear during the investigation of the higher-boiling fraction of argon. This is probably due to two causes. In the first place, in order to prepare it, the manipulation of air, amounting to no less than 60,000 times the volume of the impure sample which we obtained was required; and in the second place, while metargon is a solid at the temperature of boiling air, krypton is probably a liquid, and therefore more easily volatilised at that temperature. It may also be noted that the air from which krypton has been obtained had been filtered, and so freed from metargon. A full account of the spectra of those gases will be published in due course by Mr. E. C. C. Baly.

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## ON THE STABILITY OF THE SOLAR SYSTEM.[1]

ALL persons who interest themselves in the progress of celestial mechanics, but can only follow it in a general way, must feel surprised at the number of times demonstrations of the stability of the solar system have been made.

Lagrange was the first to establish it, Poisson then gave a new proof; afterwards other demonstrations came, and others will still come. Were the old demonstrations insufficient, or are the new ones unnecessary?

The astonishment of these persons would doubtless be increased if they were told that perhaps some day a mathematician would show by rigorous reasoning that the planetary system is unstable. This may happen, however; there would be nothing contradictory in it, and the old demonstrations would still retain their value.

The demonstrations are really but successive approximations; they do not pretend to strictly confine the elements of the orbits within narrow limits that they may never exceed, but they at least teach us that certain causes, which seemed at first to compel some of these elements to vary fairly rapidly, only produce in reality much slower variations.

The attraction of Jupiter, at an equal distance, is a thousand times smaller than that of the sun; the disturbing force is therefore small; nevertheless, if it always acted in the same direction, it would not fail to produce appreciable effects. But the direction is not constant, and this is the point that Lagrange established. After a small number of years two planets, which act on each other, have occupied all possible positions in their orbits; in these diverse positions their mutual action is directed sometimes one way, sometimes in the opposite way, and that in such a fashion that after a short time there is almost exact compensation. The major axes of the orbits are not absolutely invariable, but their variations are reduced to oscillations of small amplitude about a mean value.

This mean value, it is true, is not rigorously fixed, but the changes which it undergoes are extremely slow, as if the force which produces them was not a thousand times, but a million times smaller than the solar attraction. One may, therefore, neglect these changes, which are of the order of the square of the masses. As to the other elements of the orbits, such as the eccentricities and the inclinations, these may acquire round their mean value wider and slower oscillations, to which, however, limits may easily be assigned.

This is what Lagrange and Laplace pointed out, but Poisson went further. He wished to study the slow changes experienced by the mean values—changes to which I have already referred, and which his predecessors had at first neglected. He showed that these changes reduced themselves again to periodic oscillations round a mean value which is only liable to variations a thousand times slower.

This was a step further, but it was still only an approximation. Since then further advance has been made, but without arriving at a complete definitive and rigorous demonstration. There is a case which seemed to escape the analysis of Lagrange and Poisson. If the two mean movements are commensurable among themselves, at the end of a certain number of revolutions, the two planets and the sun will be found in the same relative situation, and the disturbing force will act in the same direction as at first. The compensation, to which I have referred, will not any more be produced, and it might be feared that the effects of the disturbing forces will end by accumulating and becoming very considerable. More recent works, amongst others those of Delaunay, Tisserand, and Gyldén, have shown that this accumulation does not actually occur. The amplitude of the oscillations is slightly increased, but remains, nevertheless, very small. This particular case, therefore, does not escape the general rule.

The apparent exceptions have not only been dispensed with, but the real reasons of these compensations, which the founders of celestial mechanics had observed, have been better explained. The approximation has been pushed further than was done by Poisson, but it is still only an approximation.

It can be shown, in certain particular cases, that the elements of the orbit of one planet will return an infinite number of times to very nearly the initial elements, and that is also probably true in the general case; but it does not suffice. It should be shown

[1] Translation of a paper, by M. H. Poincaré, in the *Annuaire du Bureau des Longitudes*, 1898.