I have now given you a brief sketch of the magnitude of the complete undertaking, of the various causes which led up to it and of the results which it has already been responsible for ; I will now conclude my lecture by giving you some idea of how the work is carried out and of the enormous amount of detail and figuring involved ; by the help of the slides I shall now show and explain to you.

Slides of an astrographic telescope, and slides of a complete set of record sheets of one plate were then shown and explained by the lecturer.

Jupiter, the Giant Planet

BY THE REV. J. MITCHELL, M.A., F.R.A.S.

THE subject of my lecture to-night is Jupiter, the Giant Planet, and it is fitting that this lecture should be delivered on a Thursday (Jupiter's Day or বৃহস্পতিবার).

The name Jupiter is a most appropriate one. Mythologically, Jupiter was supreme among the gods. As Zeus, he was the earliest, the greatest and the most renowned deity in the Greek Pantheon. As Jupiter, he was also the chief deity of the Romans. In the Solar system he is supreme, for he is the largest in size among the planets. He is almost supreme in brightness, only Venus surpassing him in this respect. When Jupiter and Venus appear side by side in the heavens, *i.e.*, when they are near conjunction, they present a most brilliant spectacle. Such a spectacle I well remember witnessing in the evening sky in January 1892, about 22 years ago, and the impression it made on my mind will never be effaced.

During the greater part of last year Jupiter was a brilliant object in the southern sky, and its altitude being about 45° it was favourably situated for an observer in this latitude, but our friends in England were not so fortunate, for Jupiter's altitude being only 17° no serious telescopic work could be done. It was, therefore, hoped that all possessors of telescopes living in lower latitudes would make good use of their opportunity. Fortunately for our Society, early in July, the mounting of the 7″ Merz refractor, belonging to the Observatory of the Indian Association for the Cultivation of Science, was completed, and Mr. Raman, to whose energy that mounting is largely due, lost no time in turning it on Jupiter. I also, in Bankura, used my 5″ Cooke on the planet on almost every favourable night. Between us, for we (to

use an astronomical expression) have been in conjunction during most of the year, we have made a number of useful observations and about 150 sketches, of which I shall make the fullest use during the course of this lecture.

The regular observing of Jupiter in this country from May to almost the end of the year, when the planet disappeared in the Sun's rays, has taught me one lesson, and I would impress this on all amateur astronomers in India ; the lesson is this : " Do not despise the hot weather, and still more the rains, for astronomical purposes." To tell you the truth, the finest definition I have obtained, and certainly the most perfect views, of Jupiter were in July. I had also splendid views of the planet in May and a few in June. The old adage " All is not gold that glitters " is true when applied to the sky. Most of the brilliant nights in November and December I found were almost useless. The definition was scarcely even good. Stars more often than not were bloated, blazing masses of light and colour, instead of being points with regular diffraction rings round them. It is true the definition during the last month improved, but I scarcely think finer views of any object in the sky could be obtained than those in the middle of the year.

And here I would point out that Jupiter is, *facile princeps*, the planet of the amateur with a small telescope. In these days photography has to a considerable extent displaced the eye observations of not only small instruments but telescopes of the largest aperture for a great many purposes. No telescope can now compete with the photographic plate in the mapping of stars, in the delineating of comets and nebulæ or in the mapping of spectra. Photography is now competing strongly with small telescopes for detailed work on both Sun and Moon, for to-day photographs of small areas of both Sun and Moon of surpassing beauty and clearness of detail are taken. But a good 3″ or 4″ can still reveal a little more detail on the Moon visually than any telescope can produce photographically. With the planets, however, the state of things is different. Photographs of Mars, Jupiter and Saturn are taken systematically, but they are small and the details are meagre and indistinct at the best. Here, then, there is scope for the amateur. Jupiter through a good 4″ or 5″ on a good night is a revelation. It is dangerous prophesying, but it seems to me that for many years to come the camera will have no chance with the telescope, used visually, on Jupiter.

Let us now look at the position of Jupiter in the Solar system. The Sun's family is divided into two classes of 4

each. The first 4, Mercury, Venus, Earth and Mars, are the small yet dense members, the other 4, Jupiter, Saturn, Uranus and Neptune, are the large giant yet light members of the family. Between these two groups we have the asteroids, numbering several hundreds and considered by some to be the remains of a fractured planet. The asteroids consist of a ring of tiny planets circling round the Sun in the same way as the Leonids, or ring of meteors, the difference being that meteors are very much smaller fragments, mere dust compared with the minor planets. Of the 2nd class, *i.e.*, the class of the giants, Jupiter stands head and almost shoulders above his brethren, and he might be looked upon as the guardian brother of the family, and indeed he does exercise a considerable influence over his relatives and outsiders too, for no celestial object can come within the range of his influence without being attracted very considerably in his direction. Especially is this the case with comets. I remember in my lecture on Comets, a year ago, in this Hall, referring to the action of Jupiter in delaying the coming of Halley's Comet in 1759. It was calculated that the comet was delayed 618 days by the two planets, Jupiter and Saturn, and of these 518 were due to Jupiter.

For many centuries, and even to-day the belief is held by many in this country, people have believed that Jupiter exerted an influence, sometimes for good, and sometimes for evil, over the destinies of mankind. There are few guardians to-day who would allow their children to attend school for the first time on any day but Thursday. For such a purpose বৃহস্পতিবার (Thursday) is the auspicious day. To most people in Bengal 21 hours of this day are auspicious, but the remaining 3 are just the reverse.

If a child be born when the planet is in Cancer, then happy is that child. He will be magnanimous, faithful, bashful, of sweet and affable conversation, honourable, religious, just, wise, prudent, grateful and virtuous. He will be indulgent to his wife and children and will revere old age. He will be a great reliever of the poor and will hate all sordid actions. Would that Jupiter could be nailed up permanently in that benign constellation ? But if the child be born when the planet happens to be in Capricornus woe comes to the unfortunate one. He will waste his patrimony and will be hypocritically religious. He will be tenacious and obstinate in maintaining false tenets in religion. Ignorance, carelessness, grossness and dulness will characterise him through life. He will abase himself in all companies and will stoop when there is no necessity. When we consider Jupiter's brightness we are not surprised

that people credit him with such power, and when we consider its immense size we are not surprised that its influence upon other celestial orbs should be so great. Compared with our Earth its diameter is 10 times as great, while compared with the Sun its diameter is only $\frac{1}{10}$ that of the parent, so that it occupies, in point of size, or volume, a sort of mid-way position between the two. In round numbers we have 8,000 miles as the diameter of the Earth, 85,000 as that of Jupiter and 850,000 the diameter of the Sun.

Whilst Jupiter is immensely larger—1,300 times—in volume than the Earth, yet, being a light planet, its mass is considerably less, being in fact only 300 times that of the mass of the Earth. Its density, therefore, is about $\frac{1}{4}$ that of the Earth, *i.e.*, a little higher than that of water.

Thus proportionately the force of gravity on the surface of Jupiter will not be the same as on the surface of the Earth; it is in reality only $2\frac{1}{2}$ times as great. From this we must conclude that inhabitants on Jupiter—if any exist—must be much less than those here. A graceful young lady of 10 stones would, if transported to Jupiter, be at once changed into a heavy weight of 25 stones. The inhabitants of the planet will therefore be somewhat Lilliputian in stature and weight. It would not do to build a tower or chimney of the ordinary diameter and 100 yards high on Jupiter, for it would be crushed by its own weight, so the size of the inhabitants as well as buildings will have to be inversely as the gravity.

Jupiter revolves round the Sun about once in 12 years at a distance of 482 million miles, but this does not matter very much to its inhabitants, for it is practically without seasons, the reason being that its axis of rotation is almost vertical to the plane of its orbit. What a monotonous state of things this produces it is scarcely possible to imagine.

How many of us realise what we owe to the fact that the axis of the Earth's revolution is inclined $23\frac{1}{2}°$ from the vertical to the plane of our orbit. Surely this is not accidental! Surely there is design in this! Suppose the axis were not inclined, that is were vertical, then all our days would be alike. There would be monotony everywhere, the temperature would vary with the latitude and the winds would blow every day with an irritating regularity. At the Poles the Sun would hang on the horizon eternally. Round and round he would appear to revolve once in 24 hours, never sinking below and never rising above the horizon. At the Equator he would rise due in the East, move vertically

overhead and set dead in the West. Every day would be the same from the Poles to the Equator, the altitude of the Sun at noon would be the true latitude, the Sun always rising in the East and setting in the West. Suppose the angle made by the polar axis to the vertical were greater than $23\frac{1}{2}°$, then the seasons would be accentuated. Tropical weather would characterise for a time the temperate regions in summer and polar weather would obtain in winter in the same latitudes. Jupiter is in the former position. Pity the poor inhabitants.

Let us now examine the planet through a good 4″ or 5″ Refractor (a good 3″ will show the main details). If we are fortunate to see the interesting side we shall notice certain definite markings, perhaps a black spot. Watch steadily this spot for $\frac{1}{2}$ hour and you will notice that it has shifted from right to left (really from left to right, for the telescope inverts all objects like an ordinary camera). Look from time to time for another $\frac{1}{2}$ hour ; the spot has travelled still farther and all the other definite markings along with it. Keep up the watch for another hour and the spot will by the end of that period have almost disappeared round the edge of the disc. What has happened ? The observation shows that Jupiter is revolving so rapidly on its axis that 2 hours is sufficient to cause any particular feature situated fairly centrally on the disc to disappear. Continued observations upon the same spot, especially if the exact time of transit across the central meridian be noted, through a few weeks and then divided by the number of revolutions will give most accurately the true rotation period of that spot and of the planet itself—if the spot is a stationary one. The time for one rotation turns out to be about 10 hours or to be more exact 9 hours 55 minutes 28 seconds, but, as we shall afterwards see, it is difficult to ascertain what is the true rotation period of the planet itself, as spots have different rotation periods.

Think of it, such a mass revolving once in 10 hours. Now the diameter of Jupiter at the Equator is 88,000 miles. A little calculation will reveal the striking fact that a spot on the Equator travels, in the course of its revolution, at the rate of 8 miles per second. It is rather a strange coincidence that the planet in its orbit round the Sun travels bodily at the same rate. Comparing the velocity of Jupiter at the Equator with that of some of the other planets, we find that Saturn's velocity is 6 miles per second, our Earth 15 miles per minute, and Mars $10\frac{1}{2}$ miles per minute, while the Sun's velocity is 12 miles per second. What must inevitably be the result—a globe 88,000 in diameter revolving once in 10 hours ? Think of the centrifugal force, *i.e.*, the tendency of the particles to fly off at a tangent and so to bulge out at the Equator.

Hence we shall not be surprised to find that the shape of Jupiter is not spherical. A glance through a good telescope will show at once that this is actually the case, for he presents a most noticeable flattened appearance at the Poles and if truly an oblate spheroid. Accurate measurements show that the equatorial diameter is 88,200 miles and the polas diameter 83,000.

From a spectacular point of view Saturn undoubtedly comes first, but Jupiter is a good second in the telescope. To the naked eye it is a striking object. Indeed, so bright is it that many observers can see it in broad daylight especially when in opposition. In the telescope it presents a large, clear, slightly oval disc which is crossed by a series of dark and light bands, some of which are distinctly ruddy in colour. Then there are 4 satellites easily visible, nay some of them have been seen by the naked eye when favourably situated and a powerful telescope will see them in the day time. I have myself seen them several times with my 5″ quite easily when the Sun has been well up in the sky. (By the way, it does not take a large telescope to see the brighter stars in the day time. I can see Polaris, a star of the second magnitude only, by day through my Transit instrument, and this has an aperture only $2\frac{3}{8}$″ in diameter.) A more careful view of the planet reveals the fact that it is one particular belt that is most reddish in colour, and this is the *South Equatorial* and one of the most interesting of all the belts. I once saw this ruddiness to great advantage. As a young man I was greatly interested in Astronomy, and I would walk or ride any distance to see through a telescope. On one occasion, in July 1889, I went to Southport, a distance of 60 miles from my home—and 60 miles was considered a great distance in those days. There I remained for a fortnight purposely to look through the telescope—a 6″ Cooke Refractor—belonging to Mr. Joseph Baxendall, Meteorologist to the Corporation. For 13 days I remained and each night was cloudy, and the last night came, for on the following day I had to return, but I was repaid for all my trouble and expense. The night turned out clear and there was an occultation of Jupiter by the Moon that night—a somewhat rare occurrence—and the only one I have ever witnessed. The occultation took place in daylight about an hour before sunset. It was an exhilarating sight to see the Moon creep up nearer and nearer to the planet, first occulting the satellites one by one, then the planet itself, then the remaining satellites. But it was at the re-appearance of the planet with its train that what I want to describe took place. It was then dark and the stars and Jupiter shone out brightly. At last one satellite burst forth from the edge

of the Moon's disc, then another, then Jupiter itself appeared slowly, sharp and beautifully defined. As soon as the planet was clear from the Moon I noticed a wonderful contrast. The Moon was silvery white, the Southern Equatorial Belt of Jupiter, especially, showed up with a marked deep red colour, but the other belts appeared slightly red also. I shall never forget the contrast and I shall never forget the glorious spectacle. Now it was often a puzzle to me why Jupiter did not look, if not red like Mars, at any rate slightly red, for its chief belt is ruddy, but it shines out almost as *white* as Sirius. The reason is now known. It is because its reflective power is very great, greater than that of any other planet, twice that of Mars and the Earth, and 12 times that of Venus. It reflects 62% of the total light it receives from the Sun. When it is remembered that newly fallen snow only reflects 78% we can understand how wonderfully great its reflective power is. Thus the reason why Jupiter does not show up slightly red is because the slight redness is altogether masked by the whiteness reflected from the white belts.

Perhaps the most striking feature on Jupiter as seen through a good telescope is the famous *Red Spot* which is to be found in the red Southern Equatorial Belt. It is an elliptical shaped spot of enormous dimensions, being some 24,000 miles long from East to West and some 7,000 miles broad from North to South. It has a curious history which we must refer to.

It was first discovered by Professor Pritchett, of Glasgow, Missouri, United States of America, in July 1878 as a pale pinkish oval spot. Next year, 1879, it began to attract attention owing to the intensification of its colour. It was then brick-red in appearance, sharp in outline and somewhat like an elongated hexagon. It was by far the most conspicuous object on the surface of the planet. After 3 years of brightness its colour began to fade and in 1882 and 1883 it had almost ceased to be visible. In 1885 it began to recover and then it showed up as a faint, pink oval ring with its centre occupied by a white cloud which in the following year so extended as to almost obliterate its outline. Gradually the white veil cleared away and in May 1891 it had recovered much of the intensity of colour which had rendered it so conspicuous an object in 1879. It remained a bright object throughout 1892 and then began to fade again and by 1897 it had become practically invisible. From this date to last year it has been a difficult object, for the most part was searcely visible. During the last year Mr. Raman and I were fortunate in having the Red Spot visible again and our work has centred largely on this famous feature. We have noticed

in the course of our observations two striking characteristics of the spot :

(1) Its influence (both attractive and repulsive) on its surroundings ;

(2) Its westward drift.

So far back as 1879 when the Red Spot first became conspicuous, Barnard, the celebrated American Astronomer, called attention in the *English Mechanic* to the repulsive force exerted by the spot. The belts on the North and South sides of the ellipse were bulged out and there was a sea of light almost completely round it. Drawings taken in 1888 show the same feature though not in so marked a degree. During the past year we have found evidence that this repulsive force still exists. Invariably I have noticed that immediately round the spot there is a sort of white border and that the darkness of the belt shades off in the neighbourhood of the spot, but what is even more interesting, we have evidence which seems to show that the spot exerts now an attractive force. A black narrow elongated spot, which on the 1st August was some 17,000 miles to the West of the ellipse, drifted East until on the 3rd September it had actually collided with it, *i.e.*, it was attracted at the rate of 500 miles per day. That it was attracted, and not merely drifted, appears to be shown by the fact that when it reached the spot there it struck and gradually shortened in length and became fainter and fainter until by the end of the month (September) it had completely disappeared. It appears certain that the lesser spot was entirely swallowed up by the greater.

Then as regards the drifting East of the Red Spot itself, Lohse investigated this drift most exhaustively between the years 1878 and 1897, and he found that its rotation period was longer than the rest of the surface of the planet. Calculating backwards he found it had wandered over more than $\frac{2}{3}$ the circumference of the parallel in which it was situated. Our observations last year undoubtedly confirmed Lohse's conclusion as regards the drift generally, but we found its rate of progress backwards, that is East, to be even more rapid than he calculated. We have found its rotation period to be 9 hours 55 minutes 41 seconds, whereas the general rotation appears to be about 9 hours 55 minutes 28 seconds. What, then, can the surface conditions of Jupiter be like which allow an enormous area to drift slowly backwards in this strange manner that at one and the same time exerts a repulsive and an attractive force ?

Inside, but on the southern side of the dark South Equatorial Belt there runs a narrow bright band about $\frac{1}{2}$ way round the

planet, known as the South Tropical Disturbance. This bright band comes stealing along like a snake, when the Red Spot is on the left of the disc, for the preceding end has often a snake-like appearance, sometimes pointed, sometimes rounded, and sometimes swollen out like the top of a walking stick. On the 20th October I noticed a dent in the knob-like end and this persisted for 10 days, gradually filled up and then disappeared. I have also noticed irregularities along the northern edge of this band. These changes and appearances have been seen also by Mr. Raman.

Immediately preceding the South Tropical Disturbance Mr. Raman and I, about the end of August, noticed a notch in the dark band between the Southern Tropical Disturbance and the South Tropical Zone. This kept its position and persisted until well into September, when it appeared no longer as a notch but as a long drawn out hollow which gradually filled up.

In the middle of May I noticed a curious notch in the same dark band but much further to the West. Bad weather in June and the early part of July prevented further observations. However, on the 26th July there was no trace of it, but on the 23rd August I noticed a curious swelling in the same belt and in about the same longitude. This swelling continued until September 9, when it changed into a kind of faint gap in the belt, lengthening slightly as the days passed by until by the 30th October it was fully twice as long as before. Calculations show that this gap rotates more slowly than the Great Spot, *viz.*, 9 hours 55 minutes 25 seconds, and as this corresponds with the general rotation period of the planet it follows that there is not much drift in connection with this feature.

We now come to the great Equatorial Zone. This is a most active area and differential movements are going on here right round the planet. The most striking feature is the fairly regular system of arches with their bases pointing North. This arrangement can be seen at any position of the planet's revolution. The pillars of the arches are generally vertical, but they are often tilted. Sometimes to the left and occasionally to the right ; sometimes two arches coalesce into one large arch though the middle base remains.

At the lower part of each pillar is invariably a black rectangular spot or base. These arches are a most striking feature and were visible every time the planet was observed.

But we have not yet finished with this great Equatorial Band. Up to the 23rd September the dark South Equatorial Belt and the bright Equatorial Zone were about equal in breadth, but the next day I noticed that the South Equatorial

Belt was widening. Mr. Raman noticed the same change. This widening went on until October 15, when the belt had widened to such an extent as to swallow up the entire southern half of the Equatorial Band. This was surely a most momentous change. It meant that this belt had increased in breadth, some 13,000 miles in 22 days or at the rate of 600 miles a day

Both Mr. Raman and I have noticed other minor changes too numerous to be mentioned here such as the sudden appearance of bright and dark spots persisting for a day or two and then disappearing.

Up to this point I have confined my attention to the southern portion of the planet, and it is a striking fact that most of the changes that are visible occur in the southern regions (of the planet). Only very occasionally are spots or changes in the arrangement of the belts or zones seen in the northern areas. I have seen both dark spots and white spots in the Northern Equatorial Belt, but these have been infrequent. From Mr. Raman's slides you will see that this has been his experience also. The dark belts and the bright zones retain their regular straight appearances and are rarely ever ruffled.

We must now pass on to the consideration of Jupiter's satellites. To the possessor of a good 4″ or even 3″, if it be of excellent quality, the satellites are a never failing source of interest. Examine them on a good night. Four satellites are easily seen. An ordinary opera glass will see them, but they may not be seen all together. Sometimes 2 are visible on one side the planet and 2 on the other, sometimes 3 on one side and only 1 on the other. Sometimes they are all on one side. Sometimes 3 are visible on one side, the other being eclipsed by passing into the planet's shadow or by passing behind the disc of the planet. Occasionally no satellite is visible being either all eclipsed or occulted. This is a rare occurrence. Very often the shadow of a satellite may be seen on the disc. This is always a beautiful spectacle. The shadow is round and inky black, but cases have been known where the shadow was oval near the edge. But an even more beautiful sight is the satellite itself on the disc, and this is a frequent occurrence, for the planes of the satellites correspond closely with the plane of the planet's orbit. You see the bright satellite approaching the edge of the planet; then it passes on to the disc, and strange to say it remains for some time almost as brilliant as before. Then its light begins to pale, but not until several minutes have elapsed does it become dull. Now it loses its light and becomes so faint that when it traverses a bright zone it is very difficult to follow its course across the disc. Then when it nears the edge it begins to brighten up again, and long before

it reaches the edge it shines out with the same brilliant lustre it possessed before.

The reason for this brightening up at the edge must be that the planet at its edge is darker or rather duller in appearance than in its central regions, and this seems to suggest that here we are looking through a greater depth of atmosphere than on the centre of the disc. The Sun shows the same darkening at its edge, but not so the Moon which has but little atmosphere if any at all.

From time to time strange phenomena take place with reference to these satellites. On one occasion the planet occulted a certain satellite, but the satellite instead of disappearing instantaneously, as is the case when a star is occulted by the Moon, was some 45 seconds before it entirely disappeared, in fact during that period it was actually shining through the edge or limb of the planet. This extraordinary phenomenon was seen by Mr. Todd, of Adelaide (Government Astronomer for South Australia), and his Assistant; no doubt can possibly be entertained by any impartial person as to the credibility of this occurrence, for both Mr. Todd and his Assistant were most capable and reliable observers, and they used a first-class telescope, an 8″ Cooke Refractor, moreover on 4 separate occasions they witnessed the same occurrence.

This can only mean that the outer layer of the planet on those occasions must have been sufficiently gaseous and transparent for the satellite to shine through an immense depth of the planet's outer substance.

The more we study the planet the more overwhelming do the problems associated with it appear to become.

The satellites of Jupiter follow the rule of the planets, *i.e.*, the inner ones are less than the outer ones. Nos. I and II are each about 2,000 miles in diameter and III and IV are about 3,000, their periods of revolution round their primary ranging from $1\frac{1}{4}$ day to $16\frac{1}{4}$ days.

To an inhabitant on the Moon, our Earth in the sky will look a huge object, but what will Jupiter with his mighty bulk look like to a dweller on its nearest satellite. A little calculation shows that the planet will appear in the sky as a globe with a diameter about 40 times greater than that of the Full Moon. Think of that monstrous ball in the heavens.

In our schooldays we were taught that Jupiter had 4 moons, but knowledge has advanced since then. On the 9th September (at midnight) 1892, Barnard of the Lick Observatory (California), whilst carefully examining the neighbourhood of

Jupiter with the 36″ Refractor, detected "an exceedingly small star" close to the planet and which he at once suspected to be a new satellite, a suspicion he soon verified. It was the discovery of the year and created a great sensation in the astronomical world. We with our 3″ or 5″ or 7″ telescopes cannot hope to see this addition to Jupiter's family for it is but a child of the 13th magnitude and lies very close to its parent.

But this is not all. In 1904 a 6th satellite and in 1905 a 7th were discovered photographically at the Lick Observatory, and in February 1908 an 8th was discovered by the camera at Greenwich, and this latest addition is of special interest, because its motion round the primary proves to be retrograde. The latest (*i.e.*, the 9th) addition (Phoebe) to Saturn's system has a retrograde motion also. How the supporters of the Nebular hypothesis reconcile these retrograde motions with their pet theory I am waiting to hear.

To formulate a theory that will fit and accurately account for all the extraordinary phenomena seen on the surface of Jupiter will require a better theorist than your lecturer to night, and I have to confess that theorising has never been my forte, still speculating as to the condition, or some of the conditions of things on such a strange planet is such a fascinating occupation that I feel in some measure drawn to it, even though hitherto I have been quite a stranger to such pursuits.

I think we may take it for granted that some kind of atmosphere exists on the planet. Vogel and Huggins have shown that the spectrum of Jupiter cannot be explained except on the ground that an atmosphere exists, for there are absorption lines which in all probability owe their origin to the dense atmosphere that surrounds the planet. Then how can we explain the dusky edge of the planet except on the ground that it has an atmosphere.

In Text Books it is generally stated that Jupiter shines to some extent by its own inherent light. If this be so, how can we explain the total extinction of a satellite when it enters the shadow cast by the planet? So far as I know, no satellite has ever been known to be visible, however faintly, white in the shadow. Now if any light emanated from the planet surely some of the great modern telescopes would either reveal the satellite visually or it would make some slight impression on the sensitive plate. If the planet give out light of its own it must be very slight. But even though it be proved that Jupiter gives off but little light, this is no proof that its surface is of the same cold nature as that of our

Earth. It may resemble cooling lava, hot and viscid, but giving off practically no light. Indeed, there is much to show that this is probably Jupiter's surface condition, otherwise how shall we explain the strange differential movements that are taking place almost everywhere in the southern regions and to some slight extent in the northern areas also? Some of these changing features are sufficiently permanent to persist for years. The Red Spot has been observed systematically for 38 years, and the general finding is that its rotation period is greater than that of any other feature on the planet. Indeed, scarcely any two spots or areas have the same rotation period. This would seem to show that the surface which we see is of a liquid or viscous nature and that the great Red Spot is a kind of floating island continent of a still more viscous nature which lags behind slightly owing to the friction of the atmosphere. Difficulties there are of course, but other phenomena appear to point in the same direction. You will remember the black rectangular spot I referred to in the early part of the lecture. This was attracted by the Red Spot and eventually entirely absorbed into its own substance. The elliptical shape of the spot, too, is evidence of the same kind. The broadening of the great South Equatorial Belt can be partly explained by this theory and so can the notch that appeared in front of the South Tropical Disturbance, at first deep and narrow but later shallow and long drawn out. To explain the origin of the spots, white and black and red as well as notches, protuberances, arches and such like phenomena is not easy in this state of our limited knowledge of the planet. If we assume that the surface is in a more or less viscous condition we must also take it for granted that vulcanicity is rife, and in all probability on an enormous scale on the planet. There have been periods in the past on the Earth when there have been outpourings of volcanic matter on a stupendous scale, the lava so poured out has varied in colour. We have the basic lava-basalt, black as ink in places, we have the acid lavas, the trachytes and rhyolites light or grey in appearance. And then we must not forget the immense volumes of steam that always accompany each outpouring. Take one or two areas: the *Deccan* outpouring and the basaltic outflow covering the North of Ireland and West of Scotland. We can quite imagine a black spot could be found on Jupiter's surface when we remember what has taken place on our own planet. The notch preceding the South Tropical Disturbance might well be a huge outpouring partly in the South Tropical Belt and South Tropical Zone. And we see it as a notch only because the southern half is of the same colour as the South Tropical Zone.

The gap I referred to appeared at first as a kind of swelling, but afterwards the colours in the swelling and zones merged and we could only see it as a gap. But there are difficulties and I can at best only make a few suggestions.

And, after all, we must not be dogmatic for our knowledge of the planet is still meagre. But I think "we have seen sufficient to show us that the planet is not yet in a condition to sustain life such as this Earth sustains." It is evidently still in its infancy, but surely it is being prepared for some noble purpose. Can such a magnificent orb, with such a magnificent array of attendants circling round it, exist merely to reflect a feeble light to a few planets in this Solar system? I cannot think this. I would prefer to think its Creator has designed it for a higher purpose. I prefer to apply to it the words of the great inspired seer who spoke: "For thus saith the Lord that created the heavens, God himself that formed the world and made it; he hath established it, he created it not in vain, he formed it to be inhabited."

Saturn and His System

By C. V. Raman, M.A.

At the Town Hall on the evening of Friday the 12th March 1915, a lecture on Saturn, his system of rings and moons was delivered by Mr. C. V. Raman, M.A., under the auspices of the Astronomical Society of India. The Hon. Mr. W. A. Lee presided.

The lecturer said that Saturn was undoubtedly the most beautiful and most interesting of all planets, if not indeed of all celestial objects; and the constitution of the planet and rings as disclosed by modern telescopic and spectroscopic research certainly added greatly to this interest. Saturn was known and his movements had been studied from the remotest antiquities and in common with the other planets he had been given a place in the Pantheon. The fact that had most impressed the ancients was the extreme slowness of his movement along the signs of the Zodiac. The lecturer explained that according to modern ideas, this apparent movement was due jointly to the movements of Saturn and the Earth round the Sun, and its smallness was due to the great length of the period of revolution of Saturn; and also to his distance from the Sun being large compared with the diameter of the Earth's orbit. This slowness of Saturn's