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## AMATEUR OBSERVATIONS WITH A SIX-INCH TELESCOPE.

By W. Reid.*

It is usual on an occasion of this kind for the retiring President to give an account of the activities of the Society during his term of office. As this has not been done for some time, I will now give you a short account of what we have been doing since the Society was started. As is well known, the Society was formed by the amalgamation of the Cape and Johannesburg Associations in 1922. The Society is composed of both professional and amateur astronomers, in fact, nearly all the professionals have joined, and the amateurs are distributed over the whole of the Union, Rhodesia and South-West Africa. Regular meetings are held both at the Cape and at Johannesburg. At these meetings papers have been read by many members on almost every conceivable subject in connection with astronomy. At the Cape a series of articles on the Solar System has just been completed. These described the Sun, the planets, their satellites, the asteroids, also the comets, shooting stars and zodiacal light. They were the work of several members, and were all illustrated by the latest slides or by diagrams. We have tried to make our subjects as diversified as possible, and while some were given in simple language which could be understood by everyone, other papers were more technical, and tried the thinking powers of the best of us. I had thought of giving you a list of some of the papers, but I find this would take up too much time.

Soon after the Society was brought into working order it was felt that an effort should be made to do some original work. Several Observing Sections were started, and I will now give you a short account of their activities.

*The Variable Star Section.*—Under various Directors, this Section has been a great success, about fifty southern variable

* Presidential Address for the Session 1925-26, delivered on June 8th, 1927.

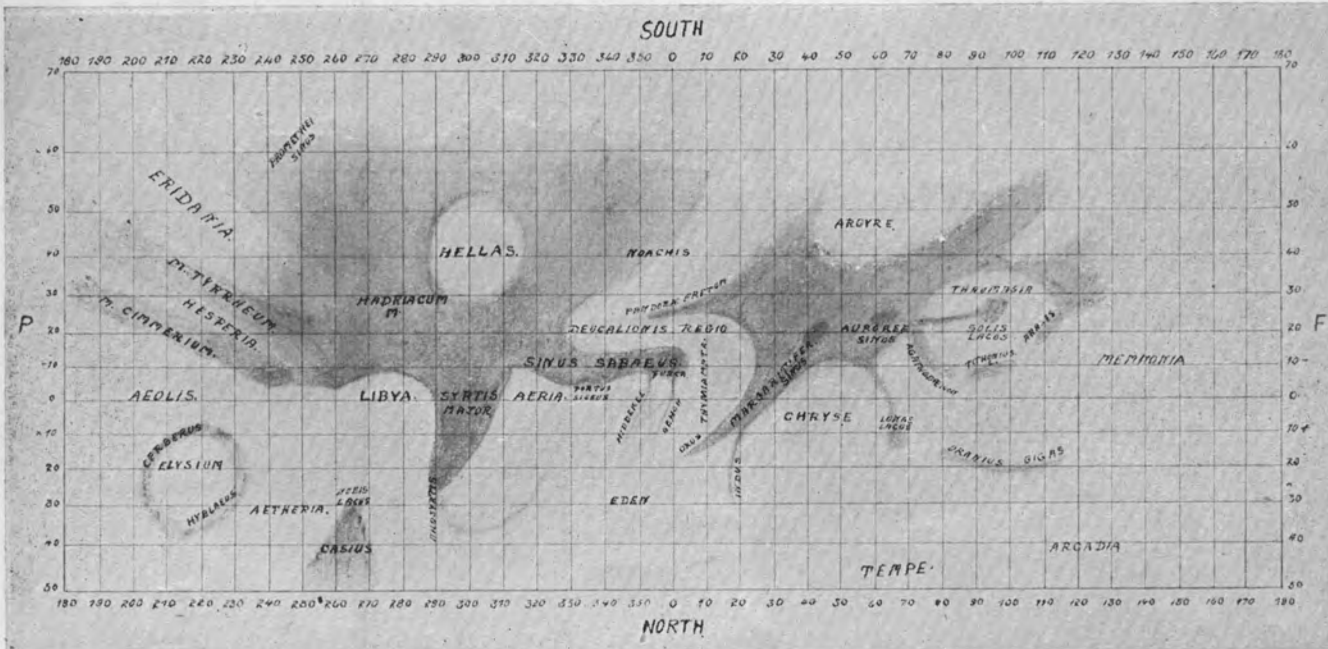


Plate No. 1.—Composite Map of Mars, 1924, from drawings by B. F. Jearey.

stars being kept under constant observation. And seeing that the number of observers could be counted on the fingers of one hand, it will be admitted that they are very much alive when I tell you that the number of observations is nearly 3,000 per annum. The most outstanding event connected with this Section has been the discovery of two new stars by one of our country members. Had these discoveries been made outside South Africa the whole astronomical world would have been ringing with them. In South Africa discoveries of this nature are simply taken as a matter of course, and nothing much is heard about them.

*The Comet Section.*—This Section has been under one Director from its inauguration. It has had a very successful career. We have now discovered fourteen new comets, and rediscovered two periodicals, one of which was supposed to be lost, and the other was only seen by one observer at its first apparition. We have also several independent discoveries to our credit.

*The Mars Section.*—This Section has also been under one Director since it was started. His last report, together with a fine series of drawings, was a regular mine of information, and spoke well for the perseverance and insight for fine detail of his assistants. This report, and a selection of the drawings, were published in our Journal.

*The Meteor Section*—This Section owes its inception to the efforts of one member, who made many observations of Southern meteors, and for years made a study of this branch of astronomy. Unfortunately he has not been able to do any work for some time, and no one has yet been found to take his place. This is specially to be regretted, as it is work which can be prosecuted without a telescope, and at the present time very little is known regarding Southern meteors.

Successful astronomical classes for Girl Guides and Boy Scouts have been held by various members. These have been much appreciated; it is to be hoped that some of the pupils will take up the study in earnest, and derive as much pleasure from it as their teachers have done. The Society has also published a number of pamphlets and circulars, many of which are now out of print and unobtainable. Monthly notes also appear in several of the daily papers. A Journal is published at irregular intervals. It has been our object to make this a quarterly publication, but unfortunately this has been found impossible up to the present owing to want of funds.

Curiously enough, I find the idea is prevalent throughout the world that our Society must be a very rich one to have been able to accomplish so much in such a short time. Quite recently a letter was received from a foreign country deploring the want of interest in astronomy in a certain European town. Among other things, it said that the Municipality had supplied them with an observatory and a very nice instrument, and that several gentlemen had contributed to keep the observatory in repair, but they had to depend on a few workers for everything else. The letter continued:—"No doubt you are secure from monetary troubles, seeing your country is such a rich one, and having a plethora of millionaires you will only have to let them know and you will be supplied with funds." On my recent visit to England I was surprised to find that this idea was also prevalent among astronomers there, and it was thought by them to account for our successes.

I have given you some idea of our activities, and I would now point out a severe handicap. We are accumulating observations and many articles on a great variety of subjects, but we are unable to publish them. Our Society has brought South Africa to the forefront of astronomy, and made its name ring throughout the world, yet being a small Society of men who, though enthusiastic and hard-working, are not possessed of a superabundance of this world's goods, we are forced to see most of our work kept from the public for want of funds to publish it. I am an Aberdonian, and Aberdonians are said to be able to wheedle money out of granite rocks. Unfortunately I have been so long in this country that I have become a South African, and have lost the art of wheedling. Also unfortunately I do not number any millionaires among my friends. Possibly some of the other members may be in a more fortunate position. If so, I hope they will bring this matter to the notice of their friends without delay. If South Africa is to retain its place in the astronomical world funds must be found to enable us to publish our observations.

America, as you all know, has found out that we have a grand field for observation, and is establishing observatories "all over the place." We extend a very hearty welcome to them, and wish them luck. At the same time we do not want to be left in the lurch, which we soon shall be if we are unable to make our observations known. An effort must be made to rectify this. Surely there are some scientifically inclined people who are patriotic enough to assist our endeavour to keep our Society in the forefront of the astronomical world. I have not the slightest doubt that we should get more observers if they were assured that their observations would be published. There is no inducement for people to work when they know that their efforts will never see the light of day.

It had been my intention to give an account of the astronomical discoveries of past and present amateur astronomers, but I soon found out that this was too big an undertaking. Instead of a short paper one would require volumes. I have therefore decided to restrict myself to things which I have personally seen, and the deductions which I have arrived at in connection with them. You must understand that my instrument is a six-inch telescope, and the subjects are treated as if I knew nothing more than this instrument reveals.

Like the majority of astronomers, I will start with the Solar System, and then go out into space until I reach the confines of the unknown. The first object to come under notice is our Sun, by far the most interesting to us, as it is also the most necessary to our well-being. Without the Sun our existence on the Earth would soon be at an end, and I am not surprised at our forefathers worshipping at his shrine. Indeed, while on a recent visit to Scotland I became a Sun worshipper myself, and lost no opportunity of basking in his welcome rays whenever I had a chance. Like every amateur astronomer, I have spent a certain amount of time examining his surface and making drawings of what I saw. I have also managed to secure several fairly successful photographs of sun spots; but as my time was always limited to about twenty minutes at noon, it soon became apparent that my work was not of a very useful nature, and for several years I have not even looked at the Sun through my telescope. Work on the Sun may be left to the many Observatories and professional astronomers, who are better equipped and have more experience for work of this nature than any amateur. My advice is to leave the Sun alone, as even our best work falls far short of the professional, and, as a matter of fact, is only interesting to the party making the observation.

*Mercury.*—The great majority of British writers on popular astronomical matters have laid great emphasis on the wonderful discovery of this planet by the ancients. Personally, I do not consider it was a wonderful discovery at all. True, it is rather difficult to see in Great Britain, but the discovery was made while the Britons were wandering savages. In all probability the discovery was made in Egypt or Arabia, and in those countries it must have been a very conspicuous object. At Cape Town it is often brighter than a first magnitude star, and I have followed it without difficulty for six weeks on end with the naked eye. The idea that it is a very difficult object has led many people astray, and I have had it reported to me as a new star on more than one occasion. Once it was reported as a comet, and when I told the discoverer that it was only the planet Mercury, he wrote back and told me to read what Sir Robert Ball said about it in his "Story of the Heavens"! Although Mercury is often very easily seen, it is not an easy object to observe, as it is always low down near the horizon when it is conspicuous. By day it is excessively difficult owing to the difficulty of seeing it at all. I have always had the best views of it in the morning sky, and on many occasions have seen the phases very distinctly. So far I have not been able to detect any markings on its surface, and I do not consider anything of any scientific value can be discovered by amateurs with their small glasses, however much time they may spend on a scrutiny of its surface.

*Venus.*—This planet is always a very beautiful object, and can often be picked up quite easily by day with the naked eye. All my observations of this planet have been made by day when it was near the meridian. Several years ago I spent a lot of time observing it, and although I occasionally thought I could detect faint dark patches upon it, they were so very difficult that I could never be sure whether they were only imaginary. I have also seen what I considered were faint white patches near where I thought the poles were situated, but these also were so faint that I could never vouch for them. I have at different times followed the planet to within a few degrees of the Sun, and then one phenomenon was very noticeable: the horns of the crescent continued round the planet for more than half a circle. At the last transit of the planet across the Sun's disc in 1882, Venus was outlined by a thin white thread while it was still partly outside the limb of the Sun. I have also noticed that there is generally a brownish border to the terminator. This cannot be caused by mountain shadows, and I think it may be the result of the Sun's rays being refracted through the planet's atmosphere. The lengthening of the horns, and the planet being outlined by a thin white line while entering the Sun's disc, are no doubt due to the same cause. I do not think the body of the planet is ever seen with any certainty. I am inclined to think that its atmosphere is very dense, and that any dark markings which may appear are only glimmerings seen through the thick layer of clouds with which Venus seems to be eternally covered.

*The Moon.*—Several years ago I read a paper to the Society regarding the Moon, illustrated by lantern slides. As that paper was rather lengthy and entered fully into every aspect of the Moon's appearance, I do not propose going over the same ground again. One observation which I made along with Mr. C. L. O'B. Dutton since that date may be related. On the occasion of the total eclipse of the Moon on July 4, 1917, Mr. Dutton and I decided to watch the behaviour of the craters Linné and Tycho. We had been asked to do so by a friend in England. The night of the eclipse turned out to be a beautiful one—clear skies and first-class seeing. Before the eclipse took place we made a prolonged examination of both the craters. We could not detect any change in either before they were obscured by the black shadow, indeed, we could not detect any change in Tycho either before or after the shadow phase, though it was rather difficult to see while in the shadow. With Linné the change was remarkable. Before the shadow encroached upon it it was a rather large hazy patch, nebulous, one might say. It completely disappeared while in the shadow, but came out of it as a distinct small oval ring of light with a very dark centre, and without a trace of the former nebulous appearance. As time wore on, the centre gradually became bright, and when we concluded our observation (over two hours after it came out of the shadow) it was still a small oval patch of light, very clearly defined and with very little appearance of haze round it. Next night it was the usual fairly large indistinct hazy patch of light, which is its normal appearance.

Before leaving the Moon, I should like to call attention to some of the small dark patches, and especially the crater Archimedes. As the Sun approaches the vertical, some of these spots seem to get darker instead of lighter, as one would expect. I am quite persuaded they do get darker, and that it is not an effect of contrast. The appearance of the crater Archimedes is most remarkable, and the shading and dark patches appear to move in a manner for which I cannot account. So far the Moon has proved to be an absolute enigma. Not a single feature on its surface can be explained with an assurance that we are anywhere near the truth.

*Mars.*—Every visitor to my Observatory knows more about Mars and its inhabitants than I do myself. One of the very first questions I am asked when dealing with this planet is: "Do you think it is inhabited?" So far as I am concerned I have no difficulty in answering this question: I do not know, and I am never likely to know! Mars, in my opinion, is not an easy object to observe. With the exception of the snow caps, which are sometimes very clearly defined, the markings, though sometimes easily recognised, are never very clear, and are often much obscured, especially on the limb, by what I consider is morning or evening mist. Even on the disc it is not unusual to see hazy white patches which obscure the darker markings. My own opinion, after long deliberation and observation, is that seasonal changes can be detected. The snow caps can be seen to wax and wane, even in the course of a very few nights. I am also inclined to think that Mars has a denser atmosphere than is generally recognised. I can only account for the occasional white misty appearances on the limb and the white misty patches on the disc as real mist. The planet at all times has a more or less hazy appearance, as if it were difficult to focus, and I think we are looking at a body with a fairly dense and sometimes cloud-laden atmosphere.

*Jupiter.*—This may be said to be the most interesting and spectacular of all the planets, with the single exception of the next one, Saturn. The constantly changing appearance of Jupiter's cloud belts, and the transits, occultations and eclipses of the four bright satellites are a source of great delight to most amateur astronomers. In fact, they are sometimes too interesting, for I have met men who are never tired of looking at the planet, and they seldom or never do anything else. I am in favour of specializing. Several members of the British Astronomical Association have made a name for themselves by their observations of Jupiter, but it is quite a different matter spending hours observing the planet with the definite object of recording what they have seen from merely looking at it because it is a pretty sight. I am of the opinion that Jupiter is covered by a very dense cloud-laden atmosphere. At one time, in the late seventies and early eighties, I thought the "red spot" (which *was* red at that time) might be a portion of the real surface of the planet, but I am now inclined to change my views. It has recently changed so tremendously in appearance, and its rate of rotation seems also to have changed. My observations point to the planet being in an unstable state. The spots, both dark and light, and probably the red spot also, may be the effect of tremendous outbursts of some kind. They are transient in nature, but sometimes last for several rotations, and in this way slightly resemble what we see taking place on the Sun.

*Saturn.*—I consider this planet, with its rings opened to their widest, one of the finest sights in the whole heavens, especially when seen under very favourable conditions. Curiously enough, I have never yet seen a drawing which represents the planet as I see it. It is one of the easiest planets to bring to a sharp focus, and this is perhaps the chief reason why all its features are shown too sharp and in nearly every case too distinct. To me the planet appears as an oval-shaped body, with a broad belt which is sometimes fairly clearly defined. This belt extends to some distance beyond the equator on both sides. It is lighter than the other parts of the planet, the polar regions being the darkest. The planet is surrounded by three rings, the two outer rings being the brighter and look like thin solid flat wafers of light. On closer inspection the outer ring looks as if it were made up of particles, especially at the extreme ends of the oval. One can see the dark background through them. Regarding the inner ring, I do not think anyone will deny its transparency. It is so transparent that it is very difficult to see it at all, and its shadow on the planet is much more easily seen. Here again the shadow gives one the impression that it is not the shadow of a thick swarm of particles, as it is never very dark and under a high power seems to be mottled. The centre ring is much the more brilliant, but, like the other two, it is made up of discrete particles. There is not the slightest doubt that irradiation is the cause of its apparent solidity. When seen absolutely edgeways on, the rings disappear entirely from my view, but only for a very short time. I have actually seen them, after disappearance, reappear as a thin white line, with a slight thickening where the middle ring is situated. The time from disappearance to reappearance in this instance was only a few hours.

This leads me to the conclusion that all the rings are more or less transparent, being made up of particles which circulate round the planet in almost the same plane and at an appreciable distance from each other. Several years ago Messrs. Dutton and McIntyre, my son and I made an observation which settles this question conclusively. At least, I am quite satisfied that the rings are all more or less transparent. Not only that, but the upper regions of the planet's atmosphere are also transparent. I will give a short résumé of the observation, so that you may follow my deductions.

On March 14, 1920, a star was occulted by the planet Saturn. This occultation should have been seen from the whole of Africa, the whole of Europe, and the greater part of Asia. Curiously enough, our station was the only one where the whole phenomenon was witnessed in its entirety, and under circumstances of exceptional seeing. Clouds and bad weather prevailed at all the other observatories, and though parts of the occultation were witnessed elsewhere, we were the only observers to see the whole occurrence. I will here quote from my notes made at the time.

"The star approached the ring at an acute angle, and we had difficulty in deciding when the star was actually behind Ring 'A.' At first there was little diminution of light, but as soon as it touched Ring 'B,' the light faded about half a magnitude. It remained like this for a few seconds, when it again fell a little further, and almost immediately gave a flicker, that is, it almost went out, but not quite. It rose again fairly suddenly. After this its light fluctuated very considerably, but never reached more than a magnitude less than its original brightness.

"When it reached what we considered the limb of the planet, it was about two-thirds across Ring B. Instead of disappearing it continued in sight until it was well inside the limb of the planet. While behind the planet's disc it was all the time getting dimmer, and when it disappeared it did so fairly suddenly, but not like a lunar occultation, where the star goes out with a snap."

Regarding change of colour. Before and after occultation, the star was a beautiful bright orange; during the passage of the ring it faded to a dull orange, and before disappearance and reappearance was a brown orange.

We had no difficulty in following the star the whole time except when the flicker took place, but even then I do not think we lost it. I was fortunate enough to observe the star at the moment of reappearance. It was then about two magnitudes below its original value, and brownish orange in colour, and was well within the disc. We all had time to see it before it was clear of the disc. It gradually brightened up until it emerged.

Up to the present I have refrained from giving any account of my own deductions regarding this rather unique experience. From what I saw I should say that all three rings are transparent that they are lumps of matter, circulating round the planet in individual orbits, and in almost the same plane. I think they must also vary in size, and that there must be some distance between them. I once saw a motor car pass me, with its spot light turned on to a privet hedge behind which I happened to be standing. While it was passing I never lost sight of the light, although it fluctuated considerably, and was certainly much dimmer than when seen without anything obscuring it. It also flickered two or three times. Examining the hedge next day, I found I had no difficulty in seeing through it when looked at from a short distance, but it presented a solid mass when viewed from afar. The flicker was caused by the trunks of small trees which were growing beside the hedge. I have tried several experiments, but this one is the best illustration of what I saw take place when the star was behind the rings. I should particularly like to emphasize the fact that the star disappeared and reappeared well within the planet's disc. I have little doubt that Saturn is surrounded by a very deep atmosphere, the upper portion of which, though transparent, is able to reflect light. I once asked an eminent South African professional astronomer if a transparent atmosphere would reflect light, and his reply was, "I should certainly think it would!"

*Uranus and Neptune.*—These two planets are too far away for effectual observation by amateurs. They are both quite easy objects even with fieldglasses, but they do not repay one for spending time upon them. Perhaps it would be worth while recording that I know of two modern discoveries of Uranus. The first was by Dr. Lunt, who found a star in a field in which he had never seen this star before. The second was by myself with the naked eye. I noticed a double star where a single should have been. In both cases the stars turned out to be the planet Uranus.

*Comets.*—I have always been interested in comets, and have often been asked why. Perhaps the following reason may account for it to some extent; at least, it will satisfy some people.

A great comet was blazing high up in the northern Heavens within half an hour of perihelion when I first saw the light. The first comet to leave an indelible impression on my young mind was the comet of Coggia. This comet was an extraordinary phenomenon to me. It was very brilliant, with a long bright tail, the rapid growth of which one could almost visualize, and it disappeared as quickly as it had appeared. Since that time I have seen many great comets, many much brighter and bigger than Coggia, but none of them has left so great an impression on my mind as Coggia. Perhaps it may have been that it came at a time when my mind was beginning to grasp some of the truths of astronomy. Its sudden appearance, and the difficulty I experienced in understanding its movements, impressed me most vividly. I put Coggia down as the starting-point of my interest in comets. I have seen quite a number of extraordinary, and what one would call great comets, but I have not the time to describe them. From about the year 1879 to 1883 we had great comets every year, sometimes two could be seen at one time. Since then there have been very few, only the great comet of 1901 and Halley.

Comets are most mysterious objects, and even at the present time very little is known regarding their composition or origin. From my own observations I have come to the conclusion that there is very little difference between comets and meteors. In all probability the meteors are wandering debris from the comets, and in the case of some of the large fireballs, they are comets which are all nucleus without any attendant companions. I saw both my last comets pass almost centrally between me and a star without the star losing any perceptible light. This would lead one to deduce that the head of a comet was composed of a swarm of particles, no doubt varying in size and some of them sufficiently large to keep the whole together by the force of gravitation. When I rediscovered D'Arrest's comet it looked, under a power of 216, like a compact cluster of very tiny scintillating stars. It was only under a very low power that it had the slightest appearance of haze. In 1872 the earth passed through the path of Biela's comet, and, although we were a considerable distance from where the head of the comet was computed to have been, the particles were sufficiently numerous to give us a fine display of shooting stars.

I could mention many other instances of a like nature which I have seen myself, but this is sufficient, I think, for us to conclude that the head of a comet is composed of a vast quantity of meteorites spread over a very large space, but in the majority of cases more condensed towards the centre. In a large comet I have no doubt some of the particles may be of a large size. If the meteoric theory of the lunar craters is correct, I think the earth would come off very badly in an encounter with a really great comet. I am inclined to think that all comets belong to the Solar System, and that their paths are ellipses, in most cases tremendously elongated ellipses. So far I do not think that any comet has been discovered travelling at a speed sufficient to enable it to get beyond the Sun's influence. The Jupiter comets are generally supposed to have been caught by this great planet, but I incline to the theory that Jupiter is the parent of many of them—possibly all.

It has been proved that comets have disintegrated and disappeared within living memory, and if this is the case with some, the process of disintegration may be going on in all. If so, we must provide some means whereby the number may be augmented. We see great changes taking place on the surface of Jupiter, and it may be that this is caused by great eruptions on the planet. I do not wish to carry this theory further, but it is a curious fact that the whole of the Jupiter comets travel round the Sun in the same direction as the rotation of the planet on its axis. I can hardly imagine that this would be the case if they were all captures.

*The Zodiacal Light.*—My observations lead me to the conclusion that the zodiacal light fluctuates in brightness, and that it is always brightest at the sunspot minima. I noticed this particularly at the last minimum; sometimes it was so bright, it interfered with my comet searching, and I was forced to give up long before dawn.

*The Stellar Heavens.*—I will now enter the domain that is generally left for professional astronomers. Within the last two decades the professional has made extraordinary strides towards a knowledge of the form, distance, and composition of the various bodies which make up what I call our stellar system. I do not intend to tackle the subject from the professional standpoint. I have tried to erase everything professional from my mind. My object is to present the subject as I see it through my small six-inch objective. My whole paper is simply an amateur astronomer's observations, and it does not profess to be anything else.

To the average individual, the vault of heaven is an uncountable number of stars, scattered promiscuously all over the dome. He is under the impression that there are countless thousands within his sight and that their arrangement is most chaotic. In both deductions he is wrong. The number of stars within naked eye vision only runs into a few thousands. It will also be noted after more careful observation that there is a certain system in their arrangement. Our earth seems to be surrounded by a ring of hazy nebulous light, and the majority of the brighter stars are arranged in another ring, either alongside or in the nebulous light which we call "The Milky Way." Further observation will reveal the fact that the bright stars are not projected on the Milky Way, but are arranged in a plane which differs slightly from it. This is most easily seen in the region from the constellation Taurus to beyond Sirius. Near Crux they cross the galaxy at a very acute angle, and again near the north celestial pole, so that for one half of the circumference of the circle the bright stars are on one side of the Milky Way, and for the other half they are on the other side. Between Alpha Centauri and Altair the galaxy is split into several branches, and the bright stars hug the outer edges of the branches. Between the branches there are long lanes void of stars. There are many other peculiarities and objects which are within naked eye observation, but I will now describe some of the things revealed by the telescope.

Through the telescope the Milky Way is composed of a tremendous number of stars, star clusters, and irregular nebulæ. Sweeping for comets, I have crossed the Milky Way again and again at all parts for about two-thirds of its circumference, and wherever I have crossed it the stars thin out as soon as it is left, at some places abruptly, and at others gradually. From Alpha Orionis to Alpha Canis Majoris every sweep reveals enormous numbers of stars and open star clusters, with an occasional nebula. But the curious thing about this region is that the stars in the Milky Way proper are very much smaller and more thickly crowded than in the region in which we see the bright stars. It would almost seem as if we had here two streams of stars, those in the Milky Way being the more distant. I am also convinced that we see to the beyond throughout the whole of this region. All the stars stand out in perfect focus to the very tiniest speck. To me, this part of the galaxy appears to be very near, and we are actually seeing all there is to see. In other words, we are nearer the edge of the ring than in any other part of the Milky Way.

From Sirius to the Cross we have greater difficulty in piercing the star clouds, and as we near the Cross we are very much impressed by the dark smoky patches which we encounter, especially to the south of Carina, towards Chamaeleon, and towards Musca. Throughout the whole of this region the stars appear to be shining through smoke, and are most difficult to get to a true focus; many of them have a curious nebulous appearance, and one eighth-magnitude star in Chamaeleon has been reported to me as a comet by several different people. The whole region from the Cross to Aquila is full of these dark patches and lanes, but more particularly near Antares, between the tail of the Scorpion and the bow of the Archer, culminating in a large patch, absolutely void of stars, near Theta Ophiuchi.

Proceeding with our examination of the galaxy from the Cross in the direction of the Scorpion, it at once becomes apparent that the Milky Way is receding from us. The groundwork of stars becomes more difficult to resolve, and when we reach the great clouds in Sagittarius it is impossible to do so. Outside the star clouds in the constellation Sagittarius, that is, outside the Milky Way, in the direction of Capricornus, there are several very large clouds, so distant that I have only been able to see them on one or two occasions during the whole time I have been comet-hunting. The easiest cloud was discovered by the late Professor Barnard while comet-searching. The others are to the south of this, and are so large they fill the whole field, but can only be seen on a night made for the purpose. They are most difficult, and I have swept over them again and again without seeing them. It is hopeless looking for them unless the seeing is superfine.

Beyond Aquila the Milky Way assumes the appearance of the Canis Major to Crux region. The bright stars again converge on and cross the Milky Way in the constellation Cepheus. Taking the stars and judging by their brightness, the law of averages would give us two streams in the direction of the bright star Sirius, one near to us and the other further away. In the direction of Sagittarius there appear to be several streams, the nearest probably belonging to the Sirius stream, of which our Sun would be a member. There is also one other, more distant than this stream, but nearer to us than the great cloud in Sagittarius. This stream breaks into several branches. I consider the Great Clouds to be the centre of the whole Milky Way system. The Barnard and other star clouds are probably the brighter portions of a star stream, situated at a more remote distance than the star cloud which forms the centre of the system. Unfortunately the dark matter encountered near the more distant parts hides what is beyond, and makes it more difficult for one to form a true conception of the shape of the stellar system to which the Sun belongs. In all probability the dark matter is nebulous, and, as an argument in favour of this idea, I may mention the fact that nearly all the bright irregular gaseous nebulæ are in or near the dark places, and, I think, are only shining from the reflected light of the stars near them.

I will now leave our stellar system and describe some objects which resemble it in appearance and construction. The first to attract attention are the two clouds of Magellan. I have heard advanced astronomers assert that they resemble detached portions of the Milky Way, but this is entirely wrong, although as a whole they are similar: no portion of the galaxy of equal size resembles them in the slightest. It is quite true that every variety of object found within or near the Milky Way is also found within the clouds, and they appear to be complete stellar systems like our own, but much smaller and differing in several ways. The small cloud has an ill-defined structure; on the other hand, the large cloud has a well-defined central cluster, which is a long oval, inclined to form a hook at both ends like an elongated S. If one were placed within this cloud, but at a great distance from the nucleus, I am inclined to think the sky would somewhat resemble the appearance of our present sky, but on a smaller scale.

There is one object in the northern Heavens which in my opinion is almost a duplicate of our own system. I refer to the great Andromeda nebula. Placed within one of the outer arms of this nebula, our view would, in all probability, be very similar to what we behold on earth. In this instance our Milky Way would be quite as extensive as the pale shining light which spans our familiar heavens. There are hundreds of thousands of similar objects in the sky. Some of them are perfect spirals, some are lens-shaped objects, many have bright, almost stellar, nuclei. Others are pale, round objects, without any distinguishing features. They vary in appearance and also in size. In many cases this may be due to distance, but not always. One feature is nearly common to all of them, that is, dark patches and lanes of obscuring matter, very similar to what we see in our Milky Way. These outer objects, which I call stellar systems, are ranged in an irregular belt which crosses our Milky Way almost at right angles. They appear to form a group of stellar systems, our own Milky Way being one of the group. I am quite prepared to believe there are more groups of stellar systems away out in space, far beyond our reach. It is a grand conception. Who can say whether it is correct or not? In any case I am quite sure the unknown is far more wonderful than the known, and that all our efforts will never fathom the mystery of the Universe.

"World after world, sun after sun, star after star, is past,
Yet systems round in myriads rise more glorious than the last.
The wondrous universe of God still limitless is found,
For endless are its distances, and none its depths can sound."

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## STELLAR EVOLUTION.

By H. Spencer Jones, M.A., Sc.D., H.M. Astronomer.*

In his postponed Presidential Address, delivered last month, Mr. Reid referred at some length to the various activities of this Society. It is not necessary for me to go over the same ground; he was able to show that the Society, though a small one, has made important contributions to observational astronomy. Only a brief reference was made to what I consider one of the most important of these contributions. I refer to the discovery by one of our members of the two novæ, Nova Aquilæ and Nova Pictoris. It is true that Nova Aquilæ was discovered independently by several other persons. But Mr. Watson was the sole discoverer of Nova Pictoris, and his discovery enabled spectroscopic observations of this nova to be secured at an earlier stage than in the case of any previous bright nova. Nova Pictoris proved unique in several respects, and its detailed study will undoubtedly assist materially in solving the riddle of these stars.

* Presidential Address for the Session 1926-27, delivered on July 27th, 1927.

I desire to emphasise this discovery not merely because of its intrinsic value, but also because it shows that important contributions to astronomy can be made without any telescopic equipment. I should like to see all the members of this Society active observers in one way or another. If several members would each take a portion of the sky and watch it systematically for the appearance of new stars, the possibility of missing observations of the most interesting stages of the outburst of a new star would be considerably reduced.

In his address your late President referred to the lack of funds from which this Society suffers. The Council would like to see the Journal published at regular intervals; a quarterly Journal should not be impossible of achievement. But at the present time publication is only possible at irregular intervals as funds permit. We may hope that the establishment of new Observatories in this country will act as a stimulus and result in a greater interest in astronomy. The Yale Telescope in Johannesburg has for some while been in regular use; the building of the Lamont-Hussey Observatory at Bloemfontein, forming the southern station of the Ann Arbor Observatory, is in progress, and observations will doubtless commence at no distant date; the Harvard Observatory has closed its southern station at Arequipa, in Peru, and the instruments have been brought to this country, whilst the Director is at present investigating a suitable site. A 60-inch reflector is to be added to the equipment, and will be the largest aperture telescope in the Southern Hemisphere. I understand that it is probable that another American Observatory will establish a southern station in this country. With these observatories in operation, in addition to the older-established foundations of the Cape Observatory and the Union Observatory, Johannesburg, South Africa will become the astronomical centre of the Southern Hemisphere. It is not unnatural to anticipate that this will be reflected in an appreciable increase in membership of this Society.

Whilst astronomers have at last awakened to the fact that the climate of South Africa is second to none for astronomical observations, there still remains amongst the general public a remarkable ignorance of even the most elementary facts concerning the skies. This is doubtless due to the fact that astronomy touches the practical side of our lives in very few places; education to-day is largely utilitarian in its objects, and in few school or college courses does astronomy find any place. There was not the same ignorance centuries ago, when men lived in more intimate contact with Nature, and when a knowledge of the heavenly bodies and their movements was part of the necessary equipment of life. I should like to see one of the new Zeiss planetariums set up in one of our towns either by the municipality or by some public-spirited citizen. It would help to make plain many facts concerning the heavenly bodies and their movements, to create a great interest in astronomy, the oldest and the purest of the sciences, and it would be of great cultural value. Many municipalities in Europe have erected one of these planetariums, which have in all cases aroused remarkable interest. Can South Africa afford to be without one?

The Council allows the President entire freedom in the choice of a subject for his address. Using the discretion thus allowed me, I have chosen for my subject "Stellar Evolution." I have done so not only because the subject is one of very general interest, but also because it is at the present time in a state of flux, and current theories are neither so definite nor so generally accepted as was the case ten years ago. A survey of the present state of the problem will therefore be of interest.

A brief summary of the main observational facts which have to be accounted for will first be given. It is outside my purpose to explain how these facts have been derived. I need only say that they are all generally accepted.

Stars can be classified according to various intrinsic properties: colour, type of spectrum, temperature, absolute brightness, mass or density. The classifications according to temperature, colour and type of spectrum are essentially the same. Stars radiate approximately as black bodies, and the temperature of the radiating layers, or the effective temperature of the star as it is called, determines the spectral intensity curve of the radiation and therefore the colour of the star, which may be defined and measured in various ways. The temperatures of the stars range from about 20,000° C. for blue stars to about 2,000° C. for the very red stars. The progressive change of temperature from blue stars to red stars is accompanied by gradual changes in the nature of the star's spectrum, so that a classification of the stars by temperature or colour is essentially also a classification according to type of spectrum.

When we consider brightness and density, a different state of affairs is found. The reddest stars are either very bright or very faint, no red stars of intermediate brightness being known to exist. The bright red stars have very low density, and the faint red stars have high density. The blue stars, with few exceptions, are all bright. In passing from the blue to the red stars, the brightness of the brightest stars of each colour or temperature group remains approximately constant, but the lower limit of brightness decreases progressively. The stars may be divided into two series: firstly, a series of stars whose brightness is approximately constant throughout the range of colour or temperature, and secondly, a series whose mean brightness decreases progressively from blue stars to red stars. The first series comprises the "giant" stars, intrinsically bright stars with low density. Along the second or main series, which comprises the majority of the stars, the mean density increases progressively from blue to red stars. Owing to the range in brightness in each series, the two series are clearly separated only in the redder stars, where the extremes of brightness and of density are found.

It may seem surprising that stars of the same temperature, but differing widely in density, should be characterized by the same spectrum. The reason for this is that the spectral lines originate in the ionization of the atoms, *i.e.*, the tearing off of one or more of the outer electrons in the atom. In a gas emitting a spectrum, ionization accompanied by the recombination of electrons with the atom is continually in progress. This process of ionization is a function of the temperature and pressure in the outer layers of the star. The pressure in these layers is in all stars only a small fraction of an atmosphere, and consequently the production of the spectrum is mainly a temperature phenomenon. Slight differences have nevertheless been found in the spectra of stars of the same type, which are dependent upon the density or intrinsic brightness of the star; these differences take the form of variations in relative intensity of certain lines in the spectra of stars of different absolute magnitude. Measurements of the relative intensities of such pairs of lines have been used to determine the absolute magnitudes and thence the parallaxes of stars. The parallaxes determined in this way are called "spectroscopic" parallaxes in order to distinguish them from the directly determined or trigonometrical parallaxes.

The masses of the stars show only a small range. A range from one-tenth to ten times the mass of the Sun will comprise the large majority of the stars. On the average, the bluer stars are the more massive, and the stars of smallest mass are found at the red end of the main series.

The observational facts which have briefly been referred to fitted well into the "giant and dwarf" theory advanced by Hertzsprung and developed by Russell about 1913. According to this theory, a star starts as a cool, diffuse mass of gas, viz., as a red star of low temperature and density. The investigations of Homer Lane had previously shown that if a star, supposed to be a spherical mass of gas obeying the perfect gas law, is free to contract under its own gravitational attraction, the contraction must be accompanied by an increase in temperature. Only so long as the perfect gas law is obeyed will this result hold; it is obvious that the star cannot continually grow hotter, and it is therefore natural to assume that, when the stage is reached at which the density has increased as a result of the contraction to such a degree that the laws of a perfect gas are no longer obeyed, the further contraction will be accompanied by a gradual decrease of temperature. The theoretical investigations of Homer Lane fitted into the scheme of Hertzsprung and Russell. The giant series, to which we have already referred, comprises the stars whose contraction is accompanied by increase of temperature; during this stage of the evolution of the star, observation shows that the intrinsic brightness of the star remains approximately constant; in other words, the increase in brightness per unit area resulting from the increase in temperature is approximately balanced by the decrease in surface area resulting from the contraction.

The contraction will continue until a stage is reached when the density is too great for the perfect gas law to apply, and the rise of temperature will be checked. The more massive the star, the longer will this stage be deferred, and therefore the hottest stars should be the most massive, in agreement with observation. When the temperature commences to fall, the resulting decrease in surface brightness per unit area combines with the decreasing surface area to produce a rapid decrease in absolute brightness. The stars in this state, with decreasing temperature and brightness and increasing density and redness, constitute the stars of the main sequence, to which reference has already been made.

This theory of the evolution of a star contracting from a bright diffuse cool red star until it becomes a hot blue star with density sufficiently high for the gas laws to begin to fail and then back again to a cool red star, but now a dwarf star of high density, appears to accord well with many observational facts and to be in harmony with what theoretical anticipations would lead us to expect.

We must now digress for awhile to consider what is occurring in the interior of a star. The early investigations of Homer Lane had pictured the star as contracting under the influence of its own gravitational attraction, and had ignored a phenomenon which becomes of great importance at high temperatures, namely, the pressure of radiation. The fact that pressure is exerted by electromagnetic waves, including waves of light, was predicted by Maxwell, and the pressure calculated by Maxwell's theory has been proved by measurements. The pressure is proportional to the fourth power of the temperature of the radiation, and at a temperature of 10 million degrees amounts to about 25 million atmospheres. We have reasons to believe that the temperatures at the centres of stars in the main series are of the order of 40 million degrees, and the radiation pressure corresponding to such a temperature is about six thousand million atmospheres. Such a pressure cannot be neglected. Eddington has compared the radiation flowing outward through a star to a wind blowing through the star and helping to distend it against gravity. Theoretical considerations show that the larger the mass of a radiating globe of gas, the greater the relative importance of the radiation pressure as compared with the gas pressure. For a mass one-tenth that of the Sun, radiation pressure is relatively small compared with gas pressure, whereas for a mass 100 times the Sun's mass it is relatively large. With possibly a few exceptions, the masses of all stars are such that radiation pressure and gas pressure are comparable in magnitude.

The physical conditions for a star in a steady state require two conditions to be satisfied. The first is that the difference of total pressure, *i.e.*, the sum of the radiation and gas pressures on the two sides of a small portion of the matter in the star must counterbalance the weight of this portion. The second is the condition for radiative equilibrium, whch requres that the net flow of radiation outwards at any point in the star is directly proportional to the gradient of the radiation pressure, and inversely proportional to the obstructive power of the material. The latter depends upon the density of matter at the point and upon the coefficient of absorption. The mathematical formulation of these two conditions forms the basis of the theory of radiative equilibrium.

For the mathematical development of the theory certain assumptions must be made. These are as follows: (1) The conditions of a perfect gas are assumed to hold throughout the star. (2) The molecular weight of the material of the star is assumed constant. (3) The average rate of liberation of energy per gram for the region interior to any point in the star is assumed inversely proportional to the coefficient of absorption at the point. (4) An absorption law must be assumed, so that the absorption coefficient of the stellar material can be expressed in terms of the physical parameters which enter into the problem, density, temperature and molecular weight. The assumptions (2) and (3) are admittedly approximations which are introduced for the convenience of the mathematical manipulation, but they are reasonable assumptions. The molecular weight is the average mass per independent particle. Owing to the high temperature in the star, there is almost perfect ionization. If $n$ is the number of satellite electrons in an atom of atomic weight $A$, then when the atom becomes completely ionized the average atomic weight of the resulting particles is $A/(n + 1)$. It is well known that the atomic weight is approximately twice the number of electrons in the atom (except in the case of hydrogen), so that whatever the composition of the star, the mean molecular weight at any point cannot differ greatly from the value 2. We may expect it to be somewhat larger than this value, for some of the heavier elements will not be completely ionized. But except very near the surface of the star, the mean molecular weight at any point cannot be greatly different from the value 2. It is therefore apparent that the assumption of a constant molecular weight throughout the star is a reasonably good approximation.

The reasons for the assumptions (3) are not so easily apparent. It is obvious that the energy flowing across any sphere in the star will be lessened if the absorption at the surface of the sphere is increased. The rate of liberation of energy per gram at any point in the star may be expected to be conditioned mainly by the temperature at that point. Closer investigation shows that the assumption (3) is approximately satisfied for any law connecting the rate of liberation of energy with the temperature that can reasonably be assumed. Thus the assumption is found to be a good one whether the rate of liberation of energy per gram be assumed constant throughout the star or whether it be assumed to vary as the first, second, third, or fourth powers of the temperature.

As for the assumption (4), the law of absorption is derived from general theoretical considerations, and certain deductions from the theory which depend upon the form of this law lead to the conclusion that the assumed law is not far from the truth. The assumption (1) is a reasonable one to make; it must undoubtedly hold for diffuse gaseous stars of low density, and it may be expected that comparison between theory and observation will lead to some conclusions as to the extent to which the perfect gas law is departed from in denser stars.

The ultimate upshot of the theory is to give a formula which expresses the absolute magnitude of a star in terms of its mass, molecular weight and effective temperature. The temperature term can be used to reduce stars of different effective temperatures to one definite temperature. We then have a relationship connecting mass and luminosity for stars of a given effective temperature, on the assumption that the perfect gas law holds throughout the star.

When Eddington first derived this relationship in 1924 he set out to compare it with observation, with a view to obtaining some information as to the extent to which the perfect gas law was departed from in stars on the main series. He found that within the limits of uncertainty of the observational data and of theoretical uncertainty arising from the approximate nature of the above assumptions made for convenience of mathematical treatment, all the stars which could be used as a test fitted the mass-luminosity curve which had been derived from the theory. This result was entirely unexpected. It seemed that the theory applied to the wrong stars. Consider, for example, the case of our Sun, a dwarf yellow star with a density greater than water, for which the perfect gas law should not hold and for which, therefore, the theory should not apply. The theory should predict the luminosity of a giant star of the same mass as the Sun. But the Sun is found to fit the curve, and a giant star of the same temperature and mass would not do so. Two conclusions, therefore, appear inevitable.

The first is that for all the stars for which the theory can be tested there can be no marked departure from the perfect gas laws. The second is that the Sun cannot have evolved from a giant star of the same mass, as supposed by the giant and dwarf theory of Hertzsprung and Russell. This theory requires that for a star of given mass and temperature, two values of the luminosity are possible; it attains the first value when its temperature is increasing and its density is low, and the second value when its temperature is decreasing and its density is comparatively high.

It is not difficult to understand why the perfect gas law holds for a star on the main series. Matter in any form consists of an assemblage of atoms or molecules which are in continual motion. The violence of this motion is revealed to us as temperature. In a liquid or solid, the molecules are so closely packed together that there is scarcely room for them to move without colliding with other molecules. In a gas, on the other hand, the molecules occupy a relatively small amount of the space occupied by the gas, and a molecule can travel an appreciable distance on the average before it collides with another molecule. Suppose a quantity of gas is contained in a cylinder, closed with a sliding piston. If the piston is moved in so that the volume of the gas is halved, the pressure on the piston arising from the bombardment of the molecules is doubled. If the volume is again halved, the pressure is again doubled. If, however, this process is repeated sufficiently often, a stage will at length be reached when it will be found that halving the volume does not double the pressure. The gas no longer obeys the perfect gas law, the reason being that it has been compressed to such an extent that we are beginning to approach the condition of a liquid, in which the molecules are so close together that increase of pressure produces very little change of volume. Although atoms and molecules have no definite bounding walls, they behave exactly as though they had, so that it is not possible by pressure to increase the density of a liquid or solid beyond a certain point.

The most extraordinary thing about any atom is its emptiness. Sir Oliver Lodge pictures a cathedral with several gnats flying about in it. Abolish the cathedral and consider only the gnats, and suppose them to fly round and round within the quondam walls. We then have a pretty accurate idea of the atom and of its relative emptiness. In a star, the atoms are broken up into their constituent nuclei and electrons, each of which can be considered as a separate unit. Our cathedral walls no longer exist even in imagination, and the gnats can be placed in a matchbox, and still have room to move freely about. In other words, owing to the breaking up of the atoms in a star, matter at very high densities can still obey the perfect gas law. Under the conditions which prevail in a star we can conceive of densities exceeding one million million times those of terrestrial materials. We are safe in concluding that, with the possible exception of the white dwarfs, such as the companion of Sirius, the perfect gas laws are obeyed in all stars.

Our second conclusion was that two stars of the same mass and effective temperature, but of widely differing luminosities, cannot exist. Evolution as pictured by Hertzsprung and Russell cannot occur. The representation of stars in Russell's well-known diagram, with the giant sequence and the main sequence, does not therefore necessarily represent the evolutionary sequence, but may merely represent a statistical series of quasi-steady states. How then does the evolution of a star proceed?

A star is continually sending out radiation in the form of heat and light. According to modern views, radiation possesses all the properties of matter. It carries momentum and exerts a pressure when it impinges on a body. It necessarily follows that radiation and mass are synonymous. When we say that the Sun is emitting radiation at the rate of a million million million million horse-power, we may equally as well say that the Sun is losing mass at the rate of four million tons per second, or at a rate of more than 120 million million tons per year. Even with this enormous loss of mass, the percentage loss is only about one-tenth of one per cent. in fifteen thousand million years.

The mass of a star, therefore, must necessarily decrease so long as the star is emitting radiation, and we are justified in asserting that the evolution of a star is accompanied by loss of mass. What is happening in the star to bring about the loss of mass? If we could answer this question with certainty, the riddle of stellar evolution would be solved. The great store of energy in a star is the energy of the constitution of the atoms and electrons. In what way can this energy be released? One possible method is by the transmutation of elements—either the building up of more complex atoms from simple ones or the breaking down of atoms into less complex ones.

An atom of hydrogen consists of one proton and one electron, and has an atomic weight—on the international scale—of 1.008. Four hydrogen atoms can build up one atom of helium, whose atomic weight is 4.00. It follows that energy of mass 0.03 units has escaped during the formation of helium from hydrogen. The atomic weights of the heavier elements—or at least of their isotopes—are whole numbers, so that there is no supply of energy to be obtained by building up more complicated atoms from atoms of helium. The energy which can be released by the transmutation of hydrogen into helium, and which is represented by a percentage loss of mass of 0.8, would be sufficient to keep the Sun burning for ten thousand million years. This is too cramped a time scale for astronomical requirements, and we must look elsewhere for the main supply of energy. It is possible, nevertheless, that this transmutation does occur in some stars. If so, we should expect to find it in the giant series. The relatively small number of giant stars compared with stars on the main sequence suggests that the giant stage of a star's existence is a comparatively brief one. It should further be noted that the masses of the giant stars do not show a progressive change with increasing temperature. It therefore seems probable that a prolific source of subatomic energy is available in the giant stage, which gives rise to a rapid liberation of energy from the star, accompanied by an increase in its temperature. This supply of energy becomes exhausted when the star reaches the main sequence, and we must suppose that a new source of sub-atomic energy is tapped.

In order to obtain a correct perspective of the conditions on the main sequence consider the following three stars:—

| | *Mass* ($\odot = 1$). | *Mean Density* (*Water* = 1). | *Central Temp.* (*in million degrees*). | *Effective Temperature.* | *Colour.* | *Luminosity* ($\odot = 1$). |
|---|---|---|---|---|---|---|
| Algol | 4.3 | 0.15 | 40 | 12,000° | White | 150 |
| Sun | 1.0 | 1.4 | 40 | 6,000 | Yellow | 1 |
| Krüger 60 | 0.25 | 9.1 | 35 | 3,000 | Red | 0.01 |

These figures are typical of stars at the two ends and in the middle of the main series. It will be noticed that the passage from the blue end to the red end of the series is accompanied by a considerable decrease in mass and in luminosity, and by a large increase in density. It should also be noted that although there is a progressive decrease in the effective temperature, the central temperature remains practically constant. It is perhaps not without significance that theory indicates that throughout the main series the central temperature is approximately constant at about 40,000,000°. It may also be noted that in the giant stage the central temperature is lower than this value.

If in the stellar Universe we see stars at all stages of their evolution, it does not seem possible to escape from the conclusion that evolution must take place along the main series. It is natural to suppose that the direction of evolution is in the direction of decreasing mass, which is also that of contraction and of decreasing surface temperature. The loss of mass required for passage from one end of the series to the other is so great that we are tempted to fall back upon the theory of an actual annihilation of mass.

Suppose a proton and an electron—a unit of positive and a unit of negative electricity—could be made to combine, nothing would be left but a splash in the ether which would spread out in all directions as an electromagnetic wave carrying away the energy released by their annihilation. Now consider again the four atoms of hydrogen which we supposed to be transmuted into one atom of helium. We saw that 4.03 grams of hydrogen would produce 4 grams of helium and that 0.03 grams of energy would be released. But if we could conceive the 4.03 grams of hydrogen to be annihilated, we should obtain 4.03 grams of energy, more than one hundred times the amount obtainable from the transmutation. It seems probable that the supply of energy required for evolution along the main series is obtained in this way.

We are in ignorance as to what causes this annihilation of mass, and as to how it is controlled so that spontaneous annihilation of the whole mass of the star does not occur. In order that the star should remain stable, it is necessary to assume that the rate at which energy is liberated through annihilation of mass should increase with temperature. This may be seen as follows. Suppose more heat were generated through annihilation of mass than the star required to maintain its temperature and radiation. It would then expand, and would thereby be cooled. Provided that the rate of liberation of energy increases with increase of temperature, the cooling would reduce the supply until the star returned to its equilibrium condition. If the supply decreased with increase of temperature, instability would result. We are tempted to conjecture that the central temperature of 40,000,000° along the main series is a critical temperature which conditions the release of the sub-atomic energy.

It would then seem as though along the giant series the rapid liberation of energy is obtained from the transmutation of hydrogen into more complex elements, and that the central temperature is meanwhile rising. It has reached the critical value of 40,000,000° by the time the star has reached the main series, and then the energy is derived from the annihilation of protons and electrons. Along the main series, the evolution of a star is accompanied by a process of self-cannibalism, the continued existence of the star being rendered possible only by the consumption of its own matter.

If we suppose that the rate of evolution along the main series is determined by the rate at which mass is lost, we can determine the time-scale according to which the evolution takes place. The mass luminosity relation determines the masses corresponding to different luminosities along the main series. The following figures have been derived in this way by Eddington:—

| *Absolute Magnitude (Bolometric).* | *Mass ($\odot$=1).* | *Duration (unit $10^{10}$ years).* |
|---|---|---|
| $-$ 5.0 to $-$ 2.5 | 35 to 10 | 6.5 |
| $-$ 2.5 to 0.0 | 10 to 3.7 | 21.4 |
| 0.0 to $+$ 2.5 | 3.7 to 1.73 | 93 |
| $+$ 2.5 to $+$ 5 0 | 1.73 to 0.92 | 521 |
| $+$ 5.0 to $+$ 7.5 | 0.92 to 0.53 | 3630 |
| $+$ 7.5 to $+$ 10.0 | 0.53 to 0.31 | 28100 |
| $+$ 10.0 to $+$ 12.5 | 0.31 to 0.18 | 219000 |

These figures indicate that the proportion of the life of a star in which its mass exceeds that of the Sun is relatively small. The relative durations given in the last column should be proportional to the numbers of stars in the magnitude ranges given in the first column, provided that the stellar Universe has been in existence for a sufficient time for the stars to have run right through their course of evolution, and provided that it now contains stars of all ages. The figures represent observational data fairly well except that they give too many faint stars, which is perhaps an indication that the stellar Universe has not existed for a sufficient length of time for the old stars to have obtained their full representation.

What happens when a star reaches the end of the main series? It seems probable that a stage is at length reached at which the main supply of energy derivable from the annihilation of matter becomes exhausted. We must confess ignorance as to why this happens. But assuming such a stage to be reached, the star will no longer evolve by losing mass, and it appears probable that further evolution and radiation is at the expense of the star's gravitational energy. We have a cool red star, of high density, but in which, owing to the almost complete ionization arising from the high internal temperature, the perfect gas law is still obeyed. The further evolution will be accompanied by rapid contraction, together with increase of effective temperature, giving rise to the class of stars known as the "white dwarfs."

We have hitherto said nothing about these peculiar stars. Only three such stars are known: the companion of Sirius, the bright component of $o_2$ Eridani and the companion of $o$ Ceti. There are doubtless many others, for these three are all within a small distance of the Sun. But it is only under exceptional circumstances that we are able to establish this condition of a star. Consider, as the best-known example of the class, the companion of Sirius. Its mass is known with fair accuracy from the double star orbit and meridian observations to be about 0.85 that of the Sun. The parallax of Sirius has been determined, and from this the luminosity of the companion is found to be 1-360th of the Sun. The spectrum was found by Adams in 1914 to be that of a white star. From the surface brightness characteristic of such a star and the total observed brightness, the surface area and hence the radius of the star can be found. The radius so obtained is 18,800 km., less than that of the planet Uranus. The corresponding density is about one ton to the cubic inch, 61,000 times that of water. On the giant and dwarf theory of Hertzsprung and Russell, there seemed to be no room for these stars, and the conclusion at which we have arrived appears at first sight improbable.

It has nevertheless been substantiated by the verification by Adams of the large Einstein displacement of the spectral lines of the star. The Einstein displacement is proportional to the mass of the star divided by its radius and, on account of the small radius of the companion of Sirius, amounts for this star to a Doppler displacement of about 20 kms. per sec. The very high density of the companion of Sirius is therefore established. There is nothing remarkable in so high a density when we consider the emptiness of the atom and the extent to which it can be compressed when ionized.

The companion of Sirius does not fall on the mass-luminosity curve, and it is therefore probable that, although still gaseous, it provides us with an example of a star in which the perfect gas law is beginning to fail, so that our theories do not apply without modification. But it now finds a rational place in our scheme of evolution, as representing a stage through which stars pass after they leave the main series.

But the white dwarf class give rise to other difficulties. The close packing of their matter is the result of the ionization arising from the high temperature. When the star cools down it must presumably revert to the normal densities to which we are accustomed. But this will necessitate an enormous expansion and the performance of work against gravity. We are therefore faced with the paradox that the star is continually radiating, but cannot cool unless energy is supplied to it. How this paradox has been resolved it would be too far from my subject to discuss. It is sufficient to state that classical mechanics is no longer applicable to matter at extreme densities, and it is one of those curious coincidences which occur occasionally that a new theory of matter, which concerns high densities, was being formulated by physicists just at the time when the paradox resulting from the high densities of the white dwarf stars was puzzling astronomers. I may add that the theory indicates that the final state of such dense matter is one in which its temperature is zero, but in which its energy is still very great. Because the temperature is zero, the star ceases to radiate. Nevertheless, the individual particles of the star are moving with very great speed. If their speed is used as a measure of their temperature, it is justifiable to say that the temperature is the highest attainable by matter, and that the material of which the star is composed is the hottest in the Universe. But with matter in this state, temperature no longer has any meaning. The temperature of a particle of matter is a statistical term, measured by the average energy of the molecules in that particle. The final state of the white dwarf is to become a single star-atom in which the mysterious force which holds an atom together has extended to cover the whole star. The companion of Sirius is on its way to this stage; there may be stars which have reached it, but since they no longer radiate, we cannot tell. It may even be that it is the final state to which every star will at length come.

I have endeavoured to sketch the present state of the problem of the evolution of the stars. I have not dwelt upon the difficulties which it has to face, particularly in questions concerning the utilisation of sub-atomic energy. The physicists may not be inclined to accept the view that hydrogen can be transmuted into helium at a temperature of 40 million degrees, though it cannot be denied that helium has been produced somewhere, somehow. The hottest place we know is the centre of a star on the main series. It may well be that in this question of subatomic energy, as in other questions in the past, astronomy may give a lead to physics. Our own views on the important question of stellar evolution have undergone many changes in the past twenty years. It is not inconceivable that they are destined to undergo many more. It seemed to me, however, that in concluding my year of office as President of this Society, a review of the problem and a statement of its present position as generally—but, let me add, not universally—accepted would prove of interest to you.

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## AMENDMENT OF CONSTITUTION.

The following amendment of the Constitution was adopted at the Annual Meeting of the Society, held on the 27th July, 1927:—

Section (iii) of Article VII of the Constitution shall be amended to read as follows: the words to be added are in italics:

> "(iii) The Council shall meet at Headquarters. Any member of Council domiciled more than fifty miles from Headquarters *or who otherwise has obtained the permission of the Council* may, by notification in writing to the Secretary of the Society, appoint an elected member of the Society to be his alternate for the period of his office. In the event of his being able himself to attend any meeting of the Council his alternate may also attend, but shall not have a vote."

# ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

## Session 1926-27.

### Annual Report of the Council.

The Council, in presenting their Report for the year 1926-27, can again record a successful year's working of the Society.

The membership at the 30th June, 1927, stands at 100 members and 12 associates.

A General Meeting of the Society was held at Cape Town on the 8th June, 1927, when Mr. William Reid (President for the 1925-26 Session) delivered his Presidential Address on "Amateur Observations with a Six-Inch Telescope." This lecture appears in this Journal, page 39.

The retirement of Dr. J. K. E. Halm from the post of Chief Assistant at the Royal Observatory affords an occasion to express our great appreciation of his valuable services to the Society. He was President of the Cape Astronomical Association on its foundation in 1912, and on subsequent occasions, and was President of the Society in 1924-25. As he has remarked, Dr. Halm has seen the Society grow from a local gathering to a well-organized institution covering the whole of the Union, and we may add that much of this progress has been due to his unfailing assistance. As a lecturer and as a personal friend he has been universally esteemed. While he hopes to retain his connection with the Society on moving to Stellenbosch, it was felt that this was a suitable opportunity to make some small presentation, and a set of drawing instruments was given to Dr. Halm by members of the Council and of the Cape Centre with their best wishes.

During the year the Council has met five times, those members residing away from Cape Town being represented by their alternates. In view of the occasional absence of members of Council on long leave, etc., an amendment of the Constitution has been submitted for the approval of the Society, the object of which is to give the Council discretion to allow the appointment of alternates other than in the case of members of Council domiciled more than fifty miles from Headquarters.

Since the last Annual Meeting No. 1 of the second Volume of the Journal was issued and received very favourable notice. As Mr. Reid emphasized in his address, there is great need of increased funds to enable the Journal to be published at more frequent intervals. Copies of publications are exchanged with kindred societies, etc., and a more frequent issue of the Journal would enable astronomers in different parts of the world to gain a better idea of the activities of the Society. Our thanks are due to past contributors, and members and associates are invited to send articles for inclusion in succeeding issues.

We would also express our thanks to the authorities at the Royal and Union Observatories for their continued courtesy.

The Honorary Secretary of the Natal Astronomical Association visited Cape Town during the year, and the possibility of the Association becoming a Branch of the Society was further discussed. While no steps in that direction can yet be reported, the Council feels that the mutual advantage to be gained from such an amalgamation will be recognized.

Reference was made in the last Report to the publication by Dr. A. W. Roberts of his observations of variable stars. We are pleased to report that the reduction of the observations has been completed, and they are now ready for publication.

In November last Professor R. A. Rossiter, who succeeded the late Professor Hussey, arrived in this country from America and proceeded to Bloemfontein, where the erection of the Lamont-Hussey Observatory is being undertaken. Professor Rossiter has since become a member of the Society, and we are obliged both to him and to Dr. Alden, of the Yale Observatory at Johannesburg (who is also a member), for the interest they have shown in our work.

No better testimony can be afforded to the superior climate and observing conditions in South Africa than the establishment of branches of Northern Observatories here. The transfer to Bloemfontein by Harvard University of its Southern Station and the erection of a new 60-inch reflector is yet further evidence of our favoured position. In a short time there will be at least five large telescopes in use in South Africa: one at the Cape, and two each at Johannesburg and Bloemfontein, a greater number per head of the population than in any other country. It is permissible to urge that this increase of professional activity in South Africa should stimulate amateur astronomers to greater effort, and so show that the possession of a good climate and a wide still-unexplored field is duly appreciated. Members whose telescopes are only in occasional use will find their interest greatly helped by engaging upon a definite scheme of observation. Our Observing Sections exist to give the necessary instruction in certain lines of work, and the respective Directors will be glad to hear from volunteers. There is little need to emphasize the splendid achievements of the Comet Section which has discovered two new comets during the year under review, making a total of fourteen such discoveries since the commencement of its work.

Our President has drawn attention to the recent appeal published by Professor E. W. Brown, of Yale Observatory, asking for more observations of occultations of stars by the Moon. Many of our members are now able to obtain correct time by wireless, and it is hoped that more of these observations will be undertaken. Arrangements will be made to supply predictions for any locality in South Africa.

It has been suggested that a Computing Section should be formed, and the Secretary will be glad to hear from anyone willing to join. Such work as the prediction of occultations and the extending of ephemerides of comets, etc., is generally within the range of amateur astronomers and mathematicians.

The Society would welcome an increase in its members, and any person interested in astronomy is invited to apply for particulars of membership to the Honorary Secretary of the Cape Centre (P.O. Box 2061, Cape Town), or to the Honorary Secretary of the Johannesburg Centre (P.O. Box 2402, Johannesburg).

# Reports

FOR THE YEAR ENDED 1927 JUNE 30.

## COMET SECTION.

For the past year or two renewed interest in cometary work has been very noticeable throughout the astronomical world, and instead of three or four comets, as in former reports, we are now able to more than double that number. Probably this is due to the splendid work of the Computing Section of the British Astronomical Association on periodical comets, which has led to quite a number of them being re-discovered; to Dr. Crommelin's writings in various British astronomical publications; and to the splendid series of articles by Prof. van Biesbroeck, of Yerkes Observatory, which have been appearing in recent numbers of *Popular Astronomy*. Prof. van Biesbroeck has also been following comets for months after they have become too faint for ordinary telescopes. We will give two examples: Comet 1925 a (Schain) was kept under observation until 1927 March 4; Comet 1925 b (Reid) until 1926 December 31. These observations should prove a great help to future computers who want to improve their orbits.

The following comets have been discovered since the date of our last report:—

Comet 1926 c (Periodic Comet Kopff) was discovered photographically by Wolf on 1926 July 13, its estimated magnitude being 16. It remained an exceedingly faint object throughout the whole time it was under observation.

Comet 1926 d (Periodic Comet Finlay) was discovered by Dr. Stobbe at Bergedorf on 1926 August 3. It was large and diffuse without nucleus; at its brightest the estimated magnitude was 14.

Comet 1926 e (Periodic Comet Giacobini-Zinner) was discovered at Bergedorf by Dr. Schwassmann on 1926 October 16. At discovery it was estimated to be magnitude 14. It was kept under observation by Prof. van Biesbroeck for several months.

Comet 1926 f (Comas Sola). This new comet was discovered photographically by I. Comas Sola at Barcelona on 1926 November 4. Magnitude 12. Prof. van Biesbroeck, who observed it on November 10 with the 40-inch telescope, records it "as a nebulosity about 45 seconds in diameter, with a well-defined nucleus and a short tail." It was observed by the writer at the beginning of December as a very small, slightly elongated patch of nebulosity, with a condensation at one end; the magnitude was under 11.

Comet 1926 g (Periodic Comet Neujmin) was discovered photographically by G. Neujmin at Simeis, in the Crimea. It was very faint, and could only be seen with powerful instruments.

Comet 1927 a (Blathwayt). A new comet was discovered by T. B. Blathwayt at Braamfontein, near Johannesburg, on the morning of 1927 January 11. At discovery it was a fairly large bright round nebulous object, very much condensed in the centre, the magnitude being 9. It was kept under observation until April, when it suddenly became very faint, and in the advancing moonlight soon disappeared. The following elements were computed by Mr. H. E. Wood, of the Union Observatory, from early observations:—

$$
\begin{aligned}
T &= 1927 \text{ Feb. } 12.72 \\
&\left.\begin{aligned}
&= 228^\circ\ 52' \\
\Omega &= 18^\circ\ 40' \\
i &= 90^\circ\ 31'
\end{aligned}\right\}\ 1927.0. \\
\log q &= 0.02522
\end{aligned}
$$

Comet 1927 b (Reid). A new comet was discovered by the writer at Newlands, Cape Town, on the evening of 1927 January 25. This was a sister comet to the former in size, brightness, and physical appearance. It was kept under observation until the beginning of April. Before disappearing (which it did very rapidly) it swelled out to very large dimensions, at the same time becoming very faint, and losing all signs of the central condensation.

The following elements were computed by Dr. Halm, of the Royal Observatory:—

$$
\begin{aligned}
T &= 1926 \text{ December } 30.54 \\
&\left.\begin{aligned}
\omega &= 224^\circ\ 45' \\
\Omega &= 108^\circ\ 42' \\
i &= 83^\circ\ 40'
\end{aligned}\right\}\ 1927.0. \\
q &= 0.753
\end{aligned}
$$

Mr. Mackenzie computed the following elements from later observations:—

$$
\begin{aligned}
T &= 1926 \text{ December } 30.47. \\
\omega &= 224^\circ\ 34' \\
\Omega &= 108^\circ\ 45' \\
i &= 83^\circ\ 40' \\
\log q &= 9.87644.
\end{aligned}
$$

Comet 1927 c (Periodic Comet Pons-Winnecke) was discovered photographically at Yerkes Observatory by Prof. G. van Biesbroeck on 1927 March 3. It was then a small round nebulosity, magnitude 16.5. In time it came rapidly south, and when first seen by the writer it had become a very easy object, almost visible to the naked eye. It was still small but bright, and slightly elongated. With a low power it appeared to have a large nucleus which had a curious striated and mottled appearance, with a fair amount of haze round it. Under a high power the haze disappeared, but the nucleus did not differ very much from its former appearance. It would not come to a focus, and was rather disappointing; one expected to see something definite. A few days later it became clearly visible to the naked eye as a large cloud of white haze. Through the telescope the nucleus had become distinct, small, and very bright, surrounded by a great amount of nebulous haze which filled the whole field, and extended outwards until it faded imperceptibly from view. It had also developed a short broad tail. Mr. Forbes reports that in the second week of July the nucleus had become much larger, and had a granulated appearance. The tail had also become more distinct and longer, the comet itself having dwindled in size.

Comet 1927 d (Stearns). This new comet was discovered by Dr. C. L. Stearns at the Van Vleck Observatory, Middleton, Connecticut, on 1927 March 10. Copy of a cable having been received from His Majesty's Astronomer, the comet was picked up by several members a few days after discovery, and kept under observation for a long time. It was quite a bright though small object, and showed decided traces of a tail. Owing to its tremendous distance from the Sun it did not change much in appearance while within reach of our Southern telescopes.

Comet 1927 e (Periodic Comet Grigg-Skjellerup) was photographed by F. T. Hargreaves, and detected on the plates by G. Merton on 1927 March 27. The comet appeared as a faint blur, and its magnitude was said to be 12. As at this time it was well placed for observers in South Africa, a thorough search was made for it, but without success. There is no doubt it was much fainter than the magnitude stated. This comet at its last appearance was a faint diffuse object without any apparent nucleus, and it appears to have differed very little from this description at its present visit. Unfortunately, it was going north so quickly that it was soon outside our reach.

Comet 1927 f (Gale). This new comet was discovered by Gale at Sydney on 1927 June 7. Again owing to early notification by cable, it was observed in South Africa soon after the discovery. To the writer it appeared as a large and rather faint nebulous patch, round and condensed in the centre, but without a nucleus. The nebulosity appeared to get faint from the centre outwards, and it was difficult to say where it ended. The magnitude was less than 8. When observed a few days later it appeared

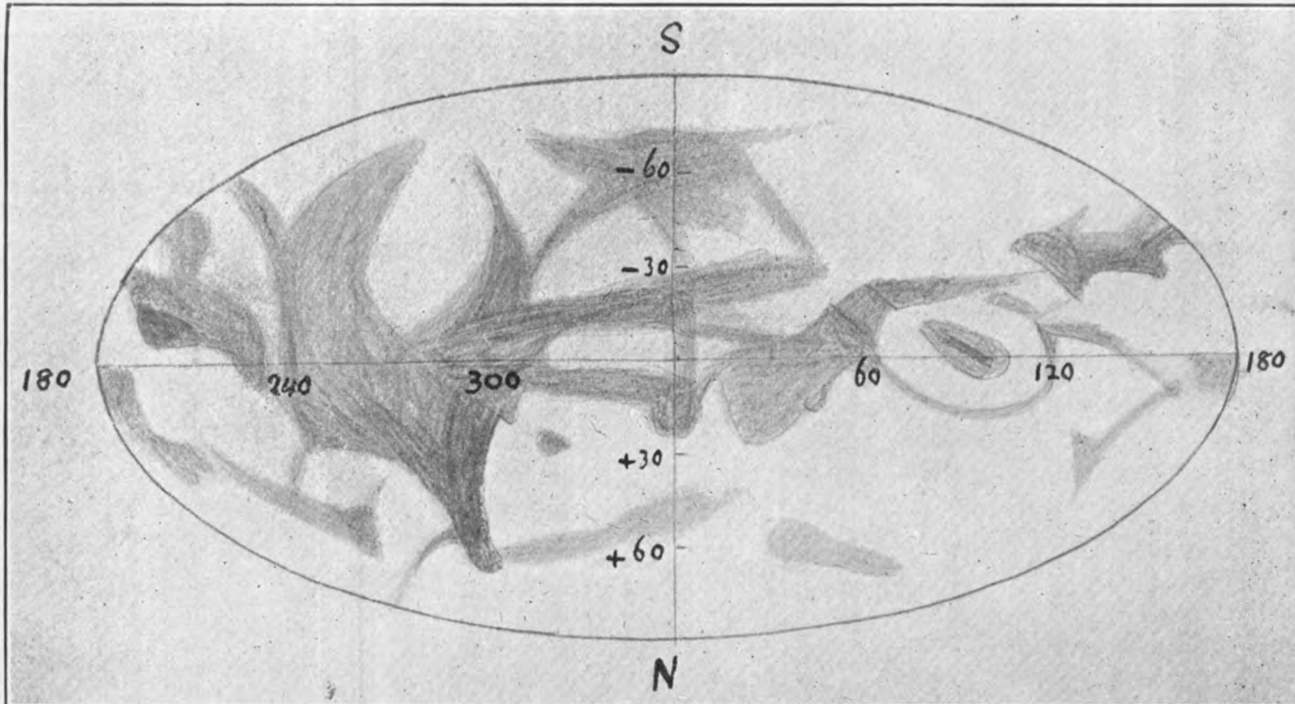


Plate No. 2.—Composite Map of Mars, 1926.

to be fainter. It reminded the writer of a Jupiter periodical. This is the third comet discovered by Mr. Gale. It will be remembered that his second one was independently discovered in South Africa by Mr. Skjellerup, and that the formation of the Cape Astronomical Association was the outcome of this discovery. This led to greater things, and now we have the Astronomical Society of South Africa.

We again tender our thanks to the Royal and Union Observatories for continued help, and to several members of the Society who have helped us during the past year.

The Donohoe Comet Medal of the Astronomical Society of the Pacific has been awarded to Messrs. Blathwayt and Reid for the discovery of comets 1927 a and 1927 b respectively.

William Reid,
*Director.*

## MARS SECTION.

Since the presentation of the planet's disc round about the time of opposition (planetocentric declination) was about the same in 1926 as in 1924, no new features could be expected to be seen, and no elaborate report is necessary.

The only striking difference between the 1926 drawings and those already published (Vol. 1, 1925, p. 196) consists in the absence of any polar cap in the drawings. The melting of a very large South polar cap formed the chief feature of the 1924 presentation, but in 1926 this phenomenon had already occurred before Mars had become near enough for small telescopes: it was observed by Slipher in America to shrink from 100° width (April 1, 1926) to almost nothing (about September 10), just as in 1924 the same degree of shrinkage was seen here between May and September (*l.c.*, p. 196-7). Our 1926 drawings commenced on August 1, and the first three of them show a small South polar cap, but all subsequent drawings show no cap. The Southern hemisphere summer soistice on Mars occurred about August 24 in 1026 and on October 6 in 1924, and the melting of a polar cap is, of course, a summer phenomenon in a particular hemisphere. In 1924 the opposition was 44 days before the solstice, and in 1926 it occurred 70 days after the solstice, *i.e.*, in the early autumn of the Southern hemisphere of Mars.

Mr. Wickes, of Durban, furnished the first drawing, but later on reported that pressure of work and the thunderstorm season there prevented further observation. The Cape Peninsula suffered from continuous bad weather round about the time of the opposition, and none of the observers there were able to get good enough seeing for drawing purposes. In Johannesburg, however, except for a period of three weeks, the seeing was continuously good. The Society owes a debt of gratitude to the Johannesburg Secretary, Miss H. L. Troughton, for making more than half the total number of drawings obtained at this opposition, made often at extremely inconvenient hours for the sake of obtaining the increased contrast visible at sunset and dawn.

The only other change visible at this presentation is a change in distinctness of the markings near the zero meridian of Mars. In 1924 the " forked-bay " and the Sinus Sabæas were uncommonly dark and Deucalion (South of these) faint. This time all of these markings had little contrast, and did not differ much in contrast between themselves, so that Deucalion was comparatively distinct.

The fading of the markings was notable on the other side also: round about 180° longitude nothing was visible near the centre, Elysium being but a mere trace. The region of the Syrtis Major (300°) was larger and comparatively poorly contrasted. The Margaritifer region (30°) was quite diffuse, much larger than before, and not pointed. The Acidalium (60°) and other spots in the Northern hemisphere were decidedly more distinct than in 1924.

JAMES MOIR, *Director.*

## LIST OF DRAWINGS OF MARS USED FOR COMPOSITE DRAWING (PLATE No. 2).

| No. on Sheets. | No. in order of Time. | Date shown. | Central Longitude. | Observer. | Notes. |
|---|---|---|---|---|---|
| | | 1926. G. M. T. d. h. m. | | | |
| 1 | 34 | Dec. 23, 17, 15 | 5° | J. M. | Diagonal. |
| 2 | 7 | Oct. 10, 21, 30 | 9 | T. B. | |
| 3* | 22 | Nov 14, 17, 30 | 10 | J. M. | Blue screen: seeing 10. |
| 4 | 6 | Oct. 8, 21, 0 | 20 | J. M. | Diagonal. |
| 5* | 36 | Dec. 26, 20, 15 | 20 | H. T. | Diagonal. |
| 6 | 10 | Oct. 18, 3, 45 | 38 | H. T. | Seeing 9, but windy. |
| 7 | 9 | Oct. 17, 3, 30 | 43 | J. M. | Seeing poor. |
| 8* | 1 | Aug. 1, 2, 45 | 45 | C. W. | Diagonal: Durban 8 in. |
| 9 | 32 | Dec. 22, 19, 45 | 50 | H. T. | Union 26 in., but poor seeing. |
| 10* | 33 | Dec. 22, 20, 15 | 60 | H. T. | Union 9 in. |
| 11 | 3 | Sept. 6, 4, 15 | 67 | J. M. | Seeing 9: yellow S. polar area. |
| 12* | 21 | Nov. 6, 18, 45 | 90 | J. M. | Seeing 9. |
| 13* | 19 | Nov. 5, 19, 30 | 110 | J. M. | Opposition. |
| 14 | 20 | Nov. 5, 20, 30 | 125 | H. T. | Seeing 10, but windy. |

* These drawings are reproduced in Plate No. 3.

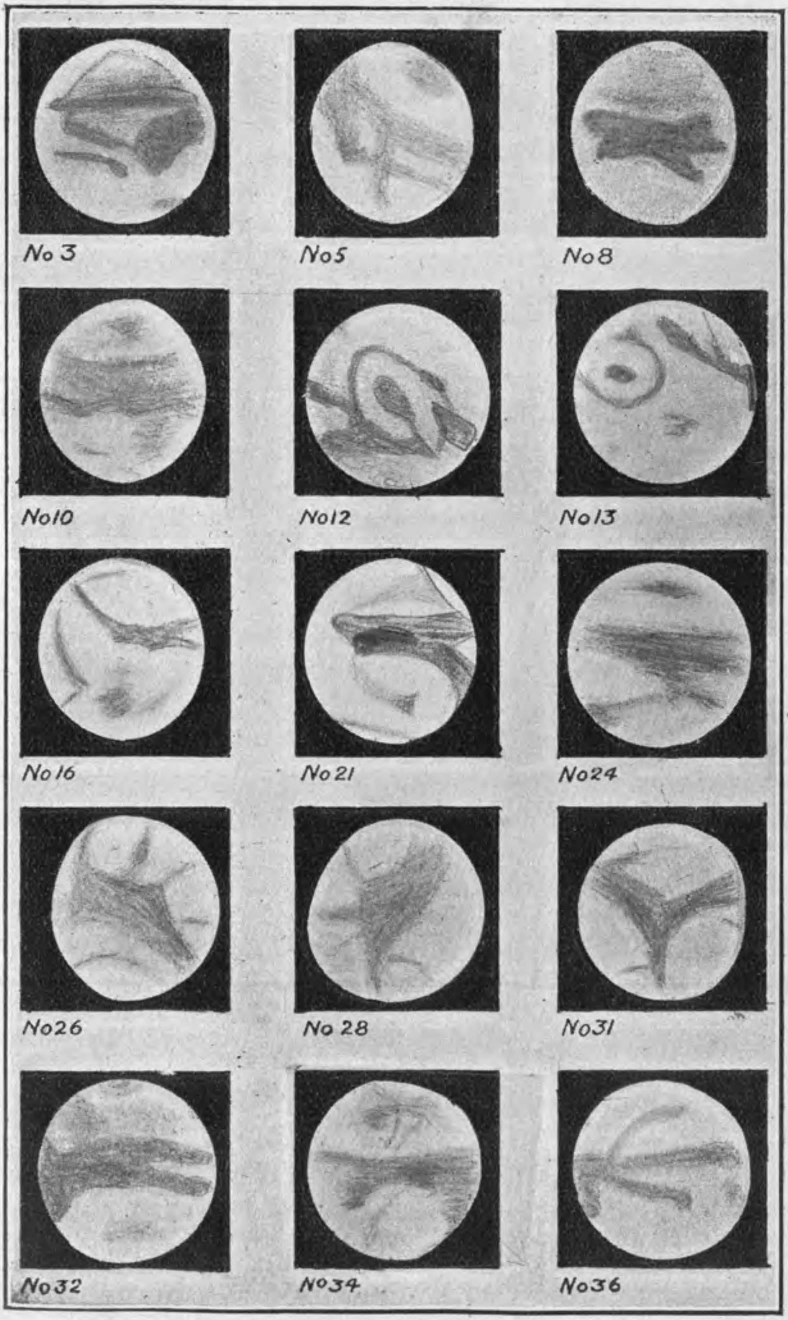


Plate No. 3.—Drawings of Mars, 1926.

| No. on Sheets. | No. in order of Time. | Date shown. | Central Longitude. | Observer. | Notes. |
|---|---|---|---|---|---|
| | | 1927. | | | |
| 15 | 37 | Jan. 17, 19, 0 | 150 | H. T. | Union 9 in., seeing medium. |
| | | 1926. | | | |
| 16* | 31 | Dec. 11, 20, 0 | 155 | H. T. | Seeing 7, slight fog. |
| 17 | 17 | Nov. 1, 20, 30 | 160 | H. T. | Red screen to improve contrast. |
| 18 | 18 | Nov. 1, 21, 0 | 167 | J. M. | Do. do. |
| 19 | 30 | Dec. 9, 19, 30 | 175 | J. M. | Meridian observation: seeing 9. |
| 20 | 16 | Oct. 28, 20, 30 | 195 | H. T. | Erecting eyepiece: seeing 8. |
| 21* | 29 | Dec. 4, 18, 40 | 200 | J. M. | |
| 22 | 15 | Oct. 28, 21, 10 | 200 | D. C.-S. | 3-in. Refractor. |
| 23 | 2 | Aug. 20, 4, 30 | 230 | J. M. | Diagonal. |
| 24* | 12 | Oct. 23, 20, 0 | 232 | H. T. | Seeing 8. |
| 25 | 13 | Oct. 24, 20, 45 | 234 | J. M. | Seeing 8. |
| 26* | 28 | Dec. 1, 10, 0 | 245 | H. T. | Union 9 in., seeing 9. |
| | | 1926. G. M. T. | | | |
| | | d. h. m. | | | |
| 27 | 5 | Sept. 22, 3, 45 | 273° | J. M. | Nothing at either pole. |
| 28* | 27 | Nov. 27, 19, 0 | 280 | H. T. | Diagonal and Barlow lens. |
| 29 | 11 | Oct. 20, 21, 30 | 280 | J. M. | Seeing poor. |
| 30 | 4 | Sept. 11, 21, 30 | 285 | J. M. | Do. |
| 31* | 23 | Nov. 20, 16, 40 | 305 | H. T. | Seeing 9. |
| 32* | 8 | Oct. 14, 21, 15 | 330 | J. M. | Large yellow area in South. |
| 33 | 14 | Oct. 25, 3, 30 | 333 | H. T. | Seeing 6. |
| 34* | 26 | Nov. 22, 20, 30 | 335 | H. T. | Diagonal and Barlow lens. |
| 35 | 35 | Dec. 26, 18, 15 | 350 | J. M. | Whitish at North end. |
| 36* | 25 | Nov. 21, 20, 30 | 350 | J. M. | Nothing at either pole. |
| 37 | 24 | Nov. 20, 20, 0 | 354 | H. T. | Seeing 10. |

* These drawings are reproduced on Plate No. 3.

Observers : T. B. ... ... T. Blathwayt.
D. C.-S. ... Capt. D. Cameron-Swan.
J. M. ... ... Dr. J. Moir.
H. T. ... ... Miss H. L. Troughton.
C. W.... ... C. F. Wickes.

## VARIABLE STAR SECTION.

Your Director has much pleasure in reporting that in the year just ended the Variable Star Section has produced the fine total of 3,400 observations, easily beating the previous record of 2,687 in 1919. The observations were distributed as follows: W. H. Smith, 1,145; H. E. Houghton, 1,003; A. W. Long, 80; G. E. Ensor, 1,172.

This excellent result is largely due to the healthy spirit of emulation pervading the Section. A high grade of accuracy in the estimation of magnitudes is evident throughout.

Mr. A. W. Long has resumed his invaluable work at the telescope, interrupted by his visit to England. It was indeed a pleasure to see the well-known name of the "Father of the Variable Star Section" again a feature of our lists. We earnestly hope that he may be able to continue.

Monthly reports have been sent regularly by the members of the Section to Harvard Observatory; and by your Director to Dr. Innes, of the Union Observatory.

Your Director's thanks are due to Dr. Innes and the staff of the Union Observatory for the Observatory circulars and for valuable advice on many occasions; also to the Harvard College Observatory for star charts and Variable Star literature.

During the past year Bulletins have been issued by Harvard, in which long-period variables have been discussed; acknowledgment has been made of the numerous observations that have been supplied by members of the Society. Mr. Leon Campbell has stated with regard to variable star observations: "So completely is this work now carried on that professional astronomers rely almost entirely on the results of amateur observers for the fundamental data necessary to a better knowledge of the causes underlying variation."

More observers in the Southern Hemisphere are required, and members and associates are invited to join our Variable Star Section. Star charts and all information may be obtained on application to the Director of the Section, Mr. G. E. Ensor, P.O. Box 201, Pretoria. Personal instruction in the use of the telescope and the star charts will gladly be given by any of the older members of the Section. A 3-inch telescope is quite large enough to follow practically all the stars observed by the Section.

A list of the maxima (M) and minima (m) of the stars observed by the Section is attached. Many maxima and minima have unavoidably been missed owing to proximity to the Sun. As a rule minima are much too faint to be observed by any but the very largest telescopes.

### Notes.

Nova Pictoris: This star has been fairly steady between magnitude 6.2—6.5, with the exception of a short rise on

December 26th, 1926. Mr. Reid estimated it to be of naked-eye visibility on that date.

RY Sagittarii: This interesting irregular variable dropped to magnitude 9.2 in December, 1926; unfortunately, it could not be followed further on account of proximity to the Sun.

We note with keen interest that the Harvard Southern Station is being transferred to South Africa; the members of the Section are looking forward to closer co-operation with the Observatory that has done so much for them.

G. E. ENSOR,
*Director.*

MAXIMA AND MINIMA, 1925-26 AND 1926-27.

| Designation. | Star. | | Magn. | Date. | | |
|---|---|---|---|---|---|---|
| *001032* | S Sculptoris | M | 7.0 | 1925 | Nov. 20. | |
| | | M | 6.9 | 1926 | Dec. 3. | |
| *002546* | T Phœnicis | M | 9.5 | 1926 | Aug. 18. | |
| *005475* | U Tucanæ | M | 8.2 | 1925 | July 9. | |
| | | M | 8.4 | 1926 | April 5. | |
| *021403* | *o* Ceti (Mira) | M | 2.7 | 1926 | Oct. 25. | |
| *025050* | R Horologii | M | 6.1 | 1925 | Nov. 20. | |
| | | M | 5.1 | 1926 | Dec. 24. | |
| *025751* | T Horologii | M | 8.3 | 1926 | Mar. 10. | |
| *043263* | R Reticuli | M | 7.8 | 1925 | Sept. 29. | Flat. |
| | | M | 6.9 | 1927 | April 1. | Flat. |
| *050848* | S Pictoris | M | 7.8 | 1926 | April 17. | |
| *051247* | T Pictoris | M | 8.2 | 1925 | Mar. 28. | |
| | | M | 8.0 | 1925 | Oct. 17. | |
| | | M | 8.4 | 1926 | Nov. 20. | Flat. |
| *051533* | T Columbæ | m | 12.2 | 1925 | Nov. 7. | |
| | | M | 7.1 | 1926 | Feb. 2. | |
| | | m | 11.4 | 1926 | June 1. | |
| | | M | 7.2 | 1926 | Sept. 28. | |
| | | m | 12.1 | 1927 | Jan. 31. | |
| | | M | 7.6 | 1927 | Mar. 13. | |
| *054331* | S Columbæ | M | 9.6 | 1925 | April 11. | |
| | | M | 8.9 | 1926 | Mar. 14. | |
| | | M | 9.7 | 1927 | Jan. 31. | |
| *054629* | R Columbæ | M | 9.3 | 1925 | May 10. | |
| | | M | 8.9 | 1926 | April 17. | |
| | | M | 9.9 | 1927 | Mar. 5. | |
| *055686* | R Octantis | M | 7.5 | 1926 | Feb. 15. | |
| | | M | 8.8 | 1927 | Mar. 29. | |
| *070772* | R Volantis | M | 10.4 | 1926 | Mar. 10. | Flat. |
| | | M | 10.2 | 1927 | April 26. | Flat. |

| Designation. | Star. | | Magn. | Date. |
|---|---|---|---|---|
| *074241* | W Puppis | M | 9.0 | 1925 Mar. 29. Flat. |
| | | m | 11.9 | 1925 June 12. |
| | | M | 7.9 | 1925 Nov. 30. |
| | | m | 12.6 | 1926 Feb. 5. |
| | | m | 12.2 | 1926 June 1. |
| | | M | 8.3 | 1926 Nov. 20. |
| | | m | 12.6 | 1927 Jan. 27. |
| | | M | 8.1 | 1927 Mar. 25. |
| | | m | 12.6 | 1927 May 30. Very flat. |
| *082476* | R Chameleontis | M | 8.2 | 1925 June 13. |
| | | M | 8.4 | 1926 May 17. Flat. |
| | | M | 10.0 | 1927 April 22. Flat. |
| *092962* | R Carinæ | m | 10.0 | 1925 April 5. Flat. |
| | | m | 10.0 | 1926 Mar. 14. |
| | | M | 4.5 | 1926 July 23. |
| | | m | 9.8 | 1927 Jan. 21. |
| | | M | 4.0 | 1927 May 30. |
| *094953* | Z Velorum | M | 9.4 | 1926 Mar. 10. |
| | | M | 8.2 | 1927 May 7. |
| *100661* | S Carinæ | M | 5.5 | 1925 Jan. 30. |
| | | m | 9.0 | 1925 Mar. 30. |
| | | M | 5.5 | 1925 June 13. Flat. |
| | | m | 8.0 | 1926 Jan. 20. Flat. |
| | | M | 5.5 | 1926 April 12. Flat. |
| | | m | 9.0 | 1926 June 18. |
| | | M | 5.5 | 1927 Feb. 7. |
| | | m | 9.1 | 1927 April 13. |
| *101058* | Z Carinæ | M | 11.6 | 1926 Dec. 3. |
| *101153* | W Velorum | M | 8.7 | 1926 Dec. 3. |
| *111661* | RS Centauri | M | 8.6 | 1925 Mar. 8. |
| | | M | 9.2 | 1925 Aug. 19. |
| | | M | 8.6 | 1926 Jan. 31. |
| | | M | 8.6 | 1926 July 12. |
| | | M | 8.0 | 1927 May 27. |
| *131283* | U Octantis | M | 8.7 | 1925 June 25. |
| | | M | 7.5 | 1926 April 17. Flat. |
| | | M | 9.0 | 1927 Jan. 29. Flat. |
| *132422* | R Hydræ | M | 4.2 | 1925 May 5. |
| | | M | 4.4 | 1926 June 29. |
| *133633* | T Centauri | M | 6.2 | 1925 Mar. 28. |
| | | m | 8.6 | 1925 May 10. |
| | | M | 6.2 | 1925 June 26. |
| | | m | 8.0 | 1925 Aug. 8. |
| | | M | 5.8 | 1925 Sept. 24. |
| | | M | 6.4 | 1926 Mar. 24. Flat. |
| | | m | 7.4 | 1926 May 6. Flat. |

| Designation. | Star. | | Magn. | Date. | |
|---|---|---|---|---|---|
| *133633* | T Centauri (*Continued.*) | M | 5.8 | 1926 July 3. | |
| | | m | 8.8 | 1926 Aug. 10. | |
| | | m | 9.0 | 1927 Feb. 7. | |
| | | M | 6.2 | 1927 Mar. 25. | Flat. |
| | | m | 8.2 | 1927 May 13. | |
| | | M | 6.2 | 1927 June 23. | |
| *134677* | T Apodis | M | 10.0 | 1925 Sept. 24. | |
| | | M | 9.6 | 1926 May 13. | |
| | | M | 9.0 | 1927 Feb. 7. | |
| *140959* | R Centauri | m | 9.2 | 1925 Feb. 13. | |
| | | M | 5.4 | 1925 May 17. | |
| | | M | 5.8 | 1926 Mar. 12. | |
| | | m | 8.5 | 1926 Aug. 13. | |
| | | m | 10.8 | 1927 May 24. | Very flat. |
| *145254* | Y Lupi | M | 10.5 | 1925 May 17. | |
| | | M | 10.0 | 1926 June 29. | |
| *151822* | RS Libræ | M | 7.7 | 1925 May 4. | |
| | | m | 12.1 | 1925 Aug. 24. | |
| | | M | 8.1 | 1926 July 17. | |
| | | M | 8.6 | 1927 Mar. 5. | |
| | | m | 11.5 | 1927 June 17. | |
| *152849* | R Normæ | M | 8.0 | 1925 Mar. 29. | |
| | | m | 9.6 | 1925 June 20. | |
| | | M | 7.2 | 1926 Aug. 1. | |
| | | m | 9.4 | 1926 Oct. 15. | |
| *153654* | T Normæ | M | 7.5 | 1925 Mar. 9. | Flat. |
| | | M | 5.9 | 1926 June 26. | |
| | | M | 7.9 | 1927 Mar. 29. | |
| *155823* | RZ Scorpii | M | 8.4 | 1925 April 24. | |
| | | M | 8.4 | 1925 Sept. 24. | |
| | | M | 9.3 | 1926 Aug. 1. | Flat. |
| | | M | 9.2 | 1927 June 18. | |
| *161122a* | R Scorpii | M | 10.2 | 1925 July 9. | |
| | | M | 10.7 | 1926 Sept. 15. | |
| | | M | 10.2 | 1927 May 6. | |
| *161122b* | S Scorpii | M | 10.2 | 1925 Sept. — | |
| | | M | 10.2 | 1926 Aug. 7. | |
| *164319* | RR Ophiuchi | M | 8.5 | 1926 Sept. 5. | |
| | | M | 8.3 | 1927 June 17. | |
| *172486* | S Octantis | M | 8.9 | 1925 Oct. 15. | |
| | | M | 8.6 | 1926 June 29. | |
| | | M | 7.8 | 1927 Mar. 19. | |
| *174162* | W Pavonis | M | 9.1 | 1925 April 5. | |
| | | M | 9.7 | 1926 Oct. 13. | |
| *174551* | U Aræ | M | 8.4 | 1925 May 17. | |
| | | M | 7.8 | 1926 Sept. 9. | |
| | | M | 7.8 | 1927 April 26. | |

| Designation. | Star. | | Magn. | Date. | |
|---|---|---|---|---|---|
| *180363* | R Pavonis | M | 8.3 | 1925 May 29. | |
| | | M | 7.8 | 1926 Sept. 9. | |
| | | M | 7.8 | 1927 April 26. | |
| *193972* | T Pavonis | M | 8.0 | 1925 May 11. | |
| | | M | 8.0 | 1926 Jan. 10. | |
| | | M | 8.0 | 1926 Sept. 9. | |
| | | M | 7.2 | 1927 May 4. | |
| *195142* | RU Sagittarii | M | 6.8 | 1925 Sept. 8. | Flat. |
| *212030* | S Microscopii | M | 8.9 | 1926 Nov. 4. | |
| *214247* | R Gruis | M | 8.2 | 1925 Aug. 7. | |
| | | M | 8.0 | 1926 July 16. | |
| | | M | 8.0 | 1927 June 19. | |
| *221938* | T Gruis | M | 8.7 | 1925 June 28. | |
| | | m | 11.9 | 1925 Sept. 12. | |
| | | M | 9.6 | 1925 Nov. 3. | |
| | | M | 8.8 | 1926 Aug. 7. | |
| | | m | 10.9 | 1926 Oct. 1. | |
| | | M | 8.5 | 1926 Dec. 13. | |
| *221948* | S Gruis | M | 8.2 | 1925 Jan. 20. | |
| | | M | 8.0 | 1926 Feb. 5. | |
| *223462* | T Tucanæ | M | 8.1 | 1925 Jan. 10. | |
| | | M | 7.8 | 1925 Sept. 29. | |
| | | M | 7.8 | 1926 June 4. | |
| | | M | 7.7 | 1927 Jan. 22. | |
| *232746* | V Phœnicis | M | 9.1 | 1925 Aug. —. | |
| | | M | 9.1 | 1926 Dec. 30. | |
| *235265* | R Tucanæ | M | 9.9 | 1926 Mar. 14. | |
| | | M | 9.8 | 1926 Dec. 13. | |

## CAPE CENTRE.

ANNUAL REPORT, 1926-27.

Your Committee in presenting this, the Thirteenth Annual Report, have to record the unabated interest of the members in the affairs of the Society.

### MEETINGS.

During the period under review there have been eight ordinary meetings of the Centre, at which the following lectures and papers were presented and discussed:—

"The Nebulæ," Mr. H. W. Schonegevel.
"Astronomy and the History of Man," Mr. H. C. Mason.
"The Satellites and their Movements," Mr. A. F. I. Forbes.
"The Asteroids," Capt. D. Cameron-Swan, F.R.P.S.
"The Riddle of the Moon's Surface," Mr. H. E. Houghton.

"The Green Flash," Messrs. W. Reid and A. W. Long, F.R.A.S.

"Ancient Planetary Systems," Mr. S. Skewes.

"The University of Michigan's Astronomical Expedition at Bloemfontein," Dr. R. A. Rossiter.

"The Age of the Earth," Dr. H. Spencer Jones, F.R.A.S.

"The Large Moon on the Horizon," Mr. H. E. Houghton.

In February the usual Observational Meeting was held (with the kind permission of His Majesty's Astronomer) in the dome of the seven-inch equatorial at the Royal Observatory.

The Committee have met four times.

## Membership.

Four new members and one associate have been added to the roll during the year, while five members and two associates have been struck off through resignation, death, etc. There are now seventy-one members and twelve associates, a total of eighty-three, as compared with eighty-five at the beginning of the year.

## Discovery.

A new comet was discovered by Mr. William Reid at Newlands on 1927 January 25, this being the eighth comet discovered by him.

## Articles in the Press.

Monthly notes with charts of the sky have been published in the *Cape Times* as in previous years, and articles on astronomical phenomena continue to be published in *Die Burger,* both series of articles being contributed by members of the Centre.

## Financial Statement for the Year Ended 30th June, 1927.

| *Receipts.* | | | | £ | s. | d. | *Payments.* | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|
| Balance in hand, 30th June, 1926 … … … | | | | 7 | 8 | 9 | Contributions to Headquarters under Article IX (i) of Constitution .. .. .. .. .. .. | 26 | 9 | 3 |
| Subscriptions— | | | | | | | *Ex* Credit Balances.. .. | 0 | 19 | 0 |
| Arrears .. .. | 3 | 3 | 0 | | | | Rent of Meeting Room.. | 9 | 0 | 0 |
| Current year | 44 | 0 | 0 | | | | Rent of P.O. Box .. .. | 1 | 5 | 0 |
| In advance .. | 5 | 15 | 6 | 52 | 18 | 6 | Typewriting and Stationery .. .. .. .. .. | 3 | 9 | 9 |
| Subscriptions to *Cape Times* .. .. .. .... | | | | 0 | 12 | 0 | *Cape Times* and postage to country members .. | 3 | 12 | 4 |
| Commissions on cheques | | | | 0 | 2 | 8 | Secretary's expenses.. .. | 1 | 16 | 1 |
| | | | | | | | Treasurer's expenses .. | 0 | 8 | 2 |
| | | | | | | | Alterations to Lantern .. | 3 | 2 | 6 |
| | | | | | | | Bank charges .. .. .. .. | 0 | 18 | 7 |
| | | | | | | | Balance in hand, 30th June, 1927.. .. .. .. .. | 10 | 1 | 3 |
| | | | | £61 | 1 | 11 | | £61 | 1 | 11 |

## JOHANNESBURG CENTRE.

ANNUAL REPORT, 1926-27.

The closing session, which ends the ninth year of this Centre of the Astronomical Society of South Africa, is marked by the discovery of yet another comet by a Johannesburg member, and the thanks and congratulations of the Society are due to Mr. Blathwayt for his devotion to this branch of astronomy.

The Committee have to report with satisfaction the successful completion of a fuller and more varied programme of events than for any year since 1922.

One associate and one member have been added to the Centre, and no resignations are recorded.

Visits to the Observatory are now paid half-yearly instead of quarterly, and the Society has to thank Dr. Innes and his staff for their kindness in welcoming members and arranging a programme of interest for the evening. The first visit was paid in September and the second visit arranged for March, but weather conditions prevented an attendance.

In January a letter was received from the President inviting members to participate in the American programme for the observation of occultations by the Moon, and giving full instructions for the work to be undertaken. Copies of these instructions were sent to all members possessing telescopes. The programme was deferred until correct time-signals could be obtained from the Broadcasting Station. This matter has now been adjusted, and a number of observations have been made at this Centre.

In October the Centre was honoured by an invitation from Dr. Alden to visit the Yale telescope at the University. This meeting was very well attended, and Dr. Alden explained the use and construction of the telescope. Recent photographs were examined with much interest, and Dr. Alden explained the general routine and object of the observations. A letter of thanks was sent to Dr. Alden on behalf of the Centre.

In November the members met by invitation at the house of Dr. J. Moir to enjoy the use of his 4-inch telescope, particularly in connection with the opposition of Mars.

In December Mr. J. D. Stevens read a paper on the "Motions of the Stars," illustrating his facts strikingly with a celestial globe.

In January the Centre had the pleasure of a paper from Mr. H. E. Wood, of the Union Observatory. Mr. Wood gave an exposition of the most recent theory of the "Constitution of the Stars" as put forward by Dr. Jeans. The Centre is greatly indebted to Mr. Wood for his lucid explanation of this theory, and the paper was keenly discussed.

The May meeting was postponed until early in June, when the Report of the Mars Section was presented by Mr. W. B. Jackson, in the absence of the Director, Dr. J. Moir, who is at present in England. Thirty-seven drawings made near the recent opposition, chiefly at this Centre, were exhibited; also a composite projection map drawn up by the Director.

At this meeting Mr. Worssell gave an address on the subject of observation of occultations by the Moon for the guidance of members taking part in this programme. A list of occultations had previously been drawn up by him and given to those members who were able to attend the second visit to the Observatory. The thanks of the Centre are due to Mr. Worssell for his help and encouragement to those undertaking observations of occultations.

FINANCIAL STATEMENT FOR THE YEAR ENDED 30TH JUNE, 1927.

| *Receipts.* | £ | s. | d. | *Payments.* | | | | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|
| Balance in hand, 30th June, 1926 .. .. .. .. | 22 | 6 | 9 | Contributions to Headquarters under Article IX (i) of Constitution— | | | | | | |
| Subscriptions .. .. .. .. | 21 | 10 | 0 | Arrears .... | 0 | 10 | 6 | | | |
| Donation to Society.. .. | 0 | 10 | 6 | Current Year | 10 | 15 | 0 | | | |
| Periodicals .. .. .. .. .. | 0 | 5 | 6 | | | | | 11 | 5 | 6 |
| Exchange on cheque .. .. | 0 | 0 | 6 | Donation to Society.. .. | | | | 0 | 10 | 6 |
| | | | | Periodicals.. .. .. .. .. | | | | 4 | 2 | 0 |
| | | | | Printing .. .. .. .. .. | | | | 2 | 5 | 0 |
| | | | | Bank Expenses .. .. .. | | | | 0 | 14 | 6 |
| | | | | Rent of Rooms .. .. .. | | | | 1 | 5 | 0 |
| | | | | Secretary's Membership, B.A.A. .. .. .. .. .. | | | | 1 | 6 | 0 |
| | | | | Postages .. .. .. .. .. .. | | | | 0 | 6 | 4 |
| | | | | Balance in hand, 30th June, 1927 .. .. .. .. | | | | 22 | 18 | 5 |
| | £44 | 13 | 3 | | | | | £44 | 13 | 3 |

# Astronomical Society of South Africa.

STATEMENT OF INCOME AND EXPENDITURE FOR YEAR ENDED 30TH JUNE, 1927.

| *Income.* | £ s. d. | *Expenditure.* | £ s. d. |
|---|---|---|---|
| Balance brought forward, 30/6/26 .. .. .. .. .. | 10 14 11 | Printing Journal (Vol. 2, No. 1) .. .. .. .. .. | 30 17 3 |
| 50 p.c. Subscriptions (Cape Centre) .. .. .. | 26 9 3 | Printing and Stationery | 1 15 0 |
| 50 p.c. Subscriptions (Johannesburg Centre) | 13 12 9 | Postages and Sundries .. | 3 6 0 |
| Sale of Journals .. .. .. | 4 5 9 | Bank Charges.. .. .. .. | 0 14 9 |
| Donation, Mr. Jeaiey .. | 3 3 0 | Electric Light for Council Meetings .. .. .. .. .. | 0 9 0 |
| Donation, Mr. Sausenthaler .. .. .. .. .. .. | 0 10 6 | Balance carried forward | 22 19 8 |
| 50 p.c. Proceeds on Sale of Universal Sundial . | 1 5 6 | | |
| | £60 1 8 | | £60 1 8 |

Audited and found correct.
E. J. STEER,
*Hon. Auditor.*

W. H. SMITH,
*Hon. Treasurer.*

# Reviews.

"Beyond the Milky Way." By G. E. Hale, Honorary Director of the Mount Wilson Observatory. [Pp. xv + 105, with frontispiece and 43 figures.] (London: Charles Scribner's Sons, 1926. Price 7s. 6d. net.)

This volume contains three chapters, each complete in itself, which originally appeared as articles in *Scribner's Magazine*. The first chapter, entitled the "Oriental Ancestry of the Telescope," describes the early astronomical instruments used by the Egyptians, Chaldeans, Greeks, Chinese and Hindoos. Of particular interest is a reproduction of a photograph of Tutankhamen's transit instrument. The other two chapters, entitled "Heat from the Stars" and "Beyond the Milky Way," are concerned with some of the newest discoveries in astronomy, including an account of Hubble's work on the spiral nebulæ.

The volume is written in a simple and lucid manner which should appeal to the layman interested in the recent developments of astronomy, and contains numerous illustrations, including reproductions of many photographs secured at Mount Wilson. The juxtaposition of Lord Rosse's drawing of the spiral nebula M51 and of a photograph of the same nebula obtained with the 100-inch telescope emphasizes the manner in which modern progress in astronomy has been dependent upon the application of photography.

"The Wonder and the Glory of the Stars." By Prof. George Forbes, M.A., LL.D., F.R.S. [Pp. 221, with 16 plates and 20 figures.] (London: Ernest Benn, Ltd., 1926. Price 8s. 6d. net.)

This volume is based upon several series of lectures delivered by the author at the Royal Technical College, Glasgow, in which the author states that he looked upon himself as a tourist-guide in a series of excursions over various parts of the heavens. The aim was not to teach the whole subject of astronomy, but to increase the enjoyment and the wonder felt by everyone on a starry night. The aim was a worthy one, and has been ably achieved. A vast amount of ground is covered, including many of the modern developments of the subject. The chief criticism which may be advanced is that occasionally speculative or controversial hypotheses are introduced, and the undiscriminating reader may jump to the conclusion that these are less controversial, or are entitled to more weight than is actually the case.

Nevertheless, the volume cannot fail to promote interest in astronomy. Prof. Forbes writes in a delightful manner, and with a free use of analogies to help the reader. Each chapter is complete in itself, and though a certain amount of repetition is thereby necessarily involved, the book can be taken up at any time and opened at any place and the interest of the reader gained. The value of the book for the general reader is enhanced by sixteen excellent plates.

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"The Internal Constitution of the Stars." By Prof. A. S. Eddington, M.A., LL.D., D.Sc., F.R.S. [Pp. viii + 407.] (Cambridge University Press, 1926. Price 25s. net.)

Our knowledge of the mechanical and physical conditions in the deep interior of a star is to so large an extent the outcome of the researches of Prof. Eddington that the appearance of the present volume, which contains a detailed presentation of the theory, is a notable event. The original papers in which the theory was developed are scattered through several volumes of the *Monthly Notices* and elsewhere, and various hypotheses or assumptions made in the earlier papers have from time to time been revised. The connected account of the theory which is contained in the volume under review will therefore prove of great value to present and future investigators.

The volume is naturally largely mathematical, and a considerable mathematical equipment is required of the reader. Nevertheless, there is much in it which can be read with interest and profit by the non-mathematical reader, including the detailed survey of the problem which forms the first chapter, and the important chapters on the mass-luminosity relation and on the source of stellar energy.

To appreciate the theory fully, the reader requires a considerable knowledge of the properties of atoms and of radiation. This is met in the early chapters on the thermodynamics of radiation and the quantum theory. The extent to which knowledge of the interior of a star and of the interior of the atom are dependent the one upon the other is continually brought home to the reader.

Those who desire to learn more of the theory of radiative equilibrium and of its consequences, and who are not deterred by hard mental exercise, cannot do better than tackle Professor Eddington's volume.

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The Editor acknowledges the receipt of publications, etc., from the following:—Antwerp Astronomical Society; British Astronomical Association (New South Wales Branch); East Bay Astronomical Association, California; Harvard College Observatory; Lick Observatory; New Zealand Astronomical Society; Tartu (Dorpat) Observatory, Esthonia; Vereinigung von Freunden der Astronomie and Kosmischen Physik, Berlin.

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## INTERNATIONAL ASTRONOMICAL UNION.

The next meeting of the Astronomical Union is to be held in Leiden, Holland, commencing July 5, 1928.

Dr. H. Spencer Jones, H.M. Astronomer, has been appointed Chairman of the South African National Committee on Astronomy, the constitution of which was announced in Vol. 2, No. 1, of the Journal. The Chairman, Dr. R. T. Innes, Union Astronomer, and Senator A. W. Roberts constitute the Executive of the Committee.

# Astronomical Society of South Africa.

OFFICERS AND COUNCIL, 1927-28.

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*Auditor*: E. J. Steer.

DIRECTORS OF OBSERVING SECTIONS.

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*Mars*: J. Moir, M.A., D.Sc., F.C.S., 66, Ditton Avenue, Auckland Park, Johannesburg.
*Variable Stars*: G. E. Ensor, Pretoria Hospital, P.O. Box 201, Pretoria.

*Editor of Journal*: H. Spencer Jones, M.A., Sc.D., B.Sc., F.R.A.S.
*Librarian*: A. F. I. Forbes, "Craigie Brae," Liesbeek Road, Rosebank.

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*Librarian*: S. Skewes, M.A., B.Sc.
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*Hon. Secretary*: J. D. Stevens, P.O. Box 2402, Johannesburg.

*Hon. Treasurer*: W. Geddes, 86, Kimberley Road, Judith's Paarl, Johannesburg.

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Bentley, W. W., Helmsley, Umhlali, Natal.
Beusch, A., Gobabis, South-West Africa.
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It is requested that the Secretary (P.O. Box 2061, Cape Town) may be kept informed of any change of address.

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