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of the

# Astronomical Society of South Africa.

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# The Tides.

## PRESIDENT'S INAUGURAL ADDRESS: 1922—NOVEMBER 15.

(S. S. HOUGH, M.A., F.R.S., H.M. ASTRONOMER AT THE CAPE.)

It was just over ten years ago that a meeting was called at the old Town House in Cape Town with a view to the formation of a local Astronomical Association for the purpose of encouraging the study of the Science of Astronomy and disseminating current astronomical information among its members.

As the outcome of this meeting the Cape Astronomical Society had its origin, and has since continued to further these objects " by the holding of monthly meetings of its members for the reading of papers and discussions, by the promotion and organisation of lectures and the formation of observing sections, and by the mutual help of its members in affording one another access to such astronomical telescopes as are in their possession."

I feel sure that I shall be voicing the opinion of all the local members of this Association in expressing a deep sense of gratitude to those who have placed their telescopes at the disposal of members, and in particular to Mr. Reid, who has himself afforded a most excellent example of how such telescopes may be efficiently made use of by his indefatigable search of the heavens, resulting in the discovery of no less than three comets.

Mr. Reid's enthusiasm in connection with the discovery of comets has had the well-desired effect of stimulating a certain amount of healthy emulation, and he is not the only member of our Association who has been successful in announcing the discovery of new comets. In fact, the comet which bids fair to prove of the greatest interest and importance has recently yielded itself to the search conducted by another of our members, who has also devoted himself to another and perhaps still more promising branch of research in the examination and record of variable stars.

These two illustrations of useful service to astronomical science, the search for comets, and the watching of variable stars, are among many which could be cited which are usually regarded as lying somewhat outside the domain of official astronomy, and which may well be undertaken by the members of an Association such as ours.

In mentioning Mr. Reid's name, I have departed from my original intention of avoiding anything in the nature of personalities, but having done so I wish to mention one other who has contributed in no small measure to the advancement of knowledge, and largely from the encouragement received from his association with this Society.

I refer to Mr. Warren and his work on "meteors." I mention this in particular as a branch of astronomy which may be undertaken by anyone possessed of the true scientific instinct as to what is worthy of observation and record, and which does not require any elaborate instrumental aids.

The dissemination of current astronomical knowledge among its members, which formed one of the purposes of the original organisation, is being most ably provided for by one of our members in a monthly column in the Press, which appeals not only to our limited membership, but to a much wider public.

Papers which have been brought forward and discussions which have taken place at the monthly meetings of the Association cover a wide range of subjects, among which I may make special mention of papers of a historical character, more especially in relation to the early history of astronomy as associated with South Africa.

Enough has been said to indicate some, but not all, of the directions in which the Association has been promoting useful work during the ten years of its existence.

The success so far attained has encouraged the Executive to enlarge the scope and, it is hoped, the usefulness of the Society, and to-day we meet for the first time not as The Cape Astronomical Association, but as The Astronomical Society of South Africa.

In accepting your invitation to occupy the Presidential Chair, it is my privilege to offer a welcome to the members of our enlarged Society associated with outlying branches, and to wish the Society in its new character increased prosperity and success.

While the Committee have left me a free choice of subject matter for an inaugural address, it has been strongly hinted that some remarks in relation to the Tides would be welcomed, and I have accordingly selected this as my subject to-night.

The subject is unfortunately one which cannot be adequately dealt with except with the aid of a certain amount of higher mathematical technique, which it would be inappropriate to introduce into an address of this character. I must ask your forbearance if in my future remarks I have not been successful in completely divesting the subject of its mathematical garb.

The domain of astronomy has been sometimes described as commencing with the Moon and extending from there outwards, and perhaps some of you may wonder why what appears at first sight to be an essentially terrestrial phenomenon should be selected as appropriate to put before an Astronomical Association. That, however, the Tides had an astronomical significance seems to have been recognised from very early days. References to them in early literature are rare, chiefly, perhaps, owing to the fact that most of this literature emanates from countries bordering on the Mediterranean Sea, where the Tides themselves are comparatively insignificant. There is, however, sufficient evidence available to show that it was early recognised that in some obscure way the Tides were to be associated with the Moon. But it was not till Newton propounded his great theory of universal gravitation that the Tides could be said to have taken a definite place as a subject appropriate for investigation by astronomers.

Let me just indicate briefly the nature of this great generalisation of Newton's, which is, and will always remain, even though it may be subject to partial amendment or modification in form, one of the greatest achievements of human genius.

According to Newton's theory, every particle of matter in the universe attracts every other particle according to definite laws, which, as I wish to avoid technicalities, I need not enter into now. He was able to work out mathematically the consequences of these laws and to show that there were manifestations of them in the pull whereby an apple falls to the ground, the pull exerted by the Earth on the Moon, which maintains the Moon in its orbit, and the pull of the Sun on the Earth and planets, which maintained these bodies in their orbits, as investigated by Kepler from the observations of Tycho.

The theory gave for the first time a definite dynamical explanation of the phenomenon of the precession of the equinoxes and, not the least of its achievements, it indicated whence was the origin of these hitherto obscure phenomena, the tides.

All of you who bathe at Muizenberg or fish off the rocks at Glencairn have at least a rough general idea of what these phenomena consist of. You know that even in calm weather the "level" of the water in relation to the rocks or bathing sheds is subject to continuous change of a more far-reaching nature than can be attributed to an occasional exceptionally big wave. At low water you find large areas of sand exposed to view which at high water are covered to a depth of some feet. The regular recurrences of high and low water take place at intervals slightly exceeding twelve hours, so that there are in general two high waters and two low waters on each day, but the times of high and low water are retarded from one day to the next on an average of about 50 minutes. In consequence of this retardation, the times of high and low water repeat themselves at the same hour of the day after an interval of a fortnight. On closer investigation, it will be found that the hour of the day at which high (or low) water occurs is closely associated with the phase of the Moon, the phenomena at any one place roughly repeating themselves at corresponding times on all days on which the Moon attains any one particular phase.

A second phenomenon easily distinguishable is the dependence of the range of the tide, by which I mean the difference in depth between high and low water on any one day, on the phase of the

Moon. The range is greatest at about new and full Moon and least when the Moon is about half full, either waxing or waning.

Most elementary text-books on astronomy give an attempted explanation of these phenomena as a consequence of gravitation on the lines first laid down by D. Bernoulli. Bernoulli's essay on the subject was one of four to which prizes were awarded by the Paris Academy of Science who offered the subject of the theory of the tides for a prize in 1738.

In accordance with Newton's law of universal gravitation, all the particles of water which constitute the ocean will be subject to a gravitational attraction directed towards the Moon. If this attraction were suddenly imposed on a previously quiescent ocean, it may be anticipated that, in so far as the water is free to move, it will *tend* to adjust itself to a new equilibrium form which differs from the old on account of these superadded forces. It must be borne in mind, however, that the Moon exerts a gravitational attraction on the matter which constitutes the solid crust or nucleus of the earth, as well as on the more mobile parts which constitute the ocean. The solid nucleus, together with the ocean which covers it, will for the most part give way to this attractive pull and describe an orbit. This orbit will be described about the common centre of gravity of the Earth and Moon. The mass of the Moon is known to be only about 1/80th part of that of the Earth; the excursions of the centre of gravity (or centre of figure) of the Earth in relation to the common centre of gravity of the Earth and Moon will therefore be an exact replica of the observable excursions of the Moon relatively to the Earth reduced in the ratio of 1 to 81.

But to an observer on the Earth, on account of the diurnal rotation of the Earth, in combination with the revolution of the Moon in its orbit, the position of the Moon and hence of these wave crests will appear to be constantly changing. When the Moon is rising or setting, the observer's position corresponds with that half way between the two summits of the waves. He will be in the trough of the wave and the depth of water in his vicinity will be at its lowest. As the Moon rises above his horizon or falls below it, the water will appear to rise and attain its greatest height when the Moon reaches the meridian either at its upper or lower culmination. After this, the water will fall until the Moon again reaches the horizon on the opposite side of the observer.

If the superadded forces which we have supposed to be due to the Moon were operative on the water of the ocean only, the effect would obviously be to draw the water towards the Moon and to create a high tide immediately under the Moon, accompanied by a low tide at a point of the Earth's surface diametrically opposite. The actual tide-generating force, however, does not consist of the entire gravitational pull on the water, but only of the residual part which is left over and above that absorbed in keeping the ocean, in common with the solid parts of the Earth, revolving about the common centre of gravity of the Earth and Moon. A common way of expressing this is to suppose that, while the water immediately under the Moon is attracted towards the Moon, that at the opposite point of the Earth's surface drags behind. Thus there will be a tendency for water to pile up not only immediately under the Moon, but also at the part of the Earth immediately opposite. Were the water of the ocean able to settle down immediately to an equilibrium configuration under this disturbing force due to the Moon's attraction, there would thus be, as it were, two wave-crests of high water, one directed towards and the other away from the Moon, with "troughs" of low water half way between.

Herein we have a somewhat crude explanation of the most easily conspicuous phenomena relating to the Tides—namely, that the recurrences of high and low water follow the Moon, and that there are two such recurrences in each lunar day. Another feature indicated, however, but which is not borne out by observation, is that the times of high water should always correspond with the times of meridian passage of the moon and those of low water with its rising or setting.

Before discussing this apparently anomalous result, I wish to raise another point. We have so far considered only the disturbances of the ocean due to the gravitational attraction of the Moon. It may be conjectured that other bodies such as the Sun and planets will give rise to somewhat similar disturbances.

The problem of estimating the relative intensities of the actions of these various bodies is one which presents no great difficulties, and it is found that on account of her proximity to the Earth the action of the Moon is the predominating one. On account of his large mass, the Sun will also exert an appreciable influence, but less than that due to the Moon in a ratio rather less than one half. The actions of the other bodies are found to be insignificant.

When the Moon is at new or full, the Sun and Moon are in the same or directly opposite regions of the sky. In either case their tidal action, which tends to raise the water both at the point on the Earth's surface immediately beneath them and also at the opposite point, will be cumulative, and the resultant effect may be expected to be an exaggerated effect of that due to the Moon alone. On the other hand, when the Moon is half full, the action of the Sun will be opposed to that of the Moon. Consequently, while the lunar effects may be expected to predominate, the range of the tide will be reduced. Herein we have a ready explanation of the phenomena of spring and neap tides, the former occurring at or near new and full Moon and the latter, of a range approximating to about 2/5ths of that of the former, when the Moon is half full.

We have seen how the leading features associated with the tides may be explained at least qualitatively as due to the gravitational attraction of the Sun and Moon. Let us now examine how far our crude theory will bear examination from a quantitative point of view.

The hypothesis hitherto adopted is that when the ocean is subjected to a disturbing force its surface readjusts itself to a configuration in which it could remain at rest under the action of this force and retains this figure so long as the force does not vary.

Any variation in the disturbing force, however, is supposed to be immediately accompanied by a change in the form of the water surface so as to adjust itself to a new equilibrium form.

On this supposition we may calculate without much difficulty by the rules of hydrostatics the extreme range between high water and low that would accrue. The greatest range for tides due to the action of the Moon alone has thus been found to be about 21 inches. Superimposing on this the additional action due to the Sun, we find the maximum range of spring tide amounts to not more than 30 inches.

Now, the tides round our own coasts have in most places a range of about double this amount, while in many places, especially in estuaries or partially enclosed waters, these amounts are far exceeded. In fact, there are instances where the range of tide between high and low runs up as high as 70 feet in some parts of the world.

One of the main purposes of the study of tidal theory is to be able to predict the state of the tide at any place and for any future time: *e.g.*, the construction of tide tables giving, say, the times and heights of high water for each day. It will be evident that the theory which we have examined so far is far from adequate to meet these requirements.

It has, however, been developed in some detail, not as a direct means of tidal prediction, but as a convenient method of specification and analysis of the tide generating forces.

These forces are conveniently analysed into a number of different constituents, each of which in itself tends to give rise to a comparatively simple form of tide. These different constituent tides may then be studied independently of one another, and finally the complex tide due to their superposition evaluated. Thus we have a simple semi-diurnal lunar tide which alone would exist if the path of the Moon in the sky consisted of a uniform motion in its orbit and this orbit coincided with the equator. Additional semi-diurnal tides result from the eccentricity of the lunar orbit.

Superimposed on these there are tides having an approximately diurnal periodicity due to the inclination of the Moon's orbit to the equator. These tides manifest themselves by a difference in the heights of two consecutive high waters which occur on the same day. At many places this difference is so great as to practically mask the principal semi-diurnal constituent.

In addition, there will be tides having long periodicity, the shortest of the periods having a duration amounting to a fortnight. The Sun will likewise give rise to tides having approximately semi-diurnal, diurnal and long periodicities.

The essential feature of each one of these simple constituents is that the law of variation of intensity with time is that known as the simple harmonic law. This law may be represented graphically by the trace left by a pendulum on a sheet of paper which is moved uniformly in a direction perpendicular to the plane of the swing.

But I am anticipating. We have seen that the theory we have followed so far is insufficient to explain satisfactorily the range of the tides as a whole, and it may be conjectured that it will be no less so as regards the individual constituent tides of which the full tides are compounded.

Wherein, then, does our theory need amendment? While we have attempted to obtain a specification of our tide generating forces by means of the effects they *tend* to produce, it is erroneous to suppose that they will actually produce these effects in their primitive simplicity. The actual state of affairs is more complicated. When a disturbing force acts on a system like the ocean, supposed previously undisturbed, the ocean will immediately begin to move towards its new equilibrium configuration, where it could remain under the influence of the disturbance. On reaching this configuration, it will in general have acquired a certain amount of inertia, which will, as it were, overcarry it. In time, having overshot the mark, it will be reduced to rest and commence to return, but unless there are considerable frictional influences the settlement into its new configuration will usually only take place after several passages to and fro.

Every slight disturbance thus produces not only an instantaneous effect, but also a lasting effect, and it is quite possible that some of the minor disturbances which tend to confuse the tides may be historical records of events that occurred days, weeks or even months ago.

It might well be anticipated that the introduction of the effects of inertia into our problem would thus involve us in an insuperable complexity. The situation, however, is relieved by some considerations originally due to Laplace in regard to the general dynamical properties of vibrating or oscillating systems.

When a dynamical system is slightly disturbed from a condition of equilibrium (or steady motion), it will either *tend* to revert to its initial state or to fall off into some entirely different one. In the former case, the configuration of equilibrium (or steady motion) is said to be "stable" and in the latter "unstable." Considering only the former class of systems in which the *tendency* is to regain their previous (undisturbed) state, it can be shown that, in the absence of further disturbance, and with but a small amount of frictional resistance, they will ultimately regain their initial state, but that, unless the frictional resistances to motion are large, the restoration will take place not by a gradual subsidence, but by a series of oscillatory movements to and fro, whose amplitudes, however, slowly subside. The motion of subsidence can be analysed into a number of simple oscillatory motions having definite periodicities or frequencies. These periods depend only on the dynamical properties of the system and not on the nature of the causes by which the disturbances were produced. They are known as the "natural" or "free" periods of the vibratory system. The free periods are those which may be detected in the motion following on a disturbance, which continues after the disturbance has ceased to act.

On the other hand, a continuous disturbing cause which is itself periodic in character will give rise to vibrations which are also periodic, but of which the periods correspond with those of the disturbance.

Any small motion of the vibratory system under any periodic disturbance may be analysed into a combination of periodic motions following, as a rule, both the periods of natural vibration of the system and the periods of the disturbing forces. But it was shown by Laplace that, under the influence of even only a moderate amount of friction, the former components will subside and the only vibrations maintained will be those that follow the periods of the maintaining causes.

In the case of the tides, these periods are calculable quantities depending on the motion of the Sun and Moon. But there is another property of vibrating systems associated with their natural free periods—namely, that, if a very small force act on one with a periodicity in exact unison with one of its natural periodicities, the successive applications of this force will always be effective in such a manner as to increase the disturbance and the oscillation will tend to increase in intensity until other causes are operative to prevent its further growth. This magnification of intensity will take place in a greater or less degree according to the closeness or otherwise of the period of the disturbing forces to that of one of the natural periods.

If, then, the period of any of the constituent disturbing forces, due to the action of the Sun or Moon, approximates to one of the natural periods of vibration of the ocean, we may expect the resulting disturbances to be enormously magnified. This phenomenon, known under the name of "resonance," on account of its application in the theory of sound, affords an explanation of the magnification of the actual tides when the effects of inertia are duly considered as compared with their values calculated according to the theory of Bernoulli.

Theoretically, the natural periods of vibration of the ocean could be calculated if we were in possession of a full knowledge of the depths of the ocean in all parts. The mathematics of the problem, however, present very great difficulties, which have only been overcome in a few hypothetical cases, and which far from represent the actual circumstances of nature. Newton himself investigated the nature of the tides which would result from the action of the Moon in an ocean which was conceived as being confined to a narrow canal lying along the equator. The phenomena arrived at resemble those obtained by our simpler theory, but with this important difference, that, whereas the simpler theory required that high water would always be under the Moon and at the opposite side of the earth, according to Newton, low water, instead of high water, would be found under the Moon and high water would occur when the Moon was on the horizon. The explanation is to be found in the existence of a certain critical depth, estimated at about 13 miles. This is somewhat deeper than the actual depths which occur on the Earth and the depth assumed by Newton. For depths exceeding this critical depth the tides would agree in phase with the simple or " equilibrium " theory, while for smaller depths the direction of motion would be changed and we should have what is known as an inverted tide. This critical depth is exactly that for which the natural period of vibration corresponds in duration with that of the lunar disturbing force.

The only other system which, so far as I am aware, has been fully developed from the purely theoretical aspect is that of an ocean supposed to be of uniform depth and to cover the whole Earth. For such an ocean the critical depth for lunar tides amounts to about 4,500 fathoms.

For the tides to be in the main direct, the depth of the ocean as a whole would have to exceed this amount. Now, while soundings are known to exist in some of the deeper parts of the ocean in excess of this critical depth, the general average of depth is certainly lower. It may be anticipated that the actual tides will more nearly correspond in phase with that required by the Newtonian theory, which points to low water following the Moon, than by the theory of Bernoulli, which points to high water under the Moon.

This is found roughly to be the case, but the disturbances due to the existence of the continents are so great that at different places every variety of phase, varying from full high water to full low water under the Moon, is to be found.

The only practical means of tide prediction is, therefore, to investigate the behaviour of the tides separately for each port for which predictions are required.

For this purpose a tide gauge is usually set up. A tank or well sunk to a depth below the level of low water communicates, by means of a pipe, with the open sea. The friction in the pipe will serve to damp out the minor disturbances due to local surface waves, and water in the tank will rise and fall with the tide. A float on the surface of the water in the tank operates a recording apparatus consisting of a tracing point, which rises and falls with the float and leaves a trace on a sheet of paper wrapped on a rotating cylinder or drum. This drum is driven by a clock movement at a convenient speed, say, one revolution in twenty-four hours, and a continuous record of the height of the tide is thus obtained.

For rough purposes, we may read off from such a record the times at which high and low water occurred on each day.

In most places it is found, if we select a number of days at or about full and change of the Moon, these times will not differ much among themselves, though they will differ from one port to another. The average amount by which the time of high water at any port at full and change of the Moon lags behind the time of the Moon's transit is called the " establishment of the port." For roughest purposes the times of high water may be predicted through the month by adding this establishment to the time of the Moon's transit, but for more accurate purposes a number of further corrections, depending on the Moon's declination, parallax, etc., have to be applied. The same applies to the prediction of the tide heights. To some extent these will repeat themselves from one fortnight to another, and it is thus only necessary to investigate the heights of high water at full and change of the Moon and for each successive day in the Moon's age. Here, again, however, if great accuracy is required, a large number of corrections, depending on the Moon's declination, parallax, etc., which must be determined by an examination of the tide curves taken under suitable variety of conditions, have to be applied. These corrections become so complicated for some ports, and the methods of determining them so involved, that the practice has been very largely abandoned in favour of the method I referred to, earlier, known as the method of harmonic analysis. In this method the actual tide as shown on the tidal records is conceived as compounded of a number of simple tides, which might be regarded as each due to a separate disturbing satellite whose motion, however, is of a simpler character than that of the actual Moon. To get a good representation of the actual phenomena, as many as 20 such constituent tides are sometimes required.

For each constituent tide we have then to determine, by appropriate analysis of tide curve, the amplitude—*i.e.*, the range between high and low water of the tide, and the lag—*i.e.*, the interval by which high water follows the maximum of the generating force or the time of passage of the imaginary satellite across the meridian. Having determined these two quantities for each of the 20 constituent tides, they may be regarded as remaining constant for all time, or at least for very considerable periods. By means of them we are able to evaluate the state of each constituent simple harmonic tide at any future epoch, and by re-compounding the separate curves into a single curve construct a tide curve for the port under investigation for prediction, from which all the features of the tides, such as times of high and low water, or the height of the water at any time, may be read off.

It will readily be understood that the separation of a tidal curve into its 20 or more simple harmonic constituents cannot be effected except by means of observations extending over a fairly considerable interval. At least a year's records should be used, and preferably nineteen years, which is the period of revolution of the Moon's node.

There are, however, few ports, if any, where continuous records over so long an interval are available.

I have confined my remarks so far to one aspect of the tides—viz., the rise and fall of the water in relation to the land.

An additional question naturally presents itself—viz., where does the excess of water come from at high tide and depart to at low tide? There is not, of course, a complete transfer of the water from places when the water is high at one instant to the places when it is high, say, half-an-hour or an hour later, but there must be some horizontal motion of the water. In other words, besides the phenomena of the rise and fall of the tide, there exist the phenomena of "ebb" and "flood."

(A diagram was shown illustrating the fact that slack water is generally found at about high tide and low tide, while the tidal currents are strongest whether on the ebb or flood, at about the mean height.)

These currents are of considerable importance in the case of tides in rivers, narrow channels between islands or entrances to land-locked harbours, where they may become so large as to constitute a serious danger to navigation.

Both the "rise" and "fall" and the "ebb" and "flood" of the water are to be accounted for in the main as due to the direct gravitational action of the Sun and Moon. The strictly astronomical tides having definite periodicities, which may be found by harmonic analysis of the tidal records, are, however, subject to large disturbances. Thus, it is often found that the actual height of a tide may be rendered abnormally high or abnormally low by a favourable or unfavourable wind.

For instance, in the Admiralty tide tables for the Port of Devonport, it is stated that "The height of the tide may be increased or decreased by meteorological conditions, southerly winds causing an increase of height and northerly winds having the opposite effect," or, again, for the Port of Leith, we are told that westerly and northwesterly winds cause an increase in height, while easterly and south-easterly winds have the opposite effect.

Again, the ocean is sometimes subject to erratic disturbances due to earthquake phenomena. Such disturbances are known popularly by the name of "tidal waves," but differ entirely in character from the true astronomical tides in that the former are transitory, while the latter persistently occur.

It is this quality of persistence which renders the tides of high astronomical importance from the point of view of evolutionary astronomy. Even a minor cause, if persistently operating in the same direction, may with length of time produce a large effect. Now, such a cause exists in the friction due to the tides. It may be demonstrated as a consequence of the law by which friction invariably results in dissipation of energy that the tides must act in some slight measure as a kind of brake tending to slow up the rotation of the Earth. We may anticipate, then, that the day is slowly lengthening. While this process is too slow in its action to be definitely recognisable during the very short interval, extending only over a few centuries, covered by modern observations of precision, there are decided indications as to its reality to be found in the records of ancient eclipses, which give us data of precision for much earlier times. The actual amount, as is not surprising in view of the small quantity involved, is, however, still somewhat in doubt.

This slowing up process, being due to the action of the Moon, will be accompanied by an equal and opposite reaction on the Moon itself. It may be shown, as a consequence of dynamical laws, that the effects of this reaction will be to cause the Moon gradually to recede from us and to lengthen the duration of the month. Though these processes are slow to-day, there are reasons for believing that they have been more rapid in the past.

Assuming that they have been going on for some millions of years, we may expect that the state of the Earth-Moon System in the past was very materially different from what it is to-day. Sir George Darwin has made an attempt to trace the process backwards and to derive from our knowledge of the existing conditions the nature of the early history of the Moon.

By reasoning which leaves little room for doubt, but which is too technical for me to put before you, he has shown that the history of these changes may be traced backwards until a condition is reached in which the Moon would have been revolving in close contact with the Earth, and the changes in duration of the day and month were such that both amounted to between three and five of the present hours. Previous to this, it seems to be highly probable that the Moon and Earth formed part of a single body consisting of a liquid or plastic mass of molten rock. The processes by which instability, resulting in the severance of such a body into two separate parts, set in, perhaps, must always remain largely a matter for speculation, but it is a remarkable fact that the tracing of the history from the time when the disruption occurred to the present time, to quote Darwin, " brings into quantitative correlation the lengths of the present day and month, the obliquity of the ecliptic and the inclination and eccentricity of the lunar orbit."

The phenomenon of tidal friction further affords an adequate explanation of the rotation period of the Moon whereby, except for small disturbances or librations, the same face is always presented to the Earth, and gives the following indications as to the future history of the Earth-Moon System. At the present time the day and month are both lengthening, the former more rapidly than the latter. There will come a time in the remote future when the length of the day will attain to that of the month. By this time each will have been prolonged to the extent of 55 of our present days. In the final state the Earth will present the same face to the Moon in the same manner as the Moon at present exhibits the same face to the Earth. To the observer on the Earth the Moon will appear stationary in the sky and there will consequently be no lunar tides and no further evolution traceable to lunar tidal friction.

It is perhaps a remarkable fact that, though the other planets of the solar system are accompanied by satellites, the relative dimensions of the satellites and their primaries, and of their relative orbits, are such as to preclude a similar explanation of the origin of these satellites. Within the solar system the Earth-Moon System is unique. So far as our present knowledge goes, it may even be regarded as unique in the universe. Where, then, may we look for confirmation or otherwise of this view? Perhaps the most hopeful field is in the observation of binary stars. Here we have large masses of matter in relatively close proximity which must be raising enormous tides in one another. There are some reasons for believing that their origins as double stars resulted from the severance into two parts of a parent body due to rotational instability. Is it too much to hope that in a comparatively short time refined measurements may lead to the detection of the evolutionary changes of star orbits?

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# Cape Astronomical Association

## (Now the Cape Centre).

## Summary of Annual Report, Session 1921-2.

### Meetings.

Your Council has met ten times during the period under review to conduct the affairs of the Association. There have been nine ordinary meetings of the Association, at which the following lectures and papers were contributed:—

"On the observation of Sunspots with the sun at low altitudes," Mr. A. Bull.
"The Earth's attraction on objects at the surface," Mr. H. E. Wood, M.Sc., F.R.A.S.
"Formulæ for rising and setting of Sun and Moon," Mr. A. W. Long, F.R.A.S.
"Observations of the New Moon," Messrs. Long and MacKenzie.
"Modern investigations into the distribution of the Stars," Dr. J. K. E. Halm, F.R.A.S.
"La Caille's Stellar Observations at the Cape," Mr. T. MacKenzie.
"Reflecting Telescopes, with practical directions for grinding and figuring the mirror," Mr. A. F. J. Forbes.
"Method of Engraving Circles for Equatorials," Mr. A. Humphries.
"Mounting an 8½-inch Mirror," Mr. M. Deas.
"A Home-made Equatorial," Mr. H. C. Kolbe.
"Changes in the Earth's Climate," Mr. H. E. Houghton.
"Methods and Instruments of the Early Portuguese Navigators," Mr. T. MacKenzie.
"Life in Other Worlds," Mr. C. L. O'B. Dutton.
"The Rotation of the Sun," Dr. J. K. E. Halm.
"Absolute Magnitude," Dr. J. K. E. Halm.
"Spherical Distances and Co-ordinates," Mr. A. G. Hoyer.
"Variation of the Moon's Declination," Mr. J. F. Skjellerup.
"Duration of Twilight," Mr. T. MacKenzie.

As customary, the February meeting was held at the observatory of Mr. W. Reid, and was of an observational character.

## Proposed Astronomical Society of South Africa.

In accordance with the resolution adopted at the Special General Meeting of June 7th, 1921, instructing your Council to open negotiations with the Johannesburg Astronomical Association with a view to union and the formation of an Astronomical Society for South Africa, your Council have been in communication with the Johannesburg Astronomical Association and have submitted a draft constitution. This has now been adopted at Johannesburg and will shortly be submitted to you for your acceptance at a special general meeting to be called for that purpose.

## Committee, 1922-3.

*Chairman*: J. K. E. Halm, Ph.D., F.R.A.S.
*Vice-Chairman*: A. W. Long, F.R.A.S.
*Honorary Secretary*: H. W. Schonegevel.
*Honorary Treasurer*: A. F. J. Forbes.
*Members*: T. MacKenzie, D. G. McIntyre, W. Reid, W. H. Smith, R. Watson.

## Report of the Comet Section.

FOR YEAR ENDING 30TH JUNE, 1922.

Your Director has pleasure in recording another very successful year's work, two new comets having again been discovered by members of the Section and the discovery of Encke's Comet also standing to their credit.

Comet Reid, 1921 a, was well observed in the Northern Hemisphere, where it was seen as a naked-eye object for a short time. Fine photographs were obtained by Barnard and others, Barnard's photograph showing two distinct tails, one several degrees long. Dr. Crommelin has published a long list of observations, made by members of the Comet Section of the British Astronomical Association (see *Journal*, 1921, for June, pp. 333 to 337). Your Director has been awarded the Donohoe Comet Medal of the Astronomical Society of the Pacific, for the discovery of this comet. From three early observations Dr. Halm computed the following orbit:—

$$\begin{array}{rl} T = & 1921,\ \text{May } 11.121,\ \text{G.M.T.} \\ \pi = & 333^\circ\ 12'.6 \\ \text{Asc. Node} = & 268\ \ 48{\cdot}7 \\ i = & 130\ \ 43{\cdot}4 \\ \text{Log } q = & 0{\cdot}00994 \end{array}$$

The following orbit, taken from Lick Observatory, Bulletin No. 331, was computed from later observations and a longer arc:—

$$\begin{array}{rl} T = & 1921,\ \text{May } 9{\cdot}91876,\ \text{G.M.T.} \\ \begin{array}{r} \omega = \\ \text{Asc. Node} = \\ i = \end{array} & \left.\begin{array}{rrr} 64^\circ & 24' & 46'' \\ 268 & 17 & 57 \\ 132 & 05 & 40 \end{array}\right\} 1921. \\ q = & 1{\cdot}00895 \end{array}$$

Dr. W. Baade, of Bergedorf, obtained a photographic observation on October 1st, 1921. This is the latest, as far as is known. It was thus under observation for over eight months.

Comet Pons-Winnecke, 1921 b., was followed for several months after it came South. The following observations, taken from your Director's note-book, will give a fairly accurate idea of its appearance:—

July 3rd: Comet surprisingly bright about 6.5 magnitude; no distinct nucleus, but much brighter in the middle, gradually fading off towards the outside. The brightest part of the comet seemed to be surrounded by a slight haze, which extended out for a considerable distance on all sides, and was most pronounced on the side where the tail should have been.

August 4th: Comet still bright and large. Detected a very small and faint cometary patch quite close to, but slightly to the north of, the comet; it was moving at the same speed as the parent body. Nucleus quite distinct and looking like three small stars, the brightest in the middle and slightly in advance of the other two. Comet fan-shaped, but no tail. It was well observed at both the Royal and Union Observatories: at the latter until the 5th September.

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

Comet Encke, 1921 d. Discovered independently by Messrs. Skjellerup and Reid on the evening of 27th July, 1921. At discovery it was a bright, round nebulous object, with slight condensation. It did not show any unusual features at this apparition, and gradually faded, until near the end of August, when it became too faint to be followed any longer.

Comet Reid, 1922 a. This unknown comet was discovered by your Director on the evening of 20th January, 1922. At this date it had already passed perihelion by nearly three months, and had, curiously enough, been missed by all the Northern comet-seekers. At date of discovery it was a small, but fairly bright, little object; it fluctuated greatly in appearance. Sometimes it looked like a small nebulous patch, and again as a small cluster of stars with very little nebulosity surrounding it. A distinct stellar nucleus was always a fairly prominent feature. It was well observed at both our observatories.

Comet Skjellerup, 1922 b. This comet was discovered by Mr. Skjellerup at Rosebank on the evening of the 16th May, 1922. It was a faint diffuse patch with very little central condensation; it was travelling rapidly in a north-easterly direction. From observations made at the Royal Observatory on May 18, 19, and 20, Dr. Halm has obtained the following elements:—

$$\begin{array}{rl} T = & \text{May } 17{\cdot}450 \text{ G.M.T.} \\ \begin{array}{r}\pi =\\ \text{Asc. Node} =\\ i =\end{array} & \left.\begin{array}{l}209^\circ\ 47'.4\\ 211\ \ \ 29{\cdot}4\\ \ \ 18\ \ \ 39{\cdot}3\end{array}\right\}1922{\cdot}0 \\ \text{Log } q = & 9{\cdot}94654\end{array}$$

We may have something further to report about this comet at a future date.

Taylor's Periodic Comet, 1916A. Should return to perihelion in June. It is very badly placed for observation and will probably not be seen. Mr. Wood has been exposing plates in an effort to photograph it, but without success. Several other periodical comets return this year, but they are better placed for early discovery in the North, and in all probability will be discovered before we can reach them.

De Vico's long-period Comet has not yet been seen, although a good look-out has been kept for it. Its position is now rather uncertain, but if discovered long before perihelion, it will be very far South.

The Director wishes to take this opportunity to return his thanks to all those who have helped him during the past year. In this connection he is specially indebted to His Majesty's Astronomer, Mr. Hough, and Mr. Innes, Directors of the Royal and Union Observatories respectively, and to various members of their staff.

W. REID.

## REPORT OF THE VARIABLE STAR SECTION

### FOR THE YEAR ENDED 31ST MAY, 1922.

Eight hundred and sixty-seven observations of variable stars were made during the year under review. The anticipations of a year ago have, therefore, not been realised; but, as the two principal observers of the section have been away from home for long periods during the year, a decrease in the number of observations was unavoidable. This circumstance clearly emphasises the need for more assistance from our members, so that should one or more of the regular observers be compelled to fall out for a time, others will be ready to carry on, and thus ensure continuity of observation, an important point in variable star work.

We again desire to express our appreciation of the assistance given by Mr. R. T. A. Innes, the Union Astronomer, in continuing the publication of results in the *Union Observatory Circular*.

The following members contributed to this report:—

| | | |
|---|---|---|
| Mr. J. F. Skjellerup .... .... | 562 | observations. |
| Mr. A. W. Long, F.R.A.S. .... | 202 | „ |
| Mr. H. F. Houghton .... .... | 78 | „ |
| Rev. S. Solberg .... .... .... | 25 | „ |

31st May, 1922.

J. F. SKELLERUP.

# Johannesburg Astronomical Association

## (Now the Johannesburg Centre).

### Summary of Annual Report.

The first meeting of the Johannesburg Astronomical Association for the year should have been held on February 22nd, but owing to the very disturbed industrial conditions which prevailed over the Witwatersrand until the end of March, it was not found possible to hold a meeting until April 15th.

Eight meetings were held during 1922, three of which took the nature of visits to the Union Observatory. One of these visits took place on Saturday afternoon, October 21st, with the special purpose of viewing Venus at greatest brilliancy.

The papers read during the year were as follows:

*The Calendar*, Mr. T. Beamish.
*Mars with a Small Telescope*, Dr. J. Moir.
*Venus*, Mr. W. B. Jackson.

One meeting was devoted to a "Question Night."

A proposal has been received from the Cape Astronomical Association that the Johannesburg Astronomical Association should amalgamate with them. The matter is still under consideration..

### Office-Bearers, 1922-1923.

*President*: W. B. Jackson, M.Sc.
*Vice-Presidents*: J. D. Stevens, W. M. Worssell, F.R.A.S.
*Hon. Treasurer*: F. Hall.
*Hon. Secretary*: W. Eaton.
*Committee*: Messrs. Beamish, Geddes, Holmes, Moir, Nance, Wood.

# The Orbit of Comet 1922 a (Reid).

(H. E. Wood, M.Sc., F.R.A.S., Chief Assistant Union Observatory.)

This comet was discovered in 1922 (January 20) by Mr. W. Reid, at Rondebosch, near Cape Town. During the period of its visibility, its declination lay between —29 degrees and —37 degrees, so that observations of it were practically confined to southern observatories.

The comet was observed at the following observatories:—

| | |
|---|---|
| Union Observatory, Johannesburg, from 1922 | Jan. 23 to Apr. 25 |
| Royal Observatory, Cape Town, | Jan. 23 to Feb. 26 |
| Santiago de Chile | Feb. 6 to Mar. 31 |
| La Plata | Feb. 1 to Mar. 23 |

I have computed several orbits from single observations as follows:—

| Observations on | Jan. 23 | Jan. 23 | Jan 23 |
|---|---|---|---|
| | ,, 25 | ,, 30 | Feb. 26 |
| | ,, 27 | Feb. 5 | Mar. 29 |
| T | 1921, Oct. 17·46 | Oct. 26·40738 | Oct. 16·52245 |
| ω | 184° 3′ 53″ | 183° 31′ 9·4 | 184° 40′ 49·0″ |
| Asc. Node | 278 26 56 | 275 6 26·8 | 274 2 8·8 |
| i | 35 22 18 | 32 56 6·1 | 33 23 17·1 |
| Log q | 0·25798 | 0·2183570 | 0·2409052 |

and an ellipse from the observations on Jan. 23, Feb. 26, and Mar. 29.

| | |
|---|---|
| Epoch | 1922, Jan. 1·0 |
| M | 0° 2′ 1.3″ |
| ω | 183 37 32·0 |
| Asc Node | 274 30 13·5 |
| i | 32 30 16·5 |
| Phi | 81 38 58·8 |
| μ | 1″·8571.857 |
| Log a | 2·1874524 |

On the receipt of the South American observations, I decided to compute a further orbit, utilising all the available material. A one-day ephemeris was computed from the third parabolic orbit. With the help of this, the various observations were corrected for parallax and aberration, and, finally, normal places were obtained for 1922—Jan. 28.0, Feb. 25.0, and March 26.0. The first normal depends upon 23 observations between Jan. 23 and Feb. 2, the second upon 28 observations between Feb. 20 and Mar. 2, and the third upon 19 observations between Mar. 21 and Mar. 31. From these normal places the following ellipse was obtained:—

| | | | | |
|---|---|---|---|---|
| Epoch | 1922, Jan. 1·0 | | | |
| M | 0° | 2′ | 44·4′ | |
| ω | 183 | 41 | 59·6 | 1922·0 |
| Asc. Node | 274 | 29 | 37·9 | |
| i | 32 | 26 | 37·5 | |
| Phi | 80 | 44 | 24·0 | |
| Mu | 2″·5386 | | | |
| Log a | 2·0969420 | | | |

The time of perihelion passage obtained from this elliptic orbit is—1921, Oct. 28.26612, and the perihelion distance 1.62909. The period of the comet is about 1,400 years.

# Phenomena, 1923.

South African
Standard Time.

Jan. 3: 1 a.m.—Earth in Perihelion.
,, 10: —Appulse of Saturn and the Moon.
,, 11: 3 a.m.—Saturn in Quadrature.
,, 13: noon. —Mercury at greatest elongation East.
,, 29: 6 a.m.—Mercury in Inferior Conjunction with the Sun.
Feb. 4: 9 a.m.—Venus at greatest elongation West.
,, 6: 4 p.m.—Neptune in Opposition.
,, 7: 7 p.m.—Jupiter in Quadrature.
,, 23: 7 a.m.—Mercury at greatest elongation West.
Mar. 3: 5.32 a.m.—Moon eclipsed. Visible in South Africa (1).
,, 5: 6 p.m.—Uranus in Conjunction with the Sun.
,, 17: 2.24 p.m.—Annular eclipse of the Sun. Visible in S.A. (2).
,, 21: 5.29 p.m.—Equinox.
,, 21: 7.41 p.m.—Mercury in conjunction with Uranus Mercury 1° 40' South.
Apl. 2: —Occultation of Saturn. Visible in S.A.
,, 7: 5 p.m.—Saturn in Opposition.
,, 8: 8 p.m.—Mercury in Superior Conjunction with the Sun.
,, 14: 0.25 p.m.—Venus in Conjunction with Uranus Venus 0° 23' South.
May 5: 4 p.m.—Jupiter in Opposition.
,, : 7 p.m.—Mercury at greatest elongation East.
,, 7: 2 a.m.—Neptune in Quadrature.
,, 26: —Appulse of Saturn and the Moon.
,, 29: 5 a.m.—Mercury in Inferior Conjunction with the Sun.
June 9: 10 a.m.—Uranus in Quadrature.
,, 21: 6.22 p.m.—Mercury in Conjunction with Venus. Mercury 2° 38' South.
,, 22: —Occultation of Saturn.
,, 22: 1.3 p.m.—Solstice.
,, 23: 7 a.m.—Mercury at greatest elongation West.
July 4: 4.36 p.m.—Mercury in Conjunction with Venus Mercury 0° 47' South.
,, 6: 2 a.m.—Earth in Aphelion.
,, 6: 9 p.m.—Saturn in Quadrature.
,, 22: noon. —Mercury in Superior Conjunction with the Sun.
,, 26: 4.18 a.m.—Mercury in Conjunction with Mars Mercury 0° 39' North.
,, 31: 1.28 p.m.—Mercury in Conjunction with Neptune Mercury 1° 36' North.
Aug. 3: 3 p.m.—Jupiter in Quadrature.
,, 8: 10 p.m.—Mars in Conjunction with the Sun.
,, 11: 5 p.m.—Neptune in Conjunction with the Sun.

South African
Standard Time.

Aug. 12: 5.12 p.m.—Mars in Conjunction with Neptune
Mars 0° 59' North.
„ 18: 6.24 a.m.—Venus in Conjunction with Neptune
Venus 0° 58' North.
„ 23: 6.3 p.m.—Venus in Conjunction with Mars
Venus 0° 6' North.
„ 26: 0.40 p.m.—Moon eclipsed. Invisible in South Africa.
Sept. 3: 1 a.m.—Mercury at greatest elongation East.
„ 9: 9 a.m.—Uranus in Opposition.
„ 10: noon. —Venus in Superior Conjunction with the Sun.
„ 10: 10.30 p.m.—Sun eclipsed. Invisible in South Africa.
„ 24: 4.4 a.m.—Equinox.
„ 29: 6 a.m.—Mercury in Inferior Conjunction with the Sun.
Oct. 9: 7.47 a.m.—Venus in Conjunction with Saturn
Venus 1° 22' South.
„ 14: 7 p.m.—Mercury at greatest elongation West.
„ 17: 1 p.m.—Saturn in Conjunction with the Sun.
„ 30: 2.0 a.m.—Mercury in Conjunction with Saturn
Mercury 0° 42' South.
Nov. 4: 10.11 p.m.—Venus in Conjunction with Jupiter
Venus 0° 45' South.
„ 13: 9 p.m.—Neptune in Quadrature.
„ 16: 2 a.m.—Mercury in Superior Conjunction with the Sun.
„ 20: 7.53 a.m.—Mercury in Conjunction with Jupiter
Mercury 1° 24' South.
„ 22: midnight.—Jupiter in Conjunction with the Sun.
Dec. 2: 9.42 a.m.—Mars in Conjunction with Saturn
Mars 1° 30' South.
„ 6: 10 p.m.—Uranus in Quadrature.
„ 22: 10.54 p.m.—Solstice.
„ 27: —Occultation of Regulus.
„ 27: 6 p.m.—Mercury at greatest elongation East.

(1) A partial eclipse. Magnitude 0.376 (Moon's diameter 1.0).

| | |
|---|---|
| Moon enters Penumbra .... .... | 3.13 a.m. |
| Moon enters Umbra .... .... .... | 4.28 a.m. |
| Middle of the eclipse .... .... | 5.32 a.m. |
| Moon leaves Umbra .... .... .... | 6.36 a.m. |
| Moon leaves Penumbra .... .... | 7.51 a.m. |

(2) The path of the Annulus enters South-West Africa in the District of Luderitzbucht and passes centrally through Southern Rhodesia and Portuguese East Africa. Bulawayo and Quilimane are near the central line.

At Cape Town a partial eclipse is visible, commencing at 1.35 p.m. and ending at 4.48 p.m. Magnitude 0.77.

At Johannesburg a partial eclipse is visible, commencing at 2.11 p.m. and ending at 5.12 p.m. Magnitude 0.83.

# Jupiter's Satellites.

ECLIPSES OF SATELLITES I, II & III, 1923, MARCH—OCTOBER.

| | | | | | |
|---|---|---|---|---|---|
| Mar. | 1 | I | *c* | 11.3 | p.m. |
| | 5 | II | *c* | 4.42 | a.m. |
| | 9 | I | *c* | 0.56 | „ |
| | 15 | II | *c* | 8.34 | p.m. |
| | 16 | I | *c* | 2.49 | a.m. |
| | 17 | I | *c* | 9.17 | p.m. |
| | 22 | II | *c* | 11.10 | „ |
| | 23 | I | *c* | 4.42 | a.m. |
| | 24 | I | *c* | 11.11 | p.m. |
| | 27 | III | *c* | 10.11 | „ |
| | | | *f* | 11.57 | „ |
| | 30 | II | *c* | 1.46 | a.m. |
| | | I | *c* | 6.35 | „ |
| Apl. | 1 | I | *c* | 1.4 | a.m. |
| | 2 | I | *c* | 7.32 | p.m. |
| | 4 | III | *c* | 2.9 | a.m. |
| | | | *f* | 3.54 | „ |
| | 6 | II | *c* | 4.22 | „ |
| | 8 | I | *c* | 2.57 | „ |
| | 9 | I | *c* | 9.25 | p.m. |
| | 11 | III | *c* | 6.6 | a.m. |
| | 13 | II | *c* | 6.58 | „ |
| | 15 | I | *c* | 4.50 | „ |
| | 16 | II | *c* | 8.16 | p.m. |
| | | I | *c* | 11.19 | „ |
| | 22 | I | *c* | 6.44 | a.m. |
| | 23 | II | *c* | 10.53 | p.m. |
| | 24 | I | *c* | 1.12 | a.m. |
| | 25 | I | *c* | 7.41 | p.m. |
| | 31 | II | *c* | 1.29 | a.m. |
| | | I | *c* | 3.6 | „ |
| May | 2 | III | *c* | 6.0 | p.m. |
| | | | *f* | 7.45 | „ |
| | | I | *c* | 9.34 | „ |
| | 8 | II | *f* | 6.27 | a.m. |
| | 9 | III | *f* | 11.43 | p.m. |
| | 10 | I | *f* | 1.37 | a.m. |
| | 11 | II | *f* | 7.45 | p.m. |
| | | I | *f* | 8.6 | „ |
| | 17 | I | *f* | 3.31 | a.m. |
| | | III | *f* | 3.41 | „ |
| | 18 | I | *f* | 10.0 | p.m. |
| | | II | *f* | 10.22 | „ |
| | 24 | I | *f* | 5.25 | a.m. |
| | | III | *c* | 5.54 | „ |
| | 25 | I | *f* | 11.54 | p.m. |
| | 26 | II | *f* | 0.59 | a.m. |
| | 27 | I | *f* | 6.22 | p.m. |
| June | 2 | I | *f* | 1.48 | a.m. |
| | | II | *f* | 3.36 | „ |
| | 3 | I | *f* | 8.16 | p.m. |
| | 9 | I | *f* | 3.42 | a.m. |
| | 10 | I | *f* | 10.11 | p.m. |
| | 12 | II | *f* | 7.33 | „ |
| | 14 | III | *c* | 5.50 | „ |
| | | | *f* | 7.35 | „ |
| | 18 | I | *f* | 0.5 | a.m. |
| | 19 | I | *f* | 6.34 | p.m. |
| | | II | *f* | 10.10 | „ |
| | 21 | III | *c* | 9.49 | „ |
| | | | *f* | 11.35 | „ |
| | 25 | I | *f* | 1.59 | a.m. |
| | 26 | I | *f* | 8.28 | p.m. |
| | 27 | II | *f* | 0.47 | a.m. |
| | 29 | III | *c* | 1.48 | „ |
| July | 3 | I | *f* | 10.23 | p.m. |
| | 11 | I | *f* | 0.17 | a.m. |
| | 12 | I | *f* | 6.46 | p.m. |
| | 14 | II | *f* | 7.20 | „ |
| | 18 | I | *f* | 2.12 | a.m. |
| | 19 | I | *f* | 8.41 | p.m. |
| | 21 | II | *c* | 7.36 | „ |
| | | | *f* | 9.57 | „ |
| | 26 | I | *f* | 10.35 | „ |
| | 27 | III | *c* | 5.43 | „ |
| | | | *f* | 7.30 | „ |
| | 28 | II | *c* | 10.14 | „ |
| | 29 | II | *f* | 0.34 | a.m. |
| Aug. | 3 | I | *f* | 0.30 | a.m. |
| | | III | *c* | 9.42 | p.m. |
| | | | *f* | 11.30 | „ |
| | 4 | I | *f* | 6.59 | „ |
| | 5 | II | *c* | 0.50 | a.m. |
| | 11 | I | *f* | 8.54 | p.m. |
| | 15 | II | *f* | 7.5 | „ |
| | 18 | I | *f* | 10.49 | „ |
| | 22 | II | *c* | 7.22 | „ |
| | | | *f* | 9.42 | „ |
| | 27 | I | *f* | 7.13 | „ |
| | 29 | II | *c* | 9.59 | „ |
| Sept. | 3 | I | *f* | 9.7 | p.m. |
| | 8 | III | *f* | 7.27 | „ |
| | 10 | I | *f* | 11.2 | „ |
| | 15 | III | *c* | 9.36 | „ |
| | 16 | II | *f* | 6.48 | „ |
| | 19 | I | *f* | 7.26 | „ |
| | 23 | II | *f* | 9.23 | „ |
| | 26 | I | *f* | 9.21 | „ |
| Oct. | 12 | I | *f* | 7.39 | p.m. |
| | 18 | II | *f* | 6.26 | „ |
| | 21 | III | *f* | 7.24 | „ |

*c* = eclipse commences.
*f* = eclipse finishes.

During November and December Jupiter is too near the sun for observation.

## Algol.

PRIMARY MINIMA, 1923 JULY—DECEMBER.

| July. | | August | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d | h | d | h | d | h | d | h | d | h | d | h |
| 2 | 8·3 | 6 | 6·0 | 1 | 1·3 | 5 | 11·0 | 8 | 8·8 | 4 | 4·1 |
| 11 | 10·7 | 14 | 8·4 | 9 | 3·7 | 14 | 1·4 | 17 | 11·2 | 13 | 6·5 |
| 20 | 1·1 | 23 | 10·8 | 18 | 6·1 | 22 | 3·9 | 26 | 1·6 | 21 | 9·0 |
| 28 | 3·6 | | | 26 | 8·6 | 31 | 6·3 | | | 30 | 11·5 |

NOTE.—This Table is extracted from the B.A.A. Handbook for 1923 with the times altered to South African standard times. Two primary minima have been omitted between the times given. These minima may be found by adding 2 days 20 hours 48 minutes and twice this amount respectively to the times given.

## Vesta, 1923.

APPROXIMATE EPHEMERIS, FEBRUARY—JUNE.

| Date. | | Magnitude. | Right Ascension. | | Declination North. | |
|---|---|---|---|---|---|---|
| G.M. Noon. | | | h | m | ° | ′ |
| Feb. | 4 | 6·67 | 11 | 30·4 | 12 | 51 |
| | 12 | 6·58 | 11 | 26·6 | 13 | 55 |
| | 20 | 6·51 | 11 | 21·1 | 15 | 4 |
| | 28 | 6·46 | 11 | 14·3 | 16 | 13 |
| Mar. | 8 | 6·44 | 11 | 6·8 | 17 | 17 |
| | 16 | 6·44 | 10 | 59·4 | 18 | 10 |
| | 24 | 6·48 | 10 | 52·6 | 18 | 50 |
| Apr. | 1 | 6·53 | 10 | 47·1 | 19 | 13 |
| | 9 | 6·60 | 10 | 43·2 | 19 | 20 |
| | 17 | 6·68 | 10 | 41·2 | 19 | 11 |
| | 25 | 6·77 | 10 | 41·2 | 18 | 49 |
| May | 3 | 6·86 | 10 | 43·0 | 18 | 14 |
| | 11 | 6·96 | 10 | 46·5 | 17 | 29 |
| | 19 | 7·05 | 10 | 51·6 | 16 | 34 |
| | 27 | 7·14 | 10 | 58·1 | 15 | 32 |
| June | 4 | 7·23 | 11 | 5·7 | 14 | 23 |
| | 12 | 7 31 | 11 | 14·4 | 13 | 8 |
| | 20 | 7·39 | 11 | 3·9 | 11 | 48 |
| | 28 | 7·46 | 11 | 34·2 | 10 | 23 |

NOTE.—This Approximate Ephemeris is extracted from the B.A.A. Handbook 1923.

## Occultations of Saturn and Regulus, 1923.

| Planet or Star. | PLACE. | DISAPPEARANCE. | | | | REAPPEARANCE. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | S.A. Standard Time. | Angle from | | Altitude. | S.A. Standard Time. | Angle from | | Altitude. |
| | | | North. | Vertex. | | | North. | Vertex. | |
| Saturn. | Cape Town | Apl. 2 1.7 a.m. | 130° | 306° | 58° | Apl. 2 2.22 a.m. | 283° | 127° | 55° |
| | Johannesburg | 1.21 ,, | 92 | 296 | 66 | 2.32 ,, | 321 | 189 | 55 |
| | Durban | 1.28 ,, | 100 | 307 | 61 | 2.41 ,, | 310 | 178 | 49 |
| | Cape Town | June 22 11.35 p m. | 146 | 19 | 27 | June 23 0.27 ,, | 255 | 130 | 17 |
| | Johannesburg | 11 38 ,, | 113 | 356 | 20 | 0.38 ,, | 285 | 169 | 6 |
| | Durban | 11.40 ,, | 125 | 5 | 17 | 0.36 ,, | 272 | 152 | 4 |
| Regulus | Cape Town | Dec. 27 11.17 ,, | 65 | 191 | 3 | Dec. 28 0.9 a.m. | 320 | 89 | 13 |
| | Johannesburg | 11.23 ,, | 41 | 163 | 14 | Dec. 27 11.56 p.m. | 346 | 110 | 21 |
| | Durban | 11.22 ,, | 58 | 184 | 15 | Dec. 28 0.13 a.m. | 328 | 99 | 25 |
| Appulse of Saturn. | | Time of Nearest Approach | | | | Distance from Limb. | | | |
| | Johannesburg | May 26 3.3 p.m. | 200 | 316 | 4 | a graze | | | |
| | Durban | 3.8 ,, | 200 | 319 | 5 | 3′ | | | |

# Astronomical Society of South Africa.

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*Variable Star Section*: J. F. Skjellerup (resigned 1922—December 22); W. M. Worssell, Union Observatory, Johannesburg.

*Meteor Section*: D. G. McIntyre, Ben Etive, Park Road, Rondebosch.

*Moon Section*: W. B. Jackson, M.Sc., P.O. Box 4570, Johannesburg.

*Mars Section*: J. Moir, D.Sc., 48, Ditton Avenue, Auckland Park, Johannesburg.

# Memorandum.

The Astronomical Society of South Africa was formed in July, 1922, by the union of the Cape Astronomical Association (founded in 1911) and the Johannesburg Astronomical Association (founded in 1918). In the constitution provision is made for the incorporation of other astronomical associations into the Society, each association thus admitted having a direct share in the government of the Society. Persons in any part of South Africa not attached to any such associations may be admitted as Members or Associates of the Society.

Correspondence from persons interested in Astronomy is invited, and letters should be addressed to the Secretary, P.O. Box 2061, Cape Town. The *Journal* will be published at irregular intervals, as funds permit. Extra copies can be obtained from the Secretary at one shilling each, post free.

Members and Associates of the Society resident in Cape Town or Johannesburg have access to telescopes free of charge by arrangement with members possessing such.