ORBIT OF THE SPECTROSCOPIC BINARY BOSS 5442.

By R. K. Young.

Boss 5442 (R. A. 1900, 21^h $04^m.4$, Dec. $+29°$ 48′, type B8, magnitude 5.6) was announced as a binary from this observatory. Volume 1, No. 10 of the publications. The approximate elements are as follows:

Period	= 3.3137 days
Eccentricity	= 0.0
Semi-amplitude	= 21 km
Velocity of system	= —25 km

Maximum positive velocity, J. D. 2422522.100

The star has narrow and sharp lines: Calcium K, 4128, 4131 of silicon, Hδ and Hγ of hydrogen, and 4481. Although the lines are few in number remeasures of the same plate usually agree within a kilometer or so. In spite of this fact the fifty-four observations obtained of the star give a very ragged curve and it is felt that there are complications in the system not yet discovered. The observations taken in 1921 are at least five kilometers more positive than those taken in 1920, also the lines seem to vary in sharpness as in 12 Lacertae. If the star is like 12 Lacertae in having the amplitude variable, the poor agreement of many of the plates could be explained. Owing to the fact that the period is 3, 3 days, it is impossible to get a continuous run of plates covering a single revolution and the hypothesis that the amplitude is variable is suggested on account of the other two similarities to 12 Lacertae. The calcium K line gives results in agreement with the other lines of the spectrum.

REPORT ON MARS, NO. 24.

By WILLIAM H. PICKERING.

SUGGESTIONS FOR THE APPARITION OF 1922.

Owing to a somewhat prolonged absence from the observatory, it has been found impossible to prepare the regular report on the observations made during the apparition of 1920 this past year, but it is expected that it will appear during 1922. The coming opposition will bring the planet nearer to us than has been the case since 1909, but to counterbalance this advantage for the northern observers, Mars will be found in the extreme southern portion of its orbit, and furthermore will be some 2°.5 south of the ecliptic, which on account of its low altitude will have an appreciable effect for European observers. We therefore hope that not only will amateurs from Australia, New Zealand, and South Africa send in drawings for the Report of the Associated Observers, but that professional astronomers from the

large southern observatories will be willing to devote a few hours to this work, since this is an occasion when their assistance is really needed. Six hours of time is all that is required, an hour for each of the six drawings. No preliminary practice is necessary for any man who can draw at all. Full information as to how to determine the six dates and hours will be found in Report No. 15. The especial attention of those having access to a Nautical Almanac is called to this point. Further information as to details is given in Reports Nos. 11 and 18. All drawings should be sent to Mandeville, Jamacia, B. W. I.

Opposition occurs upon June 10, and the drawings should in general be made between May 10 and July 20, but those made earlier or later will also be accepted. It is not necessary to send in a full set, but this is desirable, weather permitting. Sufficient information should be given with each drawing, if possible, to enable the writer to fill out a table similar to Table I in Report No. 23. The declination of the planet on May 10 is $-24°.5$, on June 10 $-26°.0$, and on July 20, $-26°.1$. Its diameter on these dates is $16''.2$, $20''.3$, and $17''.9$, and its solar longitude $\odot = 154°.5$, $171°.3$, and $194°.2$. These longitudes correspond to the Martian dates August 46, September 21, and October 3. The latitude of the centre of the disk is $+1°.1$, $+5°.5$, and $+9°.7$. It will thus be seen that we shall now at least be able to see its southern hemisphere to advantage, and in fact nearly as well as its northern one. The planet will be nearest to us on June 8, when its diameter is $20''.5$. Since the canals are most numerous and conspicuous immediately after the summer solstice, $\odot = 90°$, which at this apparition occurs upon December 26, 1921, we need not expect to see very many of them, and especial attention should be paid to the shapes of the larger formations. Observers should not be discouraged if but little detail is seen by them in Region **C**, longitude 120°, since there is never very much to be seen there, north of the great southern maria. After April 22, 1922, $\odot = 145°.1$, Mars will have reached a portion of its orbit, that is to say a season of its year, when it will be nearer to us, and therefore better seen, other things being equal, than has been the case at that season for many years. The corresponding Martian date is August 29. The autumnal equinox $\odot = 180°$, September 37, occurs on June 26.

To those observers who expect to pay more attention to the planet than is necessary merely to make six drawings of it, the following suggestions may be of interest. It is expected that throughout the time that it is nearest to us, it will be found that the northern boundary of the southern maria between longitude 180° and 220° is gradually moving northward, with the sun. This movement may be detected either by micrometric measurements from both the northern and southern limbs, or by means of drawings made as described in Reports Nos. 18 and 22. The former method gives less biased results, but the latter gives more correct values, on account of the large but uncertain systematic deviation of the micrometric from the true value.

During the apparition of 1920 a very marked cloud formation was seen by several observers over the Syrtis Major. Owing to local cloudy weather it was not well seen in Jamaica, although faintly shown, but two excellent descriptions of it as recorded at the Lowell Observatory are given in POPULAR ASTRONOMY, 1921, **29**, 69 and 73. The solar longitude ⊙ was 119°, corresponding to the Martian date July 33. It is possible therefore that something similar may be seen in 1922 during late February or early March. It would seem that clouds projecting beyond the terminator might also perhaps be expected at about the same time, although not necessarily in the same region. If so, they should be carefully observed continuously while visible, and on successive nights. The object of such observations is to indicate the direction and velocity of the winds on Mars. Unfortunately only an indication is possible, however, since our results might be seriously modified by a continuous condensation of moisture on one side of the cloud, and by an evaporation and disappearance of the cloud itself on the other. The phenomenon is nevertheless well worthy of careful observation, since it also enables us to determine the height of the cloud. It is moreover very rare, not having been recorded prior to 1920 for many years.

Another interesting phenomenon is the expected disappearance of Thoth and Nepenthes, and the substitution for them of Amenthes. These canals have all been so conspicuous in the past, that the phenomenon should be shown even by small telescopes under inferior atmospheric conditions. As far as can be determined the disappearance does not occur suddenly, but the canals may be alternately visible for several months, and sometimes both Thoth and Amenthes are visible together, side by side. This was the case in 1920 at ⊙ = 177°, corresponding this year to June 20. Amenthes was suspected however by Mr. Phillips at a much earlier Martian date in 1920.

We now come to the appearance of the Martian snow storms, which form a strikingly conspicuous and interesting phenomenon. They first appear in the northern hemisphere at about ⊙ = 140°, Martian date August 19. This corresponds in 1922 to April 12. They last nearly two terrestrial months, and are described and illustrated in Report No. 23. They are followed by light frosts of wide extent, which later however are confined to more northern latitudes. For the last four apparitions it has been possible to orient our drawings by means of the northern snow cap. This will now no longer be possible, since it will have disappeared. For an accurate orientation we must rely in future on the ephemeris, and set our cross hairs by means of a position circle attached to the telescope.

Until the time of the autumnal equinox, which as we have seen occurs in 1922 on June 26, the southern polar regions of Mars are expected to be enveloped in yellowish white clouds. At about that date however these clouds should begin to break away, and disclose the more dazzling and bluer polar snows beneath them. While these

are centered at a point several degrees from the pole, in longitude 30° ±, they are expected to be so extensive that this fact will not be very conspicuous at first. The date or dates when the snow makes its appearance should be noted.

The green color of the southern maria is expected to be marked this year, and the change from its earlier grey tint should be carefully recorded. Really valuable observations can however only be obtained with a fairly large aperture, a tungsten lamp shining through light blue glass, and colored crayons, as described in Report No. 18. A change in the color of the desert regions from yellow to orange may perhaps be noted by means of the Color Scale or Color Wedge. (POPULAR ASTRONOMY 1917, **25**, 419, and Report on Mars No. 20.)

Observations of the latitude and longitude of certain well-defined markings are at all times desirable, on account of their slow seasonal shift across the surface of the planet, and a list of suitable points is given in Report No. 22. This brief description includes the more important facts, changes, and measurements that it is expected may be recorded at the coming apparition, but careful and continuous observation is always liable to bring out some new and wholly unexpected fact that may turn out to be of extreme interest.

THE COLOR OF WATER.

If water were visible on Mars, of what color should we expect to find it? The natural answer would probably be blue, but a little consideration will show us that probably this is not the case. It is not at all the same question as to what color would water on the Earth appear as seen from the Moon. One reason that our lakes and oceans appear blue, especially at a low angle, is on account of the blue light reflected from our sky. On cloudy days the color is not so marked. On Mars, as is shown in Report No. 19, the atmospheric pressure is about one quarter as great as that on the earth. On account of the small force of gravity however, the amount of atmosphere is not reduced in the same proportion, but is still appreciably less than with us. The Martian skies must therefore be a darker blue than ours, just as we find our own to darken when we ascend to considerable altitudes.

A more important reason why we should expect to find the Martian seas less blue than our own is that they are much more shallow. When the northern snow cap first begins to melt, it is surrounded by a black line. Mare Acidalium soon appears as a grayish marking. Later it turns blue, and remains so for several months. It is possible that in places, if it is really water, it may attain a depth of ten feet, since it is several hundred miles across, but in general it must be much more shallow than that, since there is not enough snow in the polar cap to fill an ocean of even that average depth. Such widely extended features challenge our credulity. The Syrtis Major often turns blue for a few days or a week at a time, after what appears to be a sudden flood, but it never retains that color for long, and since all of

its changes take place so very rapidly, it can be only a few feet, or perhaps even inches in average depth, although several hundred miles across. Indeed, even where most blue it could be only a bog or marsh, with hummocks of earth rising between the puddles or little ponds. Why should such a formation appear blue?

We have seen that our own waters under a low angle are blue, but we never see the Martian seas to advantage at a less angle than 45°. We must therefore next consider how our waters would appear when viewed at angles between the perpendicular and 45°. Also the matter will only interest us when our sky, like that of Mars, is comparatively free from clouds, and when the sun is well above the horizon.

Under such circumstances our New England lakes when viewed from a balloon, and not directly reflecting the sun's light, appear not blue but black, like ink. The explanation is that at such angles very little sky light is reflected to us, even by ripples, and that which passes down through the surface is either absorbed in the depths of the water, or by the muddy bottom. If the lake have a sandy bottom, this of course shows in shallow water, but does not appear blue. The same is true of the lakes of Belgium and of Northern France, as seen from an aeroplane. While making these latter observations we crossed the Channel, and found that the appearance of salt water was utterly different from that of fresh. Its blue color was detected when its depth exceeded something like six feet, and at greater depths was pronounced.

The effect of salt in water is very peculiar. As we all know, our northern oceans when viewed at an angle near the vertical, as from a bridge or a boat, appear usually of a dark grayish green hue. When we enter the Mediterranean, or still more in tropical waters, the color becomes a pronounced blue. On a sunny day in the tropics the color is such as one never sees elsewhere, outside of a paint box. The main difference between tropical and northern waters is that of temperature, but this certainly cannot account for the marked difference in color observed. Another difference is that caused by the higher rate of surface evaporation of the tropical waters. They therefore contain a very slightly greater proportion of salt—perhaps a fraction of a per cent. This I believe is supposed to be the real cause of the extraordinary difference in color, but it seems improbable. Probably the true cause is unknown. Tropical water even in one's bath is distinctly blue.

But all fresh water is not colorless, or black as seen from above. The Niagara river is of a pronounced green. Some of the most beautiful colors in nature may be seen in some of the California lakes, notably Lake Tahoe, which exhibits wonderful greens and sudden changes to blue when the water is deep enough. But deep water is ruled out of consideration for our present purposes. Volcanic waters also sometimes show marvelous greens and blues, sometimes in two

similar lakes placed side by side, as in the Azores, and also in the Yellowstone Park. In such cases a certain depth is required, but not nearly as great as in Lake Tahoe.

Some of the elevated Swiss Lakes, such as those seen from the Gorner Grat and Eggishorn are a dark green with a tinge of blue, the color first appearing faintly at a depth of two feet. The same color is visible in the Italian lake of Maggiore at a much lower altitude. There is one little Swiss lake known as the Blaue See in the Kander Thal which is remarkable for its blue color, but it is in some of the more northern Swiss lakes that we seem to approach more nearly to what appear to be the conditions obtaining on Mars. For instance the water of the river Aare, connecting lakes Thun and Brienz, is distinctly turbid, and this quality shows when the depth exceeds six inches, the bottom becoming invisible at a depth of a foot and a half. The water then appears gray, and at a slightly greater depth a light green. From a mountain height the color is a very beautiful green, but not at all blue. When we view Mars through a large telescope we must remember that the light is enormously reduced in intensity by the high magnification employed, and also that the colored surfaces seen appear extremely small. Both of these facts tend to make it difficult to determine their color correctly, even when we illumine our recording sheet by a properly colored artificial light. The so-called seas of Mars, Acidalium and the Syrtis, as distinguished from the vegetation, have always appeared to me, and I believe to most other observers, as blue rather than green. As we have seen above however, such very slight physical changes produce such very marked alterations in the color of terrestrial water, that we might readily believe that the blue color of the Martian seas is due to their turbidity, and that the suspended particles being of perhaps a rather finer grain than we find in Switzerland, cause the resulting color to be blue rather than green.

Another difficulty however arises at this point which seems to settle the question. When we crossed the Channel by aeroplane it was a bright sunny calm day. The water was smooth as far as such conditions can exist on the Channel. Particular attention was paid to the image of the sun as reflected in the water. It was found to be about 40° in diameter, exceedingly bright, and almost dazzling over an area 10° in diameter at the centre. This implies that if Mars were completely covered by water we should find at opposition a central extremely bright area whose diameter measured twenty Martian degrees, and which was therefore one-sixth of the diameter of the planet. In the centre of this would be a spot of almost dazzling brilliancy whose diameter was five Martian degrees.

If Mars possesses a limited free liquid surface, and if any portion of this surface comes within ten Martian degrees of the centre of the disk at opposition, then this portion of the surface should become exceedingly and conspicuously bright. At the last apparition the

latitude of the centre of the disc ranged from + 16° to + 23°, and at opposition itself was + 19°. If any sea lay as far south from the north pole as Latitude + 25° we should certainly have detected it. The centre of the blue region in the Syrtis major lies in latitude + 14°, and is therefore frequently near enough to the center of the disk to lie within the illuminated circle. Especial attention was directed during the past presentation to the possibility of seeing such a bright area. Others as well as myself have looked for it before, but it has never yet been recorded. We therefore conclude that the blue color so frequently associated with this marking cannot be due to water. The southern limit of Acidalium lies in latitude + 39°, and therefore never comes within the luminous circle.

When the polar cap first begins to melt it is, as we have seen, surrounded by a black line, but this naturally never comes within the necessary limit for illumination. It seems probable that this line is a true liquid surface. Moreover under favorable circumstances I have found its image very slightly polarized, indicating a shiny surface reflecting the light of the Martian atmosphere. Although often looked for, I have never found any polarization whatever exhibited by the Syrtis Major, even when bluest and when near the limb. Neither is Acidalium polarized.

Since the blue color, which is very intense, appears and disappears in both the Syrtis and Acidalium, appearing only when they are receiving moisture from the melting snows, it seems probable that it is due simply and directly to some process of vegetation. Beyond this statement it is idle to speculate. Similar large areas of a white color appear frequently in Elysium, and also spasmodically in other portions of the planet, usually near the tropics. It has been customary to attribute them to clouds, and this view is very likely correct, although it would now appear not necessarily so as applied to all of them, especially to those which last continuously for several days at a time, appearing white even on the central meridian.

Other facts noted from the aeroplane pertaining to vegetation were first, that the English yew trees were extremely black or gray, even when viewed near at hand, much blacker than our American trees, and showing little if any green. Their color thus resembled the blacks and grays attributed to vegetation on Mars and on the moon. Secondly, freshly planted crops, where little green was visible, had the same appearance at a distance as the faint green detected on the floor of the lunar crater Grimaldi, thus suggesting the possibility of lunar chlorophyl. Third, the growing crops at a distance have the same color as the polar greens of Mars. Fourth, the hedge rows and lines of trees between adjoining properties in England have much the same appearance on a small scale as the finer straight canals on Mars. The latter however are not arranged in rectangles, or in any other symmetrical figures such as we find in England.

Oct. 17, 1921.