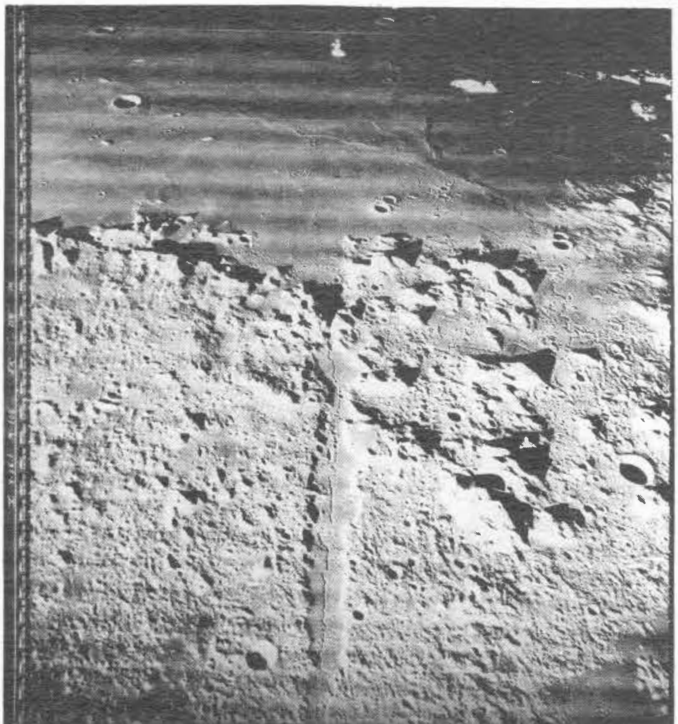
The Journal Of
The Association Of Lunar
And Planetary Observers

The Strolling Astronomer

Volume 20, Numbers 11-12

November-December, 1966
Published March, 1968



Orbiter V photograph of the lunar Alpine Valley, looking westward (IAU sense) toward the Mare Imbrium. At the time of the exposure, on August 14, 1967, Orbiter V was at an altitude of 247 kilometers. One sees Mount Pico in the upper right and the mountains in the foreground are the lunar Alps. The crooked rille running the whole length of the Valley is a fairly difficult object for earth-based lunar observers, and almost all the other features on the floor of the Valley are totally invisible. This NASA photograph is 67-H-1400 in the ALPO Lunar Photograph Library.

THE STROLLING ASTRONOMER
Box 3AZ
University Park, New Mexico
88001

Residence telephone 524-2786 (Area Code 505)
in Las Cruces, New Mexico

ASSOCIATION OF LUNAR & PLANETARY OBSERVERS
ALPO

Founded In 1947

IN THIS ISSUE

THE NATURE AND ORIGIN OF THE MARKINGS ON THE SURFACE OF JUPITER:

A MORPHOLOGICAL INTERPRETATION[1]

By: Takeshi Sato, Rakurakuen Planetarium, Itsukaichi, Hiroshima, Japan

Introduction

Since the markings on the surface of Jupiter are easy objects for observation even with a small telescope, they have been intensively observed for many years; and an innumerable amount of observational data has been accumulated so far. Regrettably, however, the nature and origin of the markings are not known well even today.

There is no doubting the fact that the observable markings on Jupiter are nothing more than phenomena in the Jovian atmosphere because they change their shape, size, intensity, position, etc. greatly and rapidly. The bright markings are usually thought to be clouds of frozen ammonia, but on the other hand there is no consensus as to the true nature and origin of the dark markings. Many students of Jupiter are in favor of the theory that the dark markings are the blank spaces among the clouds. For example, according to H. C. Urey, R. Shapiro has ascribed the bright spots to the cyclones and the dark spots to the anticyclones, an opinion which Urey himself appears to favor.[2] On the other hand, some people consider that the dark markings are the regions in the atmosphere where a predominantly greater amount of the dark material is contained. Especially, S. K. Vsekhsviatsky has called the dark material "[volcanic] ash particles."[3]

To speak to the point, there can really be no other theory than these two because the question is simply whether there is something or nothing in the dark markings. Therefore, the question is which to choose from the two. From the morphological point of view based on the analysis of the results of visual and photographic observations of Jupiter, I shall try, in this paper, to evaluate these two different theories and to explain the general behavior of the various markings on Jupiter as well.

(I) The Relative Altitude of the Markings.

On the south edge of the NTB dark spots or groups of dark spots are occasionally observed which are moving very rapidly in the direction of decreasing longitude; the rotation period of these spots is around 9^h49^m. On the other hand, large bright spots are often observed covering the whole NTrZ, and they do not move much in relation to System II; i.e., their rotation period is 9^h55^m+. Because of the large difference in motion and because of the intrusion of the dark spots into the territory of the NTrZ, these two different kinds of markings collide with each other. Actually, this phenomenon was observed on Dec. 27, 1939 by M. A. Ainslie, F. J. Hargreaves, and T. E. R. Phillips independently[4] and was photographed on Oct. 1 and Dec. 21, 1964 with a 12-inch reflector of the New Mexico State University Observatory.[5]

All of these visual and photographic observations invariably show that the dark spots were visible within the bright ones. In addition, the measurements of the New Mexico photographs do not appear to me to indicate any correlation between the changes of the motion of the dark spot in 1964 and its collisions with the bright spots, both actually observed and presumed. Two different interpretations may be possible about this phenomenon:

1. The dark spots encroach upon the bright ones in a lateral direction.
2. The dark spots pass over (in front of) the bright ones.

Because, as will be stated in detail later, there is evidence indicating that the encroachment in a lateral direction is impossible, or at least very difficult, the second interpretation appears to be much more proper; if the encroachment had taken place in spite of the difficulty, the change of the motion of the dark spots in 1964 should have been large enough to be detected.

There are a few other instances which may possibly indicate that the dark markings are higher than the other kinds of markings. When the Great Red Spot is fading and the RS Hollow is developing, the dark filament bordering the south edge of the RS Hollow is occasionally observed crossing the RS itself. See Figure 1. On Nov. 1, 1962, K. Ikeya and I independently observed that a dark spot, which was probably identical with one on the south branch of the SEB Distrubance, was encroaching upon the preceding end of the RS and that even its portion of encroachment was seen.[6] See Figure 2.

Contrary to what was mentioned above, there is also evidence which may indicate that the bright markings are higher than the others. The most demonstrative example may be so-called "irradiating spots." These spots are quite indistinct or even invisible near the central meridian of Jupiter's disk, but they shine brilliantly near the limb. As is well known, the periphery of Jupiter's disk is much darker than the central portion so that the brilliancy of the spot at the periphery may surely be a contrast effect caused by the increased darkness of the background. This may imply, as suggested by B. M. Peek,[4] that the irradiating spots are higher than the atmospheric layers which cause the limb to become dark. Because all other markings, either bright or dark, are affected by the limb darkening, the irradiating spots may be the highest of all features in the Jovian atmosphere.

Of course, in most cases the bright and dark markings are located at the same altitude in the Jovian atmosphere as is implied by the fact that they often interact with each other. The interaction between the bright and dark markings will be discussed in detail in a later part of this paper.

If it is correct that the dark markings occasionally lie higher than the other features and hide them, a most important conclusion results. Because "nothing" cannot hide anything below it, the fact that the dark markings are visible within the others very clearly shows that there is dark and opaque material in the dark markings.

(II) The Eruptive Nature of the SEB Disturbance.

Every belt on Jupiter is changing in intensity. In particular, the darkening of the SEB is most violent; and this phenomenon is known as the "SEB Disturbance." As we know, a typical outbreak of the SEB Disturbance begins with the sudden emergence of a dark spot or dark filament in the space between the SEB_s and SEB_n; and from that initial point a series of dark spots spreads to the following longitudes along the SEB_s, and another series to the preceding longitudes along the SEB_n, both very rapidly. In the space between the SEB_s and the SEB_n, a series of dark filaments connecting the belt components spreads to the preceding longitudes rather slowly. The birthplace of these dark markings is almost stationary in System II and is identical with the longitude of the initial dark spot or filament. See Figure 3. In itself, this phenomenon demonstratively indicates an eruption of dark material from below; and this point has especially been emphasized by E. J. Reese, who has successfully ascribed the beginning points of all the known outbreaks of the SEB Disturbance to a limited number of "Volcanoes" on the solid surface with a constant period of rotation.[7]

The other belts do not show their eruptive nature in such a definite manner, but perhaps it is scarcely sensible to make an hypothesis that the other belts are quite different in their origin. I assume that such main belts as the NEB, STB, NTB, SSTB, and NNTB, as well as the SEB, may have their own sources of supply of dark material.

As on earth, the wind on Jupiter is predominant in the direction parallel to the equator, especially as is presumed by Jupiter's faster rotation and in addition is clearly evidenced by the existence of rotational "Currents"; and the wind may transport the dark material and may form a belt. A small fraction of the dark material may be transported into other latitudes by local meridional winds and may form such markings as festoons. The EB is usually a long festoon or chain of festoons connected with either the NEB or the SEB, and a belt occasionally observed in the NTrZ is also in places connected with the NEB.[8] Therefore, such weak belts may not have their own sources, and are probably formed by the dark material supplied from other latitudes, namely, the NEB or SEB in the examples cited.

The most serious difficulty involved in this theory may be the question of why the sources are limited to exist only at such specific latitudes. In this respect I suppose it's likely that the sources may exist all over the planet's surface but perhaps that only those at a few specific latitudes may actually erupt dark material in sufficient strength. These latitudes may be specified by the state of the atmosphere over Jupiter. Or else, the existence of the sources may actually be restricted to those latitudes which may possibly be specified by the currents in the solid core of Jupiter, similar to those in our terrestrial mantle. The currents may be controlled by the rotation of Jupiter. But this subject is, perhaps, too speculative at present; and so I do not discuss it here in detail.

(III) An Interpretation of the Phenomena Following the Outbreak of an SEB Disturbance.

When the SEB becomes dark after an outbreak of an SEB Disturbance, the STrZ, STr Disturbance, and the dark filament bordering the south edge of the RS Hollow also become dark; and when the SEB becomes faint, all these markings become faint, or bright, too.[4] See Figure 4. A reasonable interpretation of this phenomenon may come from the assumption that the SEB Disturbance is actually an eruption of dark material. Namely, a small fraction of the dark material supplied to the SEB from the SEB Disturbance may leak out into the neighboring STrZ and may darken it: the region where an unusually large amount of dark material leaks out may be the STr Disturbance. Since the dark filament bordering the south edge of the RS Hollow can be considered to be a southward-deflected portion of the SEB_s, it may be quite natural that it should change together with the SEB. When the supply of dark material becomes exhausted after the eruption ceases, all these markings then become faint, or bright.

Many of the dark spots on the SEB_s which belong to the southern branch of the SEB Disturbance are often observed to project southward, and between them and the STB dark columns are often observed crossing the STrZ; as a result, the STrZ becomes duskier in those longitudes than in other longitudes. This place may be the very site of the supply of dark material.

The STr Disturbance has temporarily disappeared at times, but after an outbreak of the SEB Disturbance it has reappeared at the proper position which can be predicted from its previous motion.[4] Therefore, it may be in existence even when it is completely invisible. The STr Disturbance may possibly be the region where an unusually strong southward wind persists.

The Great Red Spot is usually dark and prominent when the STrZ is bright and other south tropical markings are faint, and the RS is faint or even invisible when the S. Tropical markings are dark. Regarding this fact, B. M. Peek has commented "On these occasions [when the STrZ is bright] the SEB_s and other S. Tropical markings seem to have been obliterated by the condensation of a vast obscuring cloud formation, which for some reason was unable to form above the Spot itself."[4] This certainly explains the behavior of the RS but may not be able to account for the action of the SEB Disturbance. I think that we should frankly accept the fact that we have actually observed what appear to be eruptions of dark material.

My interpretation can explain the behavior of the RS just as B. M. Peek's did; when the STrZ is bright, the RS may appear dark by contrast, and when the STrZ is darkened by the dark material supplied from the SEB Disturbance, the Spot may appear faint or even invisible because of the lack of contrast. Regrettably, however, the correctness of this attractive interpretation appears to be very doubtful because when the RS is faint it is often surrounded by the bright RS Hollow and because the RS appears to be obscured when covered by a cloud-like bright patch, according to observations. Perhaps the southern branch of the Disturbance causes the emergence of the cloud over the RS because the fading of the RS usually begins at about the time when the first dark spot on the SEB_s has reached the preceding end of the RS. However, more detailed interpretation of the behavior of the RS remains an important problem which is to be solved in the future.

E. J. Reese has commented "Indeed, there appears to be a mutual connection between the appearance of the South Equatorial Belt even in longitudes 180° distant from the Spot. Thus it might seem that, whatever its real nature, the Red Spot is more than a local disturbance in the Jovian atmosphere."[9] Again, I think that the feature which is more than a local disturbance is not the RS but the SEB Disturbance, as is evident from the actual observation of the behavior of the Disturbance. In other words, the RS does not control the SEB, but the SEB Disturbance does control the RS and other S. Tropical markings.

In the EZ numerous dark filaments known as "festoons" or "wisps" are observed. Since the 1910's most of the festoons have been connected with the NEB and only a few with the SEB, but prior to the 1910's the situation had been the very opposite.[4] The NEB has been continuously dark and prominent, and the SEB has been greatly variable in intensity since the 1910's. Prior to the 1910's the situation had again been the opposite.[4, 10] A reasonable interpretation of this phenomenon may be as follows: prior to the 1910's a continuous supply of dark material made the SEB always dark, and a fraction of this dark material may have leaked out into the neighboring EZ and thus may have formed many festoons. But in the 1910's the supply of the dark material became intermittent; and hence the SEB has subsequently been variable in intensity, and few festoons have formed because of the insufficiency of dark material. In the NEB the supply of the dark material has been intermittent prior to the 1910's and continuous since then.

(IV) The Interaction Between the Bright and the Dark Markings.

In the STempZ three prominent bright oval spots have endured for many years; and in addition some similar, but temporary, bright spots have been observed at times. In most cases, these bright spots partly intrude into the STB to form distinct bays on the south edge of the belt. The STB is often divided into two components; and its south component, the STB_s, is often observed to be deflected northward along the north edge of the bright spots. See Figure 5. This fact may suggest that the bright spots and the STB_s are arranged laterally to each other and moreover that the dark material in the STB_s cannot enter the bright spots. Otherwise, the STB_s should be simply invisible where hidden by the bright spots or else should run straight across the bright spots. In fact, such is the aspect occasionally observed; but even then the STB_s is often darker or wider where adjacent to the bright spots than in other longitudes. This effect may be a result of the accumulation of the dark material which is blocked by the bright spots there.

Along the south edge of each bright spot a dark filament is also occasionally observed. (Figure 5-A). This may also be interpreted as meaning that the dark material is deflected by the bright spots not only northward but also southward.

We can quote several other instances. However, the most significant of all may be the RS Hollow. The RS Hollow is observed as a gigantic bright spot when it is well developed. The SEB_s bends northward along the north edge of this bright spot and forms the famous RS Bay. Also, as with the bright spots in the STempZ, a dark filament is often observed to border the south edge of the Hollow. These aspects can again be interpreted as a result of the fact that dark material cannot enter the bright spot, i.e., here the RS Hollow. Furthermore, there is here much more direct evidence; the dark spots on the SEB_s which belong to the SEB Disturbance have at times actually been observed moving northwards and then southward along the north edge of the Hollow.[4]

Since the bright spots affect the dark markings, the dark ones may well do the same to the bright ones in turn. Nevertheless, I have not been able to find any such instances. Is it related to the fact that the bright spots are usually larger than the dark spots?

At any rate, the conclusion that the bright and the dark markings hardly mingle with each other may possibly support the facts that some of the markings on Jupiter are surprisingly long-lived, that the boundaries of the markings are fairly clear-cut, and finally that Jupiter continues to be a "Banded Planet."

(text continued on page 186)

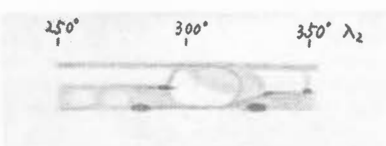


Figure 1. Drawing of Red Spot and Red Spot Hollow on Jupiter by Elmer J. Reese on July 19, 1958, 6-inch reflector, 240X. Redrawn by Takeshi Sato from Str. A., Vol. 12, Nos. 4-6, 1958. Note that the dark filament surrounding the Red Spot Hollow is visible inside the Red Spot itself. For Figures 1-6 the reader will find further material and discussion in the text of Mr. Sato's accompanying article.

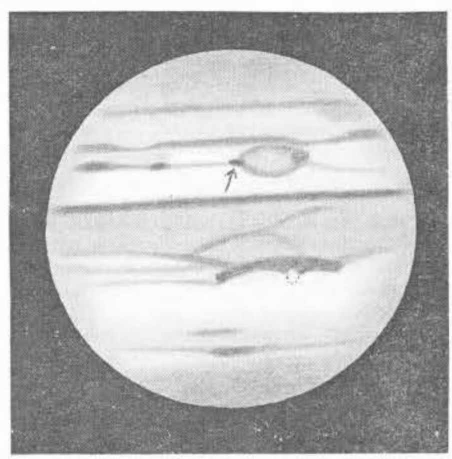


Figure 2. Drawing of Jupiter by Takeshi Sato on November 1, 1962 at 10^h10^m, U.T. 10-inch reflector, 278X. $C.M._1 = 130°$. $C.M._2 = 4°$. Seeing 3 (scale of 0 to 10 with 10 best on Figures 2-6). Transparency 4 (scale of 0 to 5 with 5 best on Figures 2-6). Some dew on eyepiece. The dark spot indicated by the arrow is probably one of the dark spots retrograding on the SEB_s branch of the SEB Disturbance. This observation by Mr. Sato was independently confirmed by Mr. Kaoru Ikeya.

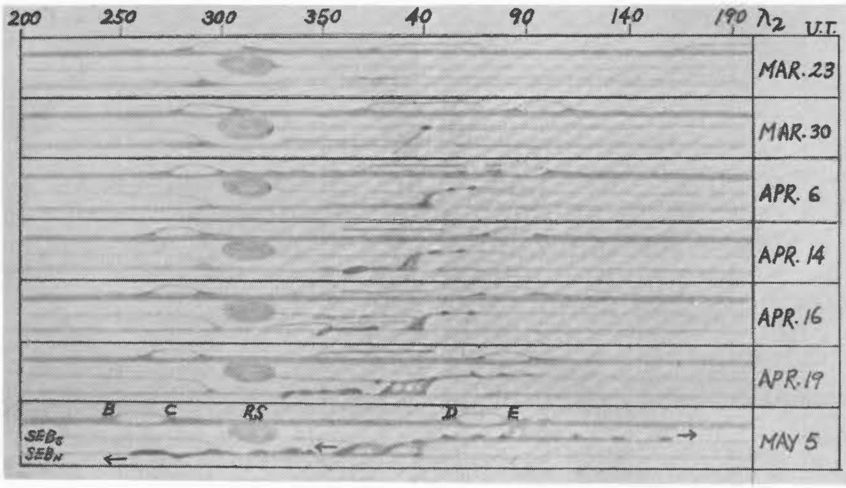


Figure 3. Early development of the SEB Disturbance in 1958. Drawn by Elmer J. Reese and based upon the work of the following observers: Jack Borde (April 6), Thomas A. Cragg (April 16 and May 5), Joel W. Goodman (April 14), Alika K. Herring (March 23 and 30, April 6 and 19), J. S. Miller (March 23 and 30, April 6, May 5), Dennis Milon (April 6, May 5), Takeshi Sato (April 14, 16, and 19 and May 5), and Chester J. Smith (May 5). This outbreak of the SEB Disturbance was one of the most typical and strongly demonstrated eruptions of dark material. These strip sketches were reproduced by Mr. Sato from Str. A., Vol. 13, Nos. 5-8, 1959.

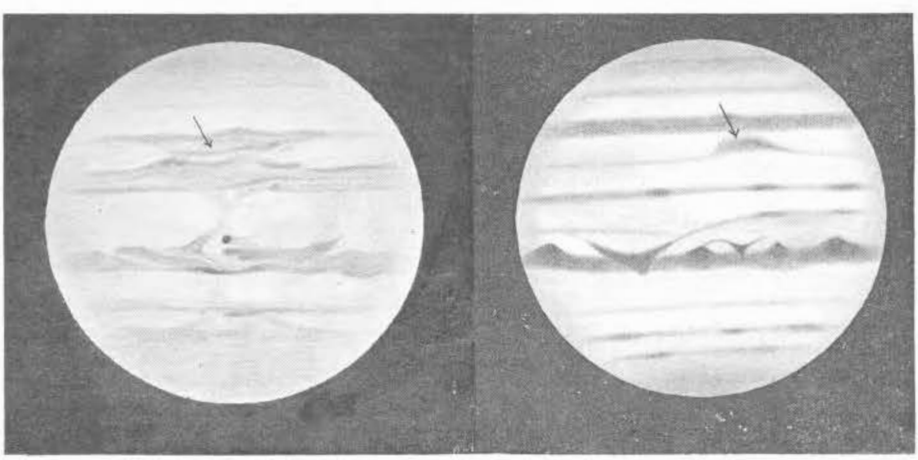


Figure 4. A pair of drawings of Jupiter to show how the fading of the STrZ Disturbance, to which the arrow points, coincided with the fading of the South Equatorial Belt. Left drawing by Toshihiko Osawa on February 14, 1956 at 15^h45^m, U.T. 6-inch reflector, 230X. C.M.$_1$ = 350°. C.M.$_2$ = 211°. Seeing 6-7. Transparency 4. Shadow of J. I near central meridian. Right drawing by Takeshi Sato on April 15, 1957 at 14^h15^m, U.T. 6-inch reflector, 224X. C.M.$_1$ = 213°. C.M.$_2$ = 64°. Seeing 5 or 6. Transparency good.

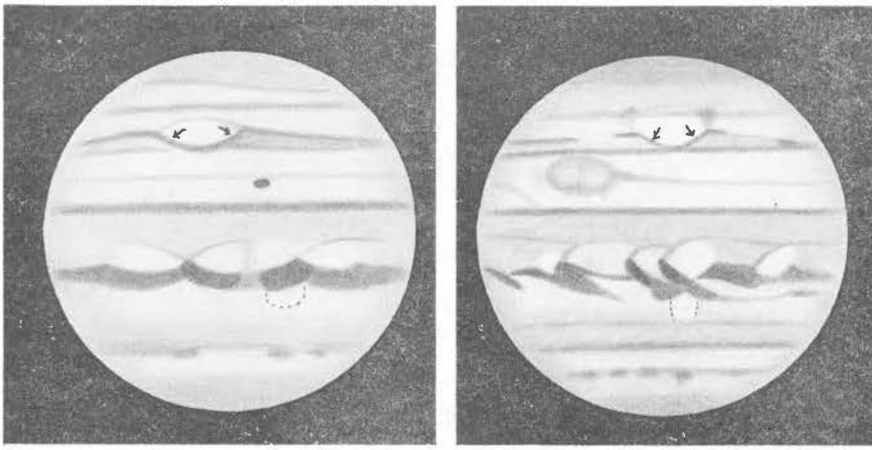


Figure 5. Drawings of Jupiter to show the influence of the S. Temp. Z. bright spots on the South Temperate Belt South. Note the arrows at these locations. Figure 5-A (left) by Takeshi Sato on June 17, 1960 at 13^h50^m, U.T. 6-inch reflector, 192X. $C.M._1 = 230°$. $C.M._2 = 238°$. Seeing 5. Transparency 5. Figure 5-B (right) by Takeshi Sato on July 17, 1960 at 12^h15^m, U.T. 6-inch reflector, 226X. $C.M._1 = 232°$. $C.M._2 = 12°$. Seeing 8. Transparency 3-4.

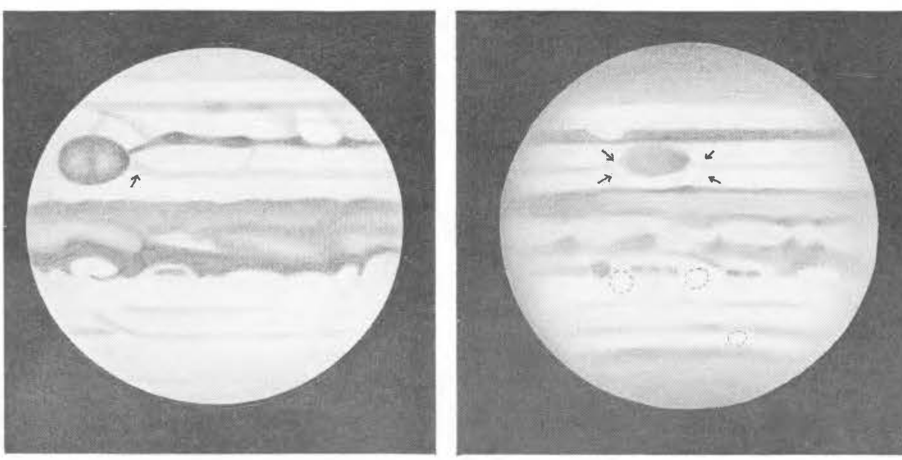


Figure 6. Drawings of Jupiter to show the behavior of the South Equatorial Belt South in the vicinity of the Red Spot. The arrows point to the phenomena discussed in the text. Figure 6-A (left) by Tsuneo Saheki on August 11, 1962 at 13^h57^m, U.T. 8-inch reflector, 330X. $C.M._1 = 276°$. $C.M._2 = 54°$. Seeing 5, occasionally 4. Figure 6-B (right) by Isamu Hirabayashi on August 27, 1964 at 17^h17^m, U.T. 10-inch reflector, 278X. $C.M._1 = 190°$. $C.M._2 = 29°$. Seeing 7. Transparency 2-3.

*****

(V) The Influence of the Great Red Spot on the SEB_s.

The SEB_s is normally located at a latitude somewhat more northward than that of the preceding and the following end of the RS. When it is connected with the RS, it usually deflects southward in the vicinity of the RS and is connected with the very points of the preceding or the following ends of the RS. See Figure 6-A. If there were no interaction between the RS and the SEB_s, the belt should be quite straight. Therefore, there must be some attractive force between the preceding and the following ends of the RS and the SEB_s.

As is well known and has already been stated, the SEB_s often deflects northward and forms the RS Bay, as if it were repelled by the RS. Moreover, the SEB_s is occasionally divided into two branches in the vicinity of the RS; one of them is connected with either the preceding or the following end of the RS, and the other branch deflects northward. See Figure 6-B. Is the SEB_s attracted and repelled simultaneously? As stated before, the northward deflection may not be the effect of the RS itself but may be caused by the fact that the RS Hollow acts as a barrier against the SEB_s. If the SEB_s is higher in the atmosphere of Jupiter than the top of the RS Hollow, it may pass over in front of the Hollow and may be connected with the RS. If the SEB_s is lower than the top of the Hollow, it may not be able to enter the Hollow and may then deflect northward. And if the higher part of the SEB_s is higher and its lower part is lower than is the top of the Hollow, the belt may be divided into two parts; and one of them may be connected with the ends of the RS, and the other may go along the edge of the Hollow. More complex behavior of the SEB_s occasionally observed in the vicinity of the RS can also be interpreted in a similar way.

(VI) The Interaction Between the RS Hollow and the South Tropical Disturbance.

Since the rotation period of the STr Disturbance was shorter than that of the RS for most of the former's lifetime and since both **were** located at the same latitude, the former passed the latter several times from the following side of the latter to the preceding side. On those occasions a number of very interesting phenomena were observed; the most interesting and perhaps most important may be the phenomencn that when either the preceding or the following end of the Disturbance reached the following end of the region of the RS, the Disturbance reappeared on the preceding side of the RS region almost immediately.[4]

As in other cases, the RS Hollow may not permit the intrusion of the material of the STr Disturbance as was shown, as far as the visible surface of the Hollow is concerned, by the fact that the Hollow was bright when it was surrounded by the Disturbance. Therefore, the channel in which the STr Disturbance was moving may have been narrower in the vicinity of the RS Hollow than in other longitudes. As is well known, the fluid in a continuous tube moves more rapidly where the tube is narrower. Similarly, the narrowness of the channel around the RS Hollow may have accelerated the movement of the STr Disturbance. Because the channel must be restricted at most to the region from the north edge of the SEB_n to the south edge of the STB, the RS Hollow, which often covers the whole STrZ and which occasionally even invades the SEB_n and the STB, may have made the channel sufficiently narrow to cause such a remarkable acceleration. On the other hand, the RS itself may be insufficient.

It was not always true that the STr Disturbance passed the RS Hollow more rapidly when their relative motion, before and after the conjunction in longitude, was larger. This result may possibly be ascribed to the variability in width of the channel. In this respect, a more detailed and more quantitative examination of past records is most desirable.

When either the preceding or the following end of the Str Disturbance was approaching the following end of the RS, the Disturbance end was a little accelerated; and when a Disturbance terminal end was withdrawing from the preceding end of the RS, the Disturbance was a little decelerated.[4] In spite of the absence of definitive evidence, I suppose that it may be possible that these accelerations and decelerations were caused by the attractive force of the preceding and the following ends of the RS simply because I don't know any other possible cause at the present time.

On the other hand, the RS was a little accelerated when the STr Disturbance passed through it[4] as if it was being kicked by the Disturbance.

The rotation period of the STr Disturbance was at first some 20 seconds shorter than that of the RS, but the period gradually lengthened and finally became almost equal to that of the RS.[4] This increase may be an effect of the resistance which was encountered by the Disturbance, especially when it passed the extremely narrow channel around the RS Hollow.

Conclusion

From the discussion presented above I have come to these conclusions:

1. The dark markings, such as belts, dark spots, festoons, and disturbances, are regions of the Jovian atmosphere which have a predominantly greater amount of dark material.

2. The dark material is supplied from the solid surface of Jupiter or at least from a lower layer in the atmosphere, chiefly at the latitudes where the main belts lie.

3. The dark markings are usually situated at the same altitude as the bright ones; but some of the dark markings lie higher than the bright ones, or vice-versa.

4. The dark markings cannot intrude into the bright ones in a lateral direction, or at least can do so only with great difficulty.

5. The preceding and the following ends of the Great Red Spot are poles of force which attract the dark material.

These conclusions accepted, I have shown in this paper that many of the hitherto mysterious phenomena of the surface markings such as belts, zones, dark spots, bright spots, festoons, the SEB and STr Disturbances, and the Great Red Spot can be explained quite reasonably. Of course, I am aware that this theory has a serious weak point; I have generalized from too little evidence, and I have applied the conclusions to other topics than those from which they have been derived directly. In addition, the discussion here is qualitative only; and a quantitative analysis is certainly indispensable. Nevertheless, I am very happy if this paper is successful in demonstrating that such an antiquated method as a morphological analysis of the results of visual and photographic observations is still very useful even in this age of mathematical science and advanced technology.

Acknowledgments

In constructing this theory, I have used observational data secured by the members of the Association of Lunar and Planetary Observers, the British Astronomical Association, and the Oriental Astronomical Association, and by many other observers. In particular, the late B. M. Peek's book The Planet Jupiter (Faber and Faber, London, 1958) was most informative. I heartily thank all these sources.

I am also very grateful to A. Fujii and T. Suzuki, both of Hiroshima University, and to T. Uda of the Funairi Senior High School, Hiroshima, for their helpful advice. Finally, it is a pleasure to express my sincere appreciation to M. Kaneda of Hiroshima University's Junior and Senior High School for his very kind assistance in translating this paper into English.

References:

1) This paper was translated, with a few minor revisions, from The Oriental Astronomical Association's The Heavens (in Japanese), 46, 486 and 487, 1965.

2) H. C. Urey: Handbuch der Physik, 52, edited by S. Flügge, Berlin, Göttingen, Heidelberg, 1959.

3) S. K. Vsekhsviatsky: Astronomical Journal (in Russian), 42, 3, Moscow, 1965.

4) B. M. Peek: The Planet Jupiter, London, 1958.

5) E. J. Reese and B. A. Smith: TN-701-66-9, University Park, N. M., 1965.

6) T. Sato: The Heavens, 44, 462, 1963.

7) E. J. Reese: Journal of the British Astronomical Association, 63, 6, 1953.
The Strolling Astronomer, 16, 11-12, 1962.

8) T. Sato: The Heavens, 44, 457, 1963.

9) E. J. Reese: The Strolling Astronomer, 7, 6, 1953.

10) S. Murayama: The Astronomical Magazine (or The Heavens), 25, 284, 1946.
26, 288 and 289, 1947.

WHY DOES JUPITER'S EQUATORIAL ZONE DARKEN?

By: Paul K. Mackal, A.L.P.O. Assistant Jupiter Recorder

(Paper read at the Fifteenth A.L.P.O. Convention at Long Beach, California, August 16-19, 1967.)

A. S. Williams, a pioneer Jupiter observer, proposed an interesting theory about the periodicity of EZ (Equatorial Zone) dusky occurrences. He suggested that the ruddy or yellowish appearance of the zone was repeated every 11.95 years, epoch 1789.25. This seasonal theory was cited by R. Wildt in his paper which proposed the theory that dark color on Jupiter is the result of temperature phase changes of sodium and/or calcium crystals in ammonia.[1] In addition to the papers[2,3] written on the periodicity of the EZ Williams wrote a paper on the seasonal periodicity of the NEB and the SEB[4]. Briefly, this paper suggested that the darkness of the northern and southern belts of Jupiter increased at perihelion and decreased at aphelion. Wildt agreed with this and cited it as an important part of his theory:

> "As for the cyclical changes of the conspicuousness of Jupiter's two equatorial belts, the northern and the southern belts alternately fade out more or less and grow prominent again at intervals which in the long run agree with the planet's sidereal period of revolution according to Williams' investigations."[5*]

According to Wildt the nature of color on Jupiter is so simple that it is likely that the same process takes place on Saturn. These changes of color on Jupiter and Saturn between belts and zones are due to the temperature characteristics of the respective atmospheres. One of the chemical mechanisms postulated by Wildt is that of sodium crystals saturated in ammonia, giving the yellowish, blue, gray, copper, and brown shades of Jupiter. The other mechanism is based on calcium crystals saturated in ammonia, which contributes to the range of color from brown to red.

G. P. Kuiper has agreed with Wildt's theory in principle:

> "...if ammonia could form crystals of varying structure, depending on the temperature, then these crystals might absorb varying amounts of solar radiation and thereby produce the observed colors..."[6]

It occurred to me not so long ago that there might be other causes contributing to the observed range of color in the EZ, independent of the seasonal variation and temperature mechanism. The accompanying graph (Figure 7) of the rotation periods of the EZ sheds light on the mystery. Note that the dark and the white occurrences appear to oscillate over a period of some ten to twelve years where the lighter EZ tends to be midway between the ruddy or yellow appearances. At the crucial periods there appears to be no definite way to predict whether the ruddy or the yellow aspect of the zone will appear. In addition, there are divergencies on the chart at crucial periods which tend to nullify Williams' theory. At these times a white EZ has appeared instead of a yellow or ruddy aspect. This suggests that another cause (or causes) is responsible for the occurrence of the darker aspect of the EZ! Thus 1952-53 is a crucial year which did not confirm the yellow or ruddy EZ.

The divergence from Williams' theory at the crucial points on the chart suggests that another factor contributes to the appearance of the ruddy or yellow EZ, but this unknown factor does not necessarily invalidate the operation of the other factors, e.g., temperature.

Equatorial Zone Rotation Periods

Circles have been drawn around the points intersecting the lines drawn on the chart (Figure 7) marking the crucial periods. These crucial periods were usually represented by a ruddy or a yellow appearance of the EZ. The chart covers the time from 1879 through 1967. Group one, the ruddy aspect, appears to have occurred in 1887--1890, 1899, 1918--1920, 1927--1928, and 1937--1940. (The NTrZ was ruddy in 1909, but the EZ was yellow.) Group two, the yellow aspect, appears to have occurred in 1909. A third group, the orange aspect, which can be explained as the simultaneous ruddy and yellow aspect, occurred in 1959--1960** and in 1962--1964.

It is interesting to compare the rotation period of the EZ_n with that of the EZ_s on the chart. I noticed very quickly that the acceleration of the EZ_n and the deceleration of the EZ_s correspond or tend towards equality! It becomes clear that the other factor which may influence the ruddy or yellow (or orange) aspects of the EZ is the near equality of the rotation periods of the EZ_s and the EZ_n. A likely physical explanation is that the NEB_s and the SEB_n spill some of their dark material into the EZ. Because the rotation periods of the EZ, EZ_n and EZ_s, stabilize the zone, they allow the material from the north and the south to diffuse throughout the entire area. If enough material fills the EZ, it will appear to be yellow or ruddy, depending upon the kind of material being brought into it from

*In a letter to Mr. A. W. Heath of the B.A.A. Jupiter Section I suggested that this theory by Williams could be confirmed: July 23, 1967, p. 3--"You could very easily confirm or refute Mr. A. S. Williams' old paper on seasonal changes as the red-blue filter combination (and technique) is much more sensitive to such trends."

**I must thank Clark Chapman for this observation. He mentioned it to me on Aug. 5, 1967.

the belts flanking the zone.

In addition to this coincidence, the deviations in latitude of the SEB_n and the NEB_s appear to suggest that the size and position of these belts are critical in determining the extent to which the entire EZ (i.e., with the inclusion of the EZ_c) is colored. (The years 1919 and 1938 show this especially. In 1962 observers were beginning to confuse the actual limits of the NEB_s with the EZ_n and the SEB_n with the EZ_s.)

These two factors appear to contribute to the occurrence of the darkened EZ. The actual causes of these crucial periods of coloration of the EZ are not wholly seasonal. The material which colors the EZ must come from some source, and the stability of the zone must be such that the material displays itself for some period of time. The surrounding belts are the source of the material, and the near equality of acceleration and deceleration of the EZ_n and the EZ_s respectively (or conversely, EZ_s accelerating and EZ_n decelerating) are the source of EZ stability for the distribution of the dark material. The stability of the NEB, north and south, and of the SEB, north and south, should also have an effect on the amount of material which can come into the EZ; but I have not investigated this problem.

Conclusions

It is the Jovian atmosphere itself which must be stable in order for the zone to appear ruddy, yellow, or orange. The importance of rotation period stability might be looked into in other areas of the planet, such as the NTrZ and the STrZ, although the evidence here is scanty indeed. However, in time the evidence might be sizable enough. Another possibility would be the relationship of dark NEB's and SEB's, given stable rotation periods between NEB_n and NEB_s, and between SEB_n and SEB_s. All experienced observers have seen light NEBZ's and light or dark, yellow SEBZ's. These studies could allow important confirmation for the EZ theory.

The yellow color of the zones of Jupiter and of the EZ at crucial periods is probably due to the existence of sodium in great enough abundance in the EZ or in the belts flanking the EZ. (I tend to reject the first hypothesis, that is, that the sodium crystals are in the EZ. That is really what distinguishes the belts from the zones; the zones tend to be colorless.) Similarly, the red color of the EZ is due to the migration of calcium crystals from the flanking belts. The orange color is due to the combined migration of sodium and calcium crystals. When the temperature, the stability of the EZ, and the stability of the flanking belts permits--simultaneously--then the dark aspect occurs! The blue-white aspect of 1952-1953, for example, was probably due to the instability of the flanking belts. All the other factors, however, were operative.

It is very doubtful whether the colors would stabilize on the visible atmospheric surface if the internal motions of the EZ were tending to be accelerated and decelerated negatively to each other rather than positively. The festoons which extend into the EZ from the NEB_s, for example, during the white aspect of the zone are very unstable due to the shifting of the internal motions of the EZ. Sodium and calcium which are in abundance in the NEB and the SEB* may not ever diffuse over the entire EZ during a white period because of the atmospheric turbulence. The equilibrium of the EZ_c with the EZ_s and the EZ_n may also contribute to the degree of EZ stability. If the rotation periods of the zones are not only off by a great amount but are accelerating and decelerating positively (towards a single value), parts of the zone begin to darken; and the entire zone darkens if the velocity approaches a common value. If the rotation periods of the zones are not off by a great amount but are accelerating and decelerating negatively (away from a single value), parts of the zone begin to lighten; and the entire zone lightens if the velocity tends to an uncommon value, a mean between EZ_s and EZ_n periods.

Summarizing then: 1) equilibrium rotation periods of the EZ_s and the EZ_n, the distended nature of the SEB and the NEB at the crucial period, the abundance of calcium and sodium crystals in the SEB and the NEB, and the possible initial amounts of sodium and calcium in the EZ itself; 2) a large range of temperatures at the surface of the visible atmosphere due to seasonal variation; 3) low turbulence of the EZ_c for a sufficient depth during the crucial period and coincident with the equalizing of the EZ_s and the EZ_n rotation periods--these are the full range of factors necessary for the appearance of a dark EZ. The dynamical simplicity of this hypothesis and the ready confirmation from rotation periods of the EZ_n and EZ_s tie together the other hypotheses presented by Wildt.

*Bullard's book on volcanoes[7] tends to confirm the fact that large amounts of sodium and calcium are common in all activity of a terrestial origin. Could such a mechanism be working on Jupiter?

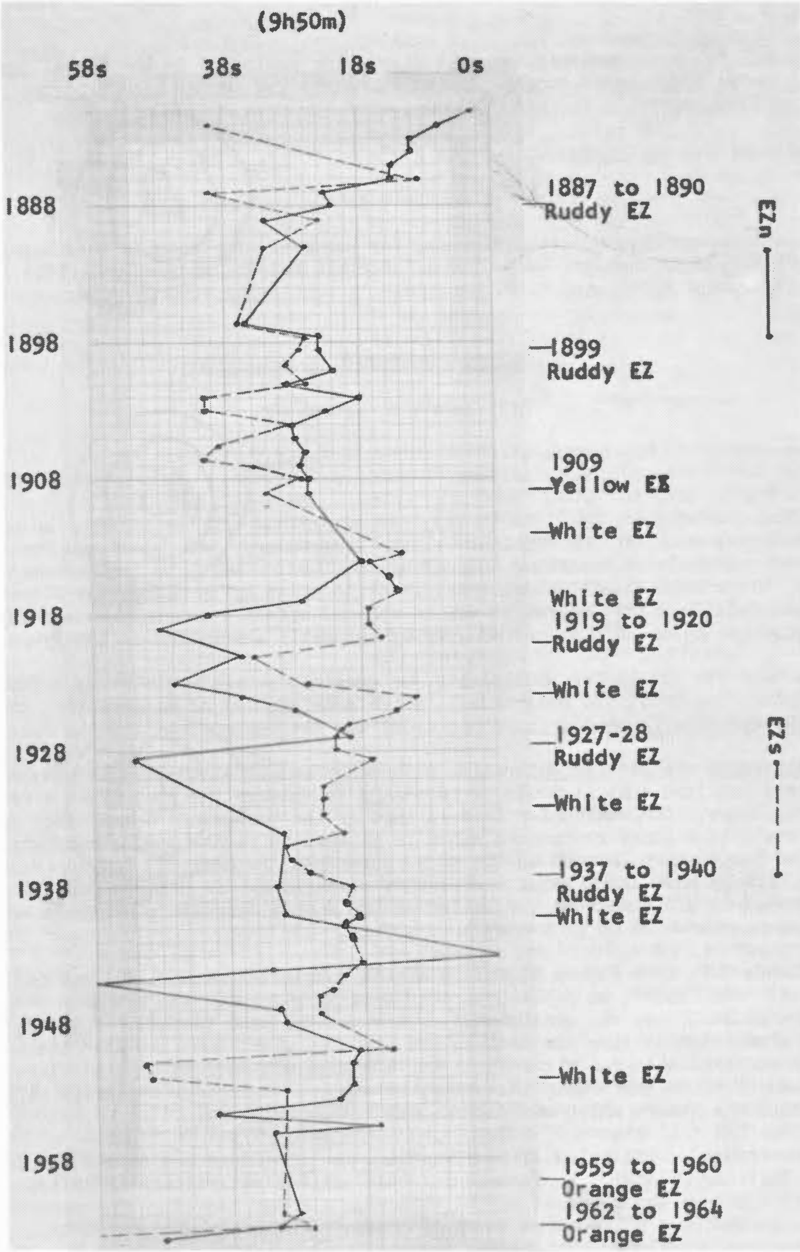


Figure 7. Chart to show variations in the color and in the rotation-periods of the Equatorial Zone (EZ) of Jupiter. Prepared and contributed by Paul K. Mackal. Based upon the observational Jupiter records of the B.A.A. and the A.L.P.O. as given in The Memoirs of the B.A.A. and The Strolling Astronomer. See also discussion in text of Mr. Mackal's article.

Footnotes:

1. Wildt, R., MNRAS, "On the Chemical Nature of the Coloration in Jupiter's Cloud Forms", 1939, p. 621.

2. Williams, A. S., MNRAS, "On the Observed Changes in Color of Jupiter's Equatorial Zone", March, 1920, pp. 467-475.

3. Williams, A. S. MNRAS, "On the Tawny Hue of Jupiter's Equatorial Zone", May, 1922, pp. 417-419.

4. Williams, A. S. MNRAS, "Periodic Variations in the Colors of the Two Equatorial Belts of Jupiter", 1936.

5. Wildt, R., Ibid.

6. Kuiper, G. P., as a participator in a discussion published in the Lowell Observatory Bulletin, "Model Atmospheres for the Jovian Planets", The Annual Report of the Observatory, about 1950, p. 94.

7. Bullard, F. M., Volcanoes, University of Texas Press, 1962.

Acknowledgments

I thank Richard E. Wend, A.L.P.O. Jupiter Recorder, for reading this paper at the Fifteenth A.L.P.O. Convention, C. R. Chapman for his helpful suggestions while I made the final draft of this paper, and W. H. Haas for his continuing support of my Jupiter studies.

A COLORATION PHENOMENON IN THEOPHILUS

By: Eugene W. Cross, Jr.

(Paper read at the Fourteenth A.L.P.O. Convention at Tucson, Arizona, August 26-28, 1966.)

At 01:24, on January 28, 1966 (U.T.), Edmund Arriola and the author, using the 19" f/7 Newtonian telescope at the Whittier College Observatory, had just begun observing some selected lunar areas when something unusual was noticed. There, on the northern rim of Theophilus, was a reddish elliptical area, about 15 miles by 30 miles (see Figure 8). At first it was felt that the coloration was an optical effect - possibly caused by atmospheric dispersion in the earth's atmosphere, or by chromatic aberration in the eyepiece.

As a test for the latter possibility, we examined several relatively bright formations (Proclus, Stevinus, and Langrenus). After some minutes of observation, it was apparent that the eyepiece (a good orthoscopic zoom) was not responsible for the coloration.

To determine whether the coloration phenomenon was an earth-based atmospheric one, the observers realized that it would be necessary to observe the phenomenon over a period of an hour or more. The reason for this is that if the phenomenon became less intense, it obviously would be a lunar phenomenon since if it were an earth-based atmospheric phenomenon, it would become more intense as the moon approached the horizon, and consequently would be visible through more and more of the earth's atmosphere. In other words, if the phenomenon increased in brightness as a function of the moon's decreasing height above the horizon, the phenomenon would be an atmospheric effect.

At 01:50, U.T. (see Figure 8), using almost double the magnification (300X) that had been used at first (155X), we noticed another area of redness. The new area was on the floor of Theophilus, near the shadow cast by the central peak complex. However, it appeared much less conspicuous than the area on the rim. At about the time when the central coloration was compared with the rim coloration, a change was noticed in the coloration on the rim. Instead of being uniform in intensity, it appeared much more brilliant at the point where it touched a shadow which was cast on the crater wall.

At once aware of the value of confirmation, we telephoned Dr. Bender, Professor of Physics at Whittier College. He recommended that another Observatory be called only after the Moon-Blink device was attached to the telescope and was tested on the coloration. However, since we had done quite a few hours of observing with the Moon-Blink during the preceding months, we considered that the device's color sensitivity was so much inferior to direct visual methods that a negative (no blink) response was expected. Unfortunately, more than an hour of observing time was wasted in using the Moon-Blink device.

Meanwhile, the moon had moved closer to the horizon, thus further degrading the visibility of an already difficult phenomenon. At 03:19, U.T. (Figure 8) another direct visual observation was made. Since the observation made about an hour earlier, the phenomenon on the rim of Theophilus had become both less intense and less extensive. While the coloration near the central peak complex had completely disappeared, another coloration had appeared on the interior of the crater wall, where the sun was rising. At the conclusion of the observation, it was obvious that the image was becoming seriously affected by deteriorating seeing conditions--all hope of confirmation was abandoned. All observations were halted at 03:45 (U.T.) because of poor observing conditions.

In an evaluation of the observations, one should note two important points. The

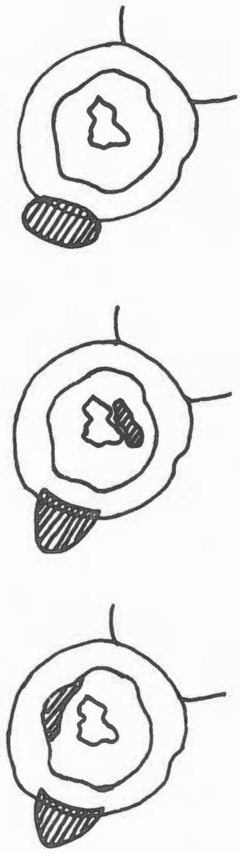


Figure 8. Three sketches of Theophilus by Eugene W. Cross, Jr. to show coloration phenomena recorded on January 28, 1966 with the Whittier College Observatory 19-inch, f/7 Newtonian reflector. See also text of accompanying article by Mr. Cross. The heavily shaded areas are red areas. The three sketches are qualitative only and do not show regions of greater and lesser intensity within each red area nor their ill-defined boundaries. Top sketch: 1^h24^m, U.T., 155X, seeing 5-6 (scale of 0 to 10 with 10 best), transparency 4 (moderately clear). Middle sketch: 1^h50^m, U.T., 300X, seeing 4-5, transparency 4. Lower sketch: 3^h19^m, U.T., 300X, seeing 2-3, transparency 4. Colongitude = 346°.6 at 2^h0^m, U.T. Lunar south at top, lunar west (I.A.U. sense) at right.

****

first is that although no confirmatory observations were obtained, every precaution was taken to avoid an error in determining the true nature of the phenomenon. The second point of interest is that the colorations always appeared on an area of the crater where the sun was rising. Therefore, if the nature of the phenomenon was correctly determined - if it was lunar in origin - the phenomenon would somehow appear to be at least partially affected by a temperature (or energy) change on the lunar surface.

A.L.P.O. COMETS SECTION REPORT:

PERIODIC COMET TUTTLE 1967a

By: Dennis Milon, A.L.P.O. Comets Recorder

On its last visit to our part of the Solar System 13 years ago, periodic Comet Tuttle was not seen. However, it was recovered in 1967 at the Tokyo Astronomical Observatory by K. Tomita on January 3rd. It was then in the evening sky, in Lacerta, at magnitude 15 photographic. As Tuttle approached the sun, heading for perihelion on March 31st, the first A.L.P.O. observation was made by Leo Boethin in the Philippines. He saw it on February 9th in his 8-inch reflector. Tuttle was described as a faint and very diffuse comet. Magnitude estimates were difficult; however, Karl Simmons at Jacksonville, Florida, used AAVSO charts for most of his estimates with an 8-inch reflector. Simmons' observations generally confirm predictions by Brian Marsden on IAU Circulars 1988 and 2006, where the magnitude is equal to $9.0 + 5 \log \Delta + 15 \log r$. For instance, Simmons' February 11th and April 24th observed magnitudes are within a few tenths of the predicted magnitudes. In between these dates the comet was sometimes seen unusually faint.

Monitoring the brightness of periodic comets like Tuttle is valuable. A determination of absolute magnitude from visual estimates figures prominently in theories on the disintegration of periodic comets. Besides, comets are indicators of solar-caused activity by means of their abnormal brightenings.

The observers of this comet were:

Leo Boethin, Abra, Philippines.

Michael McCants, Austin, Texas.

Tom Middlebrook, Nacogogdoches, Texas.

Karl Simmons, Jacksonville, Florida.

Don Wells, Austin, Texas.

A.L.P.O. Observations

1967 UT				Magnitude	Description
Feb. 9.50	Boethin	8" reflector		11.5	2', with central cond.
11.02	Simmons	8"	"	11.0	3'-5'
13.51	Boethin	8"	"		2'
15.01	Simmons	8"	"	12.8	less than ½'
16.04	Simmons	8"	"	12.5	nucleus seen
18.06	Simmons	8"	"	11.8	no nucleus
26.07	Simmons	8"	"	12.5 (full moon)	
March 1.08	Middlebrook	8" reflector		10.3	2'
2.04	Simmons	8"	"	12.0	less than ½'
2.08	Middlebrook	8"	"	10.3	3'
3.08	Middlebrook	8"	"	10.5	2'
7.08	Middlebrook	8"	"	10	3'-4'
11.02	Simmons	8"	"	10.7	1', no central cond.
11.12	McCants, Wells	10"	"	10.0	2'-3'
12.07	Simmons	8"	"	$\leq$13	less than 1'
April 24.07	Simmons	8"	"	9.9	2'
30.50	Boethin	8"	"		3½'

A.L.P.O. COMETS SECTION REPORT: COMET IKEYA-EVERHART 1966d

By: Dennis Milon, A.L.P.O. Comets Recorder

Kaoru Ikeya of Japan discovered his fourth comet on September 8th, 1966, U.T., low in the evening sky in Coma Berenices. It was independently found on September 12th by Dr. Edgar Everhart of Mansfield Center, Connecticut, who was searching for comets with an 11¼-inch Wright-type reflector. As it moved southeast, Everhart followed the comet for one month (September 12th to October 13th); but he could not find it on October 17th. It was a difficult object low on the horizon, and a nearly full moon at the end of September made the sky bright.

The following A.L.P.O. observers reported on this comet:

Leo Boethin, Abra, Philippines.
John Bortle, Mt. Vernon, New York.
Thomas Cragg, Mt. Wilson, California.
Edgar Everhart, Mansfield Center, Connecticut.
Walter Scott Houston, Haddam, Connecticut.
Michael McCants, Houston, Texas.
Dennis Milon, Tucson, Arizona.

The orbital elements for Comet Ikeya-Everhart show that perihelion occurred on August 5th (before it was first seen) at a distance of 0.8794 Astronomical Units. In September the comet was on the opposite side of the Sun at about 2 AU's from Earth, travelling away from both Earth and Sun.

A.L.P.O. Observations

1966 UT				Magnitude	Description
Sept. 12.02	Everhart	11¼" reflector		9	4' diameter
13.07	McCants	8 "	"	8½	
15.13	Cragg	6 " refractor		8	
16.06	Houston	4 "	"	9.6	
17.10	Houston	4 "	"	9.6	
17.02	Bortle	6 " reflector		8.4	3½' diameter
17.02	Everhart	11¼"	"	9	
17.14	Milon	6 " refractor		9.5	
Oct. 3.00	Everhart	11¼" reflector		11	
3.06	McCants	8 "	"	10½	3'-4'
4.00	Everhart	11¼"	"	11	
4.46	Boethin	8 "	"	11.5	3'-4'
10.00	Everhart	11¼"	"	about 12	
13.00	Everhart	11¼"	"	about 12	
16.08	Milon	61 "	"		No nucleus seen.

Notes on magnitude estimates: Houston used AAVSO charts; Bortle obtained magnitudes from the Smithsonian Astrophysical Observatory Star Catalog; Milon used the Bonner Durchmusterung catalog; McCants compared the comet to the Ring Nebula on October 3rd.

A.L.P.O. magnitude estimates agree fairly well (considering the difficulties of observation and difference in methods) with magnitudes predicted by Marsden and Aksnes on IAU Circular 1974. They assumed an absolute magnitude of 8.0 in the formula:

$$\text{mag.} = 8.0 + 5 \log \Delta + 10 \log r.$$

Absolute magnitude is a convenient measure of a comet's intrinsic brightness, which is information of high value to astronomers theorizing about comets.

Visual positions were measured by Edgar Everhart on 14 days by plotting on Vehrenberg's photographic star atlas. His technique was to determine a correction factor in right ascension and declination for the coördinate mark on a particular photograph. He did so by referring to catalogue positions of stars on the same chart. Dr. Everhart writes that reduction of one position takes about an hour. Although this method is a factor of 10 less accurate than are modern photographic measures, it can still be of value when accurate positions are not available. Such was the case with Ikeya-Everhart and more recently with Comet Mitchell-Jones-Gerber 1967f, when more than a month passed after discovery before precise positions were announced.

Comet Ikeya-Everhart was generally described as diffuse and as about 3'-4' in diameter. No central condensation was reported. If we use a diameter of 4' for the comet, it was about 150,000 miles across. An easy way to calculate comet sizes without trigonometry is to remember the figure 8".8. This number is the solar parallax or the radius of the earth as seen from the Sun's distance (one astronomical unit). Thus, to find a comet diameter at 1 A.U.:

$$\frac{\text{Earth radius (3900 miles)}}{\text{solar parallax (8''.8)}} = \frac{\text{diameter of comet in miles}}{\text{observed angular comet diameter (240'')}}$$

The diameter is 106,000 miles for 1 A.U. Ikeya-Everhart was 4' in early October when its distance from Earth was 1.4 A.U.; hence, 1.4 X 106,000 equals about 150,000 miles.

On October 18th Everhart wrote: "This comet has always been a difficult one to observe, particularly in October when it was not only low in the sky, but fading rapidly. It is now about 2 AU's away from Earth and almost too close to the Sun to see. When I last saw it on October 13th UT it was so difficult that I suspected this was the last time I would ever see it."

PLANETOLOGICAL FRAGMENTS - 7

Water Vapor on Venus

Until very recently, the only gas identified with certainty in the atmosphere of Venus was carbon dioxide, discovered by Dunham many years ago. In the past three years, reports of spectroscopic evidence for hydrochloric acid, hydrofluoric acid, carbon monoxide, oxygen, and water vapor have been forthcoming from American and European astronomers. Reports of water vapor have attracted the most attention because of its great importance in the "greenhouse effect" which tends to warm the lower atmosphere of a planet to temperatures greater than those normal solar radiation would produce. Water also appears to be an essential ingredient in the formation and development of life, and this entire subject of astrobiology has deeply interested scientists and laymen alike for years.

Astronomers usually search for gases in planetary atmospheres with high-dispersion spectrographs on the world's giant telescopes. When the relative motion of the planet (Venus in this case) and the earth are such that there is an apprciable radial component, the "Doppler Effect" serves to move spectral lines from their usual positions by small but measurable amounts. So, if spectral lines of water vapor occur in a planet's atmosphere, they will appear slightly shifted from the positions of the same lines formed by water vapor in the wet atmosphere of the earth. Astronomers M. Belton, D. Hunten, and H. Spinrad detected a spectral line in the position of the expected Doppler-shifted H_2O line in the Venus spectrum around 8200 Å. This result led them to compute the amount of water vapor on Venus based on the intensity of this shifted line. If the water vapor that they found were precipitated into liquid all over the planet, it would form a layer only about 0.2 mms. (about 0.008 inches) thick. This seems like a trivial amount, but it is quite a lot when we

Figure 9. Dr. Edgar Everhart, Mansfield Center, Connecticut, who discovered Comet Ikeya-Everhart 1966d in September, 1966, with this f/5 $11\frac{1}{4}$-inch Wright reflector. A Wright design uses a correcting plate and is coma-free. Dr. Everhart searches at 44X with a $1\frac{1}{4}$° field. In sweeping with the altazimuth mounted telescope, he believes that all objects of 11th magnitude or brighter are found, half of those at magnitude 11.5, and a few at 12. He notes that proper clothing and electrically heated telescope parts make sweeping possible at temperatures as low as 10°F. in a fairly strong wind. Comet Ikeya-Everhart is discussed by Mr. Milon on pages 194 and 195.

****

consider its effect on the radiation budget of the planet and the effects on the stability of other minor gases in the atmosphere of Venus.

Some years before these spectroscopic tests from ground-based observations, John Strong's group observed Venus from the high altitude Stratoscope balloon-borne instrument. They interpreted their data as showing the presence of ice clouds around the planet; and this result appeared consistent with the observation of water vapor by Belton, Hunten, and Spinrad. Certain astronomers built detailed models of the atmosphere of Venus based on the apparent presence of liquid and solid water. The model builders are often those scientists who have greater familiarity with theoretical treatments than with the limitations of astronomical data.

Some of those astronomers who do understand the limitations of astronomical data, themselves observers, decided to repeat the experiments because of the extreme importance of the implication of the presence of water vapor on Venus. Using techniques of high-dispersion spectroscopy, T. C. Owen showed that the Doppler-shifted line assumed to be water vapor by ground-based observers is most probably a previously unseen solar Fraunhofer line. If it is truly a water vapor line on Venus, there should be other shifted lines in appropriate places near other terrestrial water vapor lines - these others are absent, at least at the limit of current spectroscopic techniques.

In a more ambitious and difficult experiment, G. P. Kuiper observed the spectrum of Venus from a four-engine jet aircraft flying at an altitude of 40,000 ft., well above the vast majority of the water vapor in the terrestrial atmosphere. From the ground, the problem is like searching for a needle in a haystack - the expected amount of water vapor on Venus is very much smaller than that in the earth's atmosphere. But from above most of the earth's water vapor, any such gas on Venus would stand out with much greater clarity on the spectral records and thus be better for the determination of the <u>exact</u> <u>amount</u> detected.

In complete discord with the observation of Belton, Hunten, and Spinrad from the ground, and of Strong from a balloon, Kuiper found no detectable water vapor in the Venus spectrum in a spectral region where the absorption bands of H_2O are very strong and provide a more sensitive test than those observed by Belton and the others. So, Kuiper's results agree with those of Owen that there is no detectable water on Venus, at least down to the level in the atmosphere penetrated by the light that comes back to our spectrographs on earth. This actual level is unknown, but certainly lies well above the solid surface of

Figure 10. Dr. Everhart's Wormwood Hill Observatory in Connecticut. The $11\frac{1}{4}$-inch reflector is mounted on a 30-foot tower to provide a good horizon above the trees. It stands on concrete piers. The telescope is covered by the round, corrugated metal piece on the right side of the platform; and there is also a lightning rod.

On the left and near the ground is a 12-inch f/10 reflector on a 3,000 pound astrographic mount.

****

the planet.

The only measurements from the surface of the planet itself are those made by the Soviet probe "Venus 4". In an article in the October 22, 1967 issue of Pravda, the results of the probe's data were discussed; and it was noted that water vapor and oxygen together comprise no more than about 1.6% of the atmosphere. In other words, the Soviets did not actually detect any water vapor but only set an upper limit to its abundance.

The controversy about water vapor in the atmosphere of Venus continues, but it appears fairly clear that the high-altitude data of Kuiper and the explanation by Owen of previous ground-based results will win out in the end and that there is no detectable water vapor in the upper parts of Venus' atmosphere.

DPC

THE ELLIPTICITY OF URANUS

By: Stanley M. Shartle

Abstract

The oblateness of Uranus' disk was determined to be 1/20 with the aid of a Zeiss bifilar position micrometer, but without consideration of the inequalities of satellite motions. Due to gradual changes in the planet's orientation, the micrometer will soon become virtually useless for such determinations until after the year 2000. The author's sharp-eyed 16-year-old son saw belts and zones on the planet and provided information for two drawings of Uranus.

The Measures and Their Reduction

The axis of rotation of Uranus is inclined at an angle of almost 98° from the perpendicular to its orbital plane. In other words, the planet "lies on its side" during its 84-year revolution about the Sun. In 1966 the earth passed through the equatorial plane of Uranus, at which time the planetocentric declination D_E of the earth was 0°; and the apparent shape of the bluish-green disk was elliptical because the limb at that time constituted a meridional section of the spheroidal surface. Such rare moments are ideal times at which to measure the disk's flattening because only then is the true side view available. The orientation of the body is now gradually changing from side view (oblate disk) to end view (nearly circular) at the solstice in 1985, when the ellipticity will be immeasurable with the filar micrometer. In that year earthbound observers will view the north polar region almost directly on, and the visible limb will nearly coincide with the planet's equator. Thence the orientation will continue its slow change, and late in the year 2007 the equatorial region will again appear full on. Therefore, only young astronomers dare postpone until the next Uranian equinox their micrometrical determinations of the oblateness of this distant planet.

For several reasons my measurements were delayed until June, 1967. At that time D_E was in the neighborhood of $6\frac{1}{2}°$. However, the correction for this value from the apparent flattening (0.0493 or 1/20) to the adopted value (0.0500 or 1/20) was insignificant. The correction will also be small through the apparitions of 1968 and 1969. Just when the correction will become important will depend upon the quality of the observations. The correction of the observed value of oblateness for the effect of D_E ought to be made unless this correction is small compared with the known or presumed observational errors made in measuring the flattening.

The work was accomplished with an excellent Zeiss bifilar position micrometer with dark-field illumination mounted on an equatorial Cassegrainian telescope of 12.5-inch aperture and f/19.4 effective focal length. A sister to this instrument is pictured in Amateur Telescope Making, I, p. 449. A magnification of 606X was found to be the best compromise between the high power required to enlarge the tiny disk and the lower powers best suited to the state of the atmosphere.

The following table summarizes the observations. Given are the U.T. date; the atmospheric conditions, seeing S (on a 1-to-10 scale with 10 perfect) and transparency T (on a 1-to-5 scale with 5 the best); the number of times n that each axis was double-measured (once on each side of the fixed web); the weight w assigned to the results of each night's observations, it being taken as the product of S and n; the observed ellipticity ϵ where

$$\epsilon = \frac{a - b}{a}$$

and a and b denote the semimajor and semiminor axis respectively; and the observed angular value of a corrected for D_E.

1967^t U.T.	S	T	n	w= Sn	ϵ	a	w x ϵ	w x t	w x a
$12^d.12$ June	4	3	3	12	0.0303 = 1/33	2".37	0.3636	145.44	28.44
16.12 June	4	4	6	24	0.0674 = 1/15	2.21	1.6176	386.88	53.04
25.09 June	5	4	10	50	0.0463 = 1/22	2.07	2.3150	1254.50	103.50
29.07 June	$2\frac{1}{2}$	2	4	10	0.0448 = 1/22	2.14	0.4480	290.70	21.40
1.08 July	3	$2\frac{1}{2}$	5	15	0.0534 = 1/19	1.98	0.8010	466.20	29.70
			28	111			5.5452	2543.72	236.08

Discussion of Results

The weighted mean of $\epsilon = \frac{5.5452}{111} = 0.0500 \pm 0.0037 = 1/(20 \pm 1.5)$.

The weighted mean epoch $= \frac{2543.72}{111} = 22^d.916$ June, 1967 U.T.

The weighted mean of a at the mean epoch $= \frac{236.08}{111} = 2''.12$, which is not corrected for irradiation. There probably is no precisely known irradiation constant for Uranus. Using T. J. J. See's 1901 value, however, which was 0".39, the observed quantity a (2".12) becomes 1".925. Remember that semiaxis measurements receive only one-half the irradiation constant correction. The A.E. value for the semidiameter at the mean epoch is 1".86. But in 1914 Lowell and Slipher used 0".1 and 0".12, respectively, for the irradiation constant of Uranus. Applying these, my value of a is corrected to 2".07 and 2".06, respectively. Irradiation tends to enlarge a and b equally, and this fact causes the ellipticity to seem smaller than it really is. For example, employing See's irradiation constant, my semiaxial measurements at the mean epoch become 1".925 and 1".819; therefore, $\epsilon = 1/18$. The influence of the Lowell and Slipher constants would not be so pronounced. But since the actual amount of irradiation present in my observations is unknown and cannot be estimated to my satisfaction, I prefer to adhere to 1/20 as the best determination of the planet's oblateness obtainable from my observations.

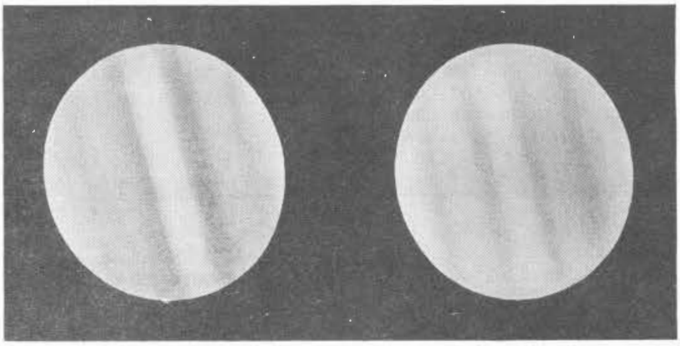


Figure 11. Drawings of Uranus by Randy Shartle with Mr. Stanley Shartle's 12.5-inch Cassegrain. See also text on pgs. 199 and 200. The bright Equatorial Zone was the most conspicuous feature, and the limb is shown too sharply defined. Left drawing: 6/6/67, 596X, 2^h30^m, U.T., seeing 6, transparency 5. Right drawing: 6/25/67, 606X, 2^h0^m, U.T., seeing 5, transparency 4.

The flattening may also be expressed in terms of the eccentricity e of the ellipse formed by the meridional section. The eccentricity equals the ratio of the distance between the planet's center and either focus to the semimajor axis, and is computed from:

$$e = \sqrt{2\epsilon - \epsilon^2} = 0.312 \text{ for my value of } \epsilon .$$

The following are some of the oblateness determinations made by others, visually and otherwise, over the last 125 years (the dates given refer either to the year of observation or of publication of results): Mädler (1842) 1/(10.85 ± 0.9), (1843) 1/9.92, (1845) 1/9.45; Meyer (1881) no flattening; Schiaparelli (1883) 1/(10.94 ± 0.67), (1884) 1/(13.04 ± 1.01); Young (1883) 1/13.99; Seeliger (1884) spherical; Barnard (1894) 1/14.32 and 1/20*; See (1900) 1/83 if real, (1901) 1/56.8 if real; Wirtz (1905) flattening not proved, (1926) 1/10; Bergstrand (1909) 1/46 as a lower limit; Lowell (1914) 1/22 or 1/27; Lowell and Slipher (1914) 1/11.55; Lvoff (1932) 1/(18 ± 0.05); Becker (1933) 1/11 to 1/13; Parenago (year unknown) 1/18; and Mourão (1959) 1/17. In his The Nature of the Planets, Sharonov quotes references as generally citing an average value of 1/15 or 1/14. The Royal Astronomical Society of Canada's The Observer's Handbook 1967 gives 1/16, which agrees with the Explanatory Supplement of the A.E. Norton's Star Atlas gives 1/14. The modern value, according to The Planet Uranus, is 1/17.

One should not prematurely conclude that these discordant results disparage planetary astronomy as an exact science, or that the professionals are less competent than had been supposed. Notice that few of the dates coincide with the times when Uranus was ideally oriented for visual measurements of her ellipticity. Also, consider the extreme difficulties of such undertakings even during the most favorable apparitions, notwithstanding the high quality and large size of the instruments used. One might understand the problem more thoroughly if he were to simulate the measurement of ϵ terrestrially. At night view a green apple measuring 2 3/8 inches by $2\frac{1}{2}$ inches from a distance of about 2.1 miles. Dimly illuminate the apple with a light placed behind the telescope. While observing the telescopic image of the apple, precisely measure its 1/8-inch difference in dimensions. Such an experiment would be impractical, of course, but it would demonstrate the scale involved and would help explain why the visual measurement of Uranus' ellipticity has always been considered a very difficult undertaking at even the largest observatories.

Satellites and Surface Markings

In the apparition of 1967 the Uranian satellites were not seen in my telescope. This failure is understandable since at that time a very tarnished silvered star diagonal was in use and lowered the limiting magnitude of the instrument. The diagonal probably had not been recoated since leaving the hands of its maker, the late Harold A. Lower, decades ago.

Being unable to see markings on the planet with any certainty, I called my 16-year-old son Randy to the observatory for a look. He had never seen Uranus before and had no previous knowledge of its appearance. Without telling him what the object was, I asked for a description. After 4 or 5 seconds he said, "I can see the belts; they are running this way" (motioning). He set the fixed thread of the filar position micrometer parallel with the band structure (which the A.E. later proved to be nearly at the position angle of the satellite orbits). Being quite unimpressed with it all, he asked to rejoin friends play-

*Both values are given in Alexander's The Planet Uranus. I have not seen the original sources.

ing nearby. After making a rough drawing and answering a few questions, he left me amazed and futilely straining at the eyepiece. It was not until June 25 when much the same thing occurred that I told him that the object was Uranus. The accompanying drawings (Figure 11) were transcopied from his originals and were improved from his verbal descriptions. He edited repeatedly before approving them; and, though they are rather dissimilar, he asserts emphatically that they correctly represent what he saw.

MERCURY DURING THE TOTAL SOLAR ECLIPSE OF 1970 MARCH 7

By: Richard G. Hodgson, A.L.P.O. Mercury Recorder

One of the objectives of the A.L.P.O. Mercury Section is to secure drawings and photographs of Mercury when it is well placed during total solar eclipses. A second eclipse project of the section is photographing the vicinity of the planet in search of any faint satellites; a third project is conducting a similar photographic search for any Intramercurial minor planets.[1] Out knowledge that Mercury has no satellite is based on observations which extend only down to the ninth magnitude; the same limit exists with regard to any possible Intramercurial minor planets.[2]

In the light of these observing projects the total solar eclipse of 1970 March 7 has occasioned interest. This eclipse will be visible as total in parts of Mexico, Florida, many of the states along the Atlantic coast, Nova Scotia, and Newfoundland. In many areas totality will last three full minutes, a duration better than average.

After consultation with the Naval Observatory in Washington, D.C., and the yet unpublished American Ephemeris and Nautical Almanac for 1970, I must report that Mercury will not be well placed for observation on the day of the eclipse. The planet will be approaching superior conjunction, which it will reach on March 23. At the time of the eclipse Mercury will be 1.33 Astronomical Units distant from the Earth; and its disc will be a mere 5 seconds of arc in diameter, too small to show much detail except in very large telescopes. One must await a more favorable eclipse to observe Mercury or to conduct a photographic search for possible satellites.

The photographic search for Intramercurial minor planets, of course, is a worthwhile undertaking during any solar eclipse with totality of moderate duration. This will be true of the 1970 eclipse.

It is not too early to plan observing expeditions for the eclipse. Consideration should also now be given to the equipment necessary for the task. Persons intending to undertake an Intramercurial planet search during the 1970 eclipse should contact the Mercury Recorder.

References

1. Cf. "Mercury: Research Projects for the Small Observatory" in The Strolling Astronomer, Vol. 20, Nos. 1-2 (published January, 1967), pp. 7-8.

2. Cf. Gerhard Kuiper and Barbara Middlehurst, The Solar System III: Planets and Satellites, pp. 575ff.

COMET OBSERVING

By: Dennis Milon, A.L.P.O. Comets Recorder

The purposes of the A.L.P.O. Comets Section are threefold: 1. To inform observers of new comet discoveries, 2. To stimulate amateur observations, 3. To publish comet observations in The Strolling Astronomer. Our Comets Section was organized ten years ago by David Meisel. It began shortly after the two spectacular comets of 1957 -- Arend-Roland and Mrkos. Due to increased school work, Mr. Meisel eventually relinquished the post, and in 1964 the present Recorder was appointed.

Obtaining Comet Information

IAU Announcement Service. Speed is a necessity if an observer is to see a new comet. Many comets are discovered close to the sun, and may move rapidly to sky locations where they cannot be seen. The clearinghouse for discoveries is the International Astronomical Union Central Bureau for Astronomical Telegrams. Anyone may subscribe to the IAU telegrams for new discoveries and ephemerides. These are sent collect and in a code to reduce the expense.

The IAU publishes announcement cards which can be subscribed to at the following rates: air mail in North America: 50 consecutive cards, $8.00, 100 cards, $14.50; to the rest of the world, air mail: 50 cards, $12.50, 100 cards, $23.50. Order from IAU Central Bureau for Astronomical Telegrams, Smithsonian Astrophysical Observatory, Cambridge, Massachusetts 02138.

A.L.P.O. Announcement Service. Information received from the IAU is forwarded by the Comets Section to interested observers. Also included are the latest A.L.P.O. observations of a comet. The Recorder will call or telegraph collect any A.L.P.O. member who wants this service. The observer should specify a magnitude limit so that he will not have the expense of faint comet discoveries beyond the reach of his telescope. An air mail service for comet news is also in operation. To receive these notices, send the Recorder a supply of self-addressed air mail cards and some addressed, stamped long envelopes. Occasionally A.L.P.O. cards reach an observer before the IAU card announcing a discovery.

Within a week after a discovery card we send an ephemeris. In the past many orbits have been computed for the A.L.P.O. by Michael McCants, who is now a graduate student at the University of Texas (address: 5481 Cedar Creek, Houston, Texas). These ephemerides often contain information not available on IAU cards. Included are the following: orbital elements, predicted right ascension and declination, distance from earth and sun in astronomical units, angular distance from the sun, predicted magnitude for a given aperture, and a value in miles for a degree of arc at the comet's distance.

Use of an ephemeris. After an orbit is received, an observer knows whether a comet will brighten or fade, in other words, whether it will be an exciting object. Also, the comet orbit can be visualized in space. An orbit model can be constructed to further this visualization (instructions are given by Steve Larson in *The Strolling Astronomer*, March-April, 1965, pages 47-49).

How To Make Comet Observations

The A.L.P.O. Comets Section report forms outline what should be included in an informative observation. These are available from the Recorder for 25 cents in stamps.

The prospective comet observer has a varied choice of instruments and star charts. Certain types of binoculars and telescopes are more suitable for comet observations; in general, wide-field instruments are desired.

Binoculars. Wide field binoculars (12° or 578 feet at 1000 yards) are the best, for they allow many comets to be viewed in their entirety. Also, comparison stars for estimating a comet's magnitude are more easily found. Quite suitable 7 X 35 and 7 X 50 binoculars for comets can be purchased for less than $50. It is desirable to mount binoculars firmly, and a camera tripod used with a binocular attachment is excellent.

Telescopes. Either a refractor or a reflector is good; and the bigger the aperture, the better. Wide field eyepieces, such as Erfles and orthoscopics, are best. A clock drive is not essential, except for high power inspection.

Richest Field Telescopes. A 6-inch RFT will give a field of view of about 3° and will provide beautiful views of comets. RFT's can be cradled in your arms for casual observing or mounted for serious work. A 6-inch RFT costs about $125, but many amateurs make their own. For a discussion of the RFT see *Amateur Telescope Making Book Two*.

Star Charts. The following are recommended for comet observations: *Norton's Star Atlas*, Skalnate Pleso *Atlas of the Heavens*, *Atlas Eclipticalis*, *Atlas Borealis*, and *Atlas Australis*. All of these are for the epoch 1950, allowing positions from an ephemeris to be plotted directly. Comet observers should note several useful features about these charts. *Norton's* and the Skalnate Pleso plot galaxies and nebulae, useful in avoiding confusion with a comet. All the atlases indicate variable stars. This is valuable for magnitude estimates; for if a faint comet (below magnitude 8) passes near an AAVSO chart field, its brightness can be estimated, which could not otherwise be done. The procedure is first to plot the path, then check the AAVSO catalogue to see whether there is a suitable chart of the area. This list is available for 25 cents plus postage from AAVSO, 187 Concord Avenue, Cambridge, Massachusetts 02138.

A comet's motion can be detected by plotting on the large scale Becvar atlases (Eclipticalis, etc.). Also, quite accurate positions can be found. Star colors are shown; and this is a handy feature for comet enthusiasts, who should avoid red stars in comparing a comet's brightness. (Red stars seem to grow brighter the longer they are stared at.)

Many amateurs use all the atlases in conjunction because it is convenient to proceed from a small scale (Norton's) to a medium (Skalnate Pleso) and even to a large scale (Eclipticalis).

Recommended Star Charts

	Scale	Limiting Magnitude
Norton's	7.9 degrees per inch.	6 1/3
Skalnate Pleso	3.3 degrees per inch.	7.75 visual
Atlas Eclipticalis	1.25 degrees per inch.	complete to about 9.0
" Borealis	same	photographic, but goes to
" Australis	same	12.75 in places.

Will a Comet be Above Your Horizon? The Phillips' Planisphere (order from Sky Publishing Corp., $3.50) is very handy for showing the stars above your horizon at any given hour. Another idea is to draw a horizon on Norton's by these steps:

1. Plot the sun on the ecliptic for 0^hUT from the ephemeris for the date following the local time evening date on which you want to observe.

2. Draw a line representing your horizon at sunset. First, lay a protractor on a parallel of declination, and center the protractor on the sun. The horizon line is defined by the sun and another point determined from your latitude as follows. An angle is measured east (90°) from north (0°), and is the complement of your latitude (subtract latitude from 90°). For 30° latitude the angle is 60°; for 40°, it is 50°.

3. For the horizon one hour after sunset, measure one hour of right ascension at the equator on Norton's. Then move your sunset line up by this amount.

Comet Positions. During the first few days after a comet discovery, amateur positional measurements are of value, particularly for a twilight object. However, professional positions with large scale photographs are superior. Therefore, usually the amateur should not try to make extremely accurate positional plots; for they will not be used in computing an orbit if photographic positions are available.

Shortly after a new discovery, it is interesting to compare predicted positions with observed ones. The latter will frequently be different if the orbit was preliminary. An accurate comet ephemeris requires an orbit calculated from at least three precise positions, suitably spaced. The right time interval varies with each comet. A "precise" position means one reported to one-hundredth of a second of right ascension and one-tenth of a second of declination, with the time of exposure known to the nearest second.

Comet Magnitudes. One of the most valuable amateur projects is estimating comet magnitudes. A comet's brightness may change unpredictably from day to day or even in hours, so that a patrol program is worthwhile. It is interesting to correlate brightness changes in comets with solar-caused events. One way of comparing different comets is by calculating their absolute magnitude, as astronomers do for stars. A comet's absolute magnitude is defined as its magnitude at one astronomical unit from the sun and also at an A.U. from the earth. It may be determined by using our visual magnitude estimates (even if the comet never occupied that particular place in space).

We must have something to compare a comet's brightness to, and galaxies and nebulae appear to be a logical choice. However, their magnitudes are not so precisely known as are stellar magnitudes, which also give us a wider range in brightness. Thus, our technique should be to compare comets with stars. The two objects are comparable if the stars are placed out of focus.

The smallest optical aid needed conveniently to show a comet should be used, starting, of course, with the unaided eye. What we want to define is the total magnitude of a comet, and so the idea is to use an instrument which places all the light in a small angular area. In actual practice we estimate the brightness of the coma or head, since there is no feasible way to integrate all the light from a long tail. Coincidentally, the major brightness changes occur in the coma.

A.L.P.O. COMETS SECTION — COMET IKEYA - SEKI 1965 f

Observer: Mr. John E. Bortle — Date (UT): 1/2 October 1965

Address: 29 East Fourth St.(P.O.Box 241) Mount Vernon, N.Y. — Time (UT): 09:25 - 09:45

Dist. from horizon: ~8°

Place of Observation: Dorset Road, Scarsdale, N.Y.

Approximate R.A.: 09h 51.9m — Approx. declination: -12° 12'

Sky conditions (transparency, haze, moonlight, twilight, city lights, etc.):

Seeing 5 Sky 6.4 some city lights

MAGNITUDE ESTIMATES (state methods and telescopes used): Inst. 10x50 bin. Met. extra-focal star images(nuc. 5"refr)

Total magnitude: 5.5 — Magnitude of nucleus: 9.1

Nucleus was stellar in all but the highest powers, which showed it as a small disk about 6" in diameter.

Comparison stars, magnitudes, and catalog used: (total) CBS Yale U. (nuc) H. Draper Cat.

3846 37 Hya 6.19 — BD -11° 2756 9.5
3848 Hya 6.19 — BD -12° 2758 7.7
3909 γ Sex 5.16

DESCRIPTION (state methods and instruments used--i.e., photo, visual, micrometer, etc.): Inst. 5" f/5 refr. Met. visual

Tail length: 6'-7' — Pos. angle of tail (plot on an atlas and measure): 261°±2°

Remarks on tail (detail, color, shape, etc.): Tail faint and colorless, dia. at junction with coma 1.5', becoming slightly wider along its extent. best seen at 52x.

Coma description (diameter, shape, jets with P.A., etc.): Coma seems somewhat smaller and not so condensed, with star-like nucleus(?). Its dia. ~2.5'.

Degree of condensation of coma. Scale: 0=diffuse, 9=stellar. (A sketch will be of value): 6

FIELD SKETCH: (Draw on an atlas if possible and recopy.)

see attached drawing

Power: 18x

Diameter of field: 4°

Note: Drawing paper may be used instead. If the sketch is intended for publication it should not be folded.

Figure 12. Sample A.L.P.O. Comets Section Report Form with an example of a comet observation recorded by Mr. John Bortle. These report forms are available from Mr. Dennis Milon, 378 Broadway, Cambridge, Massachusetts 02139. These forms will allow more complete and more accurate recording of needed kinds of comet observations and will greatly assist the A.L.P.O. Comets Recorder in his analysis of the work of the Section.

Binoculars are a good choice to follow a comet's brightness for several months. They have a wide magnitude range and a large field of view to locate comparison stars. Mounted finder telescopes are also good. Estimates are considerably more accurate when the comparison stars are in the same field of view as the comet. Also, there is then less problem from differential atmospheric extinction at different altitudes.

Technique of estimating magnitudes. Once the comet and nearby stars have been located on a chart, move the eyepiece out of focus until the stars and the comet have about equal disks. Then find a star slightly brighter and one slightly fainter than the comet, trying to avoid red stars. The comet is simply placed between the two stars in brightness. The magnitudes of the stars do not have to be known at this time; just identify them on your map. An example would be:

Comet Everhart is brighter than star A and fainter than star B. More exactly, Everhart is judged to be closer to star A in magnitude; and we make it over ½ the way in brightness from star B to star A. Therefore, our estimate could be: the comet is 7/10 of the way from star B to star A. A notation that may be used when a number of estimates are made would be in the form: A 3 C 7 B, meaning that the comet is 3/10ths of the way from star A to star B; also it is 7/10ths of the way from B to A.

Greater accuracy is obtained by making several estimates using different stars. It is truly surprising how small a magnitude difference the eye can detect. This method has been shown to be quite accurate by simultaneous A.L.P.O. observations at different locations. Observers using similar telescopes and the same star catalogues often agree exactly, or vary by not more than a few tenths of a magnitude. It has been noted from experience that for the highest accuracy, the two comparison stars should not be more than a magnitude apart, and preferably less.

Star Catalogues. It is most important that all observers use the same catalogue magnitudes for their comparison stars. For stars 5th magnitude and brighter we should use the Arizona-Tonantzintla Catalogue. It is based exclusively on photoelectric measurements and supersedes all previous compilations. It was published in the July, 1965, Sky and Telescope, and reprints are 50 cents from Sky Publishing Corporation, 49 Bay State Road, Cambridge, Mass., 02138. Stars not in the Arizona-Tonantzintla Catalogue should next be looked for in the Catalogue of Bright Stars, 3rd revised edition, 1964. Order for $15.00 from Yale University Observatory, Box 2023, Yale Station, New Haven, Conn., 06520. Not all these magnitudes are photoelectric; therefore, avoid red stars because of systematic errors in the Harvard photometry for red stars. Earlier editions use only Harvard visual magnitudes.

Nearly as good as the Yale catalogue is the Skalnate Pleso Catalogue, but it does not contain certain revisions nor go as faint as the Yale. Order from Sky Publishing Corp., $9.50. For still fainter stars use the Smithsonian Astrophysical Observatory Star Catalog (four volumes, $20), available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Because uncertainties of several tenths of a magnitude occur in this catalogue, several comparison stars should be used. Comets of the 10th magnitude and dimmer will require variable star charts from the AAVSO, whose chart catalogue is 40 cents including postage, from AAVSO, 187 Concord Ave., Cambridge, Mass. 02138. If a comet passes through a chart field and stars from the Arizona-Tonantzintla or the Catalogue of Bright Stars are not of suitable magnitude, the AAVSO magnitudes should be used.

Magnitudes obtained from the size of stellar disks in an atlas are not accurate enough for comet magnitudes.

After the magnitudes of your comparison stars have been found, it is a simple matter to interpolate for the comet magnitude. Estimates should be reported to the nearest tenth of a magnitude. Always list your comparison stars and the source catalogue.

I should point out that very interesting observations were made by A.L.P.O. Comets Section observers using AAVSO charts for Comet Kilston. Short period brightness changes were confirmed by widely separated observers.

Charts for southern variables are available from the Variable Star Section of the Royal Astronomical Society of New Zealand. Series 3 contains 58 charts, and is $8.50. Order from Frank M. Bateson, P.O. Box 33, Lake Tekapo, New Zealand.

The most reliable magnitude estimates, with regard to changes of comet brightness, will be in the naked eye magnitude range because fainter stars are not known to uniform accuracy.

Correction for Aperture. N. T. Bobrovnikoff found that, on the average, a comet ap-

Figure 13. Gordon Solberg, New Mexico State University Observatory, Las Cruces, using a Mann machine to measure position angles on photographs of Comet Ikeya-Seki 1965f. Mr. Solberg is also active in analyzing A.L.P.O. Comets Section observations with the aid of a computer.

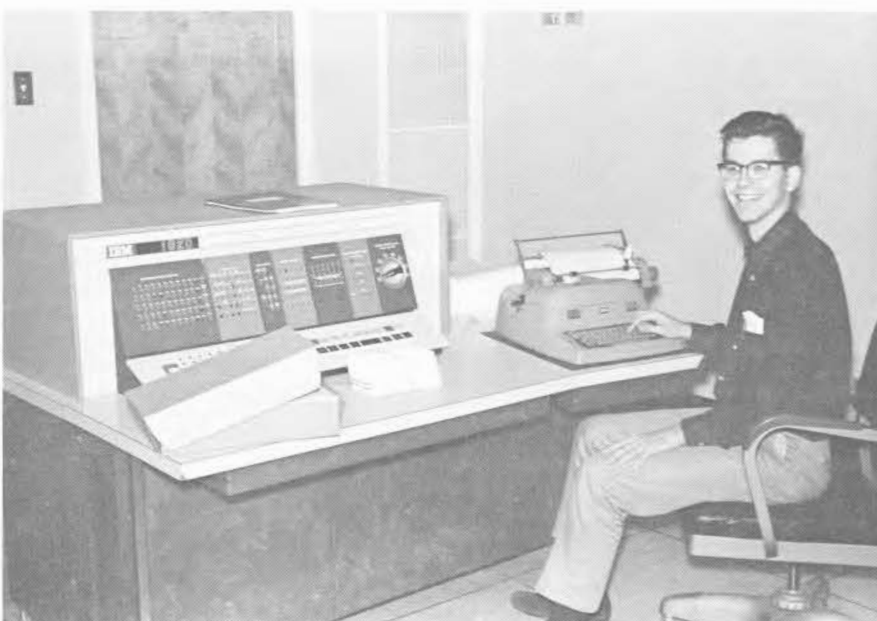


Figure 14. Michael McCants, Houston, Texas, who has computed comet ephemerides for several years for distribution by the A.L.P.O. Comets Section. Mr. McCants is here shown with an IBM 1620 computer at Rice University.

pears fainter by 0.17 magnitudes per inch of increasing aperture. This effect occurs when nebulous comets are compared to stars. A correction is probably not needed if most of a comet's light is in a stellar nucleus, such as Comet Kilston had. Bobrovnikoff's papers are in Popular Astronomy, Vol. 49, No. 467, 1941 and Vol. 50, No. 473, 1942. See also Perkins Observatory Contributions No. 15, 1941; No. 16, 1942; and No. 19, 1943. Observers should always send in the uncorrected observations so that no confusion will arise.

Describing a Comet's Size. A record of a comet's changing size, together with its orbital distance data, allows a calculation of real dimensions, thus permitting comparison of various comets. The nomenclature of the parts of a comet should be clearly understood. The coma is the overall nebulosity of the head. Head and coma are used interchangeably. There may be a central condensation inside the coma. Sometimes the coma gradually brightens toward the center, and its appearance is difficult to describe. In large telescopes a starlike nucleus may be seen. What has generally been referred to as a nucleus in small telescopes should now be termed the central condensation in order to differentiate between observations made with large and small telescopes. A drawing is helpful for interpretation when submitting diameter measures.

Eyepiece Estimates. One of the simplest methods of estimating size is in terms of a fraction of the eyepiece field. The best way of finding your eyepiece field diameter is to time the passage of a star across the eyepiece. For simplicity, use a star close to the celestial equator. Then the field diameter in minutes of arc will be $\frac{1}{4}$ of the passage time in seconds. At some distance from the equator, multiply the result by the cosine of the declination. More exact diameters can be obtained by allowing a comet to drift across the field. Two timings are made: first, time (to the second) when the comet touches the eyepiece edge; second, time when it wholly exits the field. The interval in seconds between the two contacts is multiplied by a factor varying with the declination, and the answer is in minutes of arc. This drift-contact technique works very well for diameters of diffuse comas. The following table is from Sky and Telescope, Sept., 1963, pg. 157.

Dec.	Factor	Dec.	Factor
0°		45°.7	
	0.25		0.17
12°.2		48°.8	
	0.24		0.16
20°.4		51°.8	
	0.23		0.15
26°.2		54°.7	
	0.22		0.14
30°.9		57°.4	
	0.21		0.13
35°.1		60°.1	
	0.20		0.12
38°.9		62°.7	
	0.19		0.11
42°.4		65°.2	
	0.18		0.10
45°.7		67°.7	

Comet Size from a Star Chart. An easy way to get comet dimensions is by measuring a drawing on a star atlas. Some precautions are necessary because of distortions in the non-equatorial zones. You can measure directly on charts with parallel lines of right ascension. Just get a scale from the declination marks (one degree of declination equals one degree of arc). The declination scale will work over short distances on charts close to the pole. For tails on the order of tens of degrees, chart distortions impair accuracy. Then a mathematical treatment is sometimes useful. However, usually a tail has no definite end but fades out so gradually that the uncertainty from this cause is much more important than the uncertainty from chart distortion. If a tail is so long that it runs off your chart, use the formula below, or measure a celestial globe. We can plot the locations of the beginning and end of a tail and then apply the formula below to get the angular distance in degrees. The beginning of the tail is at right ascension A and declination D; the end, at α and δ, respectively. Then:

$$\cos d = \sin \delta \sin D + \cos \delta \cos D \cos (A-\alpha),$$

where d equals the length of the tail. The difference in the two RA's must be converted to degrees by taking one hour of right ascension to equal 15 degrees.

Figure 15. John Bortle, Mount Vernon, New York, who is one of the Comets Section's most active observers. He is shown with his comet observing equipment: 10X50 binoculars and 5-inch f/5 refractor with an Aero Ektar lens on the tube. Mr. Bortle also uses a 6-inch Richest Field Telescope. He writes comets reports for The Eyepiece of the Observing Group of the Amateur Astronomers Association, New York City.

Figure 16. Chick Capen and Jim Young, J. P. L. Table Mountain Observatory, Wrightwood, Calif., doing comet guiding at the 16-inch Cassegrain. Messrs. Capen and Young photographed Comet Ikeya-Seki 1965f through a 6-inch refractor and used a wide angle or telephoto 35-mm. camera attached to the tube of the 16-inch reflector.

Photographic Measures. The scale of a photograph in inches per degree can be found by dividing the focal length by 57.3. Measure the negative with a ruler.

Position Angle. This quantity is used to describe the axis of the tail and other details in the tail and coma. P.A. is measured east (90°) from north (0°) by laying a protractor on a star atlas sketch and reading the angle from north. Sometimes a tail will wag unpredictably so that a visual P.A. estimate is of value. Visual estimates will be superseded when a photographic P.A. for the same time is available, but you never know whether a photo will be taken. The position angle of a tail can be compared to the radius vector (a projection of a line from the sun) to check the behavior of the comet.

Periodic Comets. These are generally faint, but offer interest for monitoring their brightness. Ephemerides on periodic comets coming to perihelion during the year are given in the British Astronomical Association Handbook ($1.50 from BAA, 303 Bath Road, Hounslow West, Middlesex, England).

Hunting for New Comets. Only a few astronomers in the world regularly search for comets. Bright ones with long tails will sometimes appear out of the sun's glare. Thus, twilight is the best place for the occasional comet seeker. Whenever you are in an especially favorable location with a transparent sky, sweep the horizon after sunset or before dawn.

If you discover a comet, do not fail to notify the IAU Central Bureau so that you will get credit and possibly have your name attached to the comet, if no one else has seen it before you. Novice observers must exercise caution in announcing new comets -- if possible, have an astronomer verify it. The A.L.P.O. Comets Section will, of course, be interested in spreading the news.

Wide Field Comet Photography. Ordinary hand cameras with fast lenses (f/4.5 or less) are good for overall views, especially when there is a long tail. With a fast lens and short focal length, a clock drive may not be needed. For example, a 20 second exposure with a 50-mm. focal length lens will not produce star trails. Tracking a comet's motion relative to the stars is usually not necessary on short exposures, and a sidereal drive rate will suffice. For long exposures mount a guide telescope next to the camera. R. B. Minton used this method in obtaining the superb hand-guided photos of Comet Ikeya-Seki 1965f published in The Strolling Astronomer, March-April, 1965, page 67. Another idea is to attach a small camera to the telescope tube and then, with high power, gently push the telescope along to follow the stars. An example of this technique is in Str. A., May-June, 1965, page 97.

Closeup Photos. Longer focal lengths show details in the coma. For this type, you can mount a camera at the prime or secondary focus. One plan would be to use a 35-mm. camera and a guide scope.

Film. Very fast black and white panchromatic film is now on the market. In selecting a film a compromise must be reached in balancing film speed, contrast, and grain. It should be noted that nominal ASA speed rating can usually be increased five to ten times for astronomical work. This results in more contrast and grain than is desired for everyday photography. Comet photographers have had good results with Tri-X film processed 10 minutes or more in DK60a, D19, or D11.

Spectroscopic Film. This film is valuable in studying comets because it gives clues as to what a comet is made of. Dust will show strongly on a red sensitive film, while a blue film shows gas. Sometimes a comet will have both a gas and a dust tail. Spectroscopic films have to be ordered in large batches and are expensive. A minimum order of 300 feet of 103aO in 35 mm. costs about $75.

Color Film. The difficulty with color film is that reciprocity failure causes a color shift on long exposures. This failure shows in having all faint stars appear blue, for example. In choosing a color film, look for one that gives a neutral sky background, such as dark gray or black. This tone will also depend on processing. Color compensating filters may have to be used. Trial and error is the best way to find which filters are best. Previously, Super Anscochrome had the least reciprocity failure of any color film. It is no longer manufactured (but is still available, see ads in photography magazines). The fastest color films now on the market are Ansco 500, Ansco D-200, and Kodak High Speed Ektachrome. All of these may be pushed to higher speeds.

Photographic Comet Discoveries. Caution must be exercised when a likely new comet is seen on a photograph. Be careful, especially if you are not an experienced photographer; for it is very easy to be misled in interpreting smudges on a photo. Some pitfalls are:

1. Reflections from bright stars outside the camera field. 2. Light reflections in the lens elements. 3. Dirt on the condenser lenses of an enlarger. 4. Dust on negatives, giving white specks on prints. (Such dust will print with sharp edges, while stars will be softer.)

Analysis of Comet Observations. Assistance in analysing A.L.P.O. observations is now being given by Michael McCants, Gordon Solberg, R. B. Minton, David Meisel, and Dr. George Van Biesbroeck. Although it will be some months after the appearance of a comet before definitive reports are published in The Strolling Astronomer, observers are asked to send observations to the Recorder as they are made. In this way the A.L.P.O. can be kept informed on current comet activity.

For New A.L.P.O. Members. For the information of new A.L.P.O. members I would like to mention how the organization and its Sections operate. Amateur astronomy is a hobby for the staff members of The Strolling Astronomer, and hence we cannot be expected to be as highly organized or as prompt as a professional group. This pertains to the speed in publishing the magazine and to individual Section Reports. We must sympathize with the fact that editing The Strolling Astronomer is all done by one man. We should also note that the Recorders conduct Section business (such as correspondence, report forms, exhibits, etc.) with their own money, almost without exceptions. So please be patient!

NEW COMET IKEYA-SEKI 1967n

By: Dennis Milon, A.L.P.O. Comets Recorder

"Another for the Amateurs," headlined a Time magazine story (January 12, 1968) about the latest comet discovery by Kaoru Ikeya and Tsutomu Seki. They had spotted the 14th comet of 1967 within minutes of each other on the morning of December 28th. It was then a small ninth-magnitude object moving about $\frac{1}{2}$° per day northeast through Ophiuchus.

This new comet will provide an exceptional opportunity for observers, for it will be both circumpolar and brighter than ninth magnitude for many weeks. Passing within 4° of the pole, Ikeya-Seki will allow all-night monitoring of brightness; and it will permit comparing a comet's magnitude in telescopes of different apertures.

Although Ikeya does not speak English, Seki is a regular correspondent of the Comets Section. (He is pictured on The Strolling Astronomer cover, May-June, 1965.) Recently he has used 5-inch, 20-power binoculars having a 3° field. It was with these that he discovered Comet Seki 1967b. Ikeya sweeps with an 8-inch reflector. Comet 1967n was the fifth discovery for both observers. Time reports that "Seki uses a portable hair dryer to keep his hands from turning numb and wears elelctric slippers to keep his feet warm." Seki is 37 and is a teacher of classical guitar; Ikeya is 24 and works in a piano factory.

Two other experienced comet hunters were sweeping the morning sky at about the same time that 1967n was discovered in Japan, but they missed it. George Alcock of Peterborough, England, writes: "I swept the area a few hours later, but passing cloud must have hidden the comet. Stars less than 5 degrees from its position were noted." At Mansfield Center, Connecticut, Edgar Everhart was observing. "Hats off to them," the veteran comet-seeker Everhart says. "This was not an easy one to discover so close to the bright twilight horizon."

The first A.L.P.O. announcement card was mailed on January 2nd, and on the 11th an ephemeris computed by Brian Marsden was sent. We then received a similar orbit computed by Michael McCants and Don Wells at the University of Texas on an IBM 1800. McCants notes that the comet "looks similar to Comet Kilston, small, condensed, and round. However if a sloar flare should affect it, the results might well be interesting and the magnitude brighter than predicted."

The latest ephemeris (Figure 17) accompanies this article. It was supplied through the courtesy of Dr. Marsden, who used 27 positions from December 29th to January 22nd. The orbital elements are: perihelion passage on February 26th, 1968 at 1.70 astronomical units; argument of perihelion 71°; ascending node 255°; inclination 129°. At discovery the comet was on the other side of the Solar System from the Earth, but it is moving toward us and the Sun. Perihelion is at the great distance of about 158 million miles; thus most of the predicted brightening is due to the lessening Earth distance since the solar distance (r) does not vary appreciably. With an inclination of about 130°, the comet is in retrograde motion, opposite to that of the planets. Figure 18 shows the spatial relationships of the orbits of the Earth and Comet Ikeya-Seki 1967n.

A.L.P.O. Observations

A.L.P.O. observers responded enthusiastically to the announcement of a new comet, even on cold winter mornings; and it was under surveillance upon almost every January morning. Thanks go to the following persons for their reports:

Carl Anderson	Dwight Jones
Leo Boethin	Russell Maag
John Bortle	Michael McCants
David Carriger	Tom Middlebrook
Darrell Conger	R. B. Minton
Edgar Everhart	Walter Pacholka
Bill Grady	Douglas Smith
Steve Hall	Ken Thomson
Albert Jones	Don Wells

It was indeed cold -- our ace observer John Bortle, Mount Vernon, New York, reports that several sightings were made with below-zero temperatures. The moon did not begin to hamper observations until mid-January, but even then Leo Boethin in the Philippines "could easily locate it in my 8-inch reflector, although diameter measurements are almost impossible."

Appearance in January. The 21 visual reports agree on three changes. First, the brightness increased a magnitude. Summarizing the other two aspects, and typical of other reports, John Bortle writes, "The comet has shown considerable development since I first saw it on January 6th. It has become very much condensed and nearly double in size. Also I am now occasionally glimpsing a nucleus, and a central condensation seems to be forming."

Magnitude. When Edgar Everhart, Mansfield Center, Connecticut first saw this comet on January 5th, it was much harder to see than M10 and M12. By January 22nd Carl Anderson at Manchester, New Hampshire, rated its magnitude at 8.0 by comparison with these globulars. The following observed magnitudes are based on comparison-star magnitudes from the SAO catalog and AAVSO charts.

Date		Observer	Instrument	Magnitude
1968, January	6 U.T.	Bortle	6"	8.8
	9	Bortle	6"	8.5
	12	Bortle	6"	8.6
	13	McCants, Wells	2"	8.8
			10"	9.1
	14	Pacholka	8"	8.5
	22	Smith	6"	8.4
	26	Middlebrook	8"	8.1
	27	Smith	6"	8.5
	27	Bortle	6"	7.7

On the 14th, when Walter Pacholka observed from Lakewood, California, the comet was conveniently placed in the field of TT Ophiuchi. It was 25° above the horizon when Pacholka described it as resembling a planetary nebula. Maximum brightness of 7th magnitude should come during the first weeks of March, when 1967n will be 1.3 astronomical units from Earth.

Coma Description. By the drift method Pacholka measured a diameter of 1' on the 7th. R. B. Minton at Las Cruces, New Mexico, got 1'.2 on January 12th. By the 22nd the diameter had increased to 3', on which date Anderson timed it past a reticle. At Vinton, Virginia, Douglas Smith observed on the 22nd and 27th, finding the coma 3' by comparison with his eyepiece field. The corresponding linear diameter is about 160,000 miles, almost twice that of Jupiter.

A central condensation of about $\frac{1}{2}$' was seen by Tom Middlebrook, Nacogdoches, Texas, on January 13th and 26th, along with a faint nucleus. Russell Maag of St. Joseph, Missouri, reported that "On the 21st I think I could detect a fine pinpoint nucleus in my 8-inch reflector." Maag first picked up the comet on January 17th in 7X50 binoculars. Anderson observed on the 27th that "this bright point appeared nearly stellar, and was displaced westward from the center by about 0.2 the diameter."

1968 ET		RA(1950)	DEC(1950)	DELTA	R	THETA	MAG
JAN.	5	$16^h 38^m.08$	$-0°12'.7$	2.453	1.827	$40°.9$	8.6
	10	16 42.01	+ 1 39.9				
	15	16 45.91	+ 3 46.5	2.250	1.783	49.9	8.3
	20	16 49.78	+ 6 09.6				
	25	16 53.60	+ 8 52.2	2.035	1.747	59.1	8.0
	30	16 57.34	+11 57.6				
FEB.	4	17 00.99	+15 29.7	1.819	1.720	68.4	7.7
	9	17 04.50	+19 32.6				
	14	17 07.84	+24 10.5	1.617	1.703	77.5	7.4
	19	17 10.93	+29 27.2				
	24	17 13.70	+35 24.7	1.450	1.697	85.9	7.1
	29	17 15.98	+42 02.4				
MAR.	5	17 17.49	+49 14.8	1.343	1.700	92.2	6.9
	10	17 17.75	+56 51.5				
	15	17 15.72	+64 37.1	1.319	1.713	94.5	6.9
	20	17 08.82	+72 14.0				
	25	16 48.17	+79 23.8	1.383	1.737	92.3	7.1
	30	15 19.03	+85 33.5				
APR.	4	9 02.36	+86 12.2	1.522	1.770	86.5	7.4
	9	7 16.01	+81 30.8				
	14	6 52.85	+76 55.0	1.712	1.811	79.0	7.7
	19	6 45.13	+72 49.1				
	24	6 42.71	+69 12.5	1.930	1.860	70.8	8.1
	29	6 42.70	+66 02.4				
MAY	4	6 43.97	+63 15.1	2.158	1.917	62.6	8.5
	9	6 45.99	+60 47.4				
	14	6 48.48	+58 36.6	2.384	1.979	54.6	8.9
	19	6 51.26	+56 40.1				
	24	6 54.25	+54 55.9	2.599	2.047	47.0	9.2
	29	6 57.37	+53 22.4				
JUNE	3	7 00.57	+51 58.0	2.798	2.120	39.7	9.5
	8	7 03.80	+50 41.6				
	13	7 07.03	+49 32.2	2.975	2.196	33.2	9.8
	18	7 10.24	+48 28.9				
	23	7 13.42	+47 31.1	3.128	2.276	27.6	10.0
	28	7 16.54	+46 38.1				
JULY	3	7 19.57	+45 49.6	3.254	2.359	23.7	10.3

$$\text{Magnitude} = 4.0 + 5 \log \Delta + 10 \log r$$

Figure 17. Ephemeris of Comet Ikeya-Seki 1967n. Furnished by Dennis Milon, photographed for reproduction here by R. B. Minton. There are given the distance R from the Sun, the distance Delta from the Earth, and the Sun-Earth-Comet angle Theta. The equation on which the predicted magnitudes are based is given. Distances are in astronomical units.

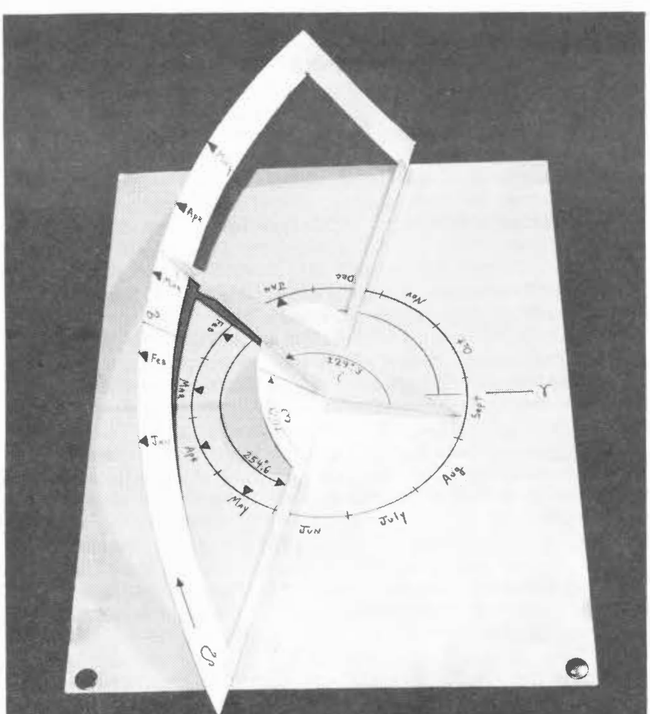


Figure 18. Photograph by R. B. Minton of scaled model constructed by R. B. Minton to show orbital planes of Earth and Comet Ikeya-Seki 1967n and elements of orbit of latter. The arrows mark the positions of Earth and the comet on the 15th of the indicated months in 1968. Model suggested by a diagram drawn by David Meisel.

ANNOUNCEMENTS

Catalogue of A.L.P.O. Lunar Photograph Library. Lunar Recorder John E. Westfall informs us that a new catalogue is now available. He will supply it upon request for 35¢ in stamps. Mr. Westfall's address is 1530 Kanawha St., Apt. 110, Adelphi, Maryland 20783. A number of articles about our Lunar Photograph Library have appeared in recent issues. It includes a large number of photographs from the Ranger, Orbiter, and Surveyor space missions (and also from the Mariner IV Mars probe).

Astronomical League National Convention. We have accepted the gracious invitation of the Astronomical League, extended by Mrs. Ann Wagner, to take part in their 22nd General Convention at Chicago, Illinois on August 30-September 2, 1968. Mr. Richard E. Wend, our Jupiter Recorder, will be in charge of the A.L.P.O. part of the program. As usual, astronomical exhibits and papers for presentation are welcome; arrangements should be worked out with Mr. Wend. The host group is the Chicago Astronomical Society.

New Address for Comets Recorder. The proper address for Mr. Dennis Milon is now 378 Broadway, Cambridge, Mass. 02139. All A.L.P.O. observations of comets should be submitted to Mr. Milon there, along with all ordinary correspondence.

Request for Lunar Dome Observations.. Reverend Kenneth J. Delano, our Lunar Recorder in charge of the Lunar Dome Survey, requests: "Any A.L.P.O. member who sees any of the lunar 'blisters' should send an estimate of its diameter (as compared to a particular crater of known dimensions) and any information about craterlets, peaks, or fissures on the dome and whether or not there is a summit craterlet. A report that no surface features were detectable is just as important as a positive finding." Mr. Delano and Mr. Leslie Rae are hoping to bring out an updated ALPO-BAA Joint Catalogue of domes by next summer.

Sustaining Members and Sponsors: As of February 22, 1968, we have in these special classes of membership:

Sustaining Members - Sky Publishing Corporation, Charles F. Capen, Craig L. Johnson, Geoffrey Gaherty, Jr., Charles L. Ricker, Alan McClure, Elmer J. Reese, Carl A. Anderson, Gordon D. Hall, Michael McCants, William K. Hartmann, Ralph Scott, A. W. Mount, Charles B. Owens, Joseph P. Vitous, John E. Wilder, Clark R. Chapman, A. K. Parizek, B. Traucki, Frederick W. Jaeger, P. K. Sartory, Nicholas Waitkus, Patrick S. Mc Intosh, Lyle T. Johnson, the Chicago Astronomical Society, H. W. Kelsey, Phillip Wyman, Harry Grimsley, Daniel H. Harris, Fred M. Garland, the Junior Texas Astronomical Society, and David Meisel.

Sponsors - Dr. Dinsmore Alter, William O. Roberts, David P. Barcroft, Grace A. Fox, Philip and Virginia Glaser, John E. Westfall, Joel W. Goodman, Dr. James Q. Gant, Jr., Ken Thomson, Reverend Kenneth J. Delano, Richard E. Wend, and Phillip W. Budine.

Sustaining Members pay $10 per year; Sponsors, $25. The excess above the regular rate is used to support the work and activities of the A.L.P.O.

Notes from A.L.P.O. Librarian. Mrs. Walter H. Haas gratefully announces the donation to the A.L.P.O. Library of "The Photographic Album of the Comet Ikeya-Seki 1965f" from Mr. Takeshi Sato of Hiroshima, Japan.

The policy of having those who borrow books pay only the postage has proved impractical, perhaps in part because this charge is not known until the book is actually mailed. In order to cover postage costs and some expenses for mailing materials, we have decided to charge 30 cents per book borrowed. A maximum of two books may be borrowed at one time. All A.L.P.O. members in the United States and Canada are eligible to borrow books, and it is encouraging that a few persons are regularly doing so.

Request for Observations of Mercury. Reverend Hodgson, the A.L.P.O. Mercury Recorder, makes the following appeal for observations of the May-June, 1968 evening apparition of this planet, the most favorable evening one of the year in the northern hemisphere: "I would urge A.L.P.O. members to make Mercury observations at every opportunity, and to make drawings of all surface features which are clearly seen. The few minutes taken to observe Mercury each evening from about May 10 through about June 10 could be of great value, and could hardly hinder any observing projects on other planets which one might have in mind.. Observing forms can be secured from the Mercury Recorder. All observations of this apparition should be reported, if possible, by July 15."

Southwestern Astronomical Conference '68. A.L.P.O. members are reminded that our next Convention will be part of this gathering at Las Cruces, New Mexico on August 21-24,

1968. Other participants will be the Western Amateur Astronomers, the Southwestern Region of the Astronomical League, and all interested persons who wish to attend. A descriptive brochure went out with our preceding issue (Vol. 20, Nos. 9-10). We regret at least one error in this brochure; the phase of the moon will be near new, not near First Quarter. A second brochure is now being prepared and will be sent out as an enclosure with this issue if it is ready in time. Qualified A.L.P.O. members are heartily invited to contribute papers; indeed, they should select a subject and begin to write soon. The General Chairman is Mr. E. R. Casey, P. O. Box 921, Las Cruces, New Mexico 88001. The host is the Astronomical Society of Las Cruces.

The Exhibit Chairman for the convention is Mr. R. B. Minton, Research Center, New Mexico State University, Las Cruces, New Mexico 88001. He requests that material for display should be submitted to him as soon as possible. All drawings, charts, and photographs should be properly packaged or wrapped to protect them against damage in mailing. All material received will be handled carefully and will be returned to the contributor after the Southwestern Astronomical Conference '68. If the exhibit material is to be mailed back, please give Mr. Minton the return postage. Persons who are bringing exhibits to the Convention with them should tell Mr. Minton soon just what they plan to bring. Early information will greatly assist the needed planning for the Convention Exhibit.

BOOK REVIEWS

Der Sternenhimmel 1968, by Robert A. Naef. Aarau, Switzerland: Verlag H. R. Sauerländer. 182 pages. In German. Available in the United States for $3.95 from Albert J. Phiebig, P. O. Box 352, White Plains, N. Y. 10602.

Reviewed by William E. Shawcross

This 28th annual edition of The Starry Heavens presents in full detail the celestial happenings of 1968. As in the past, we can only lament that a similarly detailed English-language handbook is not available. While the specific predictions listed are for Switzerland, most of the information given can be used anywhere in the world.

Generous use of line drawings continues to be a strong point of the presentation, enabling the amateur to visualize the event in advance. There are extensive presentations for each planet, a daily calendar of events for each month, coverage of eclipses, and several special features (the one on Icarus will be of most popular interest).

One hint: reinforce the spine of this paperback with a strip of cloth tape if you plan to use it at the telescope.

******

Getting Acquainted with Comets, by Robert S. Richardson. McGraw-Hill Book Company, New York, New York. 306 pages. Price $7.50.

Reviewed by W. Scott Obreza, 106 Henry's Lane, Hanover, Massachusetts 02339

There must be few amateur astronomers who have looked through a telescope and have not thought of discovering a comet of their very own, one that would always bear their name. Few have met with the success of Kaoru Ikeya and Tsutomu Seki; but, remembering the Great Comet of 1965, it does happen. Anyone who has had such dreams will want to read Robert S. Richardson's new book, Getting Acquainted with Comets. The book, as the title suggests, will indeed acquaint anyone who reads it with comets. The text is written in a style that makes the subject of comets very understandable to the average reader. The book also includes information about meteors and meteor showers, and covers the subject of comets, from how to report a newly discovered comet to spectral analysis of the light emitted by comets. Many illustrations are used to support the excellent text. Comets are noted for their wide variety of appearances and for their continual changes from day to day. This behavior could have been best illustrated by a good selection of comet photographs, but this book contains only a few such photographs.

While discussing the motions of a comet in space, the author deviates from the subject of comets to discuss another celestial body. In 1949, Robert S. Richardson was on the staff of the Mount Wilson and Palomar Observatories when a newly discovered asteroid was detected on photographs made by Dr. Walter Baade. Mr. Richardson, along with Mr. Seth B. Nicholson, calculated the orbit of the asteroid, now known as Icarus. They determined that the object was passing the Earth at a distance of four million miles. Icarus will return to the same position in space on June 15, 1968, and will again pass within four million miles of our planet Earth. The book contains much information about the orbit of Icarus and about how it was discovered. Additional information concerning the close approach of Icarus this year can be found in an excellent article written by Mr. Richardson in the April, 1965 issue of Scientific American.

Two chapters in the book are most interesting. The first, titled "Comets Across the Sun," gives an interesting account of an expedition led by Ferdinand Ellerman of the Mount Wilson Solar Observatory in 1910. During the last return of Halley's Comet, scientists calculated that the comet would transit the Sun on May 19, 1910 and that the best site for viewing would be in the Hawaiian Islands. Ellerman and other observers failed to see any markings transit the solar disk. It was determined from these observations that the nucleus of the comet, if it was a solid mass, must have a diameter of less than 100 miles. The second chapter concerns the Periodic Comet 1925 II. This strange comet orbits the Sun outside the orbit of Jupiter. Under the disturbing influence of the planet Jupiter, its elliptical orbit is slowly being made circular. What is especially peculiar about this comet is its rapid flucuations in brightness. In 1946 it brightened from a magnitude of 18 to a magnitude of 9.4 in less than three weeks. This corresponds to an increase in luminosity of about 3000 times. What could cause such a rapid increase? Perhaps a solar flare, but could such an outburst on the Sun produce an effect 600 million miles away? Or could the cause be something we don't understand as yet, such as anti-matter? Perhaps a space probe can provide an answer.

Mr. Richardson gives a reminder to comet hunters. Comet Ikeya-Seki proved to be a member of the M-group of comets, the famous Sun-grazing comets. Although comets can appear in any part of the sky, an M-group comet will approach the Sun from the direction of Canis Major. The sky near the Big Dog should be one of the areas a comet hunter would want to check in his search.

The appendix contains a list of 42 short period comets that have made more than one appearance. It includes all the orbital elements and the times of the most recent perihelion passage and the next expected return. Anyone interested in astronomy will enjoy the time spent in reading this book and will enhance his knowledge of these strange visitors from the outer regions of our Solar System.

******

Handbook of the Physical Properties of the Planet Jupiter, by C. M. Michaux. Published by NASA, 1967. Order from Supt. of Documents, Washington, D.C. as NASA SP-3031. Price 60¢. 142 pages.

Reviewed by Rodger W. Gordon

The rather long-sounding title of this book means exactly what it says: it's a handbook, and a most useful one, on the physical properties of our Solar System's greatest planet. It is crammed full of facts, diagrams, tables, and charts which most persons, not having a complete astronomical library, would have a difficult time finding. As such (in most cases) only the bare bones of some meaty information are given. After reading a few chapters, one wonders how all this information has come into being since no accounts are given as to how the results have been obtained. There is no fault here, however, since the book does not try to be a comprehensive treatise.

The reviewer was disappointed to find that much of the material concerning the usual telescopic appearance of Jupiter and the various rotation rates of its belts and zones to be mere repetitions of the descriptions in Peek's work The Planet Jupiter. This feeling is not because Peek's book is anything but excellent, which it is, but because it is evident that American sources have been overlooked -- the many reliable rotation rates of recent years published in The Strolling Astronomer, derived by Reese and others, are neglected.

Errors have crept into the book also. The radio rotation period, in one portion of the book, is regarded as the true rotation period of the solid surface. This conclusion is still conjecture; yet no mention is made of Reese's attempt to derive a rotation period of the solid surface based on successive outbursts of the South Equatorial Disturbance at certain longitudes on the planet. Another error is the mention of the Great Red Spot as identical with Cassini's Spot of 1665. We would like to think it so, it is true; but such an identification can never be proved unless some additional historical material comes to light-which appears unlikely. In all probability the two are identical, but a question must remain. In all fairness, then, we can only say that the Red Spot has existed since 1831, when the Red Spot Hollow was definitely recorded.

Despite the above criticisms of this book, it is nevertheless a worthy item for the amateur who makes Jupiter his special field of study. Even casual observers of the Giant Planet should have this handbook as a reference. The reviewer recommends that an enlarged version, which puts more emphasis on American contributions to the field, appear in a few years.

******

Astronomy With Binoculars, by James Muirden, Faber and Faber, 24 Russell Square, London, Price $5.95. 1963. 145 pages.

Reviewed by Rodger W. Gordon

Great emphasis today is placed on the value of obtaining as large a telescope as possible in many popular books. At the same time the value of simple equipment is overlooked or is thought to be non-existent. It is therefore a pleasure to read in Mr. Muirden's book that many useful observations can be undertaken with very simple equipment (like binoculars) and are still of value to professional astronomers.

Mr. Muirden shows that anyone, with the simple equipment he mentions, can make valuable studies by pursuing systematic observations of particular classes of objects over a period of time. The author states that ownership of costly and highly sophisticated instruments does not automatically make one an amateur astronomer.

Each chapter of this little book gives hints on what observations may be undertaken. Such chapters include solar, lunar, auroral, and meteoritic fields of Astronomy, variable stars, comet hunting, and the zodiacal light, as well as other related fields. Some useful work may even be done in the planetary field with a pair of binoculars, according to the author, though it is necessarily very limited in extent. However, the author should not have suggested determining the rotation period of Mars by visual observation on page 62. He suggests that a difference in magnitude can be detected since different parts of Mars have different reflectivities. This is true, but the difference of magnitude in one rotation of Mars is not more than 0.1 mag. or so - barely detectable to even the most experienced observer and completely submerged by other factors - haze, seeing, altitude, etc.

The photos and drawings in the book are of high quality, and typographic errors are few. While the value of this book will be most evident to a beginner or intermediate amateur, advanced amateurs who think that only large sophisticated equipment can do useful work would do well to read this book, and those who wish to relax from the rigors of exacting observational programs will find some of Mr. Muirden's suggestions intriguing and of absorbing interest to carry out.

Naturally the scope and intent of the book is limited, but anyone from a rank beginner to a professional in a large observatory will find it a worthwhile addition to the library.

LUNAR AND PLANETARY PROSPECTS, MARCH - MAY, 1968

Mercury. This planet will be at greatest elongation west from the sun on March 10, 1968 and at greatest elongation east on May 18. The morning apparition in March in the morning sky will be a poor one for observers in northern latitudes, but the evening apparition in May will be favorable for them. The angular diameter of Mercury will increase from 5".5 on May 5 to 10".3 on June 4.

Venus. The Morning Star will still be spectacular in March but will lose prominence as it approaches the superior conjunction of late June. On March 31 the disc is 93.3% illuminated, and the angular diameter is 10".8.

Mars. This planet is nearing conjunction on the far side of its orbit; indeed, the angular diameter is only 4".0 on March 31. The vernal equinox of the northern hemisphere will fall in June, 1968.

Jupiter. The Giant Planet was at opposition on February 20 and is accordingly well placed in the evening sky. Mr. Phillip W. Budine, A.L.P.O. Assistant Jupiter Recorder, has supplied the following data on four famous Jovian features:

Feature	Long. (II) Jan. 1, 1968	Change in Long. (II)/30 days
Center Red Spot	27°	+ 0°.0
Center STeZ Oval BC	46	-16.9
Center STeZ Oval DE	179	-20.0
Center STeZ Oval FA	302	-19.0

These numbers will allow extrapolating longitudes to various future dates. Of course, readers will realize in so extrapolating that Jovian drifts can, and often do, change with time.

Saturn. This planet will be near conjunction with the Sun during the three months considered. On May 20 the Saturnicentric latitude of the Earth will be $-12^{\circ}.2$, and the Saturnicentric latitude of the Sun will be $-10^{\circ}.5$. The minus sign means that we see the southern face of the rings.

Uranus and Neptune. Observers having access to a filar micrometer are encouraged to undertake the ellipticity of Uranus measurements described by Mr. Stanley Shartle elsewhere in this issue. On April 10, 1968 Uranus will be at right ascension 11^h47^m and declination +2° and will possess a stellar magnitude of 5.7. On the same date Neptune will be at right ascension 15^h37^m and declination -18° and will have a stellar magnitude of 7.7.

Moon. There will be a total lunar eclipse on April 13, 1968 with the following circumstances:

Moon enters penumbra	$2^h12^m.6$, U.T.
Moon enters umbra	3 10.3
Totality begins	4 23.2
Middle of eclipse	4 47.4
Totality ends	5 11.7
Moon leaves umbra	6 24.5
Moon leaves penumbra	7 22.2

It will be evident from these times that this lunar eclipse can be observed to advantage over almost all of the United States. We heartily invite our readers to make observations and to submit them soon after the eclipse either to the Editor or to Lunar Recorder John E. Westfall, 1530 Kanawha St., Apt. 110, Adelphi, Maryland 20783. Among the worthwhile projects for lunar eclipse observers are the estimation of the total stellar magnitude of the moon at frequent intervals throughout totality, the study of color and its distribution over the eclipsed moon, the careful search for possible "lunar transit phenomena" (particularly on areas reported to have been thus affected during past eclipses), the timing of umbral contacts for lunar features as a method of studying the amount of enlargement of the umbral shadow by the Earth's atmosphere, and studies of the limits of detectability of penumbral shadow both before and after the umbral eclipse. Finally, our Lunar Libration Cloud Recorder would enjoy hearing of searches for the L4 and L5 points while the full moon is dimmed in eclipse. Good Observing!

The Strolling Astronomer

SUBSCRIPTION RATES

Single Issue (in stock)	$1.00
6 Months	2.50
1 Year	4.00
2 Years	7.00

SPECIAL MEMBERSHIPS

Sustaining Members	$10 per year
Sponsors	$25 per year

☆ ☆ ☆

ADVERTISING RATES

Full Page Display Ad	$40.00
Half Page Display Ad	22.50
Quarter Page Display Ad	15.00
Classified or Listing (per col. in.)	4.00

Discount of 10% on 3-time insertion.

☆ ☆ ☆

NOTICE: In order to facilitate the reproduction of drawings in future issues readers are requested to exaggerate contrasts on drawings submitted. Extremely faint marks cannot be reproduced. Outlines of planetary discs should be made dark and distinct. It is not feasible to reproduce drawings made in colors. Following these precepts will permit better reproductions.

STAFF