Big Bear Valley Astronomical Society

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www.BBVAS.org

June 2019 Agenda and Minutes

- ✓ Welcome:
    - New members or 1st time visitors? Joe Hammond, KI6SE, and Paula
    - Members: Claude, John, Tim, Deanna, Jane, Randy, Dick, Byron, Bill
    - Any new Agenda Items? none

- ✓ News and Announcements: none

- ✓ Treasurer/Membership Report:
    - $782.50 balance
    - 2 new members, 36 paid members, 55 members on the list

- ✓ Scholarship Fund Report:
    - 3 awards given to BBHS students on June 3.
    - Many thanks to the Scholarship committee for doing the selection work.

- ✓ Librarian Report : will distribute the inventory after the start of School in September.

- ✓ Comments, reports, discussions, reviews:
    - Urban Assault Fri May 10th in the Village.
        - Teresa/Claude, Bill, just a few visitors.
    - May 30th Virtual Lecture – John Varsik, New DKIST Solar Telescope!
        - Good 2 hr presentation… very informative.
    - First Friday Under the Stars at Bear Valley Farms , June 7th.
        - Just a few visitors, but good selection of scopes/club members
    - BBSO public tour earlier today, last May tour.
        - Good group of 18 visitors…. Jane/Bill were the tour guides.
    - Discovery Center Star Party, May 31.
        - Low attendance, good seeing, 6 scopes
        - Bill gave intro talk.

- ✓ Activities
    - Urban Assault Fri July 12th in the Village.
    - June 27th Virtual Lecture – John Briggs (*Lyceum Telescope Museum and Research Center for Arts and Sciences*). He's proposed doing a talk on wintering over at South Pole Station.
    - Anyone working on the AL Lunar Project (besides Bill, Deanna, Jane & Teresa)? Or the Outreach Award? (Claude & Teresa, Steve & Josh Johnson)? Bill is ready to submit his worksheet
    - Special Thanks to Owen Phairis for the private presentation at his Planetarium Museum.
        - http://www.planetariummuseum.org/

- ✓ Chief observer report.
  - What's up this month? Nothing spectacular, but
    - June 10 had Jupiter at opposition
    - June 16/17 Jupiter near the Moon
    - June 21 is the Summer solstice (Sun farthest point north of equator)

- ✓ Scheduling:
  - Girl Scout troop request June 21 or 22. Anyone? Looking to earn Night Owl badge. Contact: wendytroop4375@gmail.com. Will be camping near Snow Summit.
    - No hard data at the meeting… more to follow.
  - July 18? - Virtual Lecture, Richard Wright "Getting Started in Astrophotography".
    - Next scheduled virtual lectures:
      - August 22: Drake Deming, Exoplanets
      - September: dark… RTMC
      - October 17?: Ifan Payne, Magdalena Ridge Obs
      - November 21: Claude, Deriving Special Relativity
  - Star Party in July? Or combine with DC or BVF? Where?
    - New date: August 3, at the east end of Golden Rod road in Baldwin Lake
  - First Fridays Under the Stars, July 5th! Should be lovely!
    - July 5, Aug 2, Sept 6
    - Need telescopes and astronomers.
    - Bill will generate PSA for these summer events (with permission from BVF)
  - Discovery Center Star Parties June 29, July 27, and Aug 30th
    - June presenter: Steve Johnson
    - Need July, August, September presenters…
    - Need telescopes and astronomers for the star parties after Camp Fire
  - RTMC moved to September 19 – 22. Still at Camp Oakes
  - Big Bear Air Fair July 6 – but we didn't get a space. So go enjoy the planes!
  - Next beginner talk? TBD

- ✓ General Discussion: Byron's presentation:
  - "How to see more w/o paying more."… Good useable info/nice handouts.
  - See the 19-page attachment that Byron wrote a few years ago.

FAINTNESS SEEING SCALE	ANTONIODI'S PLANET SCALE
1. Bright	1. Perfect seeing without a quiver
2. Easy	2. Slight undulations, with moments of calm lasting several seconds.
3. Difficult	3. Moderate seeing, with large tremors.
4. Held steadily	4. Poor seeing with constant troublesome undulations.
5. Flickering	5. Very bad seeing, scarcely allowing the making of a rough sketch.
6. Suspect (for Stars) Discern (for nebulae)	

OBSERVING TECHNICS

BY

BYRON D. GROVES, J.D.

OBSERVING TECHNICS

1. Use a Back Rest

Obvious and simple though this suggestion may seem, no other technic is as helpful. A correct filter may be as effective in some, but not in all observations Fine and faint planetary, lunar, and solar detail are more readily glimpsed when sitting in a chair with a back rest, rather than standing.

Considerable concentration is required to observe fine detail. If some conscious or unconscious attention must be given to balancing the body, it can not be wholly devoted to observing.

Position the chair so that it carries the observor's full weight. It should be easy to lean back in the chair and still have the ocular correctly positioned very close to the eye. A rotating tube is frequently found necessary to accomplish this when using Newtonian reflectors.

If the reflector's tube does not rotate, or if a chair is not feasible, a second alternative is a step ladder. The body's weight must be borne by the device used. Lean over the ladder, folding the arms on the top step for observing ease and balance.

Sit down.

2. Be Warm

Cold freezes the mind as well as the body. Extreme cold shortens one's span of attention and concentration. Amateur club-sponsored "star parties" are often held at high altitudes where the thinner air and unanticipated drop in temperature combine to disappoint the Pilgrims.

Almost any degree of cold may be tolerated if the extremities such as toes, fingers, ears, and nose, are kept warm. The body's weight tends to decrease blood circulation in the feet causing them to chill quickly and thoroughly. Certain footwear, designed for sports, can prevent this and keep the feet warm. Wool is warmer than leather for gloves, socks, clothing and ski caps. Hunters' hand warmers are another boon.

Electrically heated suits, though appealing, create heat currents which prevent seeing fine detail. Likewise detrimental is the practice of observing, then going inside to thaw out, and returning again to the telescope. Nor may drugs or alcohol be used if one wishes his eye's retina to function at peak performance.

Dress in wool.

3. Correctly Use Magnification

The less experienced the observor, the more power he seems to use. Too much power blurs detail, dims contrast and magnifies atmospheric turbulence. Too little power blinds the eye with brightness hiding detail and washing out color contrast. Correct magnification increases contrast and clarifies faint detail.

A. Decrease Brilliancy

According to Dr. Earl C. Slipher, the famous Lowell Observatory planetary photographer:

"Every skilled observor who goes to the best available site for his observation has had no great difficulty of seeing and convincing himself of the reality of the (Martian) canals. I am not aware of a single exception to this."1

Over exposing film washes out subtle shadings, just as the brightness of the beach and of Mars blinds the eye. Only after the retina has lost some of its sensitivity can much be seen on the beach or on Mars.

Subtle shadings, colorations and low levels of contrast can best be seen if the overwhelming brilliancy of the Sun, Moon, Mars, Venus, and Jupiter is reduced. At lower than normal light levels, the eye's retina can "learn" to notice and perceive delicate detail. Years of training may be required to develop sensitivity enough to see detail in very difficult nebulae, or Martian Canals, or other solar and planetary images.

A .4 neutral density filter used to observe the Moon will reveal colors on the otherwise stone-white surface. It must not be supposed that merely darkening other objects will always be as effective. Usually, the image must be magnified enough to detect detail.

The Moon presents a peculiar problem. It is so bright that the eye closes down when observing it, even in a very small telescope. When the eye's pupil shrinks, it cuts out rays from the edge of the mirror, and acts as a diaphragm over the mirror, decreasing light and resolution. Thus, a neutral filter will be required even with high power.

Magnification spreads the available light over a larger area of the retina, decreasing brilliancy per area as it increases the size of detail projected onto the retina.

The amount of magnification to use is affected by several considerations. Generally, no concern need be given to the possibility of too faint an image. The eye can detect a single candle 16.7 miles away,[2] and thus will be able to discern most low levels. Since diffraction created by natural laws of light becomes more apparent and detrimental as magnification increases, diffraction determines the upper limit. The greater the magnification, the greater the blur and the less the contrast.

B. Minimum Magnification

Sufficient magnification is required to discern the detail and this varies with each individual object. One secret of the Old Masters was knowing the exact magnification to use for their own eyes on each particular object.

Various types of objects may be seen with less magnification than other types because of the eye's sensitivity. Thus, the magnification required to make a dark line visible is much less than that required to split two double stars because the first need only appear as large as 1/2 second of arc, while the latter must appear to be about 60 seconds or more apart. The exact power used will, of course, depend upon the real, rather than apparent size of the image.[3]

TYPE OBJECT[4]	SCOPE'S RESOLUTION, R =	APPARENT SIZE DESIRED THEORETICALLY	& PRACTICALLY
1. Double Stars[5]			
a/Two of 6th Mag.	4.56"/Aperture	30[6]- 60 Sec.	240 Sec. apx.
b/Two of 9th Mag.	8.5"/Aperture		120 Sec.
c/3 Mag. difference	16.5"/Aperture		220 Sec.
d/6 Mag. difference	36.0"/Aperture		480 Sec.
2. Black Spot on White Background	1.52"/Aperture	59 Seconds[7]	20 Seconds[7]
3. Single Dark Line on White Background	.91"/Aperture	1/2 Second	12 Seconds
4. Narrowest Line Seen as a Continuous Line on Red Background[7]		3.3" equals 2.5 mls. when Mars closest	
5. Parallel Dark Lines on White Background	6.7" - 9.6"/Aperture	120-240"	
6. Blue Line seen as Blue or Green as Green on Red[7]		69" equals 32 mls. when Mars closest	

7. Brown Line seen as Brown,[7] on Red Ground — 114" equals 53 mls. when Mars closest

8. Bright Lines or Spot on Dark Background — No limit if bright enough to perceive.

9. Lunar Craters and Rilles revealed in practical studies:[8]

Aperture	Dia. of Crater (1/2 Shadow)	Rille Width
2 inch	4.5 miles	1,350 feet
3 inch	3.0 miles	900 feet
4 inch	2.2 miles	660 feet
6 inch	1.5 miles	450 feet
8 inch	1.1 miles	330 feet
10 inch	.9 miles	270 feet
12 inch	.8 miles	210 feet

Fourteen power per inch of aperture is frequently recommended to reveal all the resolution of an optical system. Yet, the above shows it is often not enough, and still more is required to reveal planetary coloration.

Some people seem to be more sensitive to faint stars and others more sensitive to faint planetary marking. So, each observor's "personal equation" will affect the amount of magnification used. This writer finds 30 - 35 power per inch of aperture to be best for Lunar and planetary detail when using a six-inch Newtonian Reflector. The inspiring 19th century observor, T. W. Webb, recommended the following magnifications with a 12-1/2 reflector:[9]

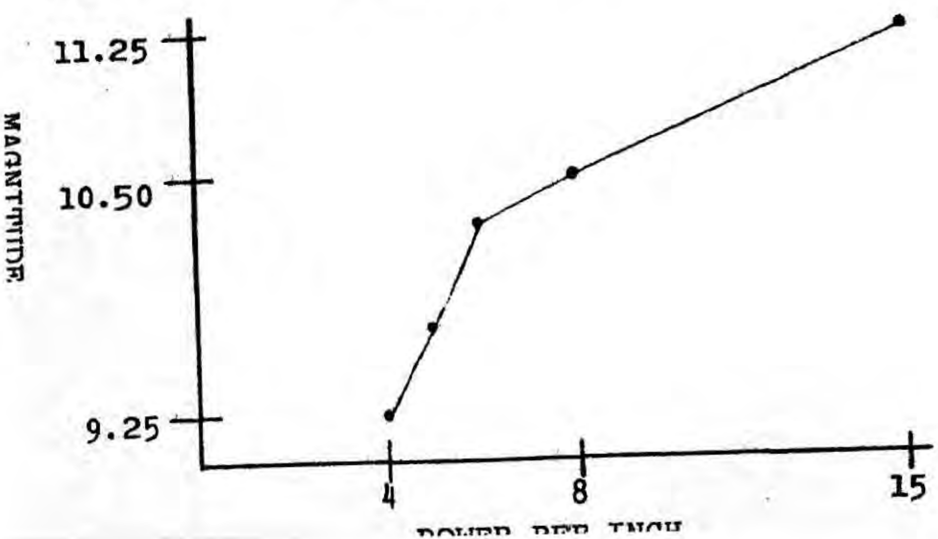
Object	Power	Low	Medium	High
Mercury		250	290	312
Venus		250	315	440
Mars		290	350	440
Jupiter		200	290	350
Saturn		312	350	440
Moon		300	440	710
Comets		25	30	40

C. Optimum Stellar Magnification

Magnification spreads the light of "extended" objects and thus decreases the brightness of any part of the image. Stars, being so minute, are normally not affected by magnification. Though the stars themselves are not dimmed, the extended light of the field background is expanded and dimmed resulting in more contrast. Thus more magnification makes more stars visibl to a point. That point occurs where the stars themselves begin to enlarge, displaying the airy disk and surrounding diffraction rings. Twenty power per inch of diameter is generally that point. However, on good nights more power may be used until the image of the star, itself, becomes a blur.

The English observor, Sidgewick, contends that a star must be 50 per cent brighter than the background to be seen.[10] This would mean that the night-time sky is about 6.2 magnitude if 6th magnitude is faintest seen. Though Professor Arthur S. Leonard (University of California at Davis) agrees with the above rationale, his experiments, as shown in the graph below,[11] indicates that the higher the power, the more visible the stars, due to increased contrast. Twelve power per inch is about minimum required to reveal the diffraction disk and with such power the background sky is only six per cent as bright as to the unaided eye.[12] This writer demonstrated this advantage by steadily holding an 8.3 magnitude star using 35 power on a 3-inch reflector, which was invisible at 15 power. It is interesting to note that 8th magnitude, or even less, may be glimpsed with the "unaided" eye, if one looks through a 1/4" tube or hole for this cuts out all extraneous light.

Many published tables merely assume the eye sees 6th magnitude and then deduce the magnitude visible with say a 6" telescope by noting how much more area a 6" mirror has than a 1/4" eye.



D. Optimum Nebulae Magnification

Like the field background, true nebulae are "extended" objects. Increasing magnification decreases their brightness, because it increases the focal ratio (f. number) of the telescope, and spreads out the light. Use the least magnification to comfortably see detail in nebulae.

To merely detect some nebulae or discern their shape, greater magnification may be required. The brain is able to piece together glimpses of various parts of a large faint object, to form and "see" such a faint object. The smaller the object, the brighter it must be, before the brain can discern its presence. The eye can see one-10,000th of a candle if it is spread over a 1 degree area, but 10 times more light is required if the size is only one-third degree. This is partly because of the eye's poor resolution at low light levels. So, some magnification makes nebulae more apparent, but decreases the apparent detail. Generally, magnify large nebulae to appear to be approximately 5 degrees in diameter. As soon as star images begin to break down into blurs, the magnification has passed the point of premium productivity.

Globular clusters behave as do true nebulae, until stars are resolved. Increasing magnification dims the nebulosity far more quickly than it dims stars. This increases the contrast between tiny stars and the unresolved "nebulosity." More and more stars become apparent as magnification is increased until the star images become "soft", and "fuzzy."

4. Observe at Culmination

Objects are twice as bright directly overhead at the Zenith, than at the horizon, because of the absorption of light by the atmosphere. Thus, faint shadings and stars are clearer at the object's highest point (Culmination).

Height Above Horizon:	1°	2°	4°	6°	10°	11°	13°
Dimmer than Zenith:	3 mag.	2.5	2.0	1.5	1.0	.9	.8
	15°	17°	19°	21°	26°	32°	43°
	.7	.6 mag	.5	.4	.3	.2	.1

Planets appear only in the southern sky to northern hemisphere observers. In the United States, planets appear between about 40° and 60° above the horizon depending on how far north or south is the observor. The further north one observes the more critical it is to observe at culmination (highest point) if the absorption effect is to be avoided. Small Martian detail may be wholly invisible, except for an half-hour or so, before and after culmination.

Observe at the best. Observe at culmination.

5. Determination

Detail at the very limits of detection, comes and goes. It remains for but a fleeting split second every several minutes. Only the constant and determined observor catches the momentary revelation.

Not only is minute to minute constancy required, but month to month. Observers who have repeatedly watched a planet over months, years, and even a lifetime have been richly rewarded by the ever changing detail.

A very limited observing schedule emphasizes repeated, and continuous observing of a few select objects. It maximizes the "chances" of seeing new, different and unique detail.

T. W. Webb, a successful 19th century observor admonished all observors:

> "Do not lose time in looking for objects under unfavorable circumstances. A very brillant night is often worthless for planets or double stars, from its blurred or tremulous definition; it will serve, however, for grand general views of bright groups or rich fields, or for irresolvable nebulae, which have no outlines to be deranged: A hazy or foggy night will blot out nebulae and minute stars, but sometimes defines bright objects admirably; never condemn such a night untried. Twilight and moonlight are often advantageous, from diminution of irradiation [Venus]. Look for nothing near the horizon; unless, indeed, it never rises much above it; nor over, or to the leeward [downwind] of a chimney in use, unless you wish to study the effect of a current of heated air."[14]

Meticulously concentrate on just part of an image. For example, look at just part of a crater wall, or part of a Jovian belt, or one Martian "bay" Don't look at the forest to discover a single tree.

Be determined!

6. Focus Carefully

A. Where to place the eye.

The pupil of the eye must be:

1. Exactly centered over the ocular's exit pupit; plus
2. Exactly the same size as the ocular's exit pupil (which is impossible if too low a power is used creating an exit pupil over 7-8 mm diameter); plus

3. Distance from the light coming from the ocular.

All three of these requirements are automatically accomplished if the eyes have been in the dark for ten (10) minutes or so. The third requirement above does require some concentration. If the eye is too close to the ocular, shadows of the secondary mirror will be seen as well as the edge of the field of view, both creating a bothersome condition. This does not occur if the eye is <u>at</u> or <u>beyond</u> the focal plane (that is the ocular's exit pupil or focus point). As a result, observors too often place their eye too far beyond the ocular and the ocular's exit pupil. The result of this is to greatly cut down on the apparent field of view, which is probably unimportant if a planet, or small detail in field center is the only aspect being observed.

The shorter the ocular's focal length, the more critical is the eye's placement. Squinting always makes placement more difficult than correctly keeping both eyes open.

The distance from the ocular to the exit pupil is shorter with shorter focal length oculars and with cheaper designs of oculars (Huygens, Ramsdens & Kellners) than with better oculars (Plossls, Orthoscopic, Symetricals). It will therefore, be necessary to remove glasses when using shorter or cheaper oculars. This is recommended with any ocular because the ocular lenses are usually better in quality than glasses and quite capable of correcting for defects of vision (except astigmatism). Still, with moderate (approximately 1/2") and longer focal lengths, the glasses may be worn and the decreased field tolerated.

B. Where to focus.

Nothing seems more difficult because there

is no one precise point of perfect focus. Rather, an image is "in focus" over a small distance, which varies with focal ratios, as follows:

Focal Ratio	Depth of Focus in Inches
f 4	.055"
f 6	.013"
f 8	.023"
f 10	.035"
f 12	.050"

Nonetheless, it is crucially important to "focus" on the center of this "depth of focus" in order to achieve the finest contrast and faintest stars. If this is not done, the eye will itself vary its own focus and "wander" in and out of focus. Advocates of rack and pinion devices point to the supposed ease of "bracketing" this depth of focus with the traditional rack and pinion system Opponents cite the difficulty in stopping exactly on target with such a device and recommend a spirally threaded device, like a screw and nut.

The eye must be relaxed and focused at infinity if the best focus is to be obtained. Squinting produces eye strain and prevents good focus. Always focus and observe with both eyes open. With practice, this becomes easier. To simplify it, at first, either paint the upper tube black or use an eye-patch.

To focus, move the ocular toward the eye until it's outside of focus. Then, slowly start moving the ocular in toward the focal plane. Stop the instant the image first becomes "razor" sharp. Do not try to focus from "inside" of focus moving <u>out</u> until the image is sharp. This last approach prevents the eye from focusing at infinity and soon tires the eye.

Every several minutes re-focus the eye both in and out of focus for variety and to relieve eye strain.

The sharpest position across the field will not be the center, unless all of the optical parts are correctly aligned. For example, if the mirror (in a reflecting telescope) is pointed away from the center line of the light path, the sharpest place in the field will also be away from the center.

When focusing to see planetary detail, or to split double stars, the object should be precisely centered in the field of view because image quality decreases rapidly away from the center.

The diameter of the field over which a Newtonian Reflector will produce images which are affected only by diffraction, and not by coma, astigmatism etc., is very small. The diameter in inches at the plane of focus is equal to the focal length divided by the product of 25 times the square of the aperture $[F/25(A)^2]$. The angular diameter is 8,230.6 seconds of arc multiplied by the focal length in inches and this quantity divided by the square of the aperture.

Diffraction Limited Field Diameters for f 8 Telescopes	Diameter of Mirror
.053"	6"
.040"	8"
.032"	10"
.027"	12"

If wide field is the primary objective, then focus sharply on a star located about two-thirds of the distance from center to edge of field.

Objects low in the sky focus further out than those high in the sky due to the thicker atmosphere toward the horizon.

Psychological effects cause a different focal point for bright and dim objects.

When the planets and the moon are low in the sky, the difference in thickness of the air crossed by light from the top and bottom of the object causes color in the image. By using an <u>un</u>acromatic ocular and placing the image off center, a better focus can be obtained. Horace Dale of England has proposed a Ramsden ocular in which the field lens tilts back and forth slightly to correct this. Usually, atmospheric turbulence is so great that this effect is not even noticed.

Rising or falling temperature also slightly changes focus because of its effect upon the mirror's figure and because it slightly changes the length of the telescope tube.

Severe heat currents around the telescope or in the atmosphere can cause so many images of the bright planets (e.g. Mars) and stars that focus is impossible. The focal point in such a situation rapidly moves in and out of the theoretical place.[15]

Further, each person seems to require a slightly different focus.

C. What to Focus

It is easier to focus upon certain aspects of the objects. The following or "sunset edge" of planets is not as crisp as the "sunrise edge" and therefore the latter should be used. It is often easier to focus sharply upon a nearby star (after it is brought to field center) than upon the nebulae or planet under observation. Objects viewed through refractors, most finders, and cheap oculars, contain some pretty but false colors. Focus back and forth until the magenta color seems brightest.

Sometimes a sharp image of a star is not wanted as when an out of focus image is being used: (1) to guide upon while photographing; or (2) to make fine "cross-hairs" apparent; or (3) to estimate the relative brightness or color of several stars.

Here follows a table of various aspects to use when focusing upon various objects:

Object	Focus Upon
Sun	White patches, spots, or flaculoe near rim
Moon	Mountains on rim
Mars	Polar caps, or "canals"
Jupiter	Moons until they are tiny disks
Saturn	The innermost ring (Crepe ring)
Stars	The dark rings between the rings of the diffraction disk
Comets and Nebulae	A star in, or near the nebulae, and focus for the <u>brightest</u> image.

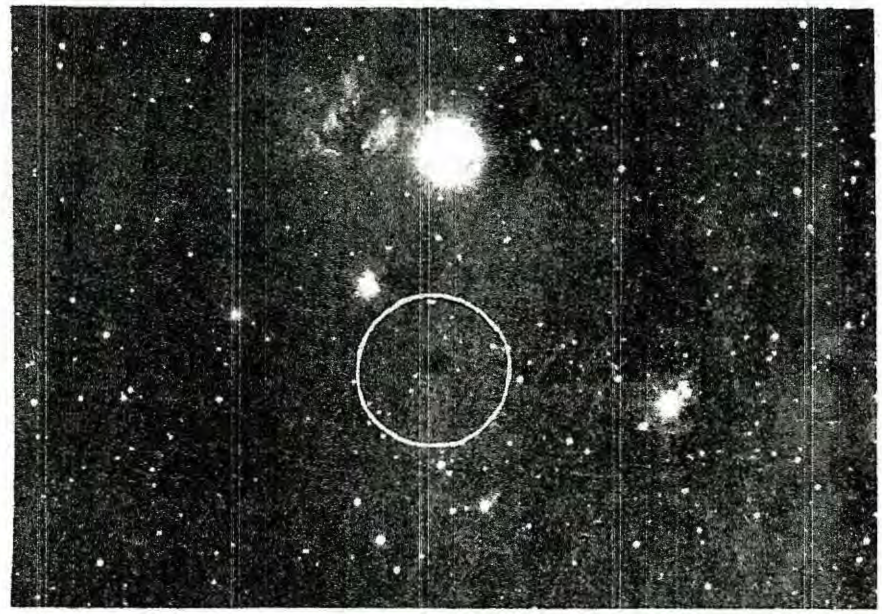
7. <u>Know Precisely Where the Faint Object is Located</u>

Obvious though this may seem, it is often overlooked.

It is not enough to know a faint object is in the field somewhere. Its exact location must be precisely known. Though, exactly how precise changes with the object and cannot be precisely stated, the position should be known to within 60 seconds or less.

The experienced observor, Walter Scott Houston, believes that this technic "may add roughly a magnitude to the observor's detection limit."[16] Know between which 12th and 13th magnitude stars the image is located.

Photograph by John Sanford



Horsehead Nebulae and Faint Stars

8. <u>Avert Your Vision</u>

Among the several technics used to observe very faint objects, averted vision is the most common and quite useful. In order to effectively use this and other methods for faint seeing, some theory of the eye's operation is helpful.

A. Theory of Vision

There seems to be no minimum light level required for seeing. Rather, the frequency of glimpsing faint and feeble stars, decreases as their brightness decreases. Thus, very feeble stars will flicker in and out of vision.

This is partly due to the variation in sensitivity of the "rods" in the eye's retina. Each little "rod" may be conceived of as a vial of pink liquid called "rapsodin".

Light strikes the end of the vial and bleaches this pink substance, which then produces a small current of electricity, which triggers the brain to recognize a spot of light. Once this happens, that particular "rod" is decharged and will no longer register light until it is charged up again after a short time. Thus, another "rod" must be used until the first recharges. This process continues among the millions of "rods" in the retina and partially explains why the eyeball constantly moves in jerks lasting approximately 1/10 second each. It also explains the disappearance of very faint stars when one stares at them. The changing sensitivity of the retina can be clearly seen by switching to the "unused" eye after observing a bright image for a few seconds. It is this changing sensitivity which permits the eye to see in the million to one change of brightness from the beach to the dark room, and not the change in the pupil's size.

The retina is so sensitive that it could detect a single candle 16.7 miles away. There would be enough light for all who had ever lived to see, if the energy of a garden pea falling 1" were converted into light.[17] In fact, it appears that the sensitivity of the retinal rods is limited only by quantum and molecular theories. Approximately 3.3 to 6.2×10^{-10} ergs of energy are required to observe a light flicker in and out of vision 55% of the time spent observing, though the retina's limiting threshold daily fluctuates 100% - 200%.[18]

The effect of this theory in practice, is to permit fainter objects to be seen if the observor stares for short periods. The threshold light required by a particular rod is added up for about one-tenth second. The brightness multiplied by length of time remains the same for each rod. So, a bright object can be seen in a split second, but a faint one will have to be stared at to add up its energy, to bleach enough rapsodin to make it visible. This is true

only if the stare lasts less than about 1/10 second. Longer than that actually decreases the ability to see faintly. So stare, but not longer than 1/10 second at faint objects.

Some observors notice that fainter objects are seen with binoculars than with monoculars (one-half of binoculars). This is true but not because more light reaches the retina. Rather, with 2 retinas the chances that there will be a rod sensitive enough to be triggered are increased. The result is that the same feeble light will be seen 75% instead of 50% of the time because the probability of seeing a particular faint object increased 38%. Objects 20% (approx.) fainter can be seen with binoculars than with monoculars. Use binoculars, if possible.

The thickness of the eye's lens and its liquid aqueous humour filling also affects faintness of light seen. Approximately three times more light must enter the edge of the lens, than the center of the lens, if it is to be seen. Thus, corner vision is not nearly as sensitive. In a wide field faint stars near the edge will not be seen. A magnitude will be lost from center field to field edge - if one looks at the center. This represents light entering 11° from the ray which passes through the eye's center, though the eye picks up light from a field 208° wide.[20]

Though the pink rapsodin pigment is most sensitive to light of 5800 Ångstrom units wave length, the cones (thought to be responsible for color vision) are most sensitive to 5400 Å (Green) and the rods to 4900 Å (Blue). Cones are located at the retina center with rods surrounding the periphal of the retina.

Fewer and fewer of the cones which give color vision are triggered to respond as light becomes dimmer. As twilight darkens, only purple and finally grey are seen. The failure of the central retina region to function, causes the colorlessness of night vision.

The rods continue to function though they are more sensitive to the blue end of the spectrum.

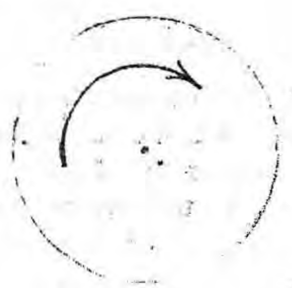
A red star observed directly can be seen as red right down to the cones' threshold, but will appear "whitish", when its light falls on the surrounding rods. Only yellow appears white near the cones' threshold, and only infra-red (7000 Å up) can be detected as red by the rods. Even then, the rods require 1.4 to 2.5 times their threshold value. Generally then, the eye must stare directly at an object to see color and avert the light beam onto the rods to detect faint stars.

Red stars appear brighter than equally bright blue stars, if stared at for some time. This "Purkinje Phenomenon", creates an untrue impression of relative brightness. Quick glances will prevent this false effect. Longer stares will assist faint detection, but fainter blue than red stars may be seen. Perhaps this explains the observation that blue stars seem to twinkle more than red stars.

B. How to Avert the Vision

Each observor's eye is different. The most sensitive portion of the retina is in a different place in each person and also in each eye. The object is to cause light to fall upon the most sensitive area of the retina. Look at the X when object is in center of field for a start (see figure). Then try a half-dozen times, or so, looking in a circle all around the object, starting at different places to determine which part of the retina is the most sensitive.

Averted Vision



Switching back and forth from one to the other eye isn't too helpful since each eye will require a refocussing of the image. Each observor seems to develop a "better" eye.

Averted vision is most helpful in observing faint stars and in seeing stars within globular clusters as Messier #31. Faint nebulae also are more apparent, but their apparent size is also crucial to their detection.

9. Observe in the Morning

City lights pervade the evening sky and brighten the background. The warm ground gives up its warmth throughout the evening into the early morning hours when the ground becomes cooler than the air. Thus, evening observing is not as satisfactory or successful as early morning observing when heat currents have decreased and the sky has become dark.

This suggestion, however, causes one problem, besides early arising. When air temperature is cooling, mirrors should be slightly undercorrected instead of being true parabolas. In practice only the very best mirrors from the best manufacturers are purposefully so figured. In the morning hours, air temperature is rising slightly and therefore the mirrors should be very slightly overcorrected i.e. deeper in the center than a perfect parabola. This can be specified and obtained when obtaining a telescope from a quality manufacturer. Since mirror figures may vary somewhat, it is good to experiment with each telescope, by observing in both evening and morning hours to ascertain which time is most suited for a particular telescope. Still, even an "evening" scope may work better in the morning due to the better observing conditions.

10. Observe in the Daytime

Because of atmospheric heat turbulence, light absorption and light refraction, it is almost impossible to decently observe objects very low above the horizon. Observation of objects when they are high in the sky is of great assistance. There are two objects that are never very high in the dark sky, Venus and Mercury. Though the Moon and some craters can be easily seen in the daytime, detail is generally faded. Venus and Mars have a higher surface brightness and thus shine above the daytime brillance. In truth, these two objects are so brilliant as to blind a twilight or evening observor and are best observed in the daytime.

How? First and foremost it is absolutely imperative that the telescope be perfectly focused on a star the night before and locked so that the focus can not be shifted. It is impossible to find these planets if the telescope is even slightly out of focus. Use a low power ocular so that the image will be brilliant enough to see.

Second, the telescope should have setting circles. The position of the planet can be plotted from its location and that of the sun as given in the American Almanac and Nautical Ephemeris or the periodicals, such as Sky and Telescope. If the telescope is accurately aligned on the pole, the circles may be set and Mercury observed. If not, locate the sun in the middle of the field by use of the telescope's shadow and projection of the solar image. Then offset the telescope the required degrees, hours and minutes. Tapping the telescope sometimes assists pick-up of these objects.

The third and most dangerous way of finding these is to merely sweep back and forth, with considerable overlap, the suspected area of the sky. This is very tedious and seldom successful.

A fourth way is to observe these planets in the twilight, lock the declination axis and then the next

day just sweep through the sky in right ascension.

CAUTION: Always sweep away from the Sun, never toward it, else an eye may be permanently lost. Those objects are found away from the sun, in the blue, not the "gold" part of the sky.

Mornings are best, before the atmosphere heats up too much.

11. Dark Adapt the Eyes

Ten minutes is seldom long enough to completely dark adapt the eye, and to permit it to work at peak efficiency. Thirty (30) minutes or so, without use of lights is a better approximation, though each individual will vary in the time required.

Shutting the eyes or staying in a closet will not appreciably speed up the process as is readily apparent from noticing the inability to see much of anything upon awakening in the middle of the night. A half-hour of star-lit sky works wondrously.

Though it is widely known that red light should be used instead of white light, it seems seldom known that too bright a red light is also detrimental. Cover all lights with several layers of red cellophane obtainable at stationery stores.

Some find a yard of black cloth, held over the head shrouding all but one eye, is helpful.

12. Stand Away From the Telescope

The body's heat, which is approximately equal to a 60-watt light bulb, creates destroying heat currents and turbulence. It will even cause a cold ocular to fog up, as will breathing upon an ocular.

Metallic tubes are especially susceptible to these currents. Aluminum paint will help to prevent this better than white or black, because of its radiation and reflectivity characteristics.

Cold, "steady" atmosphere, nights will demonstrate the advantages of this technic.

13. Avoid Drafts

Currents of different temperature air, both in and out of the telescope tube, drastically alter sharpness, contrast and faintness visible. A one (1) degree fahrenheit temperature difference in the light path will expand a star's image to 1 second diameter.[19] Since this is larger than the resolution of a 4-1/2" telescope, the full resolution of all larger telescopes is wasted in such conditions. Care should be taken to avoid and control this problem in instrument design and construction.

They may also be avoided in observing. Do not locate a telescope upon warm asphalt, concrete or dirt. Merely touching these surfaces shows how warm they are. Grass is best.

Daytime solar observation is even more affected by these warm surfaces. Wetting a concrete or asphalt area may markedly improve the image sharpness.

Never observe over houses and other structures, as they are generally warmer than the air due to furnaces and being inhabited.

Air temperature and humidity constantly change all night, as well as the equilibrium temperature of the telescope. It may therefore, be helpful to cover and uncover the mirror end of the telescope during an observing session. A ventilated tube is generally to be preferred.

When transporting a telescope to a temporary place for "better" viewing, try to observe on a ridge

or better yet, a hill top. Drafts and layers of hot and cold air, plus even fog pervade the valleys.

14. Be Healthy and Rested

Those who are healthy and rested are able to concentrate more completely. They seem to see more.

Though adequate sleep and alertness are mandatory, the exact extent of the increase in efficiency is undetermined.

Observing immediately after awaking isn't as effective as that after being up awhile, perhaps because of a lack of alertness.

Of course, any depressant, such as alcohol, will decrease the ability to see faint and fine detail, as will tobacco or any drug.

15. Tap the Telescope

Very faint nebulae and stars may sometimes be made detectable by tapping the telescope to create a slow, small ocellation of the image.

Large scale but very faint or "thin" nebulae seem most affected by this technic, for example, the "North American Nebulae".

This may assist the brain in interpreting the mosaic of rods in the retina, which are being barely triggered by the low light levels.

16. Use as Few Lenses as Feasible

Each lens and each lens surface absorbs and reflects light. Each lens wastes several percent of the light.

No lens is perfect, even if its design is perfect. Unless each element of a multi-element lens system is very carefully made, each lens will add to the "softness" of the image.

For the brightest, sharpest images, use the correct ocular, and as few lenses as possible. Avoid the use of prisms because they are very seldom made to the precision of a lens.

17. Wait for Optics to Cool to Air Temperature

Low focal ratio mirrors require very little time to reach equilibrium with air temperature. Mirrors of focal ratio six (6) and higher may require a half hour or more. If heat is being added to, or taken from an objective, its figure will be changing and sharp focus will be impossible.

Warm oculars produce a similiar, but smaller effect, if warm. So, keep oculars out of pockets and hands.

Before optics reach equilibrium, images are "fuzzy" or "soft" without sharp, contrasty detail.

18. Counteract Illusions

Highest of the observational mental exercises, and most difficult is interpreting faint, fleeting and flickering planetary detail. Lines, dots, shadings will all be seen instead of the true feature they reflect. By understanding what may create the effect seen, the real image may be grasped instead of the illusion.

Seldom do we see what isn't there.[20] Our sight is imperfect but reliable. Earl Slipher, the famed Flagstaff photographer of planets, has affirmed the truth of Martian "canals" and their visibility to all serious observors. Yet, for years after they were first reported, disbelief was rife. Though the recent Martian "fly-by" photographs infer that true depressions or "canals" do not exist on Mars, something has been seen. Frequent have been the studies

to penetrate this problem.

Interrupted lines may be what is seen instead of faint continuous lines. Seeing continuous lines is also a very common reaction to a "chain" of features, each of which is at or below the threshold of vision. Less frequently, faint continuous lines are seen as dashes or interrupted lines. Thus, if the portions of the interrupted feature appear large enough to see, they are either unconnected or are a faint continuous line. Repeatedly observe, frequently look and try to glimpse any hint of the true character.

Regardless of being black or colored, fine lines, and small dots near the eye's threshold, appear to be the same color as the surrounding area. Since these threshold images also tend to blend together, as noted above, they may merely appear as a mottled, "granular", or "rough" area of shading.

It has long been well known that neutral colors, as gray, will appear to have a color contrasting to the background, but this only applies if the object is big enough to not become absorbed by the surrounding color. Thus, suspect strong color contrasts. The smaller, or surrounded object may be some other or neutral color in reality.

As lines and images become smaller they lose their true color. Greens and blues remain true at sizes almost half as great as those needed to see the browns, oranges, yellows and reds. So, a blue or green color is more likely to be true than a red color. The greater the contrast with the blackground, the more likely the true color, so long as the complimentary effect doesn't create false colors. So, if color is seen, it must have greater width than a colorless band.

Though lines may be shorter than they appear, a line tends to be longer than it appears, if there is no noticeable end. Thus, a short projection from a dark area of Mars, which doesn't end up in another dark area, may be longer than it, at first, appears. Remember that a chain of faint features commonly appears as a faint line.

Double canals as Percival Lowell was so wont to see, draw and defend, may well be faint broad bands (as contrasted to faint lines). They have been explained as the eye seeing only the edges of the band due to the contrast with the surrounding areas.

The appearance of spokes or lines radiating from a point may be the effect of several lines close together in a small area.

Just as some people resemble others, so some observors react in the same way to these faint markings such as seeing unreal lines parallel to a heavy line. This most intriguing insight into the psychology of seeing and the eye's other reaction needs far more study.

Though sight is imperfect, it is reliable and more sensitive than the photographic emulsion. 21

19. Observe With a Level Head

Debris in the eye floats into and out of the line of vision. Very small light beams make these visible, noticeable and bothersome. Thus, they can become an annoyance when using high powers.

Observe horizontally without tilting the head either up or down, to minimize this characteristic.

20. Breathe Deeply

Many musicians are familiar with deep diaphram breathing which expands the lungs to their maximum capacity. Instead of expanding the chest when breathing in, expand the stomach.

More air and therefore more oxygen will be absorbed by the body increasing the metabolic rate and response of the eye and mind.

Some have even advocated about four deep breaths in a row to increase the eye's efficiency after a minute or so. More than five of these breaths though could cause one to black-out. Be cautious.

Good posture, and correct breathing though should assist an advanced observor of very faint images.

21. Dilate the Pupil

The diameter of light beam coming from the ocular equals the diameter of the objective divided by the power, and power equals the focal length of the objective divided by focal length of ocular. Thus, longer focal length oculars create wider beams of light. More importantly, the longer the ocular, the lower the focal ratio of the telescope and the brighter the images. Decrease power and increase brightness. Unfortunately, when the exit beam of light becomes larger than the eye's pupil, which is 7 m.m. in diameter, some of the light from the objective is cut out. If the pupil were larger, longer focal length oculars and lower focal ratios could be used. It might then be possible to see such detail as a spiral arm in the Andromeda Galaxy. Thus, the logic and goal of pupil dilation advocated by a few.

There are negative points. Aberrations of the eye are so bad that detail is drastically harmed by opening the pupil. Secondly, it is the chemistry of the retina, rather than the opening of the pupil that accounts for faint vision. It is of no assistance in detecting faint stars. Further, the observor must have a long enough ocular to produce an exit beam (exit pupil) larger than 7 m.m., but still smaller than the dilated pupil (10 m.m. approx.). Lastly, a very dark sky is required, away from the bright background of the cities. Driving with dilated pupils can be dangerous due to the poor definition of the dilated pupil.

However, if these negative points are not persuasive, an observor should contact a licensed eye doctor, <u>not</u> an optometrist since drugs are to be used. The eye is fragile. Be careful to rely only upon a doctor.

FOOTNOTES

1. Slipher, Earl C., <u>The Photographic Story of Mars</u> (1962), p. 162.
2. M. H. Pirenne, <u>Vision and the Eye,</u> Chapman and Hall Ltd., London, 2d Ed.
3. Apparent Size Desired ÷ Real Size = Magnification required.
4. Sidgewick, <u>Amateur Astronomers' Handbook,</u> London unless otherwise noted.
5. T. L. Lewis' studies reported in 37 <u>Observatory</u> 372 (1914).
6. Cones in the eye's retina are separated by about 2 to 2.5 microns. So, it should be possible to resolve 30 seconds of arc, but laboratory experiments don't seem to confirm this. It is rumored that some Polynesian natives commonly see Saturn (38") as "elongated", and also the Galilean Moons of Jupiter (38", 6th magnitudes). Ancient Babylonian and astrologers pictured the goddess Venus with crescent horn, like the phases of Venus (40"). Today with sharp eyes, lunar mountains can be seen projecting from the Northern Limb of the Moon. Still, most texts report 60 seconds to be the eye's resolution. Note from this and the table, that it should be possible to discern a few of the largest Martian Craters at its closest approaches!
7. P. Lowell and W. H. Pickering found 34 sec., May, 1956 "Sky & Telescope", p. 297.
8. "Sky & Telescope", p. 323, May, 1971.

9. T. W. Webb, Celestial Objects For Common Telescopes, editor Margaret W. Mayall, Vol. I, p. 15.

10. Sidgewick, Amateur Astronomers' Handbook, p. 30-31.

11. The proceedings of the 1967 Joint Convention of W. A. A. and A. L. P. O., in Long Beach, California, "Limiting Magnitudes of Visual Telescopes" mimeographed, unpublished.

12. Sidgewick, Id., p.30.

13. 8.8 + 5 Log A of James G. Baker or 9.1 + 5 Log D of Sidgewick both predict faintness of visible stars by comparing the area of a telescope lens to that of the fully open eye.

14. T. W. Webb, Id., p. 18.

15. "Sky & Telescope", March, 1962, p. 168.

16. "Sky & Telescope"

17. M. A. Pirenne, Vision and the Eye, Chapman and Hill Ltd., 2d. Ed., 1967, p. 85.

18. Id., p. 92.

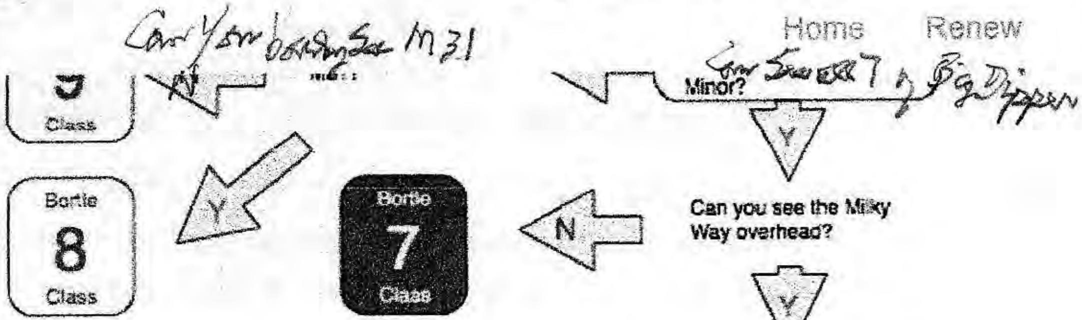
19. Sisson, "Nature", Vol. 179, p. 937 (1957).

20. Id.

21. An f50 system, or more, (which is high power) is needed to photograph what the eye can see assuming the atmosphere will remain literally "perfect" long enough to take the exposure! Sidgewick, Id.

PICKERING'S STELLAR IMAGE SCALE

1.	Very Bad:	Image usually twice diameter of 3rd ring.
2.	Very Bad:	Image occasionally diameter of 3rd ring.
3.	Very Bad:	Image about the same as 3rd ring.
4.	Poor:	Disks often visible; arc of signs sometimes seen around brighter stars.
5.	Poor:	Disks always visible; arc of signs frequently around brighter stars.
6.	Good:	Disk always visible; short arcs constantly seen.
7.	Good:	Disk sometimes sharp; rings either long arcs or complete.
8.	Excellent:	Disk always sharp; rings as in #7 but all in motion.
9.	Excellent:	As #8, but inner ring stationary and outer rings occasionally stationary.
10.	Excellent:	Disk sharp; rings stationary; detail between rings may be moving, but at best no detail is visible.



The Bortle Dark-Sky Scale

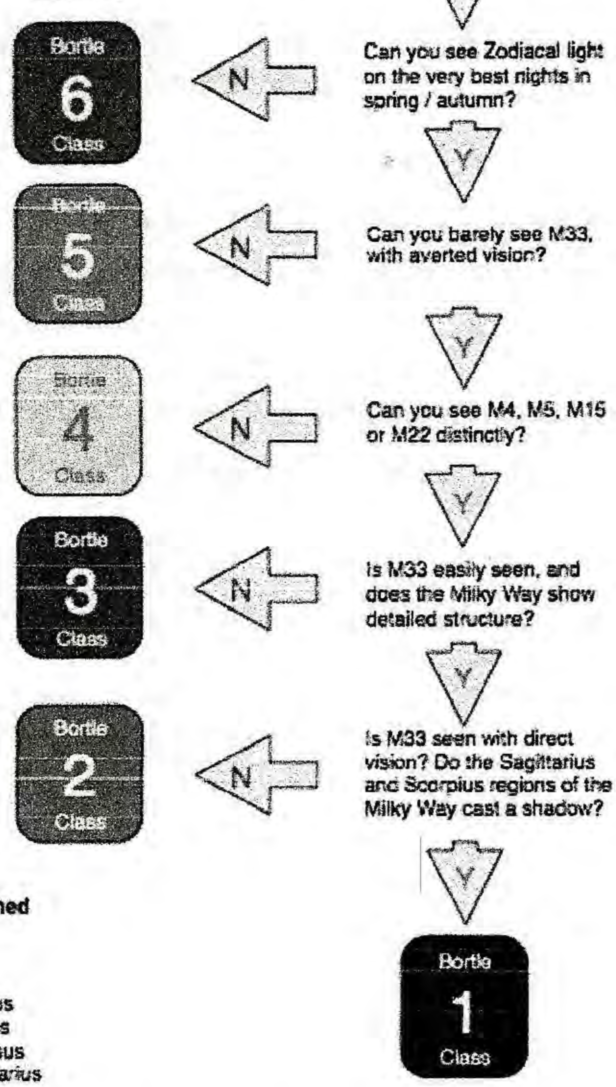
The Bortle Dark-Sky Scale is a nine-level numeric scale that measures the night sky's brightness at a particular location.

It quantifies the astronomical observability of celestial objects and the interference caused by light pollution and skyglow.

John E. Bortle created the scale and published it in the February 2001 edition of Sky & Telescope magazine to help amateur astronomers compare the darkness of observing sites.

The scale ranges from Class 1, the darkest skies available on Earth, through Class 9, inner-city skies.

The colors in each box roughly correspond to the World Atlas of Artificial Night Sky Brightness and are provided as a guide only.



Astronomical Objects Mentioned

M31, the Andromeda Galaxy
M33, the Triangulum Galaxy
M4, a globular cluster in Scorpius
M5, a globular cluster in Serpens
M15, a globular cluster in Pegasus
M22, a globular cluster in Sagittarius

Have little to no experience stargazing? No problem. Visit Sky and Telescope's article "How to Start Right in Astronomy" to learn more about picking up amateur astronomy skills.

Also see Sky & Telescope's easy guides "Getting Started in Astronomy" for the northern and southern hemispheres for star maps and other information on how to proceed.

We also recommend looking for advice and help from local amateur astronomers. Find local astronomy clubs near you hosted by NASA's Night Sky Network (USA only).