<u>SEEING AND TRANSPARENCY</u>

(This article, which has been expanded here, appeared as two separate articles in the Oct., 2000, issue of the Observer. *Both articles and the new material were written by* ***Bill Warren.****)*

Beginning stargazers often confuse the terms *transparency* and *seeing*. **Transparency** refers to how clear the sky is, as indicated by the faintest stars you can see naked-eye. **Seeing,** on the other hand, refers to the relative *stillness* of the air, not to its clarity. The more turbulent the atmosphere, the more stars seem to twinkle.

Stars twinkle because we see them as tiny points of light, unlike the **Moon** and planets that are closer to us and thus are seen as disks that reflect sunlight. When the upper atmosphere is unsteady, moving pockets of air bend the incoming starlight slightly and momentarily, creating a twinkling effect. The Moon and planets, on the other hand, reflect enough sunlight across their disks to retain their shape. But even planets will twinkle in turbulent air when viewed near the horizon, because there's more atmosphere for their light to pass through than when the planet is high in the sky.

Seeing. At any rate, seeing is important because it affects the quality of the images we receive. Under unsteady observing conditions, images flicker or blur and much fine detail is lost. In viewing, say, **Jupiter**, by telescope under poor seeing conditions, you may see its dark belts and light zones appearing to move in and out of focus, or even to disappear entirely for seconds at a time, as the planet's light is bent by the moving air.

Many of the A. L.'s observing programs ask participants to rate the evening's seeing conditions. To do so, select a bright star that is fairly high in the sky and take it slightly out of focus, producing a ball-like image with spikes of light projecting outward on all sides. Then use the **Antoniadi seeing scale** to rate the amount of flickering or dancing among those spikes on a 1-to-5 basis:

1. Perfect steadiness, no quivering of the out-of-focus image;
2. Slight quivering, with moments of calm lasting for several seconds;
3. Moderate quivering, with larger air tremors;
4. Constant, troublesome quivering; or

5. Severe quivering in which images fairly dance across the field of view render detailed observing impossible.

If that scale is unclear or confusing – well, you'll soon get used to it if you use it every time you observe. But you can also think of the old high school "A-B-C-D-F" grading scale and use the corresponding numbers 1-2-3-4-5 to grade image clarity as *excellent* (1, or "A"), *very good* (2, or "B"), *average*, or *good* (3, or "C"), *below average* (4, or "D"), or *failing* (5, or "F").

It isn't necessary to have pinpoint accuracy here, either: it's perfectly acceptable, for example, to describe fairly good seeing conditions as "2-3" and fairly poor seeing conditions as "3-4". Or, when in doubt as to whether to give an evening a seeing rating of "3" or "4", you might skip the intermediate (3-4) rating and give it the number that indicates poorer seeing – in this case, "4". The lower rating will help to explain why you didn't see more detail in whatever you observed that night.

Remember, though, that seeing conditions can change dramatically over the course of a single evening of observing – and when that happens, you need to re-calculate the seeing as described earlier. When conditions worsen, you'll find yourself seeing progressively less detail in what you observe – and the fainter the object, the less you'll see. On nights of really bad seeing, you probably won't see face-on galaxies at all unless, like **M51 (Whirlpool Galaxy)**, they have bright, compact cores; everything else in the galaxy will more or less blend into the surrounding background.

Transparency. The clarity of the night sky is expressed in terms of the magnitude (brightness) of the faintest star you can see naked-eye, whether directly or by using averted vision.

Transparency is primarily affected by two factors: (a) solid particles in the air such as water vapor (e.g., clouds, haze, ground fog), smoke, dust, pollen or any form of industrial or vehicular air pollution; and (b) the amount of light present, whether natural (e.g., moonlight or sunlight) or artificial (e.g., urban sky glow or nearby streetlights, security lights or lights from traffic) that bleaches out all or part of the night sky. The clearer the sky, the fainter stars you'll be able to see.

When we began observing at Cox Field in 1997, it wasn't at all uncommon for us to experience wintry evenings when mag. 6 stars were relatively easy to identify naked-eye. Unfortunately, Pike Co.'s low tax base has lured businesses and residents in droves since then, and the optimal transparency at Cox Field has dropped accordingly -- about half a magnitude. Nowadays, evenings of 5.8 transparency are rare at Cox Field even in wintertime, and the presence of naked-eye 5.5 mag. stars indicates a *very* clear night.

One of the many excellent features of *Seasonal Star Charts* (also sold as *Celestron Star Maps* and *Meade Star Maps*) is that the charts, which show the locations of all stars of mag. 6 or brighter, also list the magnitudes besides the stars, with half-magnitudes indicated by a line under the mag. number (e.g., <u>4</u> for mag. 4.5). Like other star atlases, *SSC* also indicates relative brightnesses by the size of the circles representing the stars, but placing the numbers by the stars simplifies the process of determining how bright a star is to within ½ magnitude.

Measuring Star Brightness. The brightness of stars is measured in *magnitudes*, with each magnitude equaling 2.5 times the brightness of a star that is exactly one magnitude fainter.

Arcturus (Alpha Bootis), the 4th-brightest star in the sky (except for the **Sun),** is mag. 0. Arcturus is 2.5 times brighter than a mag. 1 star and 2.5 times fainter than a mag. -1 star would be. A mag. 2 star is 6.25 times fainter than Arcturus (2.5 x 2.5), and a mag. 3 star is 15 times fainter (2.5 x 2.5 x 2.5).

The full **Moon** is about mag. -11 in brightness, and the **Sun** is something like mag. -28. (That means multiplying 2.5 by itself **27** times. Your hand computer isn't likely to do that.)

One final point about star magnitudes: They refer to a star's *apparent* brightness (i.e., its brightness relative to us), and not to its *absolute*, or actual, brightness. **Betelgeuse (Alpha Orionis),** the 11th-brightest star and a massive red giant, is more than 1,000 times larger than our Sun and 60,000 times brighter, yet we see Betelgeuse as a tiny point of light in the night sky because it is located 310 light-years from Earth. Thus, its apparent magnitude of 0.7.

Determining Transparency. The term *limiting magnitude* refers to the limit beyond which you cannot see stars via naked-eye, whether by direct or averted vision. For most of us, the limit is somewhere between 5.5 and 6.5 under ideal conditions.

There have been notable exceptions, however. Back in the '50s, **Walter (Scotty) Huston** reported seeing mag. 8 stars under the very dark skies of Arizona; and the late **Leslie Peltier,** who is generally regarded as the greatest American visual observer of all time, once counted 14 stars in the **Pleiades** – and in New England, no less**!**

One of the best constellations to use in determining transparency and the limiting magnitude under which you're observing is the summer constellation *Corona Borealis* (the "Northern Crown"), lying between *Hercules* to the E and *Bootes* to the W.

Look at CrB on the *SSC* chart on p. 11: there are 7 stars comprising the semicircular crown. One star is mag. 2, one is mag. 3, three are mag. 4, one is mag. 4.5, and one is mag. 5.

Now find CrB in the night sky. How many stars can you see? If you can see all of them, the sky's transparency is 5 or higher; if you can see 6 stars, the transparency is 4.5. (**Delta CrB** is mag. 4.5.) If you can see just 5 stars in the crown, the transparency is 4. The presence of only 2 stars indicates a transparency of 3, and one star (mag. 2 **Gemma**, or **Alpha CrB**) means that you won't be finding much of anything that night.

You can use the same process with any constellation in any season, or even part of a constellation. (I use the Great Square of *Pegasus* in the fall to determine limiting magnitudes, Orion and his shield in the winter, and the Big Dipper in the spring.) Just use *SSC* to find an area that contains a broad range of stars of varying brightnesses in a fairly small area of sky. Find the faintest star you can see in that area by averted vision, and then find it on the appropriate chart in *SSC*. That star represents the limiting magnitude of stars you can use in finding objects in the sky without a finderscope.

A final reminder about transparency: most of the A. L. observing clubs recommend (but don't require) that you record transparency. Check the requirements for whichever program(s) you're working on; if transparency isn't required, whether you list it or not is strictly up to you.

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