MYTHS AND LEGENDS ABOUT TELESCOPE PERFORMANCE by Dick Suiter

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There is a lot of folk-wisdom associated with telescope use. Here are some examples.

Myth #1: Short telescopes are best for dim deep-sky objects; long telescopes are best for planetary or other high-resolution viewing.

This is a complete falsehood. It probably originates because people think that their eyepieces should behave identically in all telescopes. The source of confusion with the long telescopes is the constriction of the focuser tube and the unavailability of the really long focal length eyepieces they need to work at low power. I once got some of my best deep-sky views through a 32-inch f/17.5 Cassegrain. It had an eyepiece that yielded an exit pupil somewhere just under 8 mm. That's an eyepiece of focal length around 140 mm. It was, I think, a Kellner with a field lens 5 inches in diameter. This eyepiece weighed somewhere between 10 and 15 pounds! It took two people to remove it because of its inconvenient position in an eyepiece turret.

For the more common Schmidt-Cassegrains, a reasonably large 5-mm exit pupil is provided by a 50-mm eyepiece. Although these are rare, they are available. A richest-field 7 mm would demand 70 mm, but then 2-inch focusers would be too small for the covered field. An f/12 achromatic refractor is even worse, demanding eyepieces at 60 mm and 84 mm respectively, and the problem with the focuser is again made more troublesome by the prevalence of 1¼-in focusers on these generally smaller instruments. The size of the focuser is ruled by the focal ratio, but most manufacturers think it looks nicest at some optimum fraction of the objective. A 60mm f/12 instrument still needs a focuser at least 2 inches across, but the resulting "square" appearance of the telescope tube is thought by the manufacturer to ruin the spyglass look. The really top-end apochromats don't let appearance spoil performance; they are about the same size on both ends.

Myth #2: Obstructions, because of diffraction, brighten the field of view.

This got started, I believe, from publications of lunar and planetary observers in the late 1950s. The obstruction scatters light from the Airy disk, true, but it doesn't scatter it very far. The effect of obstruction resembles broad-scale aberration more than scattering. The problem is that a further calculation used an antiquated form of the contrast that did not mention spatial frequency, or the fineness scale of the imagery. When people read this account of the so-called reduction of contrast, they used their imaginations. What most people think is a reduction of contrast is an overall scene change, kind of like turning the TV knob.

In reality, obstruction does its primary damage to resolution, not background brightness. It can be shown using more sophisticated analysis that an 8-inch with 2-inch obstruction (if that is the only thing wrong with it) has equal or superior contrast *at all spatial frequencies* to an unobstructed 6-inch. Now that is not to say that the 8-inch does not have a brighter background. It probably is a reflector, which tends to be baffled halfheartedly. It also has a spider and is probably not overly clean. But diagonal diffraction is *not* responsible for the brighter field.

Myth #3: Telescopes with aberrations greater that about a quarter wave or with a Strehl ratio less than 0.8 are unacceptable.

This rule works more for small telescopes than large ones. Large telescopes have been made with amounts of aberration that would be horrible for little ones. For example, the great Yerkes 40-inch refractor has truly profound secondary chromatic aberration. Yet it works and works fine. Why? It's simply because the atmosphere seldom allows anything as small as the Airy disk of a meter of aperture to be seen. Even bigger telescopes have less of a requirement to be perfect. Often, the specification for big telescopes are so-called "encircled energy" requirements. The buyers are satisfied if, say, 80% the energy is within 0.3 arcseconds, 97% is within 2 arcseconds, , 99.5% at some greater radius, and so forth.

Myth #4: The more complicated the eyepiece, the better.

Complicated eyepieces are designed to do special jobs. For example, some of them are designed to work with a primary having a fast f/number, or provide a wider field of view, or give larger eye relief. But if you are using a slow focal-ratio telescope and are willing to accept a smaller apparent field, you can often get profoundly good views from less elaborate eyepieces. The fewer surface that can be messed up, the better.

There is a recent retro trend in eyepieces, with TMB Optical producing a monocentric design. It's sort of like one car manufacturer deciding that next year's hot design will be horse-drawn carriages. But it makes sense for the relatively slow apos sold by TMB. Monocentrics have no internal air-to-glass surfaces.

Myth #5: The human-eye's entrance pupil is 7 mm.

It starts, when you are young, at about 8 mm. It then degrades until you are very old, where it stops at about 5 mm. The reason it is given as 7 mm is because the military measured some fairly young eyes and decided that 7 mm is about the best exit pupil to use for "night" binoculars.

Myth #6: Any scattering at all is unacceptable in optics.

Many people subscribe to the theory that refractors are better than reflectors because their surfaces scatter less light. Their logic is something like the following:

- Clearly, the average refractor gives a darker field than the average reflector.
- Refractors have been shown to have smoother surfaces than reflectors.
- Therefore, the darker field results from this smoothness causing less scattering.

A variation of the above argument is made for the obstruction myth (#2), but neither have any validity because the number of variables in the situation.

In fact, any visual use of an instrument is profoundly dominated by scattering within the eye itself. When you are a young person, about 10 percent of the light that enters your eye is scattered to bounce around before it hits the retina. Scattered light fogs the view. Of course, the eye has learned processing tricks to reduce the effect of such scattering, and it works for a while. But by the time you are old, the fraction elevates to 50% or beyond and the tricks are no longer as effective. When old folks start stumbling over the furniture, they are declared to have cataracts and the problem is viewed as something requiring clinical help. However, much of the increased scattering happened long before it got to the place where it required medical action.

A reflective wavefront might, if it is *really* rough, have a root-mean-square micro-roughness of 5 nm. No self-respecting optician would release such a mirror but, for the example, let's assume it exists. The amount of scatter is $(2\pi\ 5\text{nm}/550\text{nm})^2 = 0.0032 = 0.3\%$. Now compare that with the scattering inside of your own eye, which for people approaching middle age might be 20%. The scattering from the mirror surface is tiny. How are you going to tell the difference between 20.3% and, say, 20.1%. You can't.

The real problem with veiling glare in telescopes of any type is almost entirely a function of baffling, and refractors are easier to baffle. The thing that people are complaining about with baffling is more than the small error caused by surface roughness. They don't seal their telescopes efficiently. It's like someone complaining that his house insulation is poor when he leaves the door open all winter.

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Basically, all of this mythmaking depends on the plausibility of the blamed cause. It makes perfect sense that obstructions, since they are in the way, would cause some sort of damage, but the diffraction calculations of the precise effects are difficult. That's when the hand-waving arms come out. It also makes sense to blame scattering off the mirrors when you see the superiority of a refractor, but this neglects the infrequent counterexample that kills the whole argument. Occasionally, you see a tri-schiefspiegler that gives beautiful dark backgrounds – and it has three mirrors, not two!

People use myths to explain things if they don't know why or how they work. Myths propagate by repetition. One person seizes on an explanation – probably the first thing he or she thought of – and tells a few buddies. The expanded group tells it to their friends. Soon a newcomer gets the same explanation from a number of people, not realizing that it is traceable to the same source.

How do you tell a myth from the real thing? Unless you know some optics, there isn't really much you can do. Generally, the mythmakers are smooth talkers. They seldom use numbers, but occasionally even this rule is broken. Much of the fifty-year confusion of the obstruction myth above was caused by defective calculations. I guess if I had to pick out one characteristic of mythmakers that should put you on your guard, it is *stridency*. Mythmakers are out to convert the unfaithful. They are insulted that you don't immediately embrace their views.