REFRACTOR RED MEETS THE HERSCHEL 400

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Seduced by exquisite optics and compact size, I bought a used Vixen 55 mm f/8 refractor, whose objective used the optical material fluorite, in April, 1998. To replace by attitude what it lacked in size, I repainted the tube, and named the telescope Refractor Red, for its new, fluorescent color. I mounted it on an altazimuth mounting from an 80 mm refractor, then set out in pursuit of all the Messier objects. I anticipated the search would not be difficult, for three of my previous Messier surveys had been with less aperture. So I decided to try something harder, too -- the Astronomical League's "Herschel 400" list. That modern selection from the brighter objects discovered by Sir William Herschel, would be challenging.

I had seen them before. I have made some eleven thousand visual observations of nearly five thousand objects, mostly faint fuzzies. For such work, aperture wins: My favorite telescope, a Celestron 14-inch Schmidt-Cassegrain, is as large as my subcompact car will hold. Yet I like little telescopes, as well. Ask folks who land huge fish with light tackle, why I do what I do. I also like to remind people how to use a tiny telescope for serious deep-sky observing. Much small equipment lies unused because its owners think it takes a six-inch aperture even to see the Messier objects. It isn't so. It never was.

Technique is the heart of using minimal equipment successfully. The tricks that help me find faint objects are well-known. They can be memorized in minutes, and practiced enough to be useful in a few nights. Yet it took me embarrassingly long to learn to apply them systematically and with confidence, singly and in combination, according to conditions. My audacious little fluorite offered an opportunity to test my skills.

As summer approached, the Virgo galaxy cloud was sinking into twilight. I hurried to observe its many Herschel-400 objects before they vanished, but rarely had time to travel beyond my yard. With lots of trees and widespread full-cutoff lighting, Palo Alto, California, has darker sky than most suburbs, yet lies in the San Francisco metropolitan area. From my driveway, with patience, full dark adaptation, and excellent transparency, I sometimes detect stars of visual magnitude 5.3 near the zenith, but the light walls of cities northwest and south make conditions rapidly much worse nearer the horizon. Could my tiny telescope plumb the deep sky from such a site?

Fortunately, most galaxies have bright centers. High magnification

darkens the sky without dimming them to invisibility, and against black sky, they appear more prominent. After trial and error, I found myself using a 12 mm Brandon eyepiece, providing 37x and a 1.5 mm exit pupil. Different skies or different eyes might require another. That is three to five times as much magnification as many older sources recommend for deep-sky work. The view was not quite as good as from remote sites, but for detecting most galaxies, the tiny telescope gave up gratifyingly little to city lights.

For example, a line of galaxies called Markarian's Chain zig-zags from Messier 84 and 86, in the heart of the Virgo cloud, north and east to M88. From a fairly dark hilltop site in the San Francisco Peninsula, Refractor Red showed six of its first seven members, namely NGC 4435, 4438, 4458, 4461, 4473 and 4477. These were quite challenging -- only four are in the Herschel 400. Yet I could suspect several of them from my yard.

I would not have known the faint stuff was there without averted vision. The part of the retina that best detects detail does a poor job seeing faint objects. They are best viewed when you are not looking straight at them. What works for me, is to center the location I am examining in the eyepiece, then fix my gaze off to the side, about half way to the edge of the field. Though this technique is well-known, many observers forget to use it, particularly when examining relatively bright targets for fainter, outlying detail.

Central Virgo provided a fine object lesson about averted vision. M84 and M86 form one side of a south-pointing equilateral triangle, with a fainter galaxy, NGC 4388, at its southern tip. A still dimmer one, little NGC 4387, lies centered within it. With Refractor Red at 37x, from a reasonably dark site, the two Messier galaxies were easy with direct vision. NGC 4388 was harder, and I needed averted vision to detect NGC 4387. This simple pattern of galaxies that have quite different brightnesses, makes a good test for detectability of faint objects in small apertures.

It also introduces some other tricks: With averted vision, I fix my gaze on one part of the field, and concentrate on another. Then I must wait for the right combination of involuntary eye movements, momentarily steady seeing, and who knows what other physiological, optical, and meteorological effects, to provide the best chance of detecting the object. That can take a while -- I have sometimes stared for tens of minutes before becoming confident that I was actually seeing what I suspected was there. Thus patience and persistence are key parts of the deep-sky observer's repertoire. Furthermore, accurate positions and good star charts are vital, if all that patience is not to be wasted

looking at the wrong place.

For my Refractor Red Herschel-400 survey, I used Sky Publishing's _Millennium_Star_Atlas_. Its limiting stellar magnitude of about 11 means that any star I can easily see in Refractor Red is charted, and that there are enough charted stars for me easily to point the telescope at any object I cannot see, anywhere in the sky. It is also novel to have a star atlas that outweighs my telescope. I kept my old Norton's _Star_Atlas_ handy, too, for general orientation, and used a planisphere to anticipate what constellations would be well placed on a given night and hour.

Seeking nearly undetectable objects at precisely known positions makes it easy to be fooled into thinking I see something when I actually don't. Even with sincere attempts at honesty, visual illusions are deceptive: An observer who pushes the outer limits of perception must beware of them. For my survey with Refractor Red, double-checking with larger aperture was no help, for no object's existence was in doubt. Sometimes I confirmed a difficult observation by noting details -- perhaps the direction of elongation of a faint spiral galaxy seen obliquely. When other observers were present, I sometimes showed them what I was looking at, and generally managed to talk them through the same tricks I was using, to make the detection. Occasionally I compared notes with observers who had made observations with similar telescopes -- common results at least demonstrated that I had company in my errors!

Yet my easiest way to verify what I had seen was to be persistent: Conditions varied from night to night and place to place, and it was rare that a few more tries did not turn up circumstances in which an observation became easier and much more convincing. For example, the first time I looked for planetary nebula NGC 6781, in Aquila, was a poor night: I could barely see it. A few evenings later, better conditions made it much easier.

Other techniques helped me observe from suburbia. I took plenty of time to dark-adapt, and covered my eyepiece eye when I moved through illumination from street lights or windows. I learned which corners of my yard best viewed what parts of the sky, with least exposure to artificial illumination. To improve dark adaptation, I regularly closed both eyes for a few minutes, then cupped my eye with my hands and fumbled my way to the eyepiece with it still shut. Occasionally I hyperventilated while waiting. Sometimes when I opened my observing eye, I found the object I was seeking dimly revealed for a few seconds, after which it slowly faded from sight, as light pollution leaked through my fingers and reduced the sensitivity of my vision.

As word of my project got around, curious fellow observers asked whether I had tried their favorite difficult Herschel-400 targets. I kept hearing about NGC 6118 and NGC 6540. The former is an obliquely viewed low surface brightness spiral galaxy in eastern Serpens Caput, the latter a little cluster in Sagittarius. One June night, I looked for both from Fremont Peak State Park, a popular observing site near San Juan Bautista, California.

Uncommonly good transparency and an incomplete fog layer on the coastal plain below made the high sky quite dark. The North American Nebula was easy with the naked eye: I could detect the "Gulf of Mexico" within it. I looked for NGC 6118 with two eyepieces, alternating between my 12 mm Brandon and a 20 mm Meade Research Grade Erfle, which gave 22x and a 2.5 mm exit pupil.

With each eyepiece, I saw a faint, diffuse, and not very centrally concentrated glow, popping in and out at the limit of averted vision, at the charted position. Jiggling the telescope, or moving it slightly with the slow motions, helped a bit. The glow was detectable only ten or twenty percent of the time, but it kept reappearing at the same place. Since I did not see similar fluctuations of intensity at random places in the field, I logged it. That was the toughest object in my Herschel-400 survey with Refractor Red. Its difficulty might stem from not having nearly as large or bright a center as most other galaxies. A bright core seems to draw the eye, and to give the brain a reference point for locating the fainter, outer periphery of the object.

Since I had an equally good view at 22x and 37x, I suspect that a magnification between those values might have best suited NGC 6118 that night. Unfortunately, I had not brought a suitable eyepiece.

Herschel described NGC 6540 as a faint, sparse, relatively small open cluster, yet what _Millennium_Star_Atlas_ plots is a ten arc-minute globular. Using the 12 mm Brandon, I saw a six or seven arc-minute unresolved circular glow, just barely brighter than the background of the Sagittarius Milky Way, with a smaller, brighter core superimposed. The core was one or two arc-minutes in diameter, was unresolved, and did not appear to have diffuse edges. The entire apparition was dead on the atlas position for NGC 6540, and was easier than NGC 6118.

The large patch was what one might expect of an unresolved, highly obscured, globular cluster. The small core might have been an association of its brighter members, or a foreground open cluster, or a chance micro-asterism of unrelated stars.

Most objects were much less difficult, and some were easy. The

northern Milky Way contains many Herschel-400 open clusters that were a delight with the little telescope, even from my yard and with slightly hazy sky. For example, the two members of the Double Cluster, h and chi Persei, are both on the Herschel-400 list. They are obvious even to the naked eye.

Occasionally, I needed more magnification than the 12 mm Brandon provided. Some Herschel-400 planetary nebulae were too small to appear non-stellar at 37x. To identify them, I sometimes used as much as 110x, provided by an old Meade 4 mm Orthoscopic eyepiece. That helped me find NGC 2438, hiding in Messier 46. Higher magnifications also helped to split open clusters into stars, or simply to identify them, when the background sky was bright: I went through many open clusters in the Milky Way south and east of Orion from a dark hilltop site one chilly night. I was more interested in getting home where it was warm, than in lingering, so I worked within several degrees of the southeastern horizon, capturing clusters not long after they rose.

I finished the Messier part of my program in September, logging all 109 objects from my yard in Palo Alto. I completed my Herschel 400 survey in November, staying up late enough one night to view Leo and Hydra as they rose. Yet the last object, NGC 2985 in Ursa Major, was an anticlimax: It is relatively bright, and lay high in the sky. So I celebrated by dropping in my 4 mm eyepiece to look at the heart of the Orion Nebula. I was rewarded by a tantalizing and barely real glimpse of the E and F stars in the Trapezium. I had seen them before, but not with less aperture than 90 mm. Refractor Red is indeed a wonderful telescope.

Thus with occasional access to dark sky, and frequent use of a large bag of tricks, even a tiny refractor can do lots of challenging and interesting deep-sky observation. Small telescopes as exquisite as my 55 mm Vixen fluorite are scarce. Yet a half-way decent example of the ubiquitous 60 mm beginner refractor gathers more light, and should do at least as well with faint objects, all for less cost and hassle than with larger equipment. The observer who pushes such a program to completion will have fun, and will acquire skills that transfer immediately to larger apertures, where they will show things many big-telescope owners do not think possible to see.