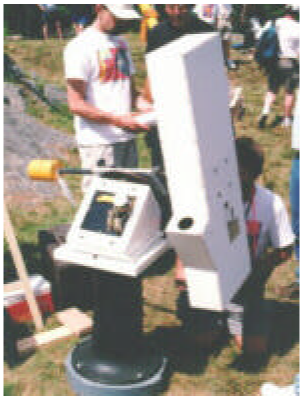
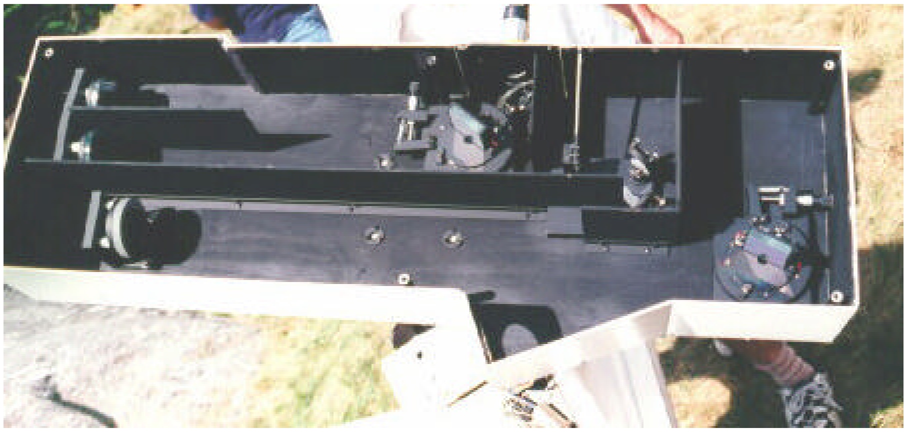


Construction Of A Dual Grating Prominence Telescope

Contributed by Michael Hill from the ATM Pages

Although the title indicates that this instrument is a prominence telescope, it can in fact be thought of also as a spectroheliosc ope and a spectroscope. It was originally built as a prominence telescope to show those fiery protuberances on the edge of the sun that seem to be in the domain of only professional astronomers. This is in fact quite untrue and these features are fairly easily visible through my instrument. Prominences on the surface of the sun when seen from above look quite different, however, and as such are called filaments instead. This is because they appear as dark sinuous strands arching across the solar surface. It turned out, after completing the prominence telescope that these features, as well as others on the solar disk could be seen quite easily and therefore the instrument in this light could be considered a spectroheliosc ope. Note however that true spectroheliosc opes show a full disk image of the sun whereas this instrument unfortunately **does not**. Lastly, if the first grating is used in the so called zero spectral order, behaving simply as a mirror, the instrument becomes a very powerful spectroscope with great dispersion and spectral resolution.

This instrument was based on an article in *Scientific American*, March 1974. I urge you to get a copy of this from a library (you may have to visit a college library which is perfectly acceptable even if you don't actually go there.) I will not be attempting to fully describe the conceptual details of this instrument. This is done quite adequately in the article. Instead this is a description of my version of the instrument component by component as well as additional notes to impart to you the lessons I learned along the way which, should you embark on this project, will certainly be of assistance. I am going to assume you have some knowledge of diffraction gratings and the solar spectrum in the use of terms I will use. To get familiar with these consult any book on physics and read the section on optical interference and diffraction for background which will typically lead to a discussion of diffraction gratings. For a simple easy to find treatment of the solar spectrum look up the chapter on the sun in any elementary general astronomy book.



Now onto the instrument. Using this image of the optical layout, notice that there are **two** gratings. The first acts as the input to the prominence scope and is 2" x 2" grating with 1200 lines/mm used in the second order. It is blazed for a wavelength of 500nm in the first order - a mistake on my part. I purchased my gratings (and all other optics) from Edmund Scientific, which I highly recommend to you for the best price around. They sell gratings, of the dimensions I required, blazed at a wavelength of 250nm, 400nm, 500nm and 750nm. I wasn't quite sure of all my grating theory when I ordered the gratings and I decided that 500nm was the one to use. What I didn't know yet was that the blaze wavelength of a grating becomes lower as the spectral order increases. Because I was to be using the second order in my instrument what I really needed was a 1000nm blaze wavelength. Now, unfortunately Edmund Scientific does not offer a 2" x 2" size blazed at 1000nm, so you'll have to settle for 750nm. If you know of a source for 2"x2" 1200 lines/mm blazed @ 1000nm do let me know!!

The dispersed image of the sun is collected and focused by the first mirror in the system - a 3" F/10 spherical. The light path is bent through 180 degrees before reaching its focus. The overall light path that results from this configuration is very easy to work with when it comes to building the instrument. This grating/mirror combination forms the input telescope which then feeds the heart of the instrument, the spectroscope. The 3" mirror must be precisely focused on the entrance slit of the spectroscope that follows. This is best done by putting the first grating in the 0-order so you are actually focusing a full disk image of the sun on the slit. Once this is done you may rotate the grating into the desired spectral order for use.

The slit is built exactly according to the Scientific American article and works very well. I used two pieces of 0.010" shim stock for the slit jaws. **RAZOR BLADES DON'T WORK.** You need two jaws that can positively butt up against each other to set them parallel. This is done by closing the jaws lightly with the jaws just loose enough to move, then tightening them down, again - lightly. Dust will eventually get into the jaws which manifest themselves as vertical lines in the spectral image. This is somewhat unavoidable in real life so I just let it go until it starts to annoy me then, to clean the jaws, I wet a piece of folded lens paper in alcohol or acetone close the slit jaws on a corner of the paper and then gently pull it down the length of the jaws and out. One pull is all and the vertical lines will disappear. Note also that I did no prep work to the jaws, I just used edges of the shim stock as it was. They looked pretty good under a microscope so I left well enough alone.

The slit is the entrance to the spectroscope. The spectroscope consists of two spherical mirrors and a second diffraction grating. This grating must be identical to the first one and is used in the second order as well. Make sure both gratings are mounted with the lines parallel to the rotation axis of the grating holders. Both mirrors are 2-1/2" F/10 sphericals. The first mirror is precisely focused on the slit, and serves to collimate the light from the slit before reflecting it to the second grating.

As the only adjustment I have for adjusting the mirror's focal point is the 3 collimation screws in the mirror support itself, focusing the 2-1/2" mirror on one side and the 3" mirror on the other side of the slit is a bit problematic. Both must be focused but changing the focus of one mirror always effects the other. I just did it iteravely but it was cumbersome at best. I would suggest some sort of intermediate relay lens between the 3" (and first 2-1/2") mirror and the slit, capable of easy linear motion to allow focusing. This addition along with the gratings being blazed at 1000nm would make my instrument much better. Problem now for me is time and more money. I want to go onto other instruments and my resources are limited...

The second grating disperses the collimated *image of the enterance slit*. When operating as a normal spectroscope, where the full solar disk is imaged on the slit. The result of this is a spectrum, dispersed more in the second order than in the first. If the first grating is used in the first or second order, and instead a slitless spectrum of the sun is imaged on the slit, then what is being dispersed by the second grating is *once again the slit* except this time what is within the slit are overlapping dispersed images of the sun, covering a wavelength range of about 10nm. The second grating spreads these out so that an image of the sun is displayed that varies continuously in wavelength across the field of view. Since this is still collimated light the second 2-1/2" mirror serves to focus the final image of the sun to be viewed through the eyepiece.

What you see is an image of the sun crossed by Fraunhofer absorption lines. By adjusting both gratings so that the portion of the spectrum containing the H-alpha line is in the field of view, then this line will be seen crossing the sun and will be *quite a bit wider* than any other line in the spectrum; The H and K calcium lines are quite wide as well. The line is in fact wide enough so that entire proiminences are visible **within** the line. Only a portion of a given surface feature will be visible within the line, therefore you must scan the H-alpha line across the feature in order to "build up an image" in your mind. In this sense the H-alpha line is acting as window onto the solar surface. If luck prevails a filament on the surface will be parallel to the line and it may be seen in its entirety by adjusting the line to a position right over it. When you move the line to one side or the other of that portion of the solar disk, the filament will disappear from view.

One of the most exiting things I've seen is when a filament shows up just *adjacent* to the H-alpha line. What this means is that the visible wavelength of the filament has shifted slightly. What I am really detecting here is a Doppler shift of the wavelength and the reason for this is that the filament is lifting off the surface of the sun at around 500 km/sec - a quite common occurrence for filaments known in this case as disappearing filaments. Although a given filament may last on the surface of the sun for weeks, once this process begins the prominence will disappear overnight. Being able to detect this activity on the sun, with an instrument that I have built myself is indeed a satisfying observational experience

All this being said and done I must say two things:

1. Although it does provide ample views of the sun in H-alpha, I would rather have a true spectroheliscope that shows an image of the full solar disk. One built as an accessory to a stationary telescope fed by a heliostat would be wonderful because of the increased imaging potential of a telescope of this caliber. Needless to say this is the direction I am headed. I built the prominence telescope only because I ran across the design in my file cabinet and realized I had put it aside for another day some 20 years ago. I now had the time and the tools to build it and I decided that day had come.
2. As a substitute to an expensive technically involved spectoheliscope / telescope / heliostat configuration, this instrument does provide a view to the sun that is quite exiting. I think with the few changes I have mentioned an instrument such as this would be quite useful. You just have to realize its limitations and use your imagination to utilize its strengths.

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