Homebuilt medium resolution Littrow-Spectrograph

KEYHOLE Observatory

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1. General approach

I tried hard to use parts that are in the possession of amateur astronomers anyway. One of the most complicated items of any Littrow design is the chamber in front of the CCD-chip holding the adjustable folding mirror/prism. Its construction usually requires sophisticated tools and material. To avoid this effort completely I decided to make use of an already existing Off-Axis-Guider (Celestron, CA USA). Firstly it was necessary to rotate the prism 180° in its housing. Secondly the small distance ring was removed so that the prism's location would be shifted a bit closer to the optical axis. A regular telephoto lens (135 mm) was then attached to the guider's flange by means of two rather strong springs since no adapter was at hand. The CCD-Camera was screwed to the other side of the guider's housing.

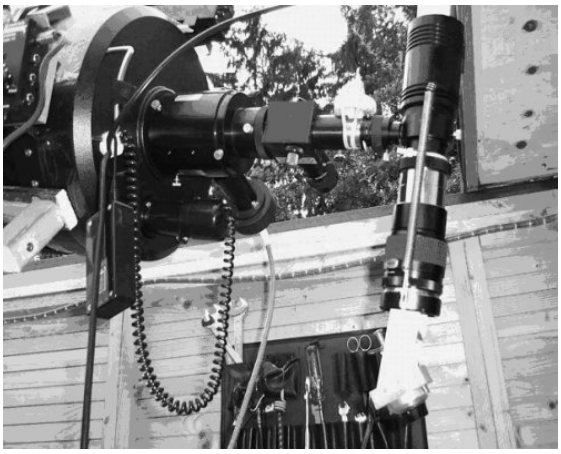


Figure 1: Spectrograph assembly attached to the C 11

2. Folding Assembly

The most troubling and critical issue during the development of my design was the fact that the space consumed by the guider's housing (i.e. the minimum distance between the CCD-chip and the photo lens) is well beyond the limitation imposed by the focal length of any regular photo lens. Finally the solution to this problem turned out to be rather simple: Just point the photo lens reverse to what you are used to! By feeding the prism's light into the front lens instead of the exit pupil the result will be more than enough space for the chamber (see Para 1). To compensate for that extra plenty of space I even had to insert an extension tube taken from a 2" eyepiece, which miraculously fitted exactly into the guider's screw cap thread.

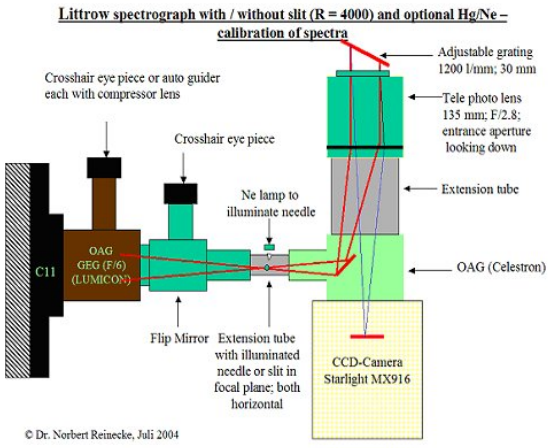


Figure 2: Schematic representation of the Littrow assembly

3. Grating

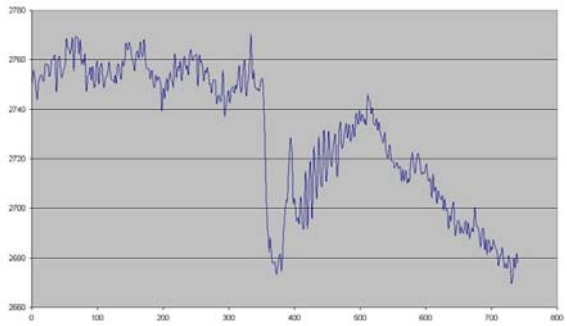
A reflecting grating (1200 grooves/mm; 30x30 mm) blazed for 1st order at 500nm was mounted at the exit side of the photo lens making use of the appropriate C-Mount's base ring as well as two pieces of aluminium. This way, only some very limited sawing and drilling was required to fit the grating to the rear side of the photo lens. One may also produce several C-mount-grating units of different dispersions and use them in a modular way thereby adapting the spectrograph's data to the type of observation in a second.

4. Sensor

My sensors are the lightweight MX916 (Starlight) or the famous ST-6 (SBIG). During operation the whole assembly is being covered by a black piece of cloth to avoid stray light since there is no housing for the sake of simplicity. The object of interest (star) will be adjusted onto the exact optical axis while looking through the flip mirror by means of a crosshair eyepiece.

5. Spectral Calibration

In case of a slitless operation the spectral calibration is done with the help of one of my wife's thin sewing needles that is located at the telescope's focal plane. The needle is being illuminated by a spectral light source (Ne/Hg) from the side (perpendicular to the optical axis) through a small slit sawed into the coupling tube between the flip mirror and the guider. This way one gets spectral lines from the calibration lamp's reflections as well as the star's spectrum correctly focused. You may observe these spectra either at the same time or alternatively - provided the star's focal point is very close to the needle's reflecting edge which is why you adjust the star's position within the field of view prior to the spectral observation (see Para 4). In case you replace the needle by a slit at the exact same location inside the tube you will get spectral calibration just by placing the lamps in front of the telescope for a second or so.



6. Elimination of Periodic Errors (…how to keep a star on the slit)

Especially if you are equipped with a low budget telescope mount you are always facing tracking errors of different sources that either smears your (slitless) spectrum or prevents the star from hitting the slit in the first place. Therefore I decided to use the Giant Easy Guider (GEG) together with the ST-4 auto guider unit in front of my spectrograph in order to compensate for all these effects including mirror shifting of my SC-telescope. As a by-product the GEG serves for the appropriate speed enhancement from F/10 up to F/5 that increases the spectral resolution greatly in case of slitless operation.

7. Example

Underneath you see telluric lines in the spectrum of Arcturus as an example of what is in reach with a spectrograph of this kind. Estimated resolution is R=4000.