Ken M. Harrison

Grating Spectroscopes and How to Use Them

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Preface

The development of the spectroscope has contributed more to the science of astronomy than any other telescope accessory. It has been said that 75% of all astronomical discoveries have been made with the spectroscope. If you've just bought, or are thinking of buying, one of the popular filter-sized transmission gratings, then this is the book for you.

The popularity of these gratings as a "first spectroscope" has been growing over the past few years, and these simple devices provide a good entry point for budding amateurs interested in astronomical spectroscopy. They are ideally suited to low resolution stellar spectral imaging.

The basic challenge facing the novice is where to start. What other equipment will you need? How do you process the CCD image? How do you analyze your first spectrum? These questions and more are addressed in this book. It provides up to date information on filter gratings and processing methods available to the amateur, and more importantly, the "how to…".

This book has been written specifically for first time users and keeps the mathematics to a minimum. Where some mathematics is necessary, a worked example or look-up table is provided. It should be possible to image your first spectra on your first night.

The low resolution and lack of an entrance slit limit the type of spectroscopy that can be done, but this should not be seen as a negative. By using the telescopes, mountings and CCD cameras currently available to the amateur, this book will show how, with the addition of a simple transmission grating, we can observe and record spectra that reveal the nature of the stars. Many amateurs have successfully obtained spectra showing the temperature, age and chemical "fingerprints" of the stars as well as recording the elements in bright nebulae and the redshift of fast receding quasars! This is the beginning of a journey into the unknown realms of amateur astronomy.

You should be excited to be among the few who will be able to record the wonders of the universe for themselves and see what stars are really made of.

As you practice and gain experience you may want to increase the resolution of your spectroscope, contribute to the ever-growing list of amateur and pro-am projects, or even construct your own spectroscope. A more complete overview of the theory, use and design of advanced amateur spectroscopes is covered in depth in the companion volume to this one, *Astronomical Spectroscopy for Amateurs*.

This is a new challenging field for amateurs. With even the most basic of equipment your activities can be interesting, thought provoking and most of all fun. Enjoy!

Wezembeek-Oppem, Belgium Ken M. Harrison

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I would like to thank in particular Christian Buil and Robin Leadbeater for all they have contributed and their continued support to many amateurs around the world.

About the Author

An avid amateur astronomer, Ken Harrison was born in Scotland where he trained as a mechanical engineer. He has been designing and building telescopes since the early 1960s and has built a series of spectroscopes for use on medium-sized amateur telescopes. He was Section Director of the Astronomical Society of Victoria, Australia, Astrophotographic Section for 10 years and past president of the society. Harrison's university thesis (and his first publication) was *Design and Construction of the Isaac Newton 98-inch Telescope* (Strathclyde University, 1970). Since then he has published articles on optical design including "*Blink Comparison*" (BAA Journal Vol87, p94) and "*Method of Radially Supporting Large Mirrors*" (Vol. 87, p. 154). He has made contributions to the Astronomical Society of Victoria Newsletter and was for 3 years the Editor of the 'N'Daba' newsletter of the Natal Centre, Astronomical Society of Southern Africa. His first book for Springer, called *Astronomical Spectroscopy for Amateurs,* published in 2010, serves as a useful companion to this volume.

Contents

Quick Start Guide

Reading manuals to get the basic instructions on how to do something is never fun, or easy. Manuals and instructions tend to be most useful when things go wrong.

However, even with a simple grating, there are things you need to know before you can succeed in recording your first spectrum. The following notes and checklist will get you started:

Equipment Needed

- A filter grating
- A DSLR camera body or webcam/CCD camera
- A telescope with a 1.25″ focuser, on a tracking mount (preferred)
- A 1.25″ T thread nosepiece to hold the grating filter
- An adaptor to fit the 1.25″ nosepiece to your camera body (DSLR will also need a T2 to camera adaptor). CCD may accept the T thread as is.

Basic Methods

With a DSLR

Set the camera to M (manual)
ISO setting to 400 or 800
Exposure time to 0.5 s

With a Webcam

Accept the default settings and target to record a video file of 5–10 s. Using the capture software screen find and focus the spectrum as per above.

With a CCD

Set up your image capture software
Use 1 × 1 binning
Start with exposures of 0.5 s

Set up the telescope and focus a bright star (Vega, Sirius, Betelgeuse, etc.). Remove the eyepiece and insert the grating/nosepiece/camera.

The distance between the grating and the CCD chip is only really important if you're using a webcam. In that case the distance should be less than 50 mm.

Look into the grating and rotate it to align the image of the CCD chip. This will allow the grating to produce the spectrum across the frame (making it easier to analyze the spectrum later).

DSLR

Check the view finder or use the live-view feature (Canon) to confirm the star is in the field of view. Focus on the star image. Look for the brightest spectrum – it should be horizontal to the frame (rotate grating if necessary); position the bright spectrum close to the centre, just keeping the star image visible. Re-focus to get the clearest image of the spectrum (this time ignore the star image).

Webcam/CCD

Take your exposure and check that the spectrum is visible; increase the exposure time if need be.

The above steps will allow you to record your first spectrum on your first night out. It doesn't come much easier than that. If things have gone according to plan, you should see some faint dark lines/marks on the spectrum. These represent the absorption lines of various elements/molecules in the star's atmosphere. Your job now is to decipher this hidden code and reveal all it can tell us about the nature of the star.

The first chapter in this book will provide you with the basic knowledge and understanding of how a grating works and how it produces the spectrum. It also

gives some insight into the basic equipment that can be used to help you collect your spectra. Chapter 2 covers in more depth the different set-up options you can use with the grating to record more detailed spectra. Recording your first spectrum is exciting. But the real excitement is yet to come….