

BAADER BACHES ECHELLE-SPEKTROGRAPH



USER MANUAL

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spectroscopy.wordpress.com

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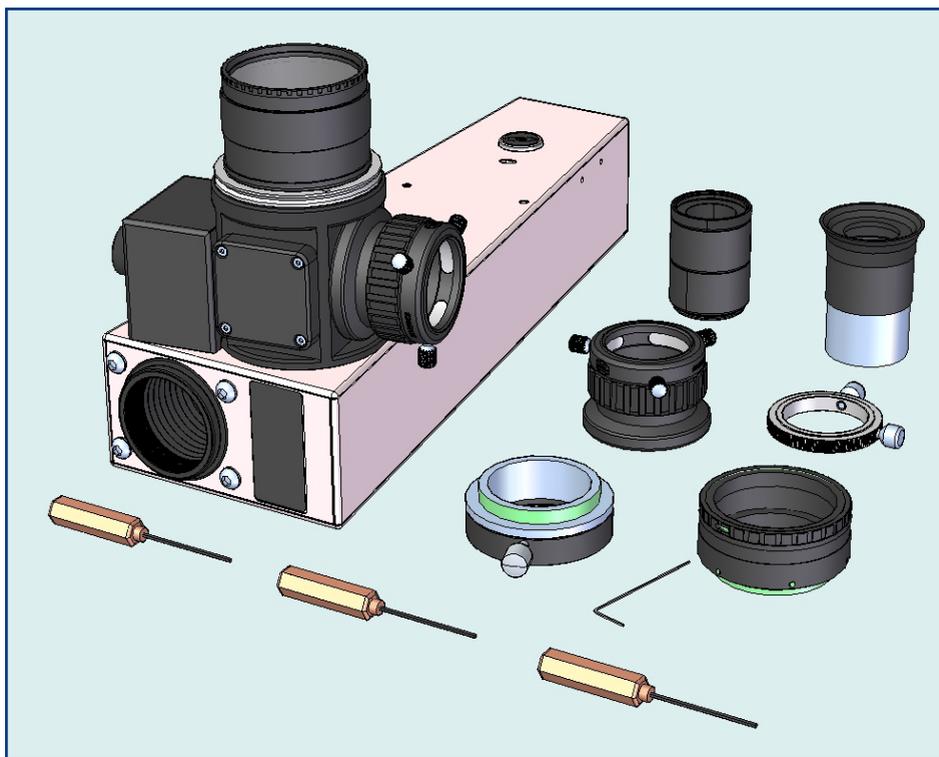
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www.baader-planetarium.de

BACHES Spectrograph

User Manual

Thank you for purchasing this Baader Planetarium product. To get the most out of your BACHES Spectrograph, please read this instruction manual thoroughly before starting to work with the spectrograph. Keep this User's Manual available for future reference and visit the Baader Planetarium website: <http://www.baader-planetarium.de> for up-to-date information about the product.



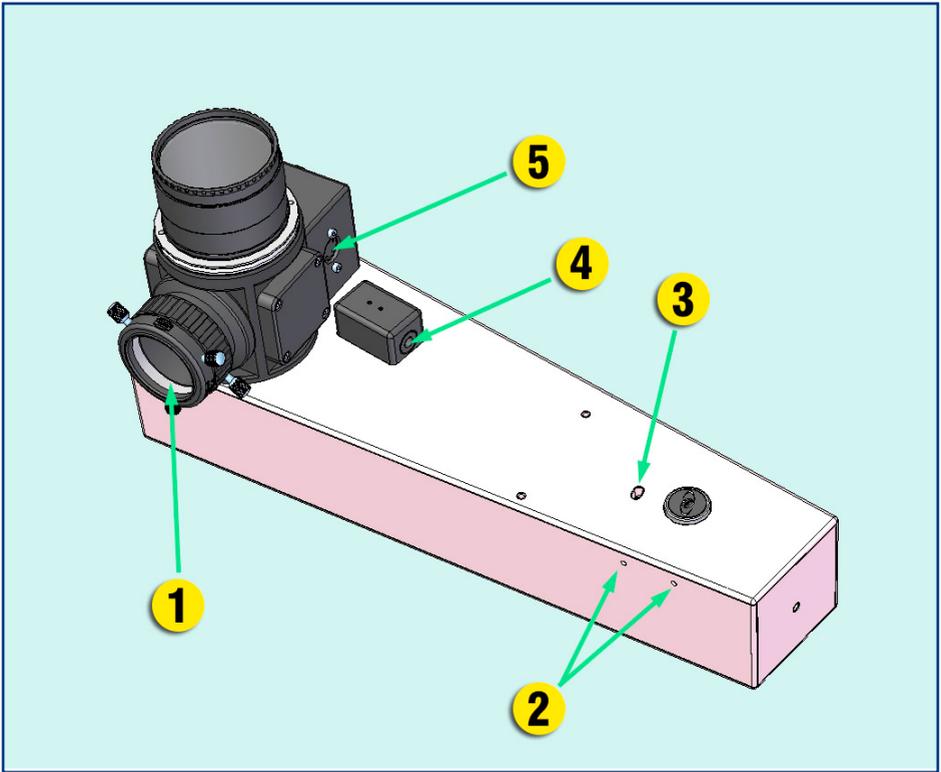
Unpacking

As you unpack the spectrograph, check the list below and make sure that all items shown above are included. If anything is missing, contact your original retailer.

Packing list for the standard model

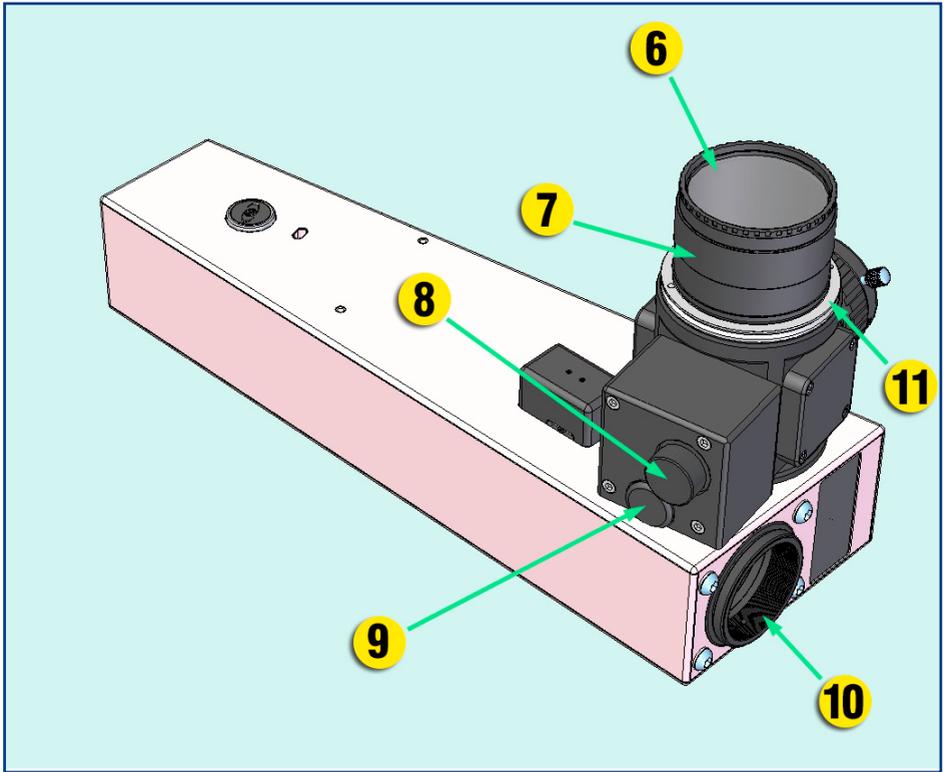
- BACHES spectrograph
- T2 Quick Changer (#2456313A)
- Eyepiece 20mm (#1304120)
- Adjustable eyepiece holder (#2458125)
- Allen Wrench 2.5 mm
- Allen Wrench 2.0 mm
- Allen Wrench 1.5 mm
- Allen Wrench 1.3 mm

- VariLock Extension (#2956929)
- 1 ¼" Stop ring (#1905131)
- Slit Viewer Assembly. (Guiding lens with M28.8-thread)
- Cotton gloves for handling the BACHES
- Wooden stick for changing the slit
- Watertight, shock-resistant ABS flight-case with machined compartments to ensure maximum transport safety
- Manual



Part description

1. 1 ¼" Slit viewer port
2. Screws for spectrum lateral adjustment
3. Screw for spectrum vertical adjustment
4. Screw for focusing the spectrum
5. Calibration power port



Part description

6. 2" Clear Filter
7. 2" Nosepiece
8. Calibration mirror manual positioning knob
9. Slit illuminator switch
10. T-2 port
11. Hardened steel adapter M55x1 to 2" thread with 58mm V-groove for use with any GAM-design.

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1 Introduction

BACHES is a light-weight, medium resolution échelle spectrograph for observation of bright objects with 20cm to 50cm aperture telescope. It is easy to use, robust, versatile, and also works as a stand-alone instrument for solar or terrestrial spectroscopy.

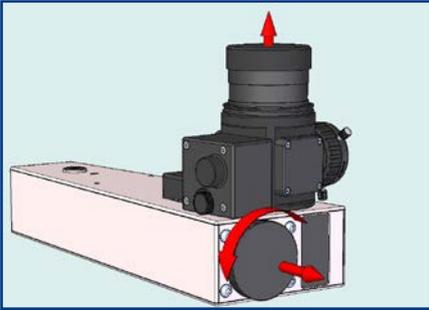
“BACHES” is an acronym for **BA**sic **éCHE**lle **S**pectrograph.

BACHES’ main features are:

- Spectral range: from 392nm to 800nm. Range depends on CCD detector size.
- Two interchangeable slits: 25 μ m or 50 μ m, each 130 μ m long.
- Spectral average resolving power ($R = \lambda/\Delta\lambda$) of 18,000 (25 μ m slit) and 10,000 (50 μ m slit).
- Compact and lightweight: only 1350g without camera.
- High mechanical stability: <9 μ m spectrum shift on detector for worst telescope position (test with SBIG ST-1603ME)
- Optimized for CCD with size of 15mm x 10mm, 9 μ m pixel size (e.g. KAF-1603).
- DSLR cameras can be used.
- Optimized for telescopes 8”-24” with f/10 aperture.
- Factory tested and aligned.
- Included red LED provides back slit illumination for easy slit identification.
- Ready to accept either of two optional calibration setups. More information about the calibration options is in Appendix D.

2 Quick Setup

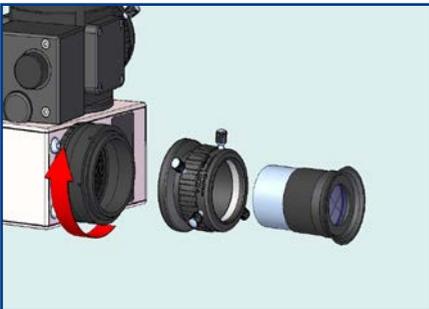
2.1 Installing an eyepiece for direct observation



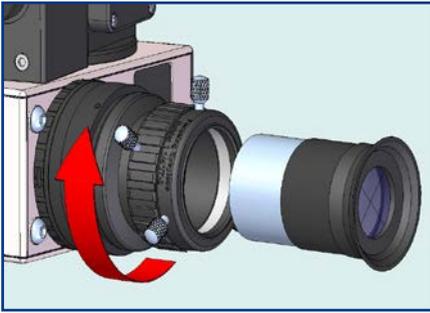
Remove the cap from the 2" nosepiece. Remove dust-cap from the T-2 port of BACHES by rotating it counter-clockwise.



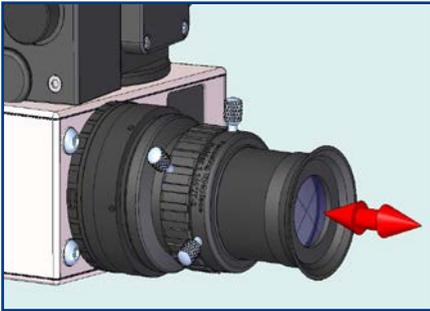
Select the Baader VariLock extension, the 1¼" eyepiece adjustable holder and the 20mm eyepiece.



Screw the Baader VariLock extension to the T-2 port of BACHES.

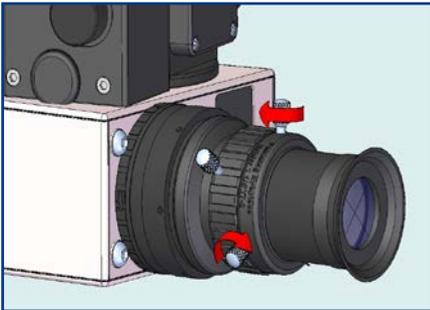


Screw the 1¼" adjustable holder to the Baader VariLock extension.

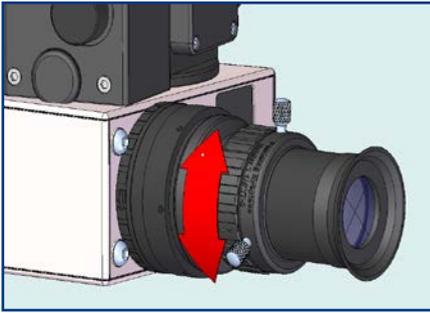


Insert the 20mm eyepiece into the 1¼" adjustable holder. Point the 2" nosepiece at a bright light source, preferably a fluorescent lamp. Focus by sliding the eyepiece in and out.

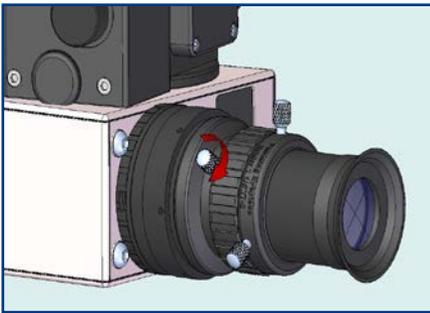
2.2 Focusing the spectrum



Lock the eyepiece with the three lock screws when you reach a rough focus position.



Rotate the focusing $1\frac{1}{4}$ " adjustable holder for fine focus adjustments while BACHES 2" nosepiece is aimed at the light source.



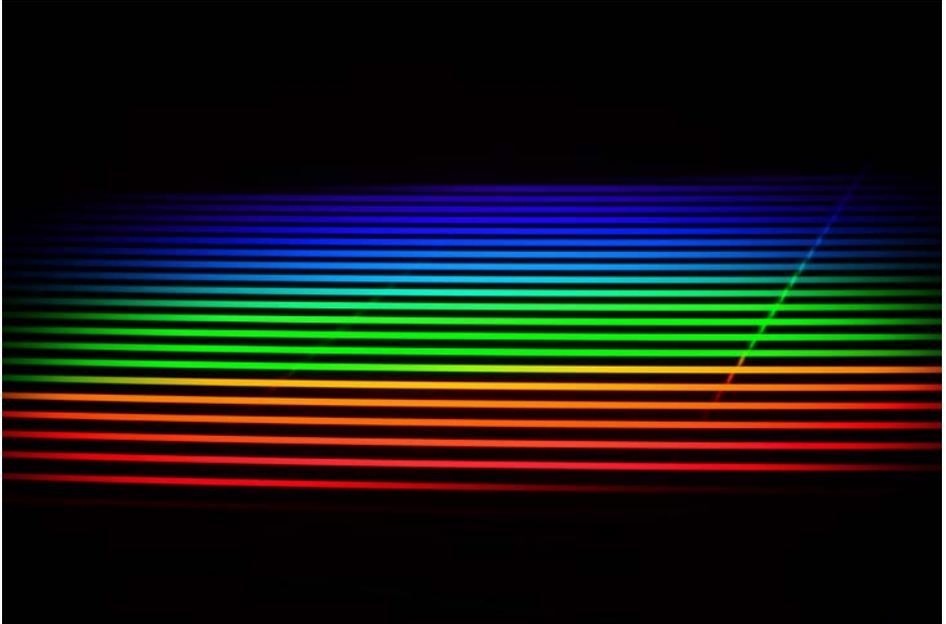
Lock the focus with locking screw once sharp focus is achieved.

2.3 Observing some common light sources:

Spectra were taken using BACHES' with the $25\mu\text{m}$ slit and a Nikon model D7100.

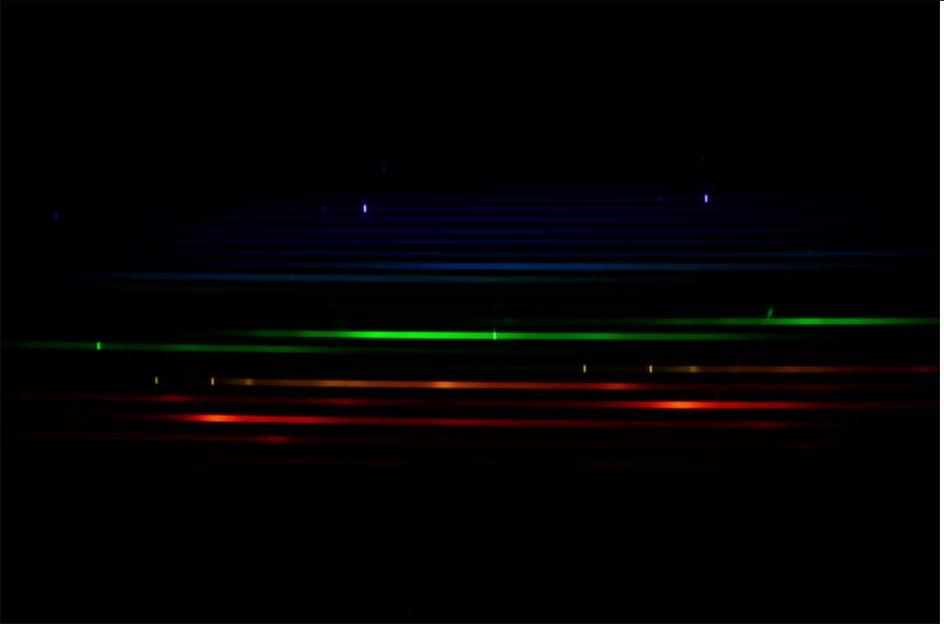
Please note that the Nikon D7100's $23.6\text{mm} \times 15.6\text{mm}$ CMOS image sensor is much larger than the $13.8\text{mm} \times 9.2\text{mm}$ Kodak KAF-1603 CCD required to cover the wavelength range from 390nm to 700nm .

Halogen lamp 5300K. (ISO 200, 0.4s)



Important remark: Please notice the presence of a ghost spectrum (diagonal trace to the right) superimposed over the échelle spectrum. This ghost is produced by the small amount of light that is reflected back from the CCD toward the échelle grating. This beam is again dispersed towards the detector generating a second undesirable spectrum. The intensity of the ghost depends of the reflectivity of the CCD!

Fluorescent lamp (ISO 200, 5s)



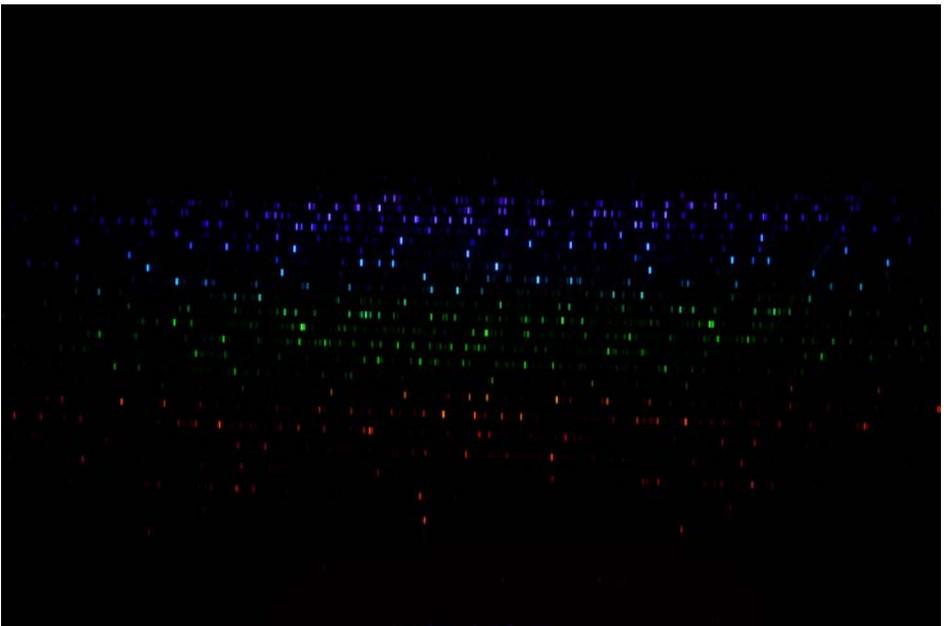
Thorium-Argon cathode lamp (ISO 1000, 10s)



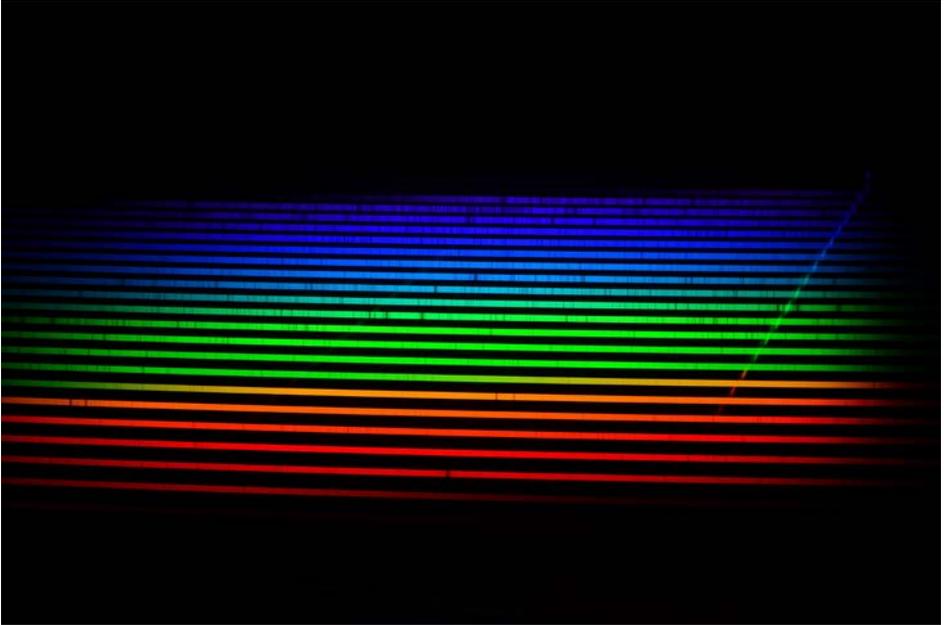
Neon lamp (ISO 200, 5s)



Helium-Argon cathode lamp (ISO 200, 2s)



Solar spectrum (ISO 200, 1/30s)



3 Configuring BACHES for astronomical observations

3.1 Coupling a detector to BACHES

3.1.1 Astronomical CCD camera

BACHES optical design is optimized to cover the field of CCD-chip KAF-1603ME with a dimension of 13.8mm x 9.2mm and a pixel size of 9 μ m. This chip size is the minimum required to cover a complete spectrum from 400nm to 700nm in one shot.

A pixel size of 9 μ m provides a sampling of 2.2 pixels per FWHM of the image of the 25 μ m slit on the detector. This size should be the maximum for adequate matching and therefore to achieve the highest resolving power with BACHES.

Detectors with smaller chip size than 13.8 x 9.2 mm may be used; however, part of the spectrum will be truncated, in particular the reddest orders of the spectrum.



Suitable CCD cameras for BACHES are: SBIG ST-1603ME, STF-8300, FLI ML1603, or Aspen CG2.

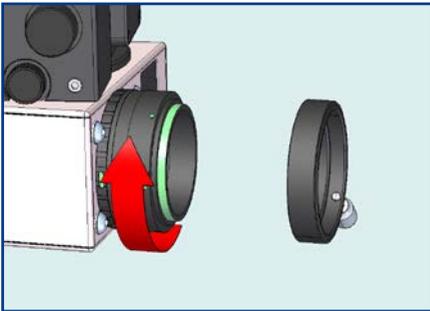
We have used the ST-1603 as an example in this manual.



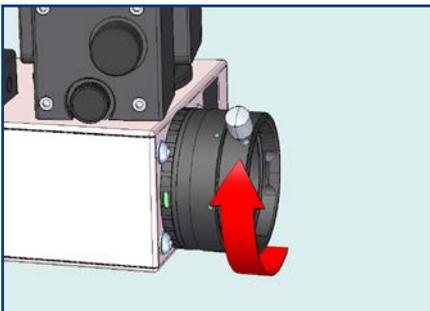
The SBIG ST-1603ME requires the T-2 Quick Changer.



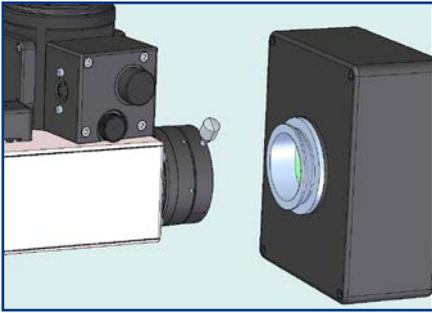
Separate the T-2 Quick Changer and screw the steel part to the detector body. The remaining ring of the T-2 will be attached to the VariLock Extension (see below).



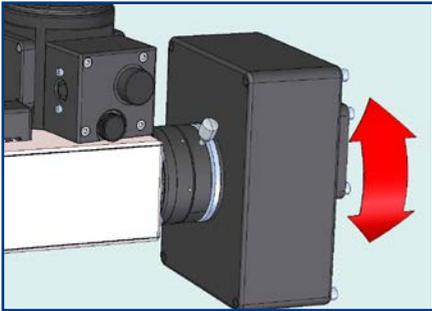
Tightly screw the VariLock Extension to the T-2 port of BACHES.



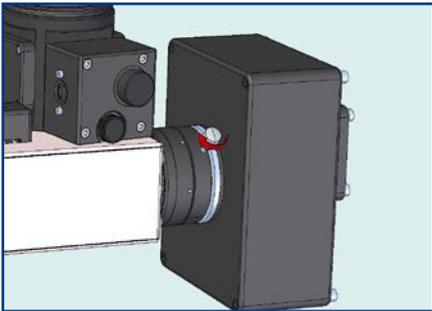
Tightly screw the ring component of the T-2 Quick Changer to the VariLock Extension.



Attach the CCD camera to BACHES by joining the two components of the T-2 Quick Changer.

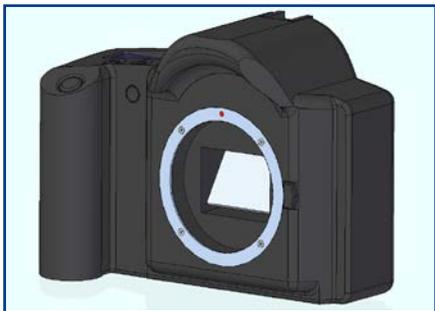


Adjust the orientation of the CCD camera to be approximately aligned with BACHES. A better adjustment will be obtained by taking spectra from a calibration lamp.

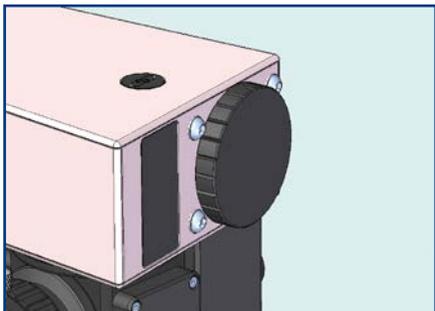


Tighten the screw of the T-2 Quick Changer to keep the CCD camera attached to BACHES.

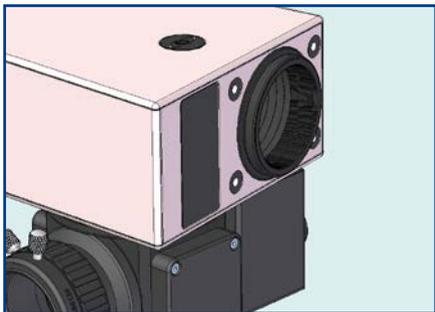
3.1.2 SLR or DSLR body



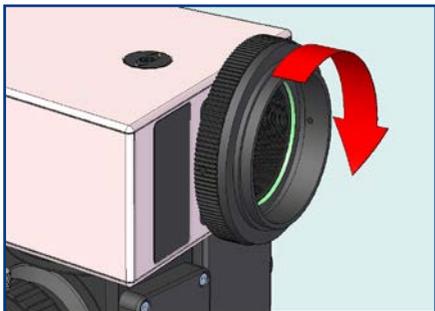
To mount a SLR camera as a detector, use the appropriate T-2 adapter. Consult Baader Planetarium for available adapters.



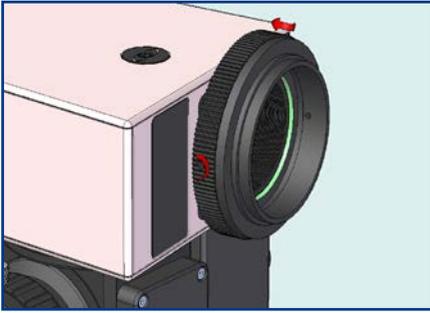
Most cameras may need to be mounted with BACHES upside down.



Remove the T2 dust cover and the four surrounding M4 screws together with the washers.



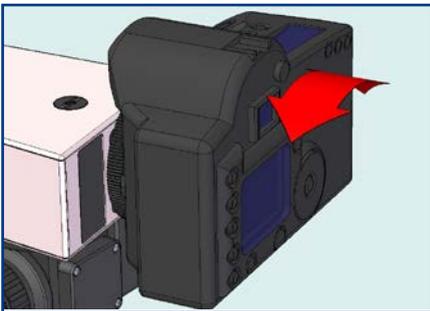
Tightly screw the T-Adapter to the T-2 port of BACHES.



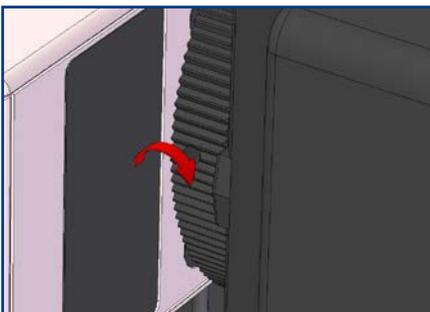
Remove the camera T-ring by releasing the 3 small screws



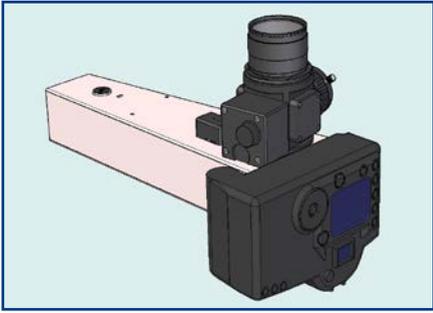
Attach the T ring on the camera body.



Attach the camera body to BACHES and set its orientation by turning the body.



Lock the camera T-ring by retightening the three screws around the ring.



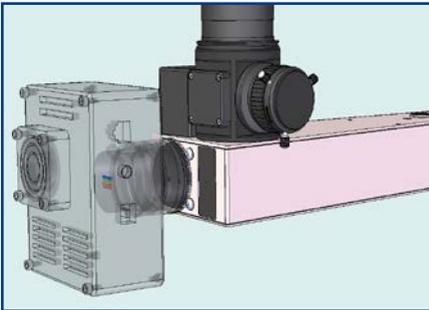
BACHES is now ready for fine focusing and spectrum alignment.

3.2 BACHES Alignment

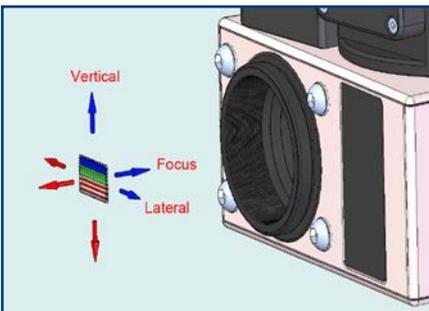
BACHES is easily adjusted to obtain the best spectra possible from the instrument.

The alignment consists in centering and focusing the spectra on your camera. The centering has been done in factory during the Quality Control process and, in principle, should not require any further adjustment. However, the focus of the spectrum on the CCD or DSLR camera needs a fine tuning.

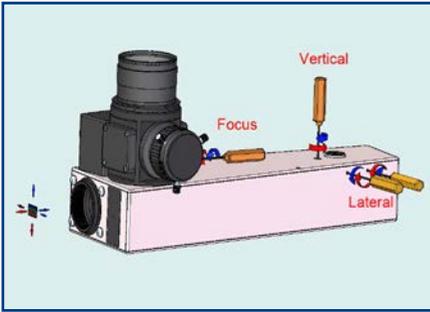
BACHES components are designed to ensure full capability for continuous remote control due to its constant focal plane in a temperature range of 30°C.



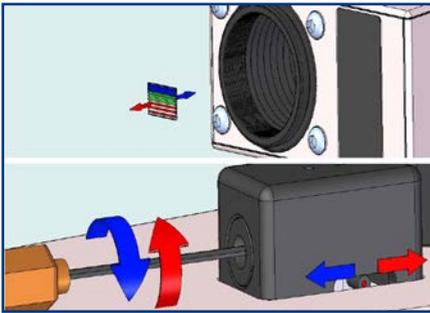
The nominal position of the spectrum (back focal plane) is located 55mm +3/-5mm outside the T2 port. The CCD or DSLR detector must be placed at this location.



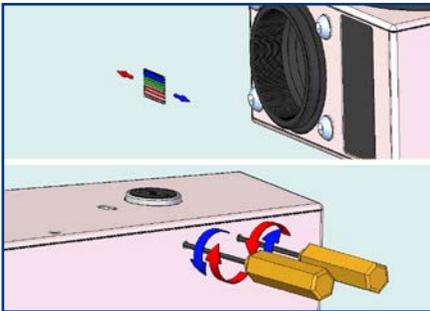
Three degrees of freedom center the spectrum on the CCD chip: X (lateral), Y (vertical) and Z (focus).



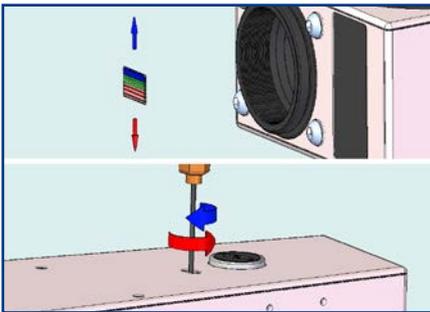
A total of four screws in BACHES control the shifts in X (lateral), Y (vertical) and Z (focus). The provided set of Allen wrenches can be used to adjust these screws.



Focusing of the spectrum on the detector is controlled by turning the screw in the focusing box with the 2.5mm Allen wrench. Notice the pin in the box indicating the physical focusing limits.



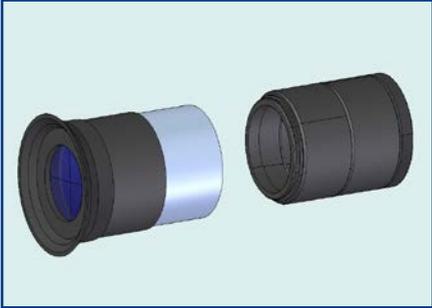
The X shift (lateral) is done by using the 1.5mm Allen wrench to move the two screws in a push-pull action. Loosen one and tighten the other. Operate them in quarters of a turn or less.



The vertical Y shift is controlled with a screw located close to the echelle axis. It is adjusted with the 2.0mm Allen wrench. Adjust it in increments of less than a quarter turn.

3.3 The slit-viewer

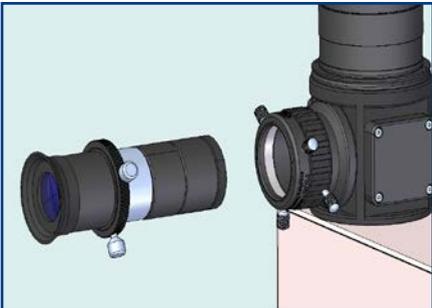
3.3.1 Attaching an eyepiece



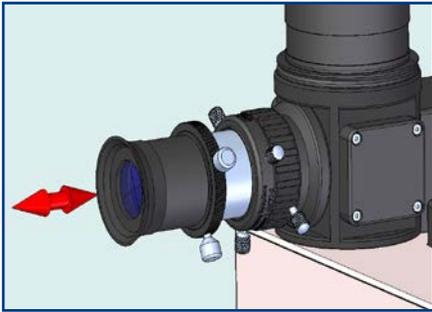
Mount the slit-viewer onto the 20mm guiding eyepiece.



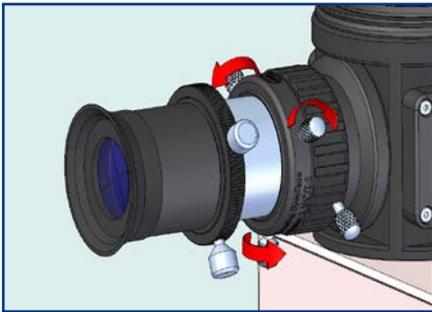
Slide the 1¼" stop ring onto the eyepiece chrome sleeve and lock it.



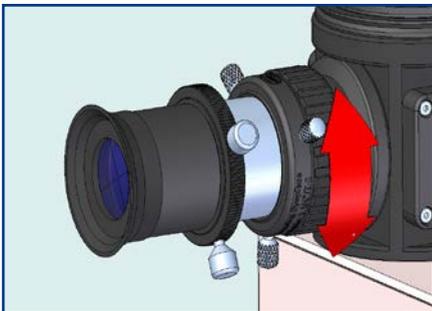
Insert the eyepiece assembly into the 1¼" slit viewing port.



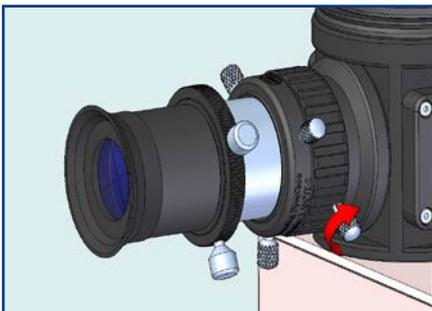
Remove the cap from the 2" nosepiece and direct it to an illuminated surface. Roughly focus the slit by manually by pushing or pulling the eyepiece.



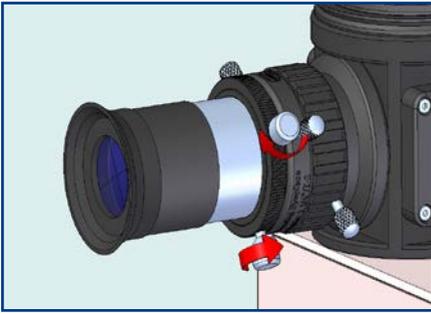
After having focused the image of the two slits, lock the eyepiece by using the three locking screws of the 1/4" slit viewing port.



Rotate the 1/4" adjustable clamp for fine focus.



Lock the clamp with the locking screw when best focus is achieved.



In order to fix the focus position for the eyepiece, slide the 1¼" stop ring until it contacts the viewer clamp. Lock it.

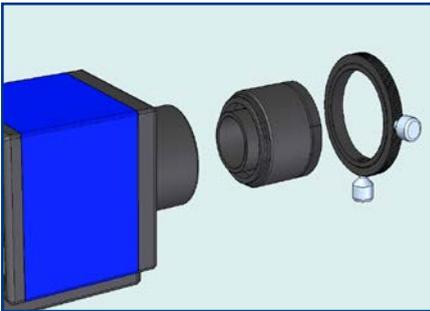


If needed, you can now remove the eyepiece and be able to set it back quickly in focus position.

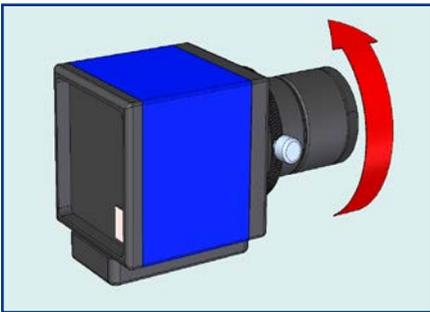
3.3.2 Attaching a guiding camera to the slit-viewer



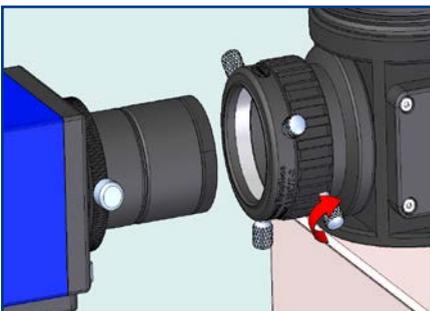
Remove the 18mm long 1/4" extension.



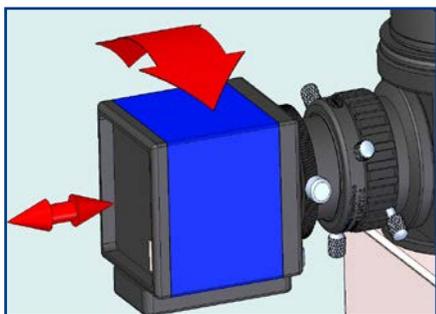
The guiding camera must be provided with a 1/4" nosepiece to accept the slit-viewer assembly and the stop ring.



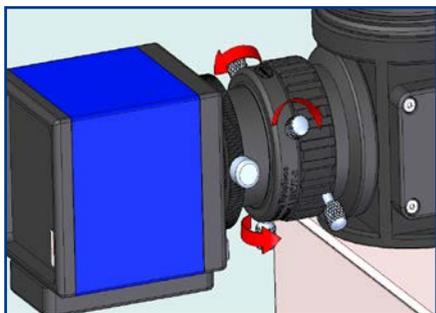
Mount the slit-viewer onto the 1/4" nosepiece of the guiding camera, and slide the 1/4" stop ring to the camera.



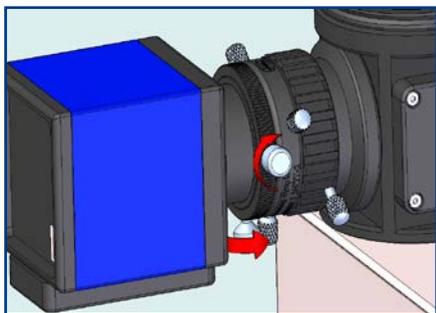
Lock the rotation of the screw 1/4" slit viewing port with the locking screw to avoid rotation of the guiding camera.



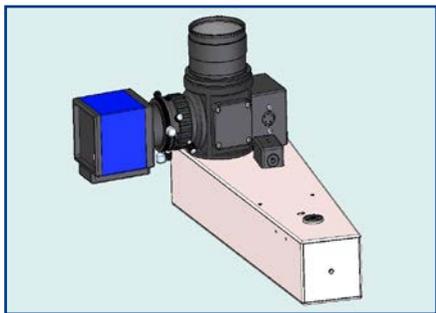
Focus the guiding camera by manually pushing or pulling it. Rotate the guiding camera body until the slits appear aligned in the CCD.



After having focused the image of the two slits, lock the guiding camera combo by using the locking screws of the 1/4" slit viewing port.



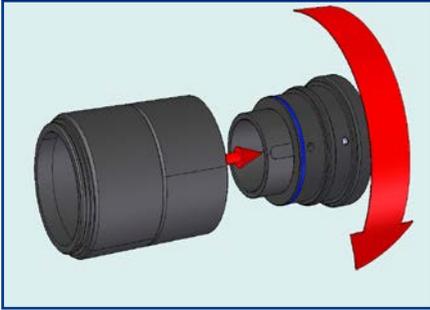
Slide the stop ring and move it to sit flush on top of the eyepiece holder / slit viewing port. Tighten the stop ring to secure the proper focus position.



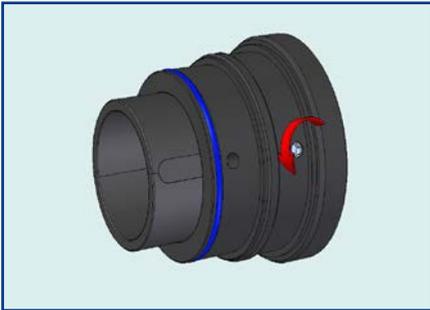
BACHES with guiding camera mounted on to the slit viewer port.

3.3.3 Zooming the slit viewer

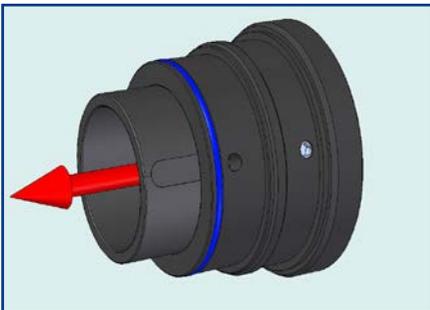
The lens inside the slit viewer can be adjusted in order to magnify the image size of the 2 slits on the guiding camera.



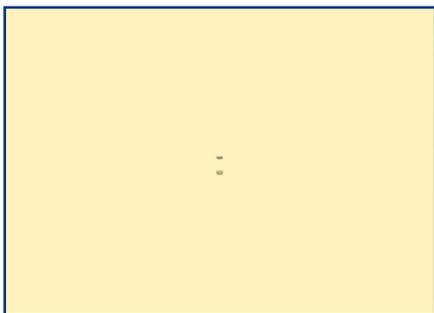
Remove the second 1¼” Extension tube from the slit viewer lens.



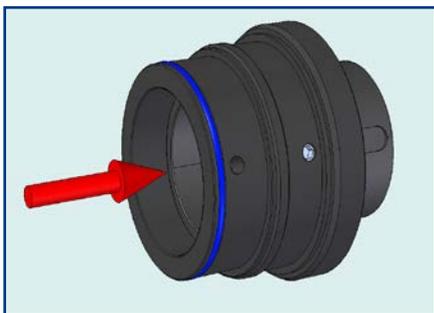
Release the screw inside the slit viewer lens by ½ turn, using the supplied Allen Wrench (1.3mm)



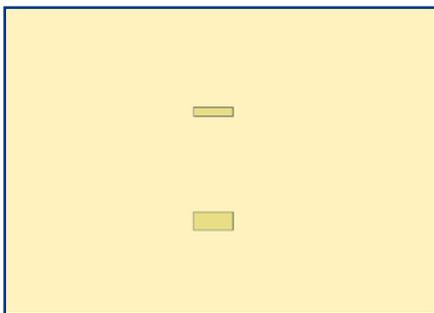
Slide the lens holder tube towards the guiding camera to reduce image size.



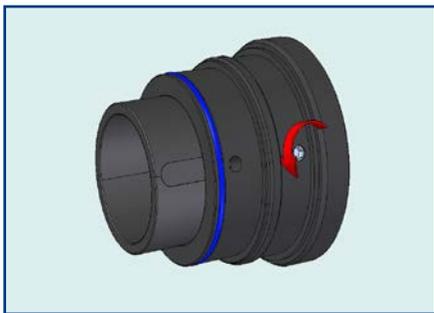
Minimum magnification as seen by the CCD chip.



Slide the lens holder tube away from the webcam in order to magnify the image.



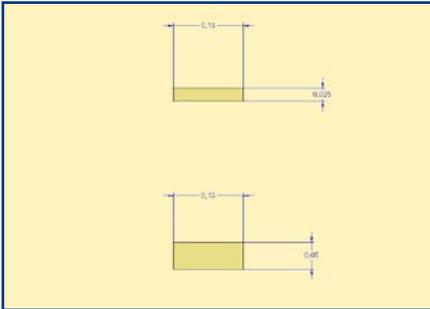
Maximal magnification as seen by the CCD chip.



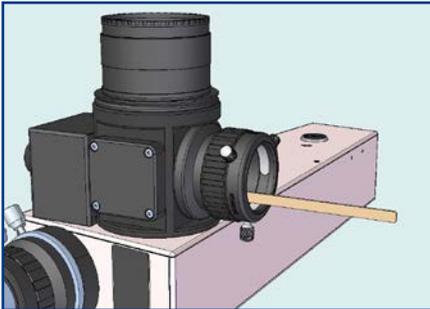
Lock the new position of the lens holder tube by tightening the screw.

Remount the slit-viewer lens in the 18mm extension tube.

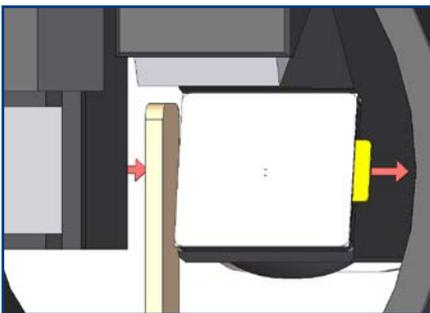
3.4 Selecting a slit



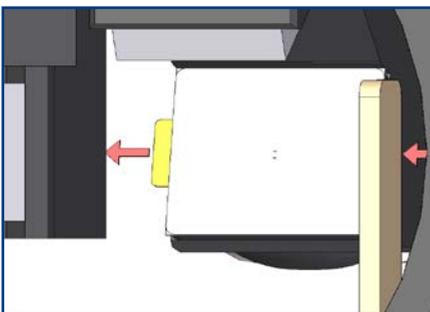
BACHES is provided with two slits: 130 μ m x 25 μ m slit and a 130 μ m x 50 μ m slit. You will select one of these two slits based on your seeing conditions and on the required resolution.



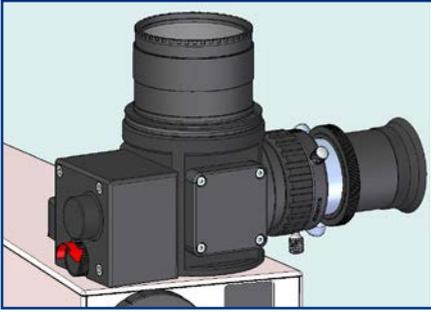
To change the slit, introduce a wooden stick through the slit-viewer port and, very gently, push the slit-selector to the required position. Do not touch the slit itself!



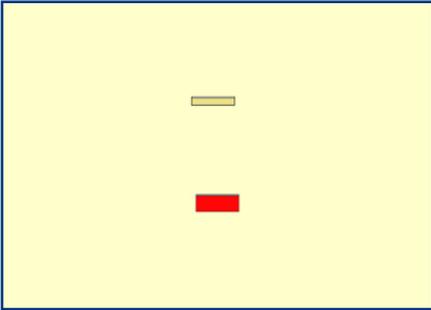
To select the 25 μ m slit push the slit-selector (in yellow) from left to right. The 25 μ m label appears.



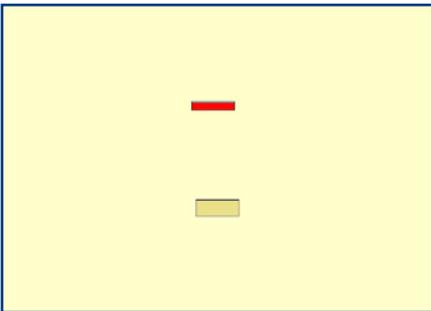
To select the 50 μ m slit push the slit-selector (in yellow) from right to left. The 50 μ m label appears.



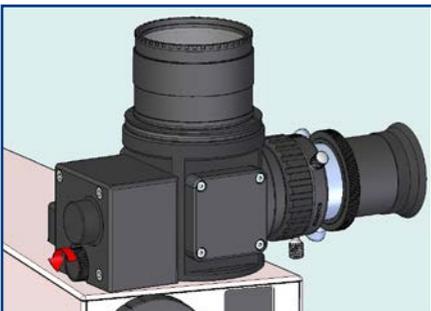
To check the slit selection insert the eyepiece in slit viewer port, focus on the slits, and switch ON the slit illuminator.



With the 50 μ m slit selected and the slit illuminator on, this is how the slit plate looks through the slit viewer.

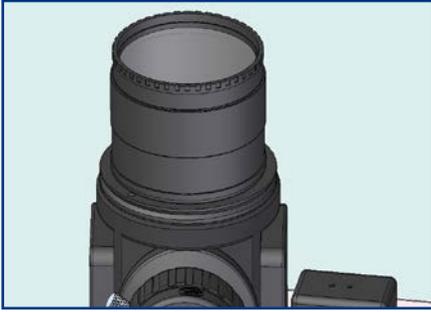


When the 25 μ m slit selected and the slit illuminator on, this is how the slit plate looks through the slit viewer.



Do not forget to switch OFF the slit illuminator, by turning the knob until you hear the click off, once you are finished with the slit selection.

3.5 Coupling the spectrograph onto the telescope



Use the provided 2" nosepiece to attach BACHES onto your telescope. The 2" clear filter attached protects the slits against dust. Do not remove it unless necessary.



Alternatively remove the 2" nosepiece and use the female 2" (24G) thread for attaching BACHES onto the 2" Schmidt-Cassegrain thread-standard.



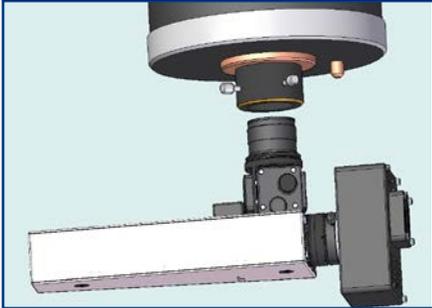
This M55/2" reducer ring is made of hardened tooling steel with an outer V-groove for customized adaption onto a GAM-unit and for archieving shortest possible backfocus with zero flexure.



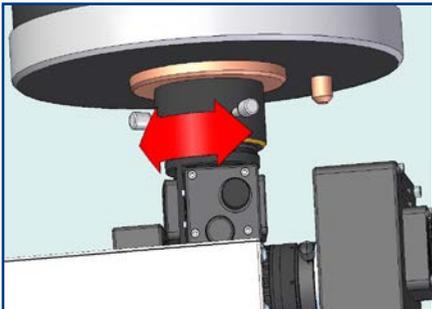
Alternatively remove the steel reducer ring to directly access the M55x1 thread cut into the BACHES guide head.

3.6 Installing the spectrograph at the telescope

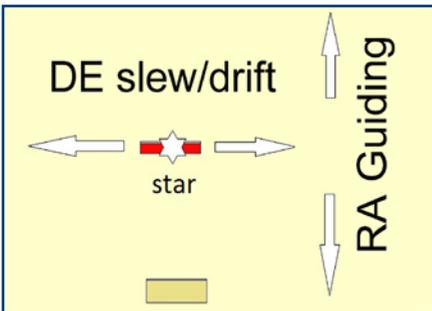
Before attaching BACHES to the telescope, make sure you have already focused the spectrum on the camera's focal plane, with the proper orientation.



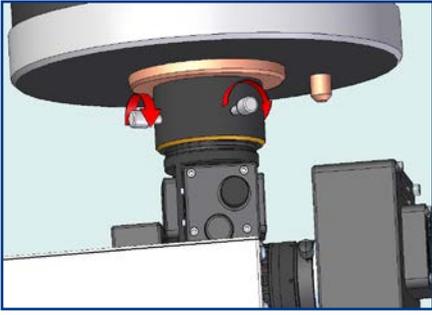
Attach BACHES into the telescope with a 2" adapter if using the 2" nosepiece.



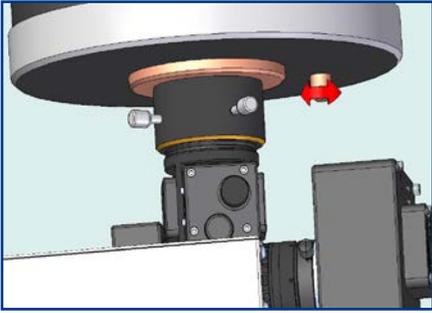
Align the instrument to the telescope. With polar aligned equatorial mounts the best orientation is the one that aligns the slits with the Declination slew/drift of the telescope.



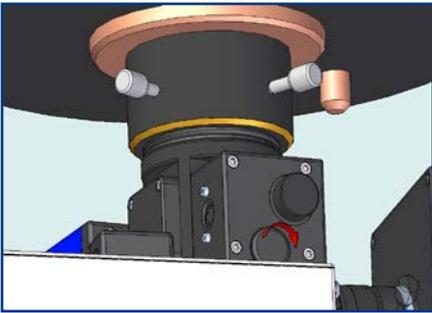
A good polar alignment results only in minor drifts in Declination DE. Guiding on the star is done best in Right Ascension RA.



Ensure the attachment of the instrument to the telescope by locking the proper adapter screws. Then slew the telescope to a bright star.

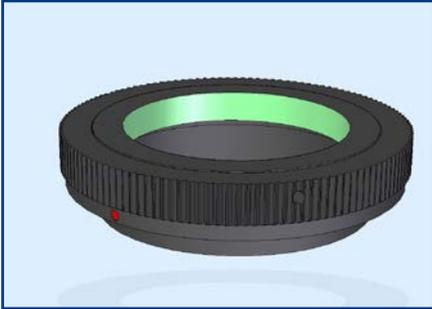


Use the telescope's focusing mechanism to focus the star in the middle of the slit by observing its image through an eyepiece or guiding camera.



Use the slit illuminator to illuminate the slits and slowly slew the telescope to bring the star inside the selected slit. Switch off the slit illuminator before starting an exposure with the detector.

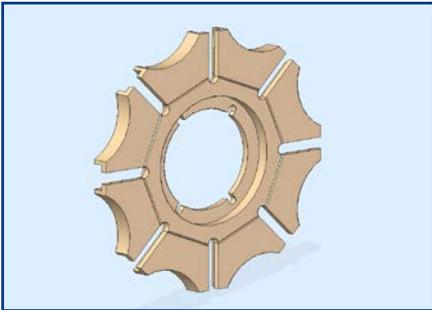
Appendix A: Optional accessories



T-2 adapters for many SLR camera models. Examples:

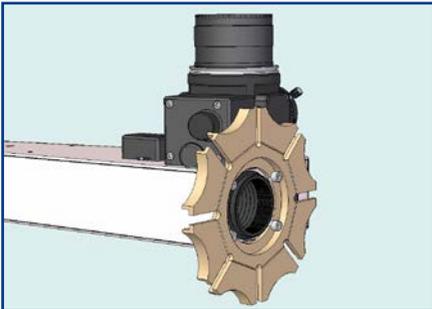
Nikon	Ref. 240 8300
Canon EF	Ref. 240 8319

Look at the Baader Planetarium website for a complete list.

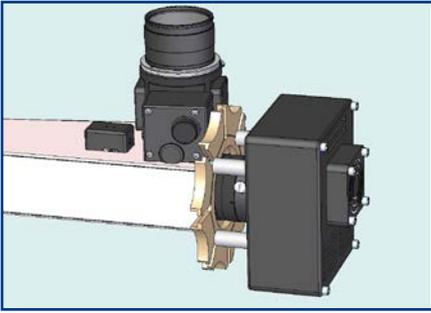


CCD Camera Support Plate (#2458635).

It can be used to fix any camera to BACHES with customized holding structure.



The Support Plate is first attached to BACHES with the 4x M4 thread around the T-2 thread.



The CCD is then fixed to BACHES with the T-2 thread. Custom made support structure can be attached to the plate to hold the camera, or posts might be used to stabilize it.



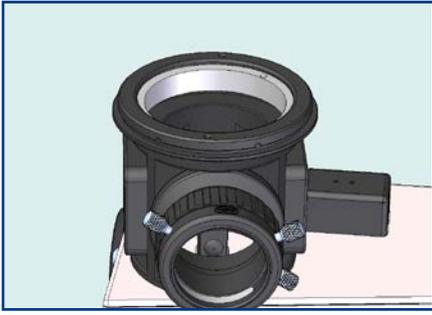
Adapter for C11/C14 (#2458633)



It permits attaching BACHES in the most rigid way to every telescope with 3.3" thread.



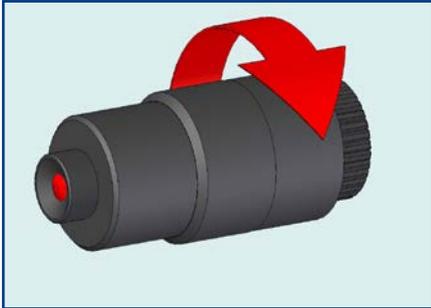
The M68x1 Adapter (#2455632) enables the usage of the Baader M68 System



which includes various adapters to most common telescopes worldwide and permits fast coupling, for example between BACHES and an imaging camera.

Appendix B: Maintenance

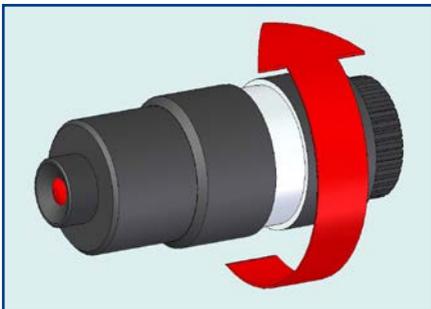
B.1 Battery replacement



Turn the back of the illuminator counterclockwise approximately three turns to open the battery compartment.



Replace dead batteries with two 1.5V SR41W batteries (#2454306 or #2454307).



Then turn the back of the illuminator clockwise until it is completely closed.

Appendix C: Care of optical components

Always replace the dust caps after working with BACHES.

Dust can only be cleaned from the grating and slit by Baader-Planetarium. Do not clean the slit plate by yourself as this will void the warranty.

Exposed optical surfaces should not be cleaned with common cleaning agents.

Use only Baader Planetarium Optical Wonder fluid (#2905007) to clean optical surfaces.

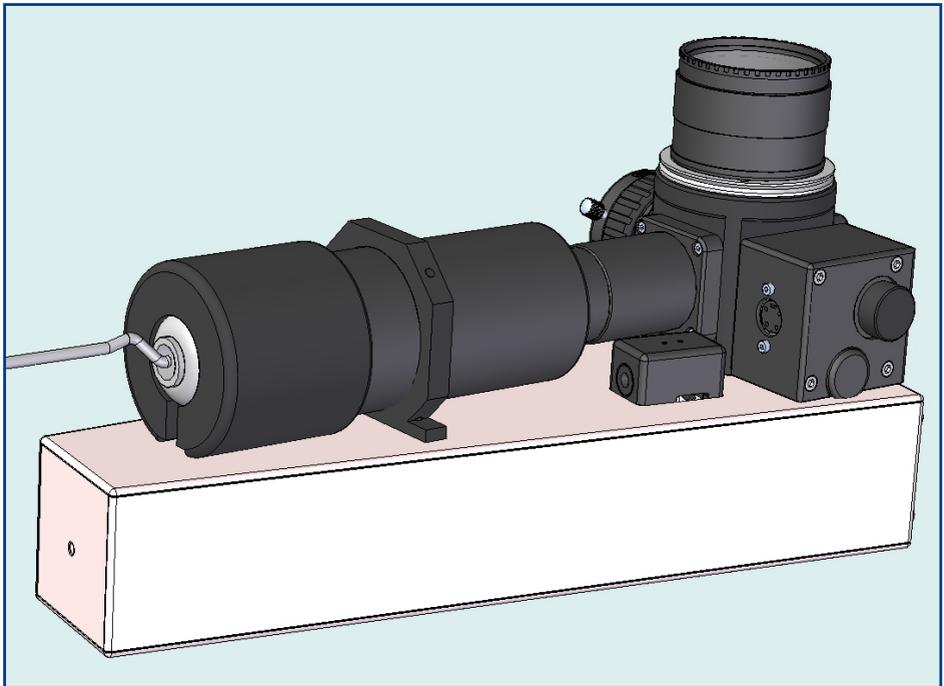
Appendix D: Calibration options

D.1 Standard Calibration Set

Consisting of:

- Thorium-Argon cathode calibration lamp (#2458610).
- Power supply for cathode lamps (#2458620).
- Power cable for the cathode lamp.
- Protective enclosure and support for the lamp.
- Docking port with coupling optic to attach the lamp to BACHES head.

BACHES with the standard calibration set:

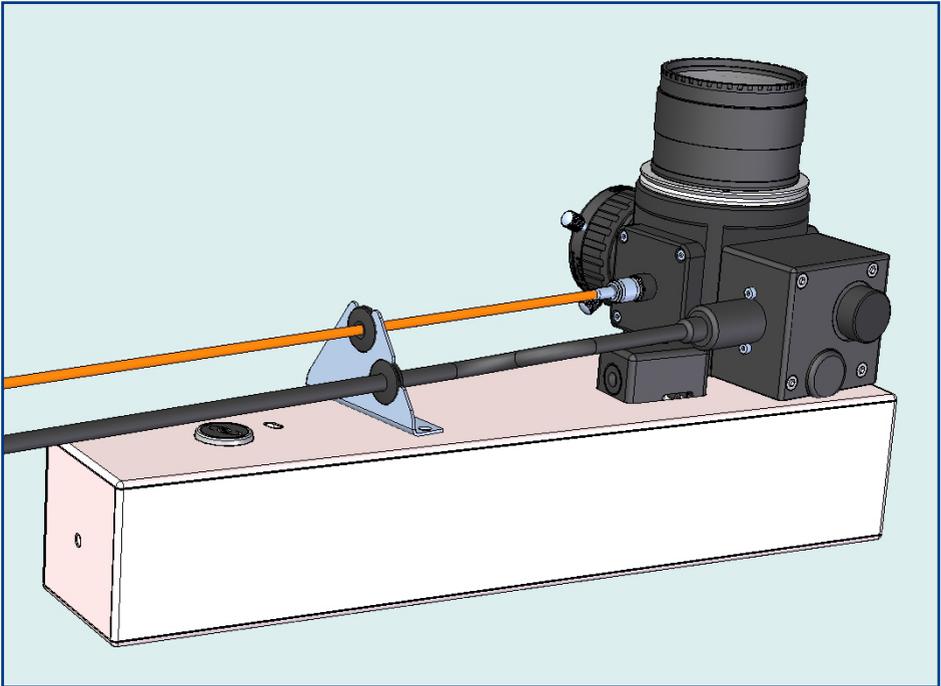


D.2 Remote Control Unit (RCU)

The RCU (#2458605) is a closed box consisting of the following components:

- Thorium-Argon cathode calibration lamp.
- Halogen lamp with blue filter for flat-fields.
- Power supplies for both lamps and for the motor activating the calibration mirror in BACHES head.
- Network control unit connects the RCU to a local network, with embedded software to control the unit from any PC via web interface or through scripting language.
- Fiber to connect RCU with BACHES.
- Power cord for motor in BACHES.
- Heavy duty mounting rods for customized attachment of the RCU to a telescope.
- Ready for standard 19" computer racks.
- Protective enclosure and support for the lamp.
- Watertight, shock-resistant ABS flight-case with machined compartments to ensure maximum transport safety
- manual

BACHES with power and fiber cords from RCU:



Appendix E: Specifications

Mechanical

Weight (without cameras and eyepieces)	1350 g
Dimensions	302 × 99 × 116mm

Electrical

Red LED Battery	SR41W
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Environmental

Operating temperature	-10 to +30°C
Storage temperature	-30 to +35°C
Operating humidity (relative)	0 to 80 %
Storage humidity	0 to 60 %

Optical

Collimator focal ratio	f/10 ¹
Spectral Range	392-780 nm ²
Slit25	25 x 130 μm
Slit50	50 x 130 μm
Average Resolving Power Slit25 ($R = \lambda/\Delta\lambda$)	18,000 ³
Average Resolving Power Slit50 ($R = \lambda/\Delta\lambda$)	10,000 ³
Back focal distance without adapter	55mm +3/-5mm ⁴

¹ Using BACHES with a telescope of focal ratio lower than f/10 increases collimator vignetting and the efficiency may drop substantially. See Appendix F

² BACHES echelogram on CCD may be adjusted to include red orders beyond 780 nm. However a sorting order filter must be used to avoid contamination by blue 2nd order.

³ Measurements performed with ST-1603ME with 9 μ m pixel size.

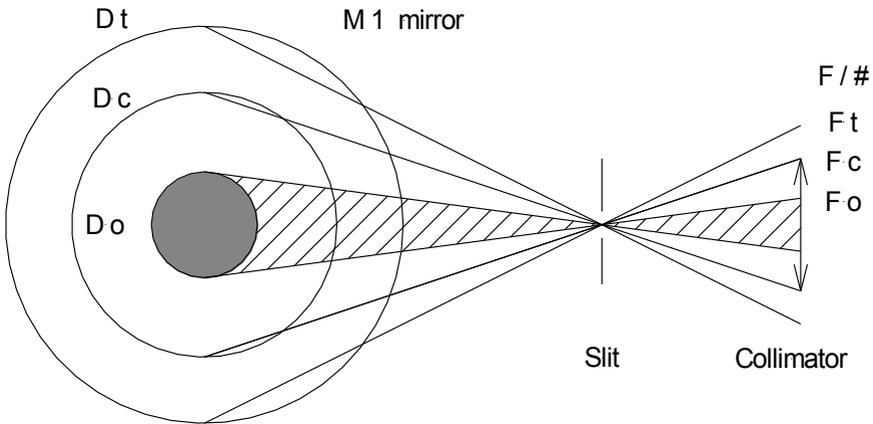
⁴ Distance from the spectrum image to the body of the spectrograph

BACHES components are designed to ensure full capability for continuous remote control due to its constant focal plane in a temperature range of 30°C.

Appendix F: Vignetting

Computation of vignetting at the collimator by telescope focal ratio lower than F/10 (collimator)

The BACHES collimator focal ratio is F/10. If the telescope focal ratio is lower than this value, not all the flux will pass through the collimator (vignetting). The amount of vignetting depends also of the diameter of the central obstruction. In order to compute the vignetting, let's define the necessary parameters as displayed in the Figure below



D_t = diameter of the telescope primary mirror (M 1)

D_o = diameter of the central obstruction. Usually it is the external diameter of the mechanical support of the secondary mirror (M 2)

D_c = diameter of the *projection* of the collimator on the M 1 mirror

F_t , F_c and F_o are the beam F/# ratio of the telescope, collimator and central obstruction respectively.

The total flux (photons/s) entering into the telescope is $I * A$ where I is the irradiance by the observed star in photons/s/m². A is the effective area (m²) of the exposed M 1 mirror. Therefore the total

flux will be:

$$\frac{I\pi}{4}(D_t^2 - D_o^2)$$

In the same way the flux crossing the collimator will be:

$$\frac{I\pi}{4}(D_c^2 - D_o^2)$$

The percentage of the flux in the collimator with respect to the total flux in the telescope will be:

$$\frac{D_c^2 - D_o^2}{D_t^2 - D_o^2}$$

But
$$D_c = \frac{f_t}{F_c} = \frac{F_t \cdot D_t}{F_c},$$

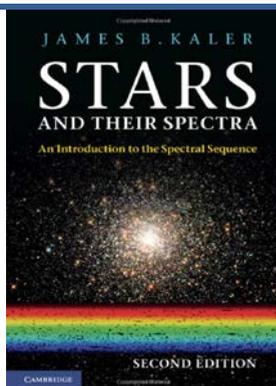
where f_t is the focal length of the telescope. Finally the portion of the flux (fraction) through the collimator will be

$$\frac{\left(\frac{F_t \cdot D_t}{F_c}\right)^2 - D_o^2}{D_t^2 - D_o^2}$$

Practical example:

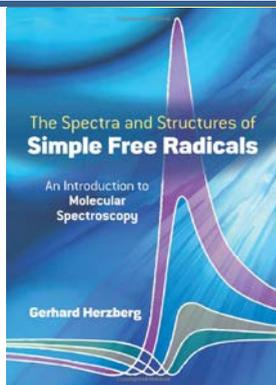
The PlaneWave 24" CDK telescope has an aperture of 610 mm and a central obscuration of 250 mm and its focal ratio is F/6.8. If the focal ratio were the same as BACHES (F/10), in the equation $F_t = F_c$, the flux through the collimator would be 1 (100%). But with F/6.8 the flux through the collimator will be only 0.354 (35.4%).

Appendix G: Bibliography



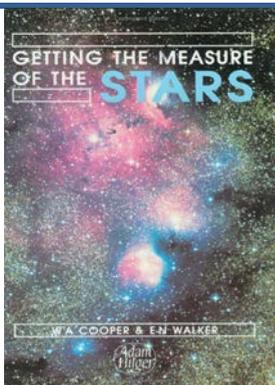
Stars and Their Spectra: An Introduction to the Spectral Sequence

Author: James B. Kaler
Pub date: 2011
Pages: 412
ISBN: 0521899540



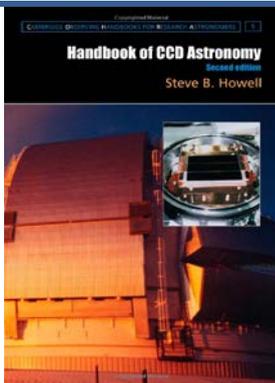
The Spectra and Structures of Simple Free Radicals: An Introduction to Molecular Spectroscopy

Author: Gerhard Herzberg
Pub date: 2012
Pages: 226
ISBN: 048665821X



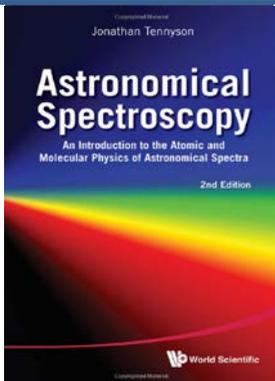
Getting the Measure of the Stars

Author: W.A. Cooper
Pub date: 1989
Pages: 293
ISBN: 0852748302



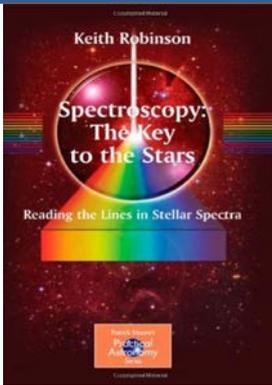
Handbook of CCD Astronomy

Author: Steve Bruce Howell
Pub date: 2006
Pages: 220
ISBN: 0521617626



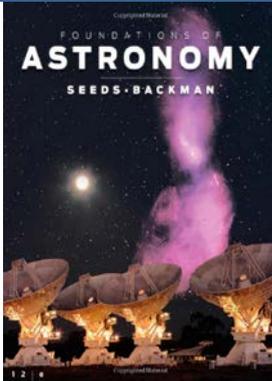
Astronomical Spectroscopy: An Introduction to the Atomic and Molecular Physics of Astronomical Spectra

Author: Jonathan Tennyson
Pub date: 2011
Pages: 236
ISBN: 9814291978



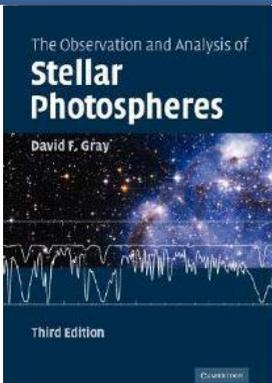
Spectroscopy : The Key to the Stars: Reading the Lines in Stellar Spectra

Author: Keith Robinson
Pub date: 2007
Pages: 160
ISBN: 0387367861



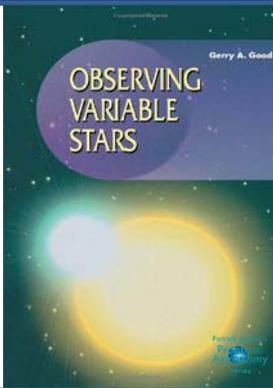
Foundations of Astronomy

Author: Michael A.Seeds, Dana Backmann
Pub date: 2012
Pages: 672
ISBN: 1133103766



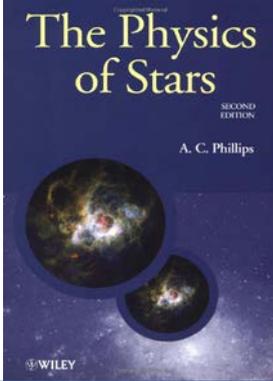
The Observation and Analysis of Stellar Photospheres

Author: David F. Gray
Pub date: 2008
Pages: 552
ISBN: 9780521066815



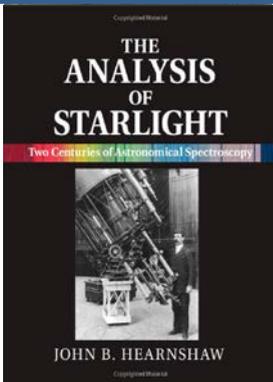
Observing Variable Stars

Author: Gerry A. Good
Pub date: 2002
Pages: 284
ISBN: 1852334983



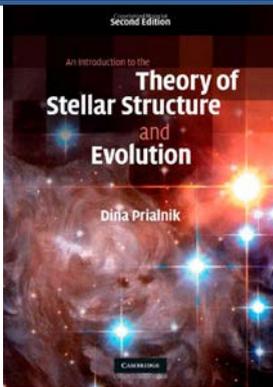
The Physics of Stars

Author: A.C. Philips
Pub date: 1999
Pages: 262
ISBN: 0471987980



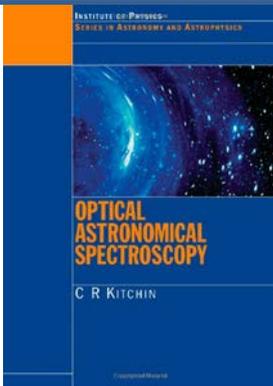
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Pub date: 2014
Pages: 382
ISBN: 1107031745



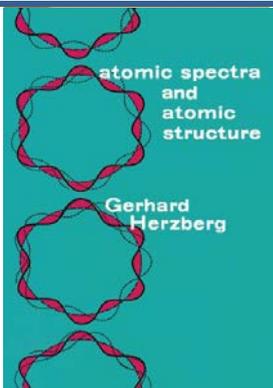
An Introduction to the Theory of Stellar Structure and Evolution

Author: Dina Prialnik
Pub date: 2009
Pages: 328
ISBN: 0521866049



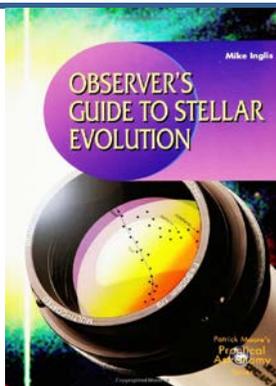
Optical Astronomical Spectroscopy

Author: Christopher R. Kitchin
Pub date: 1995
Pages: 286
ISBN: 0750303468



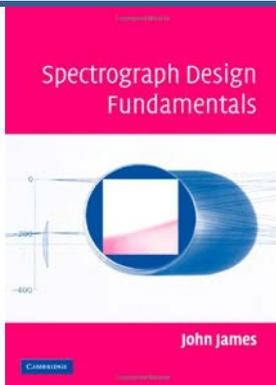
Atomic Spectra and Atomic Structure

Author: Gerhard Herzberg
Pub date: 2010
Pages: 288
ISBN: 0486601153



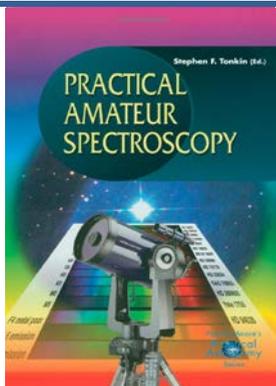
Observers Guide to Stellar Evolution

Author: Mike Inglis
Pub date: 2013
Pages: 238
ISBN: 1852334657



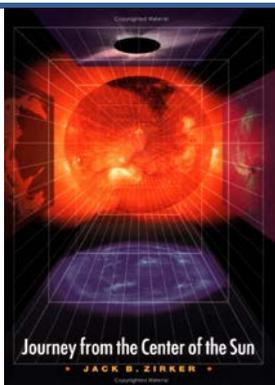
Spectrograph Design Fundamentals

Author: John James
Pub date: 2007
Pages: 204
ISBN: 0521864631



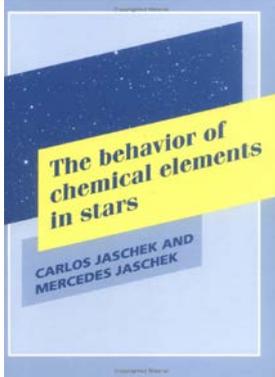
Practical Amateur Spectroscopy

Author: Stephen F. Tonkin et al.
Pub date: 2002
Pages: 210
ISBN: 1852334894



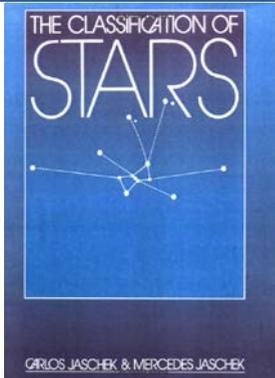
Journey from the Center of the Sun

Author: Jack B. Zirker
Pub date: 2001
Pages: 312
ISBN: 0691057818



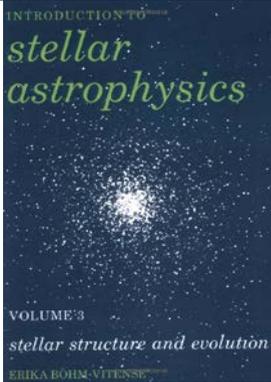
The Behavior of Chemical Elements in Stars

Author: Carlos Jaschek
Pub date: 1995
Pages: 324
ISBN: 052141136X



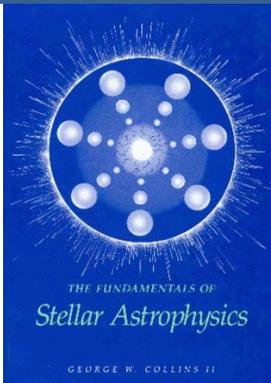
The Classification of Stars

Author: Carlos Jaschek
Pub date: 1990
Pages: 432
ISBN: 0521389968



Introduction to Stellar Astrophysics. Vol.3: Stellar Structure and Evolution

Author: Erika Boehm-Vitense
Pub date: 1992
Pages: 285
ISBN: 0521348714



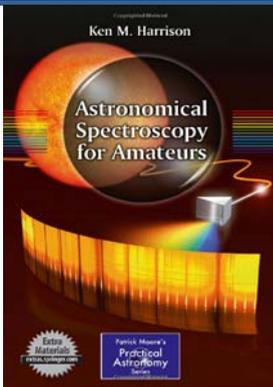
The Fundamentals of Stellar Astrophysics

Author: George W. Collins
Pub date: 1989
Pages: 494
ISBN: 0716719932



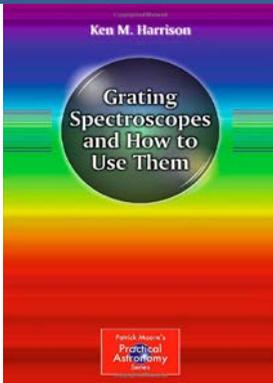
An Atlas of the Thorium-Argon Spectrum for ESO Échelle Spectrograph

Author: S. Dódorico, M. Ghigo, D.Ponz
Pub date: 1987
Pages: 169
ISBN: none



Astronomical Spectroscopy for Amateurs

Author: Ken M. Harrison
Pub date: 2011
Pages: 256
ISBN: 1441972382



Grating Spectroscopes and How to Use Them

Author: Ken M. Harrison
Pub date: 2012
Pages: 220
ISBN: 1461413966

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