PHYWE Spektrometer 2

35635-04

PHYWE Systeme GmbH & Co. KG
Robert-Bosch-Breite 10
D-37079 Göttingen

Telefon +49 (0) 551 604-0
Fax +49 (0) 551 604-107
E-mail info@phywe.de
Internet www.phywe.com

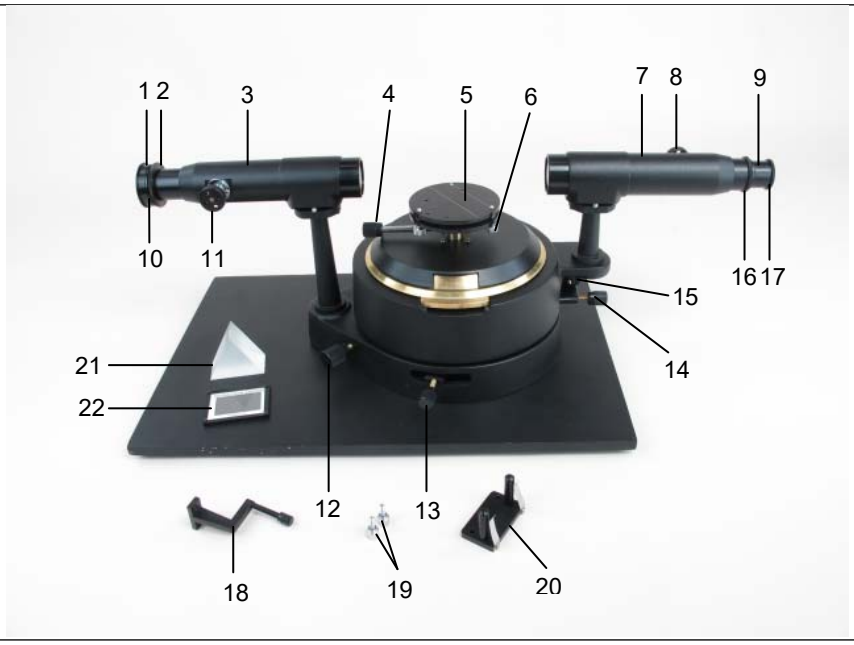


Fig. 1: PHYWE Spectrometer 2 35635-04

Betriebsanleitung

CE The unit complies with the corresponding EC guidelines.

I CONTENTS

1 SAFETY PRECAUTIONS

Caution!

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Only use the instrument for the purpose for which it was designed.

2 CONTROLS AND FUNCTIONAL ELEMENTS

1 Adjustable entrance slit, holding screw for slit cover
2 Lock ring fixing entrance slit
3 Collimator
4 Spectrometer table lock screw—for height and angle adjustment
5 Spectrometer table with threaded holes for holding screws
6 Spring fitted thumb screws for levelling the spectrometer table
7 Ocular telescope
8 Focus knob for ocular telescope
9 Ocular holder with reticule
10 Adjustment knob for slit width
11 Focus knob for collimator telescope
12 Fine adjustment knob for spectrometer table rotation
13 Lock screw for spectrometer table rotation
14 Lock screw for ocular telescope rotation
15 Fine adjustment knob for ocular telescope rotation
16 Lock ring fixing the ocular holder
17 Push-in ocular, 15x
18 Prism holder
19 Thumb screws for fixing prism or grating holder
20 Holder for diffraction gratings or diaphragms
21 Prism
22 Diffraction grating

3 PURPOSE AND CHARACTERISTICS

The spectrometer-goniometer with vernier mainly comprises a collimator telescope with adjustable light entrance slit, a telescope with reticule with same focal length as the collimator, and a table that can be rotated and levelled, on which diffraction gratings or dispersive prisms can be mounted. The collimator parallelises the light coming through the entrance slit, so grating or prism are illuminated with a parallel

beam. The ocular telescope focuses the parallel light and provides an image of the slit that can be observed by eyesight so that the position of the image of the slit can be compared to the position of the reticule.
The angle through which grating or prism deflect the light depends on the light wavelength—so for each wavelength there is a separate image of the entrance slit. By rotating the ocular telescope around the main axis of the device the reticule is brought to match the image of the slit for the respective wavelength and the goniometer used to determine the deflection angle.
The angle between collimator, ocular, and table can be read off to the precision of half an arc minute with help of vernier scales.
Rough angle adjustment is done with the lock screws open (*13* and *14*) and else with lock screws tightened using the fine adjustment knobs (*12* and *15*) with backlash free mechanics.

4 HANDLING

3.1 Adjustment of the device

Pull out the push-in ocular *17* a little from the ocular holder *9* to focus the reticule as good as possible.

If necessary, loosen the ocular holder with the lock ring *16* and turn the reticule until it is precisely vertical and fix again well with *16*.

Point the ocular telescope to a distant object and focus this with focus knob *8*. This adjustment is essential, because the angle precision depends also on the parallelism of the light beam passing prism or grating. In order that the free opening of the telescope would appear at an angle of half an arc minute, it would have to be 220 m away.

Now point the ocular telescope to the collimator. Focus the slit with knob *11* on the collimator *not* altering the adjustment of the ocular telescope focus. Then the light between collimator and ocular is parallel. If necessary, loosen the slit with lock ring *2* and adjust it precisely vertical—parallel to the reticule.

The slit has a fixed and a movable edge. For angle measurement the reference should be the fixed edge. This should be brought to match the reticule using fine adjustment knob *15* for ocular angle. This should be observed as the slit width might be changed to adapt to different brightness of different spectroscopic lines.

If without prism or grating the slit does not appear in the vertical middle of the field of view or if the line of sight does not match the centre of the table which is the main turning axis of the device, then a realigning of the device may be necessary, refer to section 3.6.

3.2 Reading the angle with help of vernier scale

One degree equalling 60 arc minutes is separated into three divisions corresponding to 20 arc minutes (0°20‘). The division of the vernier scale into 20 times two lines then corresponds to arc minutes (0°1‘0“) resp. half arc minutes, that is 30 arc seconds (0°0‘30“). To the angle of 40 lines of the vernier scale corresponds the angle of 39 lines on the main scale.

In the example of Fig. 2 the zero line of the vernier scale is in between 305° and 306°, more precise: in the second third of this degree, that is beyond the first 20 arc minutes. This reads thus: 305° 20‘ plus the number of divisions, where the vernier scale best matches the main scale. In this example it is the ninth of the 20 main divisions, which results to 305°20‘ + 9‘ = 305°29‘.

If the smaller division between eighth and ninth main division on the vernier scale would match best the main scale, (that is the 17th times 0°0‘30“ = 0°8‘30“), the read-off result would be 305°28‘30“.

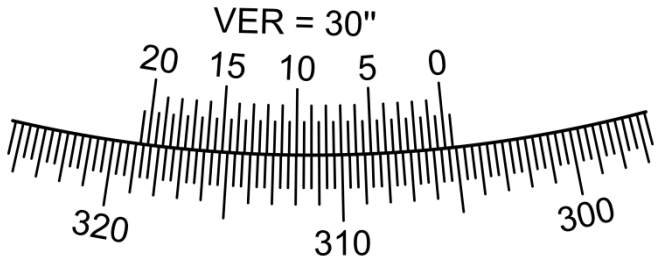


Fig. 2: Example for reading the angle


Fig. 3: Photograph of the angle scales: upper scale: position of the spectrometer table; middle scale: fixed with the collimator telescope; lower scale: fixed with the ocular telescope

3.3 General remarks

For all measurements angle differences are significant, but the position of the zero point does not play a role. By loosening the lock screw for table rotation *13* and the spectrometer table lock screw *4* the zero point of the table rotation angle can be adjusted to any value. The zero point of the relative angle between collimator and ocular is fixed and in general not at the position, where collimator and ocular are in a straight line. Thus the reference angle, with respect to which is measured, always has to be denoted.

Understanding of the basics properties of diffraction gratings and dispersive prisms is essential for successful operation of this device and they can be found in textbooks on optics or on the web, e.g. starting with Wikipedia:

https://en.wikipedia.org/wiki/Snell's_law

https://en.wikipedia.org/wiki/Dispersion_(optics)

https://en.wikipedia.org/wiki/Diffraction_grating

3.4 Measurements with a diffraction grating


Fig. 4: Observation of the undeflected light

Mount the grating holder to the spectrometer table and insert the grating. Align the table with the optical axis of the telescopes. Lock the table well with the lock screw for table rotation *13* and illuminate the slit with the light to be examined—for adjustment, a source showing lines is necessary.

Darken the room. Swing the ocular telescope to the side and observe the image of the slit through the grating. If your face is illuminated from front, then the surface reflex of the grating shows your eye. Tilt the grating about the axis perpendicular to main light beam and perpendicular to the grating lines with help of table levelling screws *6* such that the pupil appears at vertical centre of the slit image—such a tilt causes the diffracted slit images on the sides to be vertically lifted or lowered to both sides. Then turn the table with *12* until the pupil appears laterally centred about the slit image.

Now observe diffracted light on one side of the main beam through the ocular telescope and turn the grating in its holder about the surface normal of the grating along main beam axis until the diffracted slit image appears vertically centred with the reticule—a rotation about the surface normal causes the images of the slit to the sides to be vertically lifted on one and lowered on the other side. Cross check on the other side of the undeflected main beam.

Fig. 5: Observation of the deflected light

Alternatively adjustment can be done exploiting the surface reflex of the main beam on the grating observed through the telescope with the grating at 45° and the ocular at right angles with the main beam, also using diffracted light with the grating operating as reflex grating.

Finally measure for a specific spectral line the deflection angle between deflected and undeflected beam to both sides of the undeflected beam. Average the values and move the telescope with fine adjustment *15* to the according average angle position. Then use the table fine adjustment *12* to bring the diffracted slit image to match the reticule. Check the result of this procedure and repeat, if necessary.

Only if this turns out to be impossible, then consider realigning of the device, refer to section *3.6*.

The angle is to be read on the outer scale.

3.5 Measurements with a prism

Fig. 6: Observation of the undeflected light

Illuminate the entrance slit with the light to be examined and denote the angle position of the ocular telescope, where the slit image of the undeflected light matches the reticule.

The surface reflex of the prism can be exploited to align the table precisely horizontal: Turn the ocular through 120° from straight position. Then always one of the levelling screws 6 (refer to the arrow in Fig. 7) can be used to align the reflected slit image to vertical centre of the reticule. For this loosen the lock screw for the table 13 but keep the lock screw 4 fixed. Turn the table each time through 60° and repeat the alignment until the table is horizontally aligned.

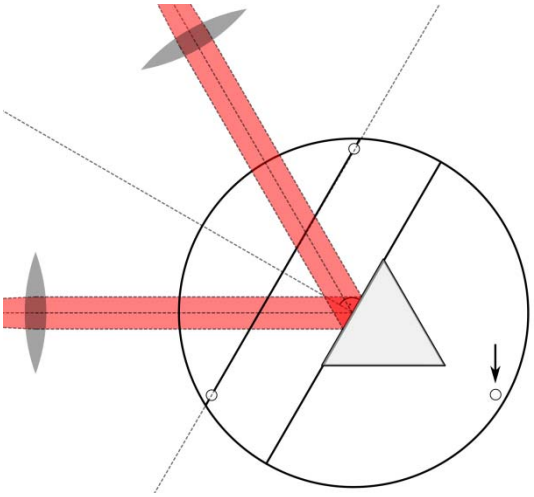
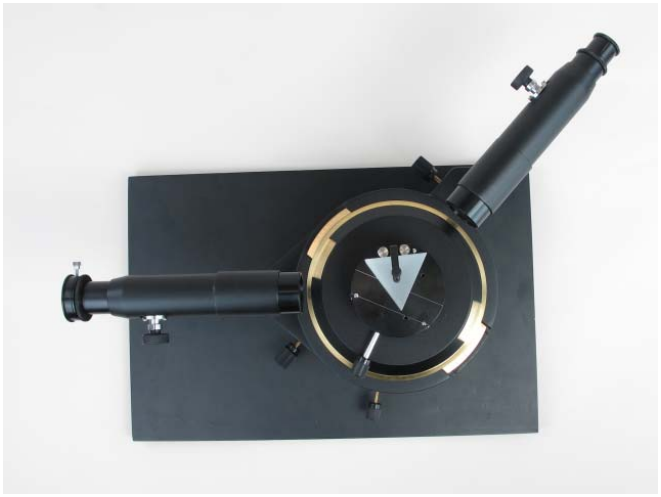


Fig. 7: Horizontal alignment of the table

If this is not successful though the prism is cut precisely, then check realignment of the device, see section 3.6.

Now attach the prism to the table as in Fig. 8. To find the rough position for prism and ocular, the ocular can first be turned to the side and the collimator viewed through the prism by eyesight. If you see the slit through the prism, then move the ocular to about the angle position where your eye has been.



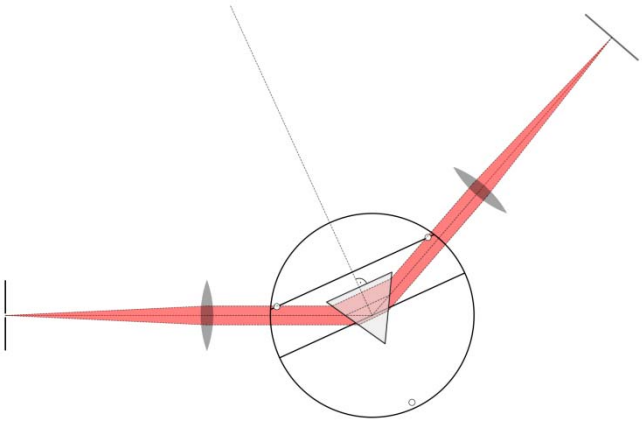


Fig. 8: Beam path at the angle of least deflection

If you can see the image of the slit in the ocular, then find the angle of least deflection by turning the table with the prism until the slit image does no further move towards straight position. At the angle of least deflection the dependence of the slit image position on table position is least. Further at this position the set up is symmetrical and the surface normal of the prism is the bisectrix between collimator and ocular telescopes. Now tighten lock screws *13* and *14* and use the fine adjustment knobs for angle measurement. For each light wavelength the angle of least deflection is to be found separately and denoted along with the angle between collimator and ocular axis.

The exact position of the prism on the table is not so relevant, if the parallelism of the light beam in use is precise, since changes in the prism position would only effect a parallel shift of the beam and all parallel beams would be focussed to the same point by the perfect lenses of the telescope. But in reality there are lens aberrations and thus the beam path should be kept as symmetrical as possible and the prism position should allow for the largest possible clear width of the light.

3.6 Realigning the device

For the holding screws of the pillars of ocular- and collimator telescopes (*4* in Fig. 9) a 6 mm Allen key is necessary. A 3 mm Allen key is necessary for the levelling screws (*1* and *3* in Fig. 9) that fix the fulcrum (*2* in Fig. 9).

Fig. 9: Changing the telescope alignment

In order that in a configuration like in Fig. 4 the slit appears vertically centred to the reticule, both collimator and ocular can be rotated about fulcrum *2* by first slightly loosening one of the screws *1* and *3* and then tightening the other. The telescopes should be aligned along a straight line as seen in Fig. 10.


Fig. 10: Telescope alignment along a straight

In order that the telescopes are aligned along a straight line that runs through the main axis of rotation of the goniometer, refer to Fig. 11, the holding screws of the pillars (*4* in Fig. 9) have to be loosened so the telescopes can be rotated around the axis of the pillar.

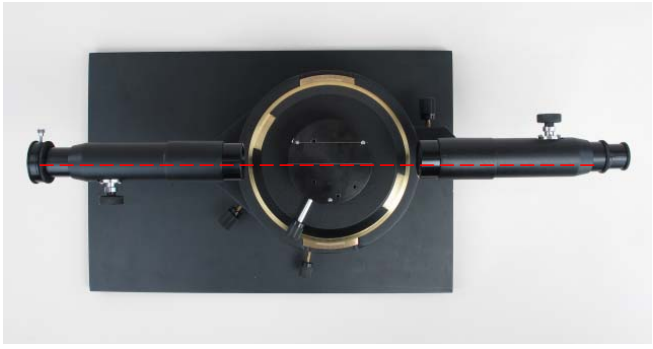


Fig. 11: Telescope alignment along a straight through centre of rotation

The table can be mounted such that the height matches the top level of the telescopes. Then the marking of the table and the telescopes are brought into a straight line looking along the upper edge of the telescopes.

5 SCOPE OF DELIVERY

All items depicted in Fig. 1, and additionally a clamping ring that can be used to set the table height. The ring must be fixed to the holding stem of the table with a 1.5 mm Allen key.

6 RECOMMENDED ACCESSORIES

Refer to experimental manuals:

P2210301 Dispersion and resolving power of a prism and a grating spectroscope

P2510601 Fine structure: one and two electron spectra

7 TECHNICAL DATA

Height light path above table	180 mm
Focal length:	
Collimator telescope	178 mm
Ocular telescope	178 mm
Magnification ocular	15x
Clear beam width	32 mm
Spectrometer table diameter	85.5 mm
Scale diameter	176 mm
Reading accuracy	0°0‘30“

8 WASTE DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.

Do not dispose of this product with normal household waste.

If this unit needs to be disposed of, please return it to the address that is stated below for proper disposal.

PHYWE Systeme GmbH & Co. KG
Customer Service
Robert-Bosch-Breite 10
37079 Göttingen
Germany

Phone +49 (0) 551 604-274
Fax +49 (0) 551 604-246