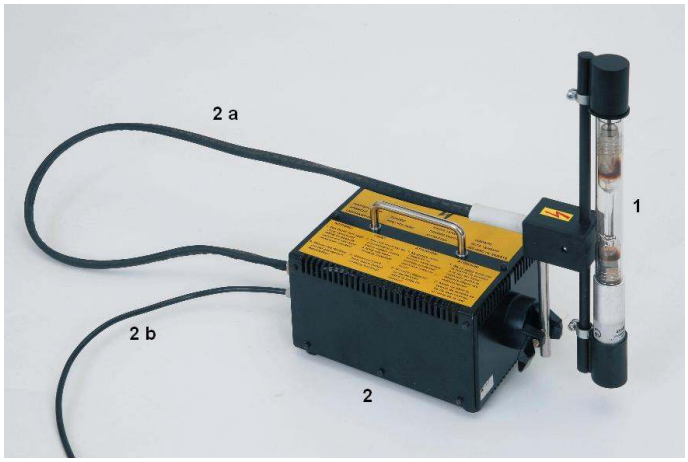
Lehr– und Didaktiksysteme
LD Didactic GmbH
Leyboldstrasse 1 · D-50354 Huerth

08/08-Kem

Instruction Sheet 451 13, 14, 41

Balmer Lamp (451 13)
Balmer Lamp, Deuterated (451 41)
Power Supply Unit for Balmer Lamp (451 14)



1 Balmer Lamp

2 Power Supply Unit for Balmer Lamp
2 a High Voltage Cable
2 b Mains Cable

The Balmer lamp (451 13) provides - in conjunction with a spectrometer array of the type used in schools - the four visible lines H_α, H_β, H_γ and H_δ of the hydrogen spectrum (Balmer series). The quantitative evaluation of the spectrum permits determination of the wavelengths, so that the Balmer series formula

$$\frac{1}{\lambda} = \frac{\nu}{c} = R_\infty \left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

with n: 3, 4, 5, 6....

and $R_\infty = 1.097373 \cdot 10^7 \mathrm{m}^{-1}$ (Rydberg constant)

can be confirmed by experiment.

For exact measurement the Rydberg constant should be corrected by the reduced mass μ :

$$R_H = \frac{R_\infty}{1 + \frac{m_e}{m_p}}$$

with m_e : mass of the electron
and m_p : mass of the proton

		Hydrogenium H	
n	colour	line	$\frac{\lambda}{\mathrm{nm}}$
3	red	H_α	656.28
4	turquoise	H_β	486.13
5	blue	H_γ	434.05
6	violet	H_δ	410.17

With a high-resolution spectrometer (resolution approx. 0.1 nm) the line doublets of a hydrogen/deuterium mixture can be demonstrated using the Balmer lamp, deuterated (451 41). The Rydberg constant of Deuterium is

$$R_D = \frac{R_\infty}{1 + \frac{m_e}{m_p + m_n}}$$

with m_n: mass of the neutron

The individual lines of the Balmer spectra of hydrogen and deuterium differ slightly in position:

colour	lines	$\frac{\Delta\lambda}{\mathrm{nm}}$
red	$H_\alpha - D_\alpha$	0.179
turquoise	$H_\beta - D_\beta$	0.132
blue	$H\gamma - D\gamma$	0.118
violet	$H_\delta - D_\delta$	0.112

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1 Safety Notes

The device complies with the safety requirements for electrical measuring, control and laboratory equipment in accordance with DIN EN 61010 part 1, and it is constructed in compliance with safety class I. The device is intended for use in dry rooms that are suited for the operation of electrical equipment and devices.

If the device is used as prescribed, its safe operation is guaranteed. However, safety is not guaranteed if the device is improperly used or carelessly handled. If it has to be assumed that safe operation is no longer possible (e.g. in the case of visible damage), shut down the device immediately.

- When putting the device into operation for the first time, check whether the value for the mains voltage indicated on the rating plate (back of housing) agrees with the local value.
- Before putting the device into operation, examine the housing for damage and the connecting leads for defective insulation. In case of malfunction or visible damage shut down the device and make sure that it is not used inadvertently.
- Do not open the device.
- Disconnect the mains plug before replacing a defective fuse.

The power supply for Balmer lamp generates dangerous voltages, which can be touched at the contacts of the holder, if there is no Balmer lamp inserted.

- Always disconnect the mains plug from the wall outlet before making any changes to the Balmer experiment setup – particularly when changing the Balmer lamp !
- Connect the power supply unit for Balmer lamp to mains only, if a Balmer lampe is inserted correctly.

- Do not touch the Balmer lamp – very hot !

2 Description, Technical Data

2.1 Balmer lamp (451 13)

The Balmer lamp is an AC operated gas discharge tube filled with water vapour. The fused tube is supplied with water vapour by means of a water supply bound in hygroscopic material. The water molecules are broken down by the electric discharge into atomic hydrogen and a hydroxyl group. A high-temperature resistant capillary inside the lamp confines the discharge within a narrow space so that a high concentration of atomic hydrogen is realized. This atomic hydrogen is responsible for the intense Balmer spectrum; interference due to molecular hydrogen bands cannot occur.
An oxidant, assisted by suitable catalysts, ensures that hydrogen formed during operation is oxidized to water so that the water inside the tube is recycled. This recycling of water involves the deposition of reddish-brown metal oxides which, however, will not have a negative effect on the capillary part of the tube.

2.2 Balmer lamp, deuterated (451 41)

In the Balmer lamp, deuterated, the water filling consists of about 10 % deuterated water. The individual lines of the Balmer spectra of hydrogen and deuterium differ slightly in position.

2.3 Power supply unit for Balmer lamp (451 14)

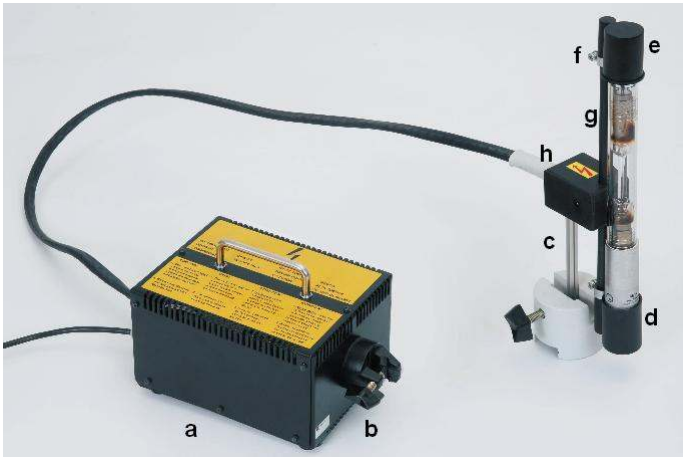


Fig. 1: Power supply unit for Balmer lamp

The power supply (Fig. 1) consists of the power supply unit (a) operated from the AC mains outlet and the Balmer lamp socket, which is permanently connected with this unit, contact-protected and high voltage-proof. The high AC voltage required to operate the Balmer lamp is produced in the high-voltage power supply by means of a high-reactance transformer.

The high-voltage cable from the rear of the power supply unit ends at a distributor box (h). The tubes fitted to the distributor box are used for two purposes:
1) to support the Balmer lamp, and
2) to enclose the high-voltage connections

At the ends of the tubes (g) are the plastic lamp sockets. The lower socket (d) is permanently connected with the tube while the upper socket (e) can be demounted by detaching the clip (f). The lamp holder can be attached via the stand rod (c) either on the portable high-voltage power supply (clamp with knurled screw (b)) or to the rider of an optical bench or to stand material.

The on-off switch with operating indicator lamp and the mains-voltage selector switch with integrated fuse holder are located on the rear of the device.

Technical Data

Mains connection voltages and fuses:

451 14	220 ... 240 V 50 ... 60 Hz T 1.25 A
451 14 NA	110 ... 130 V 50 ... 60 Hz T 2.5 A
No-load voltage:	3.5 kV
Operating voltage:	appr.. 1500 V
Operating current:	appr. 50 mA

3 Operation

3.1 Preparing the Balmer lamp

Dangerous voltages !
When setting up the Balmer lamp, make sure the power supply unit is not connected to the mains.

- Fit the lamp holder with stand rod (c) to clamp (b) of the high-voltage power supply.
- Detach the clip (f) at the upper lamp socket (e), pull it off downward and place it on the distributor box (h).
- Remove the top lamp socket (e) by pulling it upward. The high-voltage cable with contact spring bushing is exposed.
- Insert the aluminium socket of the Balmer lamp into the centre of the lower, permanently mounted lamp socket (d) and press it down. Make sure that the metal pin of the lamp is seated in the contact spring bushing of the socket.
- Connect the cable, led from the tube (g) via the contact spring bushing.
- Press on the upper lamp socket (e) until part of the ribbing in tube (g) is covered.
- Fix the upper lamp socket (e) to tube (g) by means of clip (f)

3.2 Putting the Balmer lamp into operation

- Connect to the mains.
- Set the switch on the high-voltage power supply to "ON". The Balmer lamp is ignited at once.

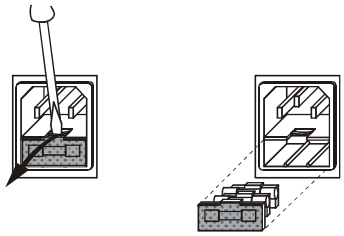
3.3 Notes on operation

- To ensure steady burning of the Balmer lamp, a certain operating temperature is required (approx. 55 ℃, measured at the aluminium socket). If the operating temperature is too low (e.g. immediately upon switching on), discharges outside the capillary may occur, causing the lamp to flicker. Steady discharge conditions will be reached after an operating time of approx. 10 to 15 minutes.
- If at high ambient temperatures the operating temperature becomes too high (above approx. 70 ℃, measured at the aluminium socket), the lamp may go out after a longer period of operation. In this case the lamp can be normally operated again after it has cooled down.
- If after a long period of operation the hot Balmer lamp does not ignite after being switched off and immediately switched on again, wait until it has cooled down before switching it on once more.
- The lamp should only be operated in the vertical position, with the aluminium socket facing downward. In other operating positions the light will start to flicker after some minutes or will even go out.

- At initial operation, a band-like background will appear in addition to the strong Balmer spectrum. This background will disappear after approx. one hour's operation. The oxygen lines in the red and green spectral region, which are very weak compared to the Balmer lines, will remain.
- With hot Balmer lamps the yellow sodium line will occasionally be visible in the middle section of the capillary. In this case it is advisable to observe the upper and lower ends of the capillary where the disturbing yellow line will not appear.

4 Replacing the primary fuse

- Disconnect the mains plug.

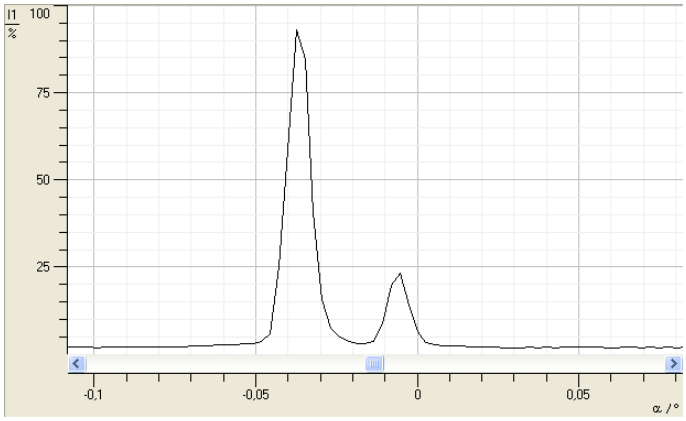


- Pry out insert.
- Remove the defective fuse and replace it with a new fuse which has been checked for the correct rating.
- Slide insert back into the device.

5 Examples of experiments

- Observation of the Balmer lines with a pocket spectroscope or directly with a Rowland grating.
- Observation and measurement of the Balmer lines with the school spectroscope or with the spectro- and goniometer.
- Demonstration and measurement of the Balmer lines in an optical set-up with a Rowland grating and screen.
- Measurement of the Balmer lines in an optical set-up with the Holographic grating (471 27):

- Measuring the splitting of the lines of the deuterated Ballmer lamp with ocular (s. Fig.)
  or with VideoCom:



- H_α , D_α -lines, measurement with VideoCom