3B SCIENTIFIC® PHYSICS

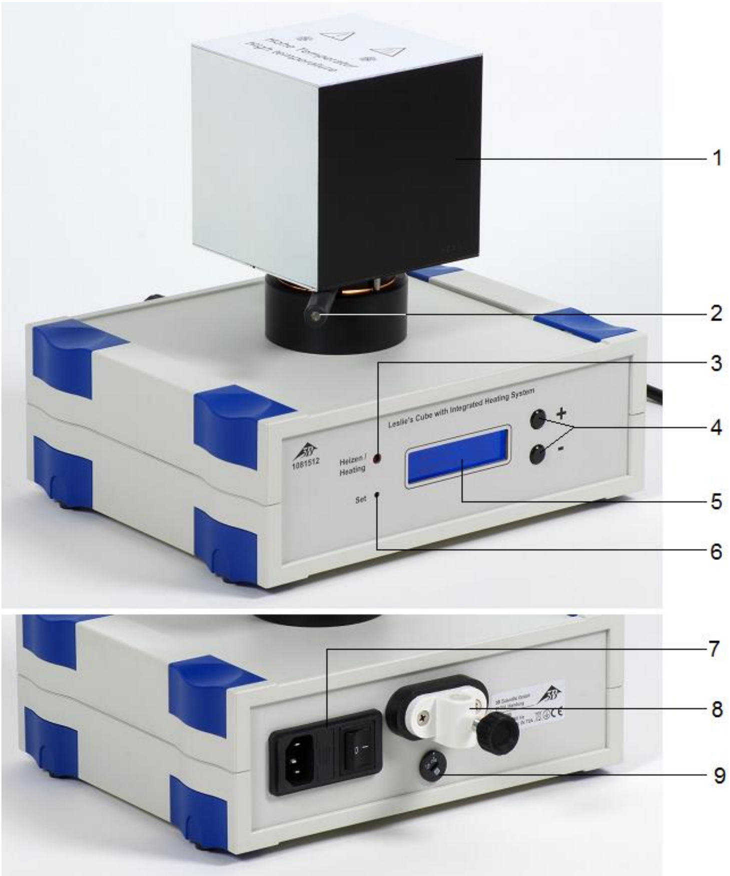
...going one step further

Leslie Cube with Heater

230 V, 50/60 Hz: 1017730 / U8498299-230
115 V, 50/60 Hz: 1017729 / U8498299-115

Instruction sheet

12/16 SD/UD



1 Leslie cube on rotating base
2 Handle
3 LED status indicator
4 Setting buttons “+/-”
5 Display
6 “SET” button
7 Mains socket with switch and fuse holder
8 Holder for thermopile
9 Voltage selector switch, 115/230 V

1. Safety instructions

The Leslie cube with heater conforms to all safety regulations for electrical measuring, control, monitoring and laboratory equipment, as specified under DIN EN 61010, Section 1, and the equipment has been designed to meet protection class I. It is intended for operation in a dry environment, suitable for the operation of electrical equipment and systems.

Safe operation of the equipment is guaranteed, provided it is used correctly. However, there is no guarantee of safety if the equipment is used in an improper or careless manner.

If it may be assumed for any reason that non-hazardous operation will not be possible (e.g. visible damage), the equipment should be switched off immediately and secured against any unintended use.

In schools and other educational institutions, the operation of the Leslie cube with heater must be supervised by qualified personnel.

- Before using the equipment for the first time, confirm that the specifications printed on the rear side of the housing are compatible with the local mains voltage.
- Before using the equipment, check the housing and the mains lead for any damage. In the event of any malfunction/operational defect or visible damage, switch off the unit immediately and secure it against unintended use.
- The instrument may only be connected to the mains via a socket that has an earth connection.
- Replace a faulty fuse only with one matching the specifications stated at the rear of the housing.
- Disconnect the equipment from the mains before replacing a fuse.
- Never short the fuse or the fuse holder.
- The equipment may only be opened/repaired by qualified and trained personnel.

The Leslie cube can reach temperatures of up to 120°C.

- Do not touch the Leslie cube during the experiments, in particular while it is heating up or cooling down. There is a risk of getting burned. Only use the handle to turn the cube.

2. Description

The Leslie cube with heater is a hollow aluminium cube used for quantitative investigation of thermal radiation from a body as a function of temperature and the nature of the surface. In particular, it allows for qualitative verification of the Stefan-Boltzmann law.

The cube can be rotated and has a lamp for heating purposes as well as a temperature sensor for closed-loop control heating so that the surfaces are at a set temperature, which can also be adjusted. The side surfaces are polished, matt or painted white or black. The control unit makes it possible to set up the system easily by means of setting buttons and a two-line display showing the temperature set-point and the actual temperature. The temperature display can be configured to display in °C or °F. An LED indicates the operating status of the heater. A holder attached to the control unit is provided to accommodate a thermopile. All the surfaces are guaranteed to be located the same distance from the thermopile throughout the experiment and a constant temperature is also guaranteed.

The 1017729 Leslie cube with heater is for operation with a mains voltage of 115 V (±10%), and the 1017730 unit is for operation with a mains voltage of 230 V (±10%).

3. Technical data

Mains voltage:	115 / 230 V AC ± 10%, see rear of housing
Mains frequency:	50/60 Hz
Power consumption:	150 W
Fuses:	115 V: 2x 4 A slow-blow, 230 V: 2x 2 A slow-blow
Lamp:	150 W, socket: BA15d, design: T4, 115 V: order no.: 5008450 230 V: order no.: 5009078
Temperature range:	40 - 120°C
Resolution:	1°C
Temperature display:	2-line LCD display for temperature set-point and actual temperature
Display accuracy:	5%
Ambient temperature:	5°C to 40°C
Max. relative humidity:	80%
Contamination class:	2
Protection type:	IP20
Inside diameter of holder:	10 mm
Dimensions:	250 x 250 x 220 mm^3
Weight:	1,8 kg

4. Operation

To perform experiments using the Leslie cube, the following equipment is also required:

1 Thermopile	1000824
1 Measurement amplifier @230 V	1001022
or	
1 Measurement amplifier @115 V	1001021
1 Digital multimeter P3320	1002784
1 HF patch cord, BNC/4 mm plug	1002748

- Use the “SET” button to configure the temperature display for °C or °F.
- The set-point for the temperature is adjusted using the “+/-” buttons.
- Pressing the minus pushbutton again at a set temperature of 40°C turns off the heating completely. The display will then show “Heating off”.

4.1 Changing the fuse

- Turn off the power switch and unplug the mains plug.
- Lever out the fuse holder on the back of the power supply with a flat-head screwdriver (Fig. 1). Insert the screwdriver from the connector side of the fuse holder.

Fig. 1 Changing the fuse

- Take out the blown fuse and replace it with a new one of the correct specification. Press the fuse holder back into place.

4.2 Changing the heater bulb

- Turn of the control unit and be sure to unplug it from the mains.
- Allow the Leslie cube to cool down to room temperature.
- Open the cover of the Leslie cube by undoing the two cross-head screws at the top.
- First push the blown bulb of the heater lamp in slightly, whilst turning it anti-clockwise, then remove it.
- Hold the new heater lamp bulb with a cloth and plug it into the socket. Make very sure you do not leave fingerprints or any other smudges on the glass of the bulb.
- Screw the cover back on.

5. Sample experiment

How thermal radiation from a body depends on temperature and nature of surface

- Fasten the thermopile into its holder in such a way that is aligned in the centre of the side of the side of the Leslie cube it is facing and at right angles to it.
- Connect the measurement output of the thermopile to the voltage input of the measuring amplifier using a high-frequency cable and set the measuring range to 10 mV.
- Connect the digital multimeter to the voltmeter sockets on the measuring amplifier and set the measuring range to DC.
- Turn on the control unit. When the actual temperature T_0 has settled to a stable figure, read off the value and make a note of it.
- Adjust the set-point for the temperature to $T = 40°C$ and record measurements, e.g. in steps of 10° over a range $40°C \le T \le 120°C$. For each of the selected temperatures T, read off the voltage U from the digital multimeter and make a note of both values as soon as the actual temperature is equal to the set temperature. Take the notes into account.
- Carry out a set of measurements for each of the four different surfaces.
- Plot the voltages for all four sets of measurements against $T^4 - T_0^4$ on a graph (Fig. 2).

Notes:

The measurements can be distorted by external influences (body heat, sunshine, radiators).

- To record each measurement, first wait till actual temperature and the voltage have both settled to stable values.

The voltage U measured is directly proportional to the irradiance $I = P/A$, i.e. the radiation power P per area A.

All temperatures need to be converted to Kelvin as follows:

(1) $\text{K} = °\text{C} + 273.15$

(2) $\text{K} = \frac{(°\text{F} + 459.67)}{1.8}$.

For each of the four surfaces, the measurements will lie very close to a straight line, thus confirming the Stefan-Boltzmann law:

(3) $U \propto I = \frac{P}{A} = \varepsilon \cdot \sigma \cdot \left(T^4 - T_0^4\right)$.

U: Measured voltage
I: Intensity of radiation
P: Radiation power
A: Area
T: Temperature
T_0: Ambient temperature

ε: Emissivity
σ: Stefan-Boltzmann constant:

$$(4)\quad \sigma = 5.67 \cdot 10^{-8} \frac{\mathrm{W}}{\mathrm{m}^2 \cdot \mathrm{K}^4}\,.$$

Notes:

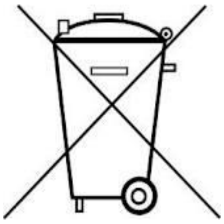
For an ideal black body $\varepsilon = 1$.

A so-called grey body cannot fully absorb all the radiation falling on its and cannot therefore fully emit radiation, i.e. $\varepsilon < 1$.

In general ε is dependent on the wavelength λ of the incident the radiation, i.e. $\varepsilon = \varepsilon(\lambda)$.

6. Storage, cleaning and disposal

- Keep the equipment in a clean, dry and dust-free place.
- Before cleaning the equipment, disconnect it from its power supply.
- Do not clean the unit with volatile solvents or abrasive cleaners.
- Use a soft, damp cloth to clean it.
- The packaging should be dis-posed of at local recycling points.
- Should you need to dispose of the equipment itself, never throw it away in normal domes-tic waste. Local regulations for the dis-posal of electrical equipment will apply.



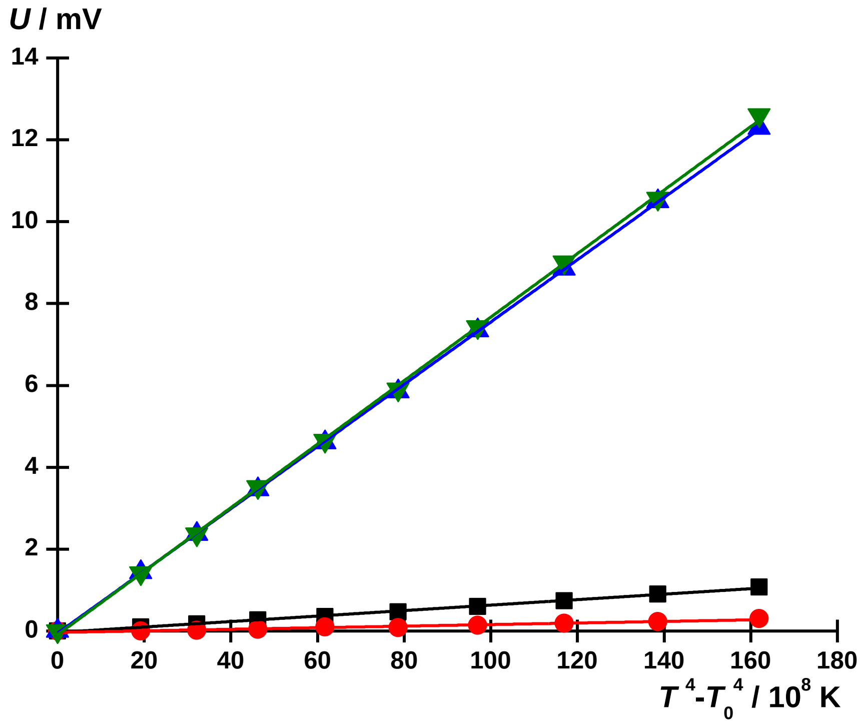


Fig. 2: Voltage U in as a function of $T^4 - T_0^4$ for the matt (black squares), polished (red circles), white (blue triangles) and black (olive triangles) sides of the Leslie cube.