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# Safety and Health – Safety in the laser laboratory

of the Faculty of Physics

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# Obligatory rules

- Laser laboratories must be marked by the warning sign on the right.
- Entering these rooms is **strictly forbidden** for unauthorized personnel who are not accompanied by an authorized member of staff.
- While class 3B + class 4 lasers are used, a warning light next to the entrance of the lab must be switched on.
- Entering the lab while the warning light is on is **strictly forbidden**.

Image source: Wikimedia (Public domain)

# Obligatory rules

- Mount laser safety curtains or protective shields with sufficient fire resistance in the lab to separate laser areas.
- New members of staff must be actively taught all safety rules on the first day of working with lasers.
- Every person is responsible for the safety in their working area.
- Only activate lasers when all safety measures have been taken and all members of staff are warned.
- Wear lamps (head lamps, flashlights) on your person if the emergency lighting is covered for experimental reasons.

# Obligatory rules

- Each incident and accident must be immediately reported to the laser safety officer. The laser safety officer of the Faculty of Physics is Wilhelm Markowitsch (Extension 72625).
- The laser safety officer will ensure that all necessary next steps are taken.

# Laser classification

| Class | Description |
|---|---|
| 1 | The laser is safe under all conditions of normal use or the laser is in completely enclosed in the case. |
| 1M | The laser is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes. |
| 2 | The laser light is only in the visible-light part of the spectrum (400 nm to 700 nm). Class 2 is considered to be safe because the blink reflex (glare aversion response to bright lights) will limit the exposure to no more than 0.25 seconds. Do **NOT** rely on this. |
| 2M | As with class 2 except when passed through magnifying optics such as microscopes and telescopes. |

Sources: Wikipedia (CC-by-sa-3.0), Wikipedia (CC-by-sa-3.0)

# Laser classification

| Class | Description |
|---|---|
| 3R | The accessible laser light is considered hazardous to the eye. |
| 3B | The accessible laser light is considered hazardous to the eye and in some cases also to the skin. Diffuse scattered light is usually considered safe. (Example: Lasers in CD/DVD burners, although the laser beam cannot be directly accessed in these) |
| 4 | A class 4 laser can burn the skin, or cause devastating and permanent eye damage as a result of direct, diffuse or indirect beam viewing. Even diffuse scattered light can pose a risk. These lasers may ignite combustible materials, and thus may represent a fire risk. Class 4 lasers are the lasers typically used in research. |

Sources: Wikipedia (CC-by-sa-3.0), Wikipedia (CC-by-sa-3.0)

# Set-up/Modification of laser optics

- Block the laser beam during the fitting of optical components with a suitable beam shield.
- Use only black (or black anodize-finish) tools.
- Only use permanently fixed optical elements.
- Adjust the laser using the smallest possible power.
- Remove any kind of jewelry or watches from your hands.
- Never insert paper or solvents in the beam of a class 3B or class 4 laser.

# Set-up/Modification of laser optics

- All safety instructions on the equipment must be followed.
- Even diffuse reflections of the beam can still have high energies. For a class 4 laser, this can have disastrous consequences like burns or severe eye damage.
- Computer monitors at beam height are a serious safety hazard because the beam can be reflected on the monitor. Turn the monitor away from the experiment, separate it from the beam by a laser protective barrier or set it at a different height than the beam.

# Danger to the eyes and skin

- Important for non-ionizing radiation: the thermal power per area as well as the wavelength-dependent absorption properties of the biological tissue.
- High-intensity sources of light (e.g. Xenon lamps) other than lasers can also lead to significant damage to the eye.
- Blue-light hazard: Permanent exposition to blue light (especially UV-C) can lead to retinal injuries even at low intensities.
- Completely cover your skin when using class 3B and class 4 lasers to prevent burns.

# Safety classification in dependence of the wavelength

| Wavelength | |
|---|---|
| < 400 nm | Organic molecular bonds are destroyed and the penetration depth becomes smaller. Damage occurs even at small surface power densities. |
| 400 nm to 1.4 µm | The cornea, intraocular fluid, eye lens and vitreous body of the eye are transparent. **Huge danger** to the eye. In addition, wavelengths over 750 nm are invisible. Therefore no defense reactions such as the blink reflex occur. |
| 1.4 µm to 3 µm | The cornea largely absorbs the radiation. This range is also considered “eye-safe”. Do **NOT** trust this because it is dangerous nonsense at higher laser powers. |
| > 3 µm | The cornea largely absorbs the radiation, but the penetration depth becomes lower than 0.1 mm. This can lead to eye damage. |

# Laser safety glasses

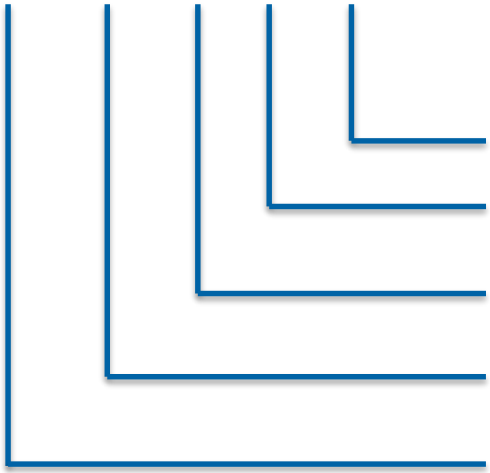
- **ALWAYS** use laser safety glasses.
- Laser safety glasses must conform to **ALL** laser types in your environment.
- Laser safety glasses are not almighty!
- Safety glasses are tested for an exposition of 5 seconds.
- Safety glasses with defects must be replaced.
- **NEVER** move your eyes at beam height even with safety glasses.

# Safety and alignment glasses according to EN 207 and 208

- The norm EN 207 defines requirements for laser safety eyewear.
- Laser safety glasses are meant to protect from unintended exposure and not from a direct look into the laser beam.
- When working with lasers, it might be necessary to see the beam clearly. The optical density of laser safety glasses is usually too high to clearly see the beam.
- To this end, laser alignment glasses are used. Requirements for this type of glasses are defined by the norm EN 208. The glasses must also carry the wording “laser alignment glasses” (in German: Laserjustierbrille).

# Safety and alignment glasses according to EN 207 and 208

- The specifications can be found directly on the glasses and/or the data sheets.
- Example: D 1064 L5 X DIN CE



Norm mark

Identification letter of the manufacturer

Protection level EN 208: R1–R5 or EN 207: L1–L10, sometimes also indicated as optical density (OD)

Wavelength range in which the glasses protect

Laser working mode: D = continuous wave, I = pulsed mode, R = giant pulsed mode, M = modelocked

# Safety glasses according to European norm 207

- European norm 207 requires that the safety glasses protect the user at least 10 s from a continuous waveform lases (D) or from 100 pulses of a pulsed-mode laser (I, R).

| Working mode | Pulse duration | Unit | Working mode | Pulse duration | Unit |
|---|---|---|---|---|---|
| D | > 0.25 s | $W/m^2$ | R | $10^{-9}$ to $10^{-6}$ s | $J/m^2$ |
| I | $10^{-6}$ to 0.25 s | $J/m^2$ | M | < $10^{-9}$ s | $W/m^2$ |

- The protection level L*n* indicates by how many orders of magnitude *n* the intensity becomes lower for the three ranges 180–315 nm, 315–1400 nm and 1400 nm–1000 µm.

# Safety glasses according to European norm 207

| Protection level | Transmission | Maximum power (E) or energy density (H) in the wavelength range | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 180 nm to 315 nm | | | 315 nm to 1400 nm | | | 1400 nm to 1000 µm | | |
| | | D $W/m^2$ | I,R $J/m^2$ | M $W/m^2$ | D $W/m^2$ | I,R $J/m^2$ | M $W/m^2$ | D $W/m^2$ | I,R $J/m^2$ | M $W/m^2$ |
| L1 | $10^{-1}$ | $10^{-2}$ | $3*10^{2}$ | $3*10^{11}$ | $10^{2}$ | $5*10^{-2}$ | $1.5*10^{-3}$ | $10^{4}$ | $10^{3}$ | $10^{12}$ |
| L2 | $10^{-2}$ | $10^{-1}$ | $3*10^{3}$ | $3*10^{12}$ | $10^{3}$ | $5*10^{-1}$ | $1.5*10^{-2}$ | $10^{5}$ | $10^{4}$ | $10^{13}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| L10 | $10^{-10}$ | $10^{7}$ | $3*10^{11}$ | $3*10^{20}$ | $10^{11}$ | $5*10^{7}$ | $1.5*10^{6}$ | $10^{13}$ | $10^{12}$ | $10^{21}$ |

# Safety glasses according to European norm 207

Example: A continuous waveform laser has a power of 50 mW/cm$^2$ and a wavelength of 780 nm.

1. The working mode is D.
2. 50 mW/cm$^2$ is equivalent to 500 W/m$^2$.
3. Protection level L1 is too small with a maximum of 100 W/m$^2$, but protection level L2 with a maximum of 1000 W/m$^2$ is sufficient.
4. The safety glasses must therefore have **at least** protection level D 780 L2.

# Alignment glasses according to European norm 208

| Protection level | Transmission | 400 nm to 700 nm | |
|---|---|---|---|
| | | Power (Pulse duration > $2*10^{-4}$ s) W | Energy (Pulse duration $10^{-9}$ s bis $2*10^{-4}$ s) J |
| R1 | $10^{-1}$ | 0.01 | $2*10^{-6}$ |
| R2 | $10^{-2}$ | 0.1 | $2*10^{-5}$ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| R5 | $10^{-5}$ | 100 | $2*10^{-2}$ |

All values assuming a beam diameter of maximum 7 mm.

# Laser safety – Further information

Further information can be found in the information sheet M 080 of the AUVA (German).

# Design and content

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