Laser Safety Instructions

Dept. of Physical Chemistry
Fritz Haber Institute

Instructor: Daniel Wegkamp (wegkamp@fhi-berlin.mpg.de)

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Formal Foundations & Regulations

EU Directive 2006/25/EC on the minimum health and safety requirements regarding the exposure of workers to risks arising from **artificial optical radiation**

Germany: Occupational Safety and Health Ordinance on **Artificial Optical Radiation** (OStrV)

Applied regulations: Technical Rules regarding the OStrV (TROS Laser)

Duties of employers:

- **Instructions of employees**
- **Documentation of the instructions**
- **Annual training**
- **Operating instructions for the Labs/Lasers (Betriebsanweisung)**

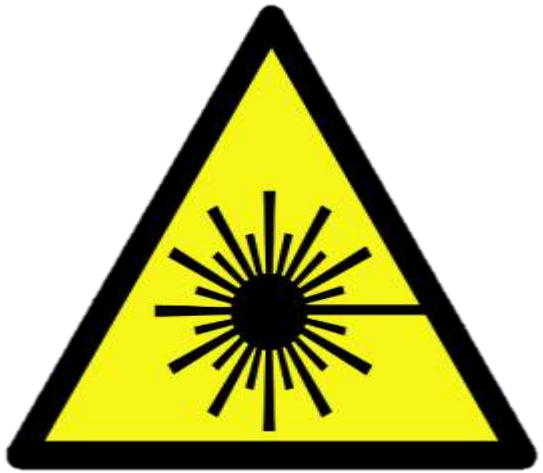
Responsible people for laser safety in the department of Physical Chemistry:

Daniel Wegkamp (wegkamp@fhi-berlin.mpg.de)
Marcel Krenz (krenz@fhi-berlin.mpg.de)

Motivation, Goals, Outline

General Laser Safety Instruction (Focus on typical laser systems in the department).
Dangers specific to certain Experiments: refer to annual specific safety instruction within work groups.

1. Hazards due to laser radiation
2. Laser labs, safety measures & rules of conduct
3. … in case of an accident?



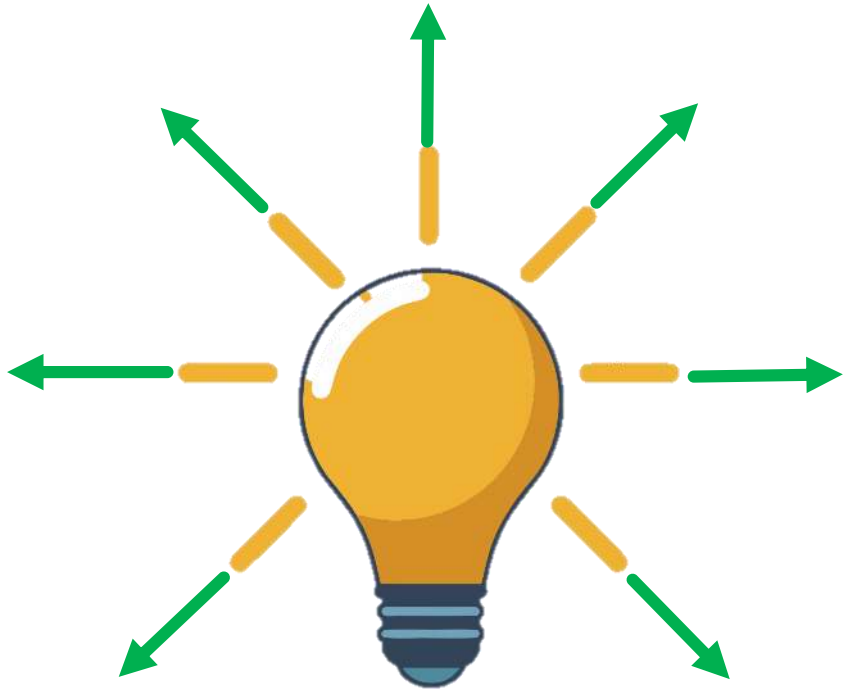
1. Hazards due to Laser Radiation

- What is special about Laser Radiation (safety aspects)
- Dangers of Laser Radiation
- Laser Classes

Laser Radiation

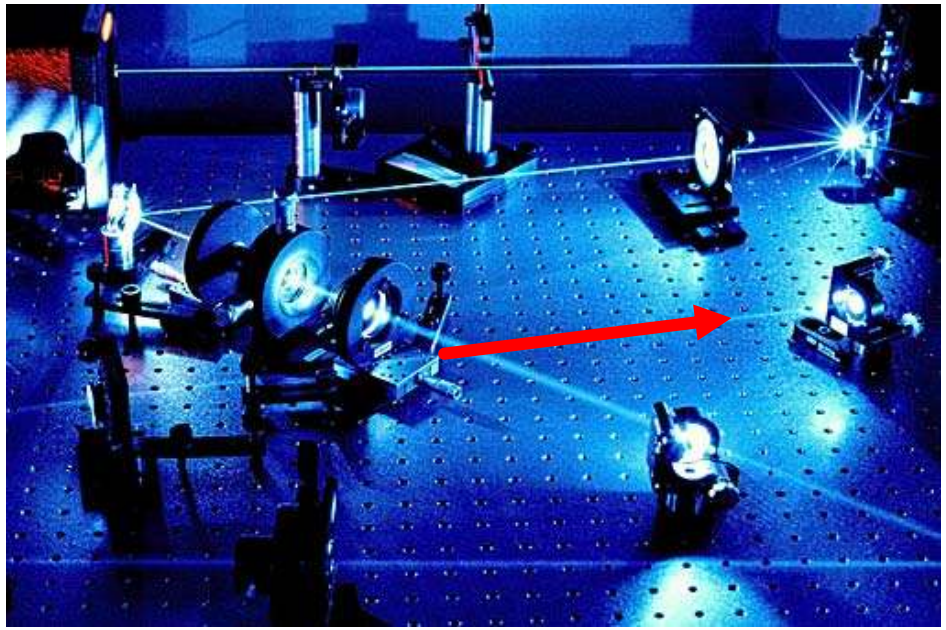
…is collimated

Common Lightsource



Distributed Radiation

LASER = Light **A**mplification by **S**timulated **E**mission of **R**adiation

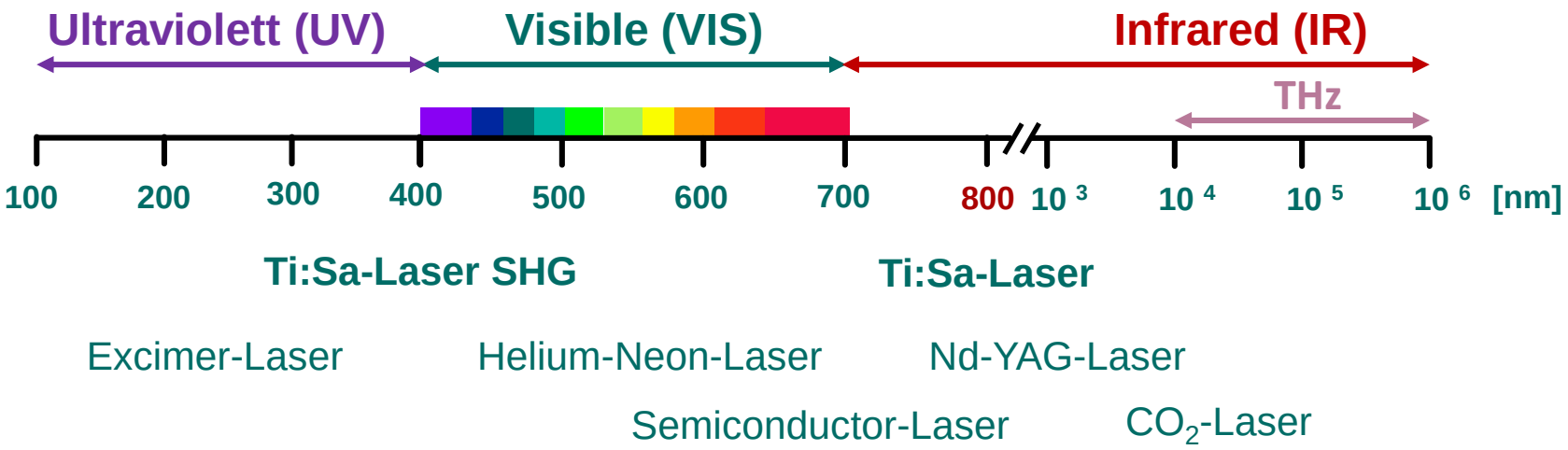


Confined Beam → Continuous High Intensity

Laser Radiation

…is broadband

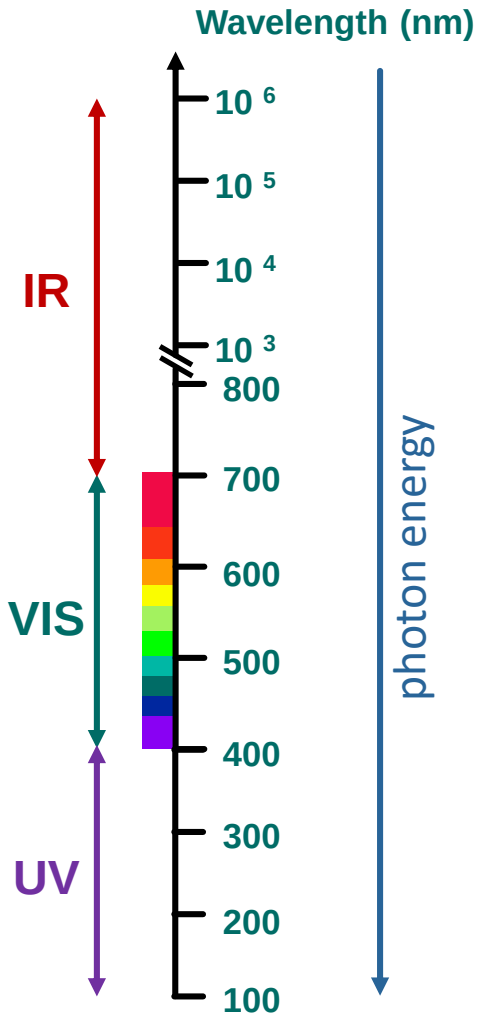
wavelength = 100 nm to 1 mm



→ Large part is invisible, but still harmful

Dangers of Laser Radiation

Overview: eye and skin damage



Effects on Eyes	Effects on Skin
burning of the cornea	
burning of the cornea clouding of the lens retinal injury	burns
retinal injury	darkening of pigment burns
lens opacity	increased pigmentation
corneal inflammation	sunburn accelerated aging skin cancer

THz sources

CO_2 Laser

Nd-YAG Laser

High Power Diode Laser

Ti:Sa Laser

NL Optics

He-Ne Laser

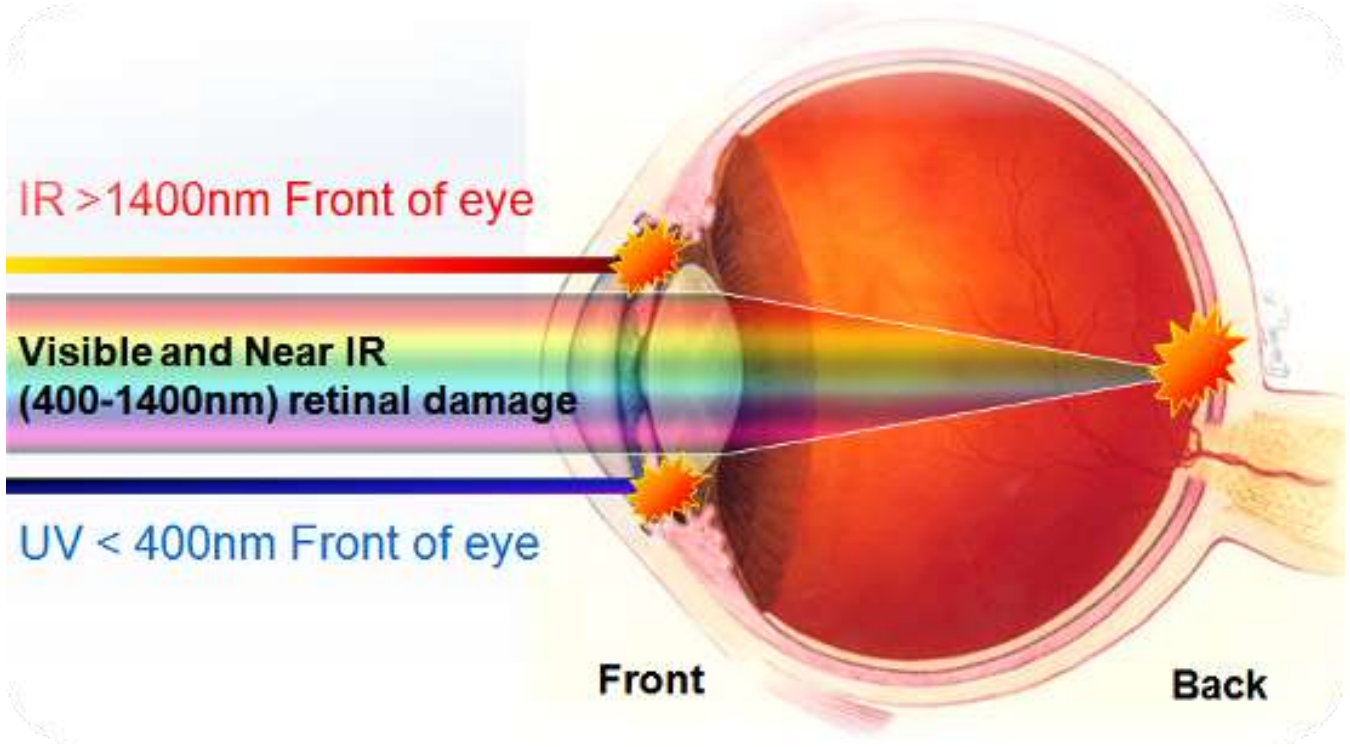
NL Optics

Excimer Laser

Dangers of Laser Radiation

Eye damage

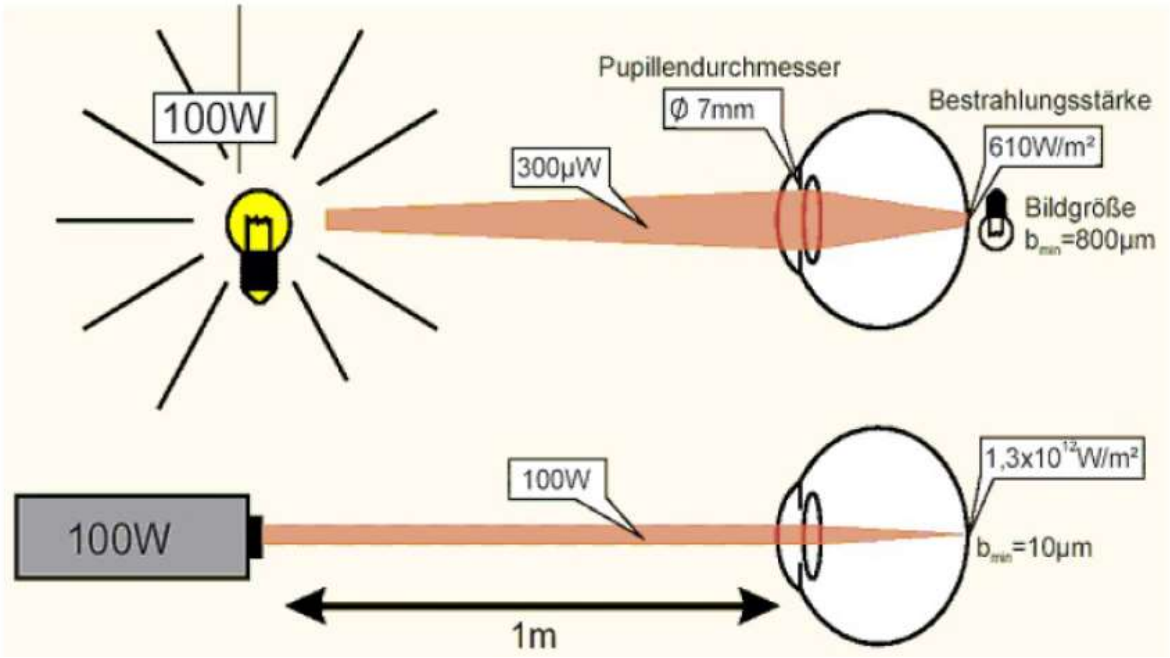
- Collimmated beam is **focused** on retina
- Type of damage depends on wavelength
- Aversion blink response reflex* only works for visible light



* aversion blink response reflex only present in 25% of all people and rarely fast *enough*

Dangers of Laser Radiation

Eye damage in numbers

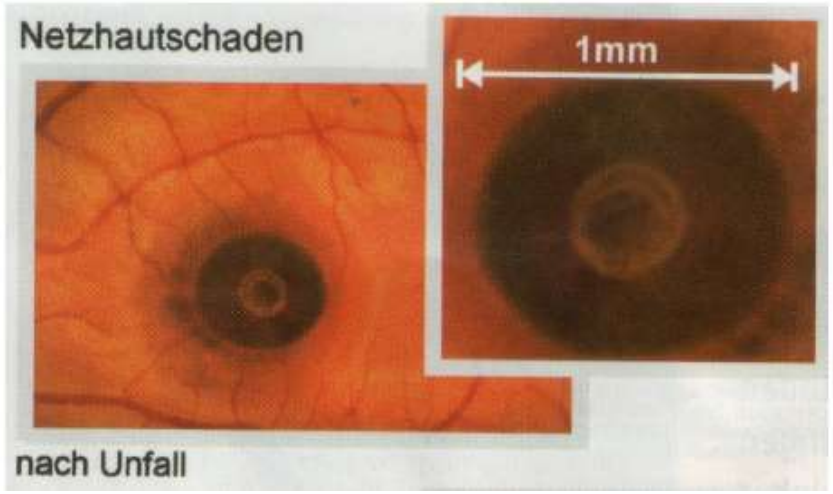


$$I_{Laser} = 2.1 \times 10^{9} \times I_{Lightbulb}$$

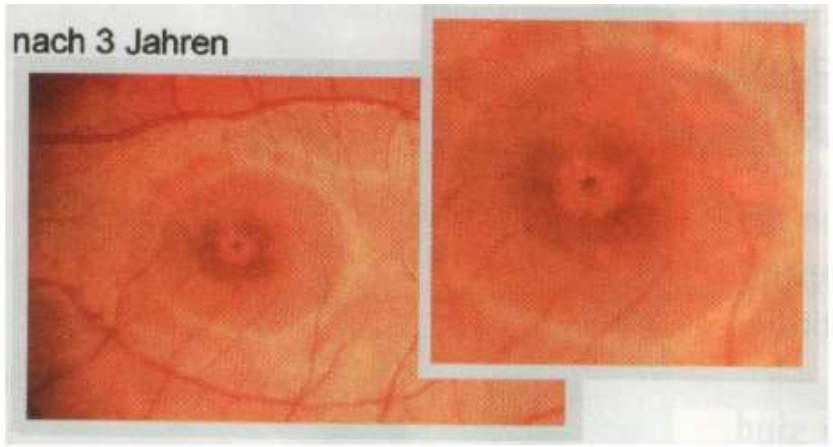
Dangers of Laser Radiation

Permanent eye damage

Immediately after accident



Only 5% of normal vision after 3 years



Strahlquelle: Rubinlaser (694nm); Pulsenergie: 20mJ; Pulsdauer: 20ns; Pulsleistung: 1MW; Entfernung: 25m; Sehstärke: 5% nach Unfall, 5% nach 3 Jahren; Persönliche Empfindung: schwarzer Fleck, abnehmende Sehschärfe

Dangers of Laser Radiation

Visual effects of eye damage

Damage to the eye is permanent and results in loss of vision!

No Damage

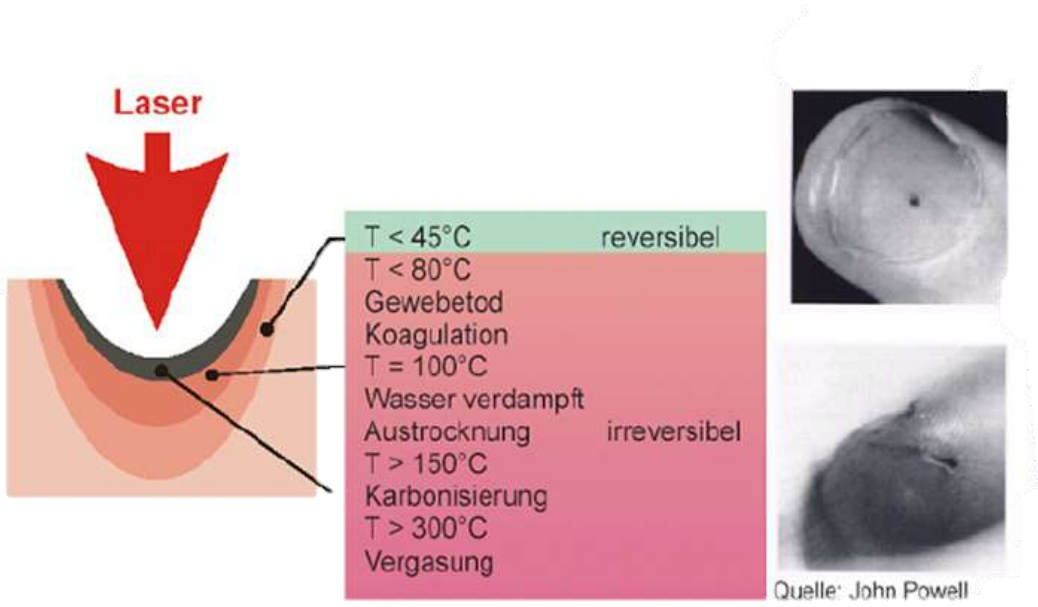
Damaged Cornea

Damaged Retina (Blind Spot)

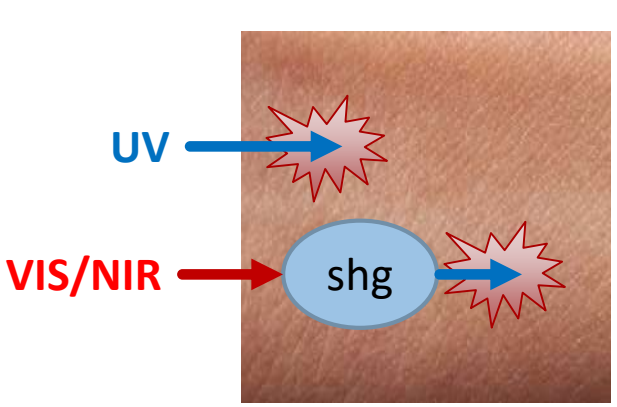
Dangers of Laser Radiation

Skin damage

Thermal Skin Injuries



UV (or ultrashort NIR) laser can cause skin cancer (accumulative effect)



Laser Classes

Definitions

AEL = **A**ccessible **E**mission **L**imit

Class	Basis for Classification
Class 1 inherently Safe (VIS/non-VIS)	Lasers which are safe under reasonably foreseeable conditions of operation.
Class 1 Laser Product (safe if not modified)	Product that contains a higher class laser system but access to the beam is controlled by engineering means.
Class 2 Low Power (VIS only)	Protection of the eye is normally provided by natural aversion blink response* which takes ca. 0.25s. These lasers are not intrinsically safe. AEL = 1mW for CW laser.
Class 1M Safe without viewing aids (302.5 nm - 4000 nm)	Safe under reasonable foreseeable conditions of operation. Beams are either highly divergent or collimated but with a large diameter. May be hazardous if user employs optics with the beam.
Class 2M Safe without viewing aids (VIS only)	Protection of the eye is normally provided by natural aversion blink response* which takes ca. 0.25s. Beams are either highly divergent or collimated but with a large diameter. May be hazardous if user emplys optics with the beam.
Class 3R Low/medium power (VIS/non-VIS)	Risk of injury is greater than for lower classes but not as high as for class 3B. Up to 5 times the AEL for Class 1 and Class 2.
Class 3B Medium/high power (VIS/non-VIS)	Direct intrabeam viewing of these devices is always hazardous. Viewing diffuse reflections is normally safe provided the eyes is no closer than 13 cm from the diffuse surface and the exposure duration is less than 10 seconds. AEL = 500mW for CW laser.
Class 4 High power (VIS/non-VIS)	Direct intrabeam viewing is dangerous. Specular and diffuse reflections are hazardous. Eye, skin and fire hazard. TREAT CLASS 4 WITH CAUTION.

* aversion blink response reflex only present in 25% of all people

Laser Classes

Examples

Class 1

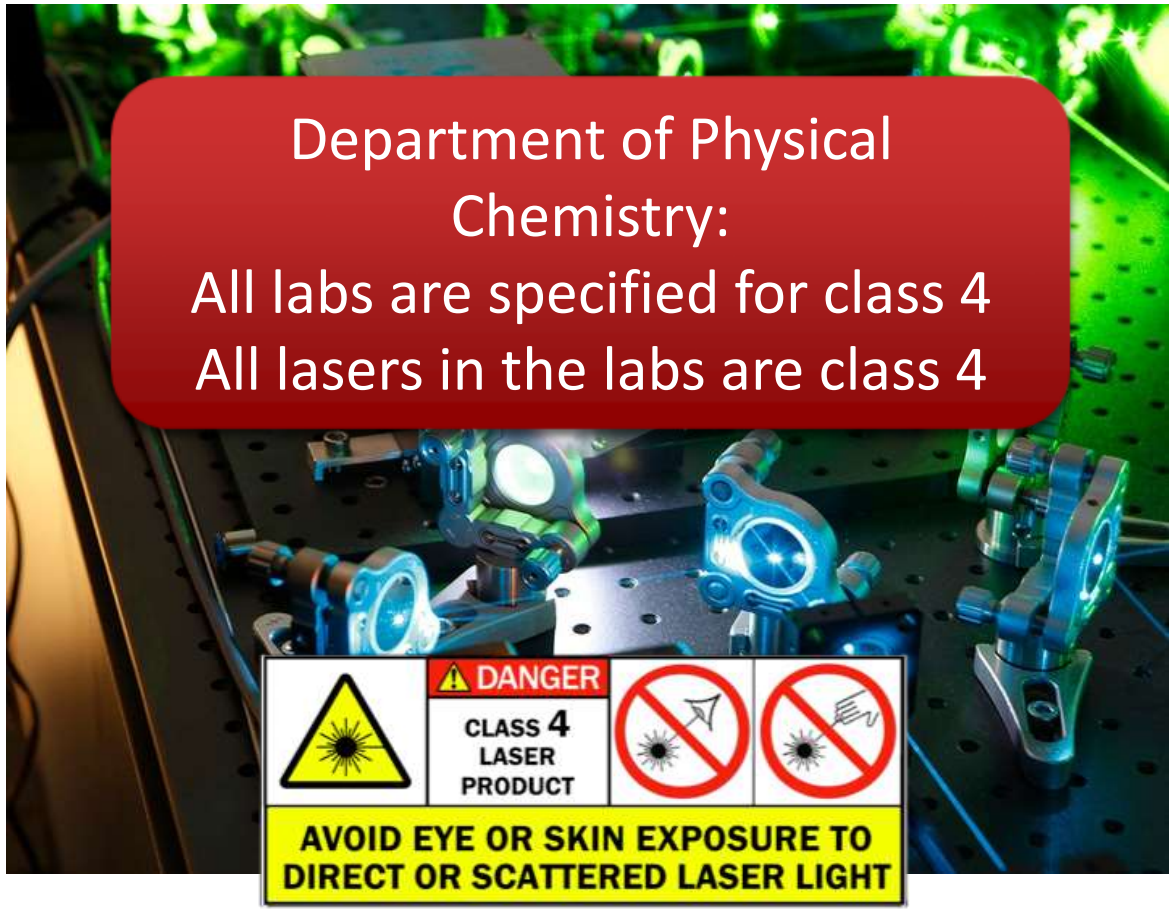
Class 2

Class 3

Laser Classes

Examples

Class 4



Manufacturer has to classify and mark their product!

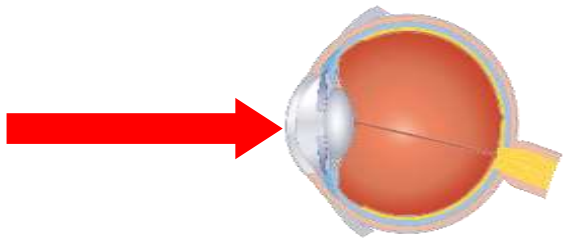
Beispiele für die Kennzeichnung von Lasern DIN EN 60825-1:2008-05

Dangers of Laser Radiation

Radiation Pathways

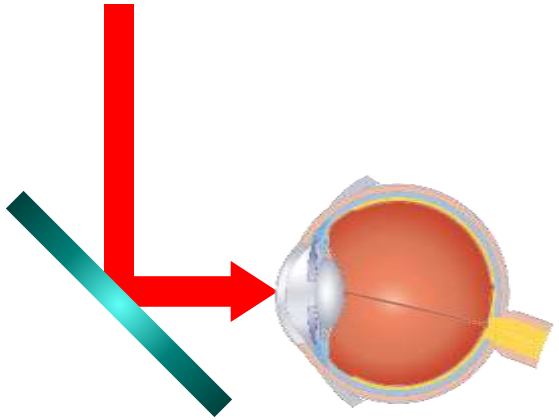
…direct radiation

e.g. laser beam
directly into the eye



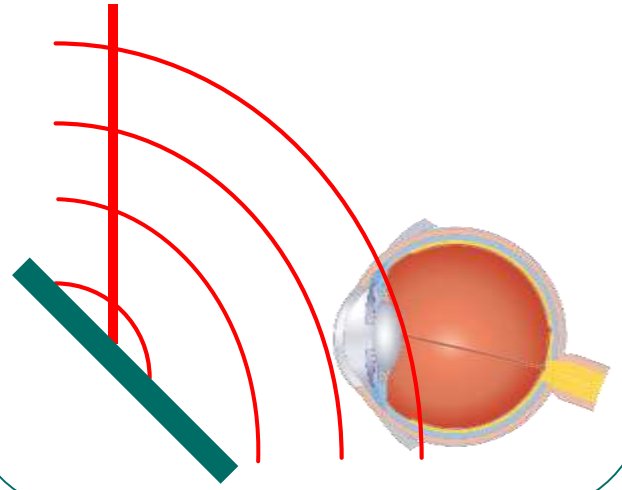
…reflected radiation

e.g. on wristwatches
or jewellery



…scattered radiation

e.g. on tools or edges

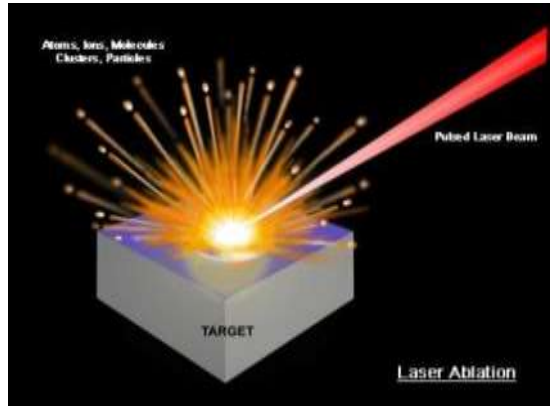


Protection from direct beam is limited even with laser safety goggles

Even detector cards scatter and potentially reflect laser radiation

Secondary Hazards…

- Electrical shock
- Fire & explosion hazard
- Laser generated air contaminants (LGACs)
- **Short laser pulses: nonlinear effects generate additional wavelengths**
- Chemical hazards: Laser dyes and solvents



IR → UV

2. Laser labs, safety measures & rules of conduct

- Laser labs in the dept. of PC
- Laser safety equipment
- Behaviour in the lab
- Laser safety goggles

Laser labs & safety measures

Risk assessment & regulations

Overview:

- Laboratories in the department of Physical Chemistry are suitable for operations of class 4 lasers and are marked as such.
- Only instructed personnel is allowed to enter, when lasers are in operation (warning signs).
- Personal safety equipment has to be used (laser safety goggles).
- Laser radiation has to be confined to the laser table(s) by 20 cm tall shielding.

Laser labs & safety measures

Warning signs

Check laser warning signs *before* you enter the lab!

No Danger Laser Off

Attention Laser On

Laser operators / scientists are responsible for correct display switch setting
Personal safety equipment (laser goggles) has to be used

Only instructed personnel is allowed to enter the lab when lasers are on

Laser labs & safety measures

Nominal ocular hazard area

Definition:

Nominal ocular hazard area (NOHA)
Lasergefahrenbereich

⟺

Area in which hazardous laser radiation can be present

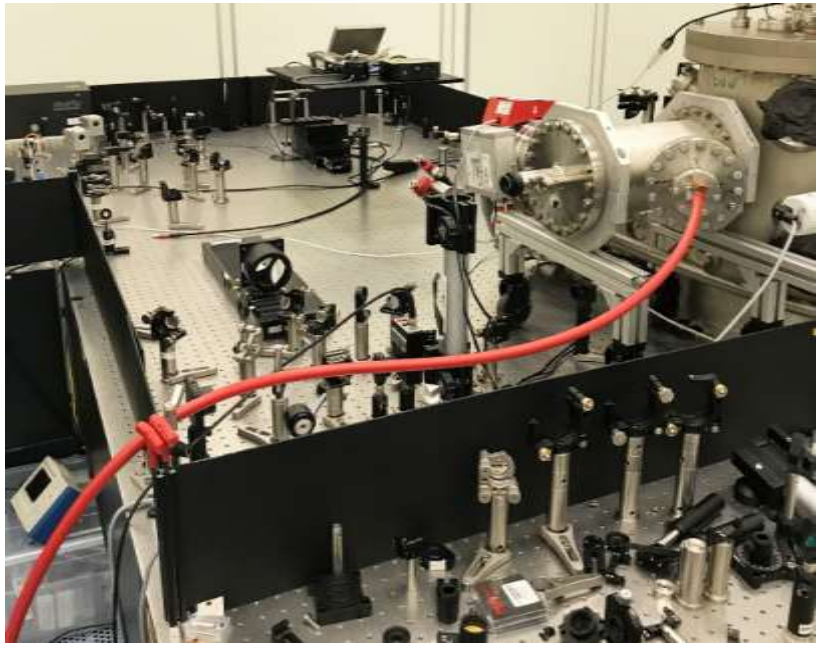
Normal operation:

NOHA is confined to the laser table if…

- … protective shielding is present around the laser table (photo)
- … laser peam runs parallel to laser table surface
- … nobody is actively manipulating the beam

Laser beam MUST NOT leave laser table!

Personal safety equipment (laser goggles) has to be used



Laser labs & safety measures

Nominal ocular hazard area

Definition:

Nominal ocular hazard area (NOHA) / Lasergefahrenbereich ⟺ Area in which hazardous laser radiation can be present

In case of maintenance…

- … within the laser system itself or
- … beams leaving the laser table or uncontrolled beams on the table for a limited period

Labs have to be marked with additional warning signs & barriers can be installed

Personal safety equipment (laser goggles) has to be used

Laser labs & safety measures

Inside the Lab

Minimize Risk:

- Workbenches at elevated height
- Elevated seats/chairs (office chairs are prohibited)
- Protect Eyes when you have to bend down
- Wear safety goggles even when you are not working with the laser, but someone else is

Do not compromise the safety of others!
Communicate with your colleagues!

Rules of conduct in the laser lab

Inside the Lab

Optimize work outfit:

- Remove Wristwatches
- Remove Jewelry and other accessories (rings, necklaces, etc.)
- Avoid shiny tools (tweezers, scissors, screwdrivers) also for UHV work

Working at the setup:

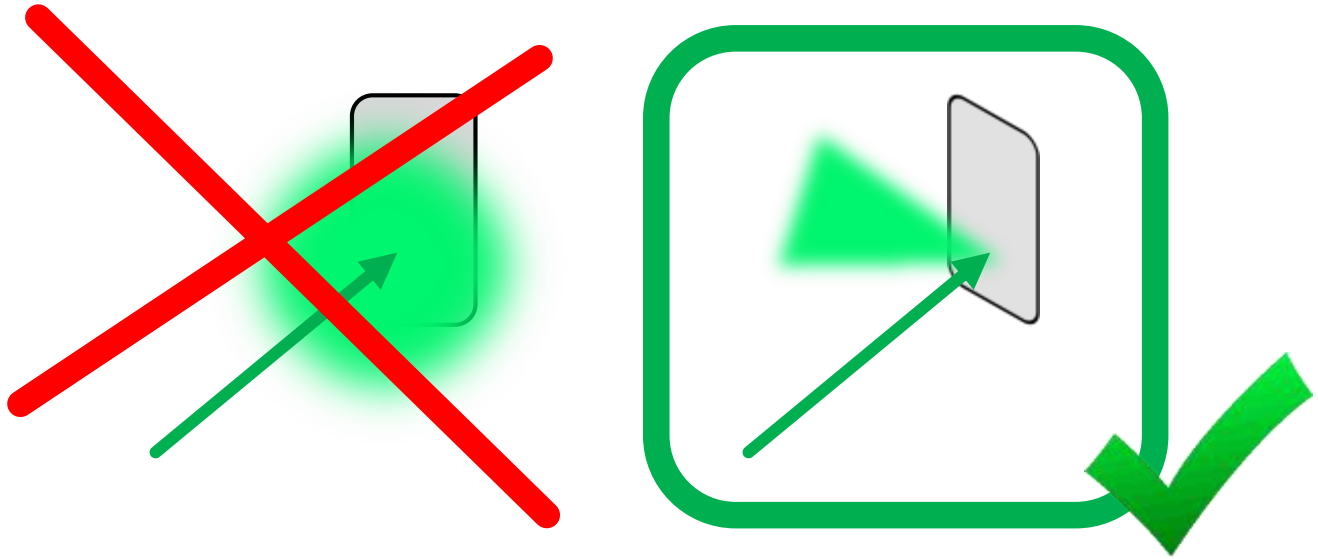
- Block beam before inserting or moving optics
- Avoid loose optics!
- Use suitable beam dumps (watercooled)
- Use tools for adjustment (fluorescent cards, cameras, etc.) **Be aware of reflections!**

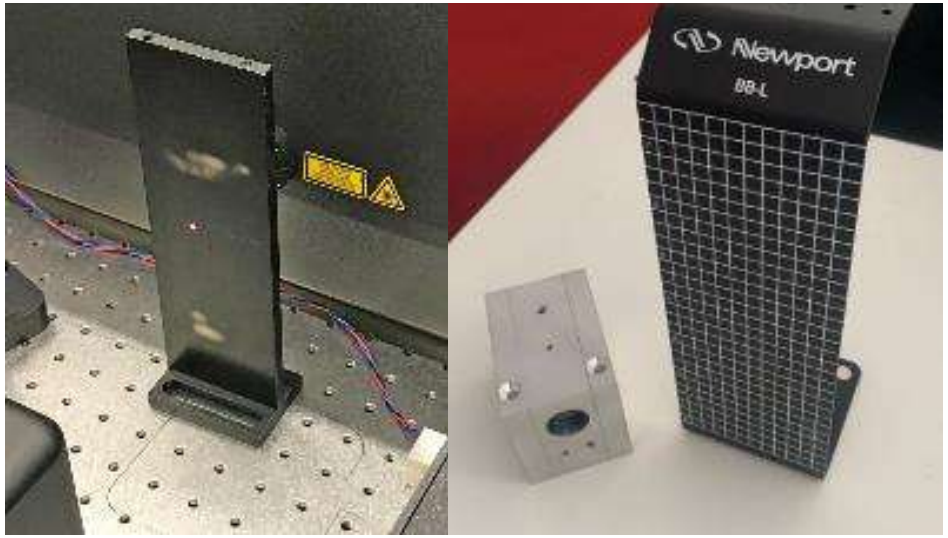
Wear safety goggles!

Rules of Conduct in the Laser Lab

Inside the Lab

- Use suitable beam dumps
- Use beam blocks carefully
- **Use detector cards carefully**





Laser Safety Goggles

Laser Goggles are personal protective gear.

Each employee…

- …gets personalized goggles with suitable specs
- …has the responsibility to make sure the goggles stay intact
- …must return the goggles when they leave the institute

Laser Safety Goggles

Product Specification

YAD

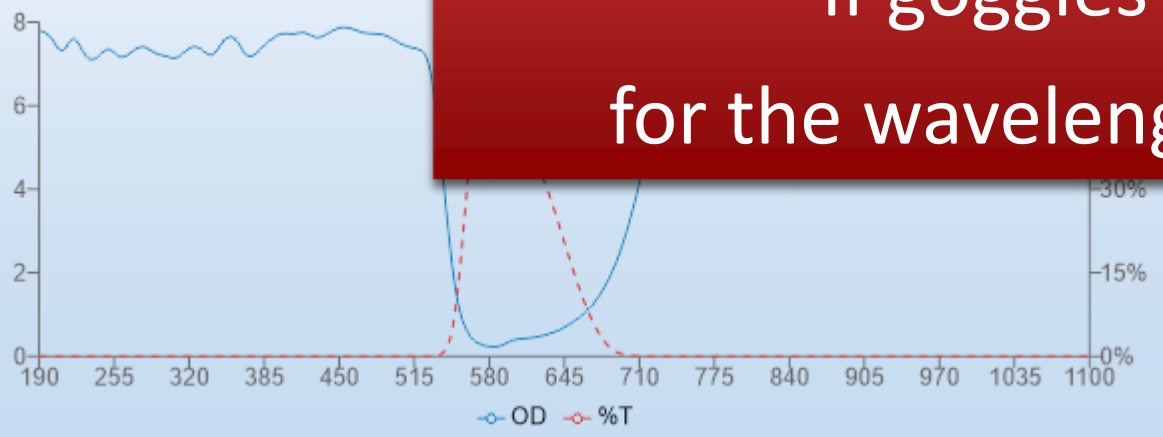
EN207Certified
Luminous transmittance:11% Amber

CE Rating

Wavelength (nm)	L-Ratings
180–315	D LB7 + R
>315–534 + 730–740	D LB5 + IR
>740–1070	D LB6 + IR

Optical Density

Spectrophotometer Data



Product Specification

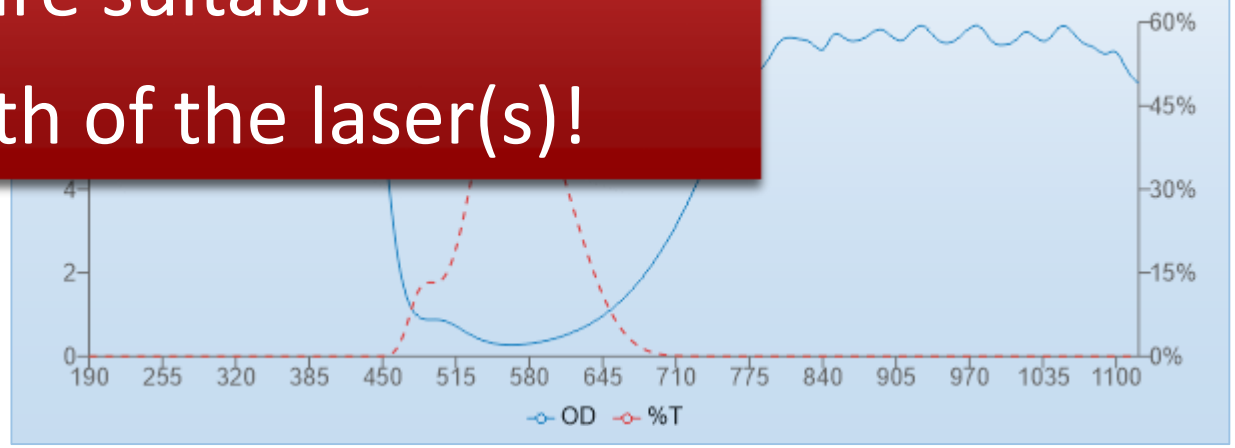
YG4

EN207Certified
Luminous transmittance:37% Green

CE Rating

Optical Density

gth (nm)	ODs
	6+
	6+
nm	7+



The protective effect only exists

if goggles are suitable

for the wavelength of the laser(s)!

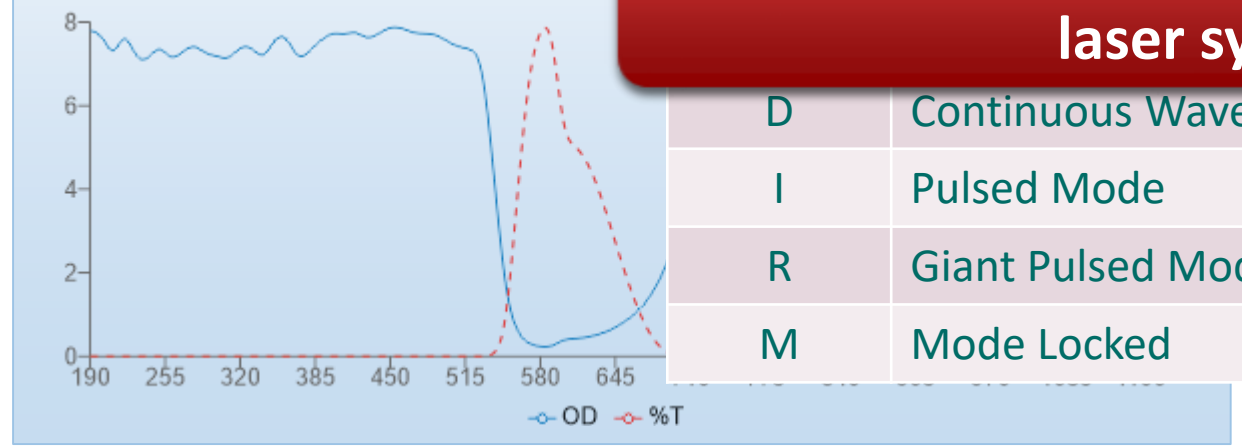
Laser Safety Goggles

Product Specification

YAD

EN207Certified
Luminous transmittance:11% Amber

Wavelength (nm)	L-ratings
180-315	D LB7 + R LB4
>315-534 + 730-740	D LB5 + IRM LB6
>740-1070	



Product Specification

YG4

EN207Certified
Luminous transmittance37% Green

Wavelength (nm)	L-ratings
180-315	D LB7 + R LB4
750-800 + >1100-1120	DIR LB6 + M LB6Y
	D LB6 + IR LB7 + M LB7Y

Contact us if you start working at a new laser system!

D	Continuous Wave (CW)	> 0.25 s
I	Pulsed Mode	> 1 µs – 0.25 s
R	Giant Pulsed Mode	1 ns – 1 µs
M	Mode Locked	< 1 ns

3. In case of an accident

In case of an accident

Immediately

Transport to

Hochschulambulanz Charité

Campus Benjamin Franklin – Augenklinik

Hindenburgdamm 30

12203 Berlin-Steglitz

Phone: 030 8445 3015

First Aid

Emergency medical eye service at the hospital rescue centre.
The ambulance is located at the north entrance on the ground floor.
It can be reached by telephone at 030 8445 3015.

In case of an accident

Later

- Report accident to group leader
- Complete „accident report“ for employer‘s liability insurance association
- Visit a „transit doctor* (Durchgangsarzt)“

Mitglied der VBG Ihre gesetzliche Unfallversicherung

The Fritz Haber Institute belongs to the Verwaltungs-Berufsgenossenschaft

Name:	Address:		Phone: (030-)
Dr. Abed Domah	Hohenzollerndamm 124	14199 Berlin	2522569
Dr. Matthias Decker/Dr. Marco Kiesewetter (Orthopädie)	Teltower Damm 15	14169 Berlin	8113106
Prof. Dr. W. K. Ertel, Charité-Campus Benjamin Franklin	Hindenburgdamm 30	12203 Berlin	84453081
Orthopädiegemeinschaft	Breitenbachplatz 21	14195 Berlin	82007430
Orthopädische Gemeinschaftspraxis	Schloßstr. 111	12163 Berlin	7918087
Christoph Olbrich, Krankenhaus Waldfriede	Argentinische Allee 40	14163 Berlin	818100
Prof. Dr. Wolf Petersen, Martin-Luther-Krankenhaus	Caspar-Theyß-Str. 27-31	14193 Berlin	89553025
Dr. Dietmar Sander, St. Gertrauden Krankenhaus	Paretzer Str. 12	10713 Berlin	82722751
Dr. Sebastian Vahrmeyer (Unfallarzt)	Hildegardstr. 28	10715 Berlin	85771427
Dr. Burkard Franz Walf	Kirchstraße 2	14163 Berlin	8021034
Dr. Thomas Wojtecki	Albrechtstraße 36a	12167 Berlin	7916005

* special medical doctor who cooperates with the employers' liability insurance association. Current list: http://lviweb.dguv.de/faces/D?_adf.ctrl-state=15sjcxrpnw_33

Further Information

& thank you for your attention!

Responsible people for laser safety in the Department of Physical Chemistry:

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Instructor:

Daniel Wegkamp

Further reading & summary (.pdf):

https://pctech.rz-berlin.mpg.de/information/