



**Radiation Safety
Institute of Canada**
Institut de radioprotection du Canada

Lunch, Learn, & Dance
Wellness Webinars

May 6, 2021

Laser Safety

Followed by Salem Dance Company

Good Science in Plain Language®



- Audio and video
 - Will be from the presenters only
 - Use computer or telephone (call in)
 - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Posted on webinar page
 - Video, Q&A answers, copy of the slides
- Follow up email will be sent
 - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.



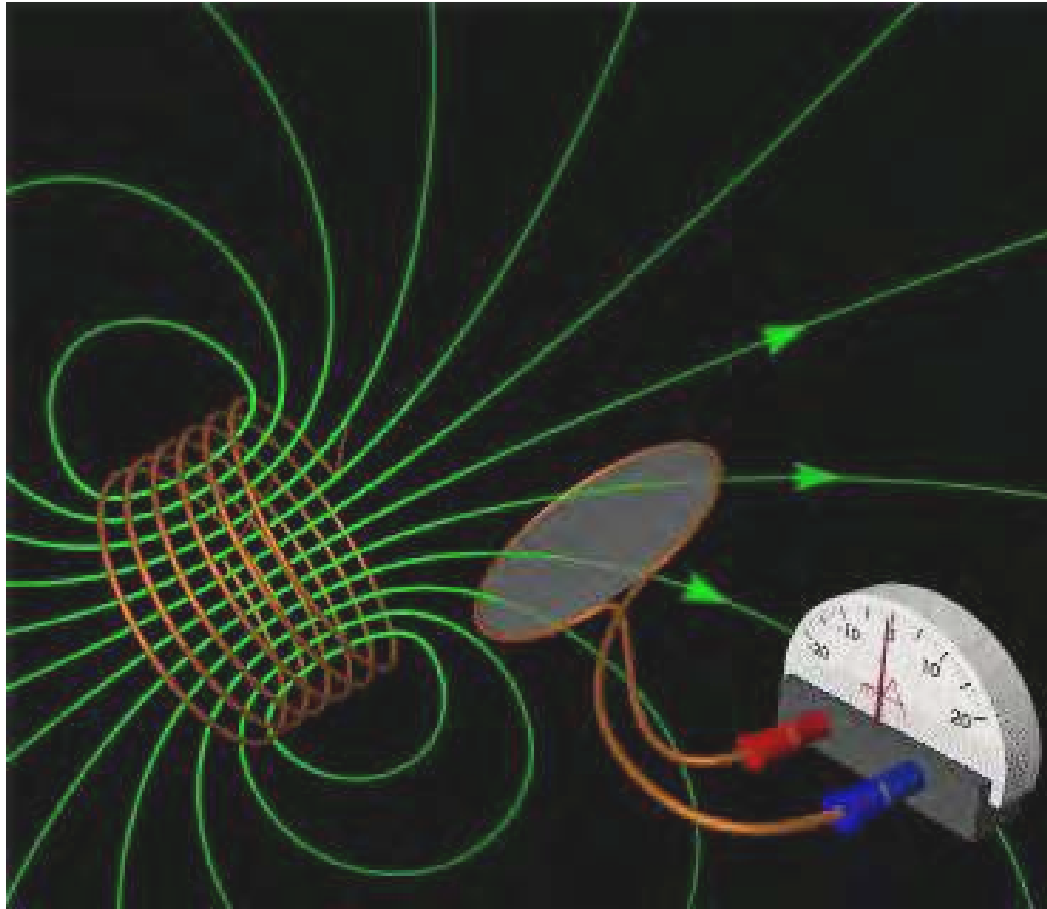
- What is light?
- What is a laser?
- Uses of lasers
- Type and classification of lasers
- Laser hazards
- Laser regulation
- Laser safety



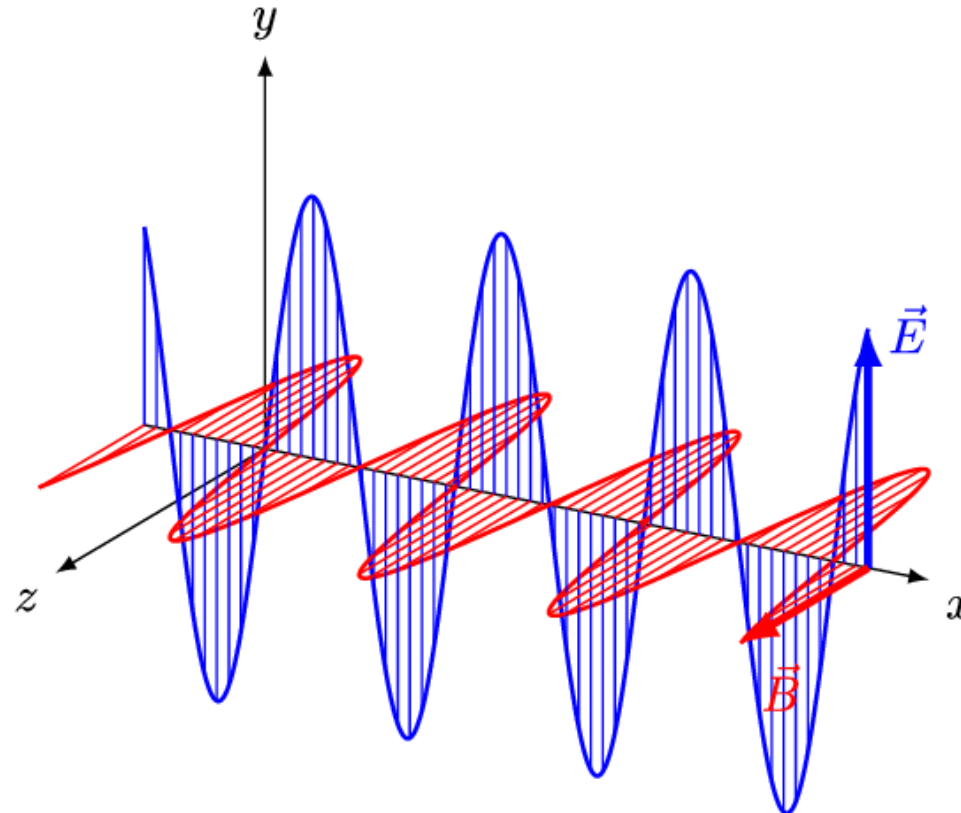


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Electromagnetism

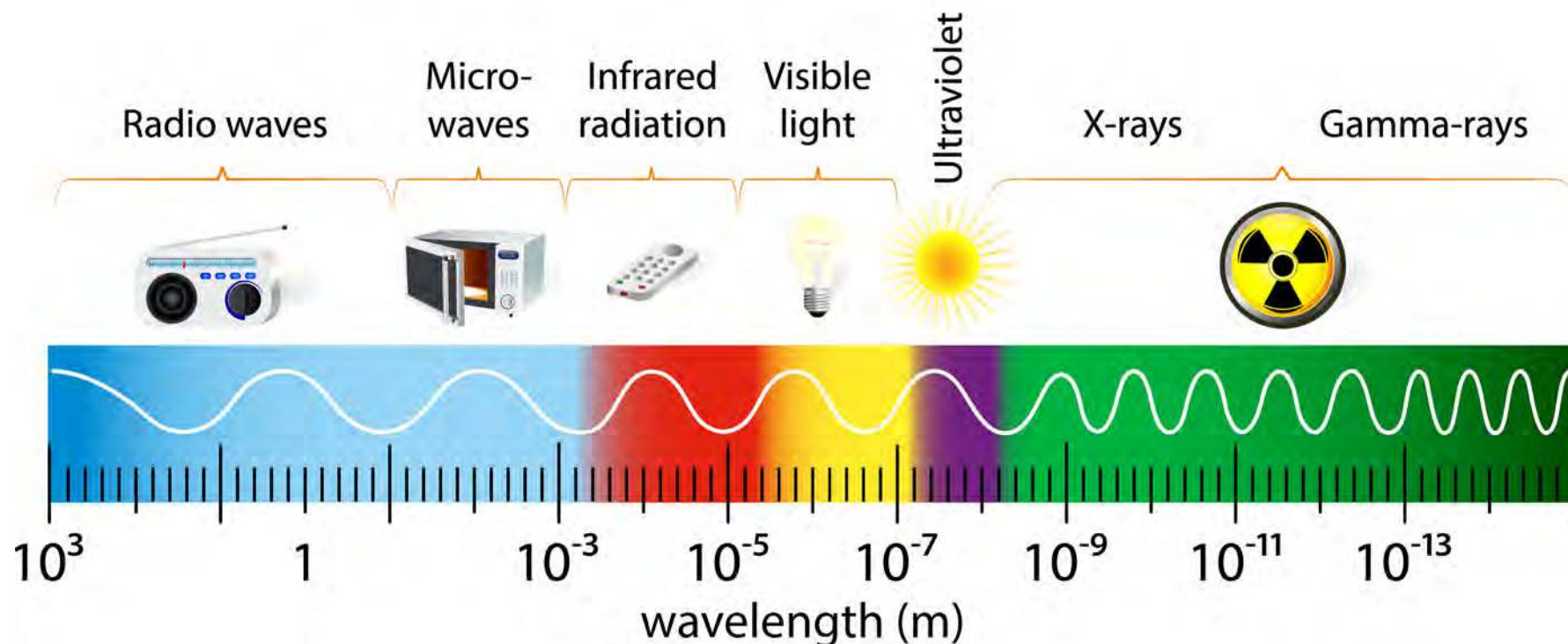


By Ponor - Own work, CC BY-SA 4.0





THE ELECTROMAGNETIC SPECTRUM





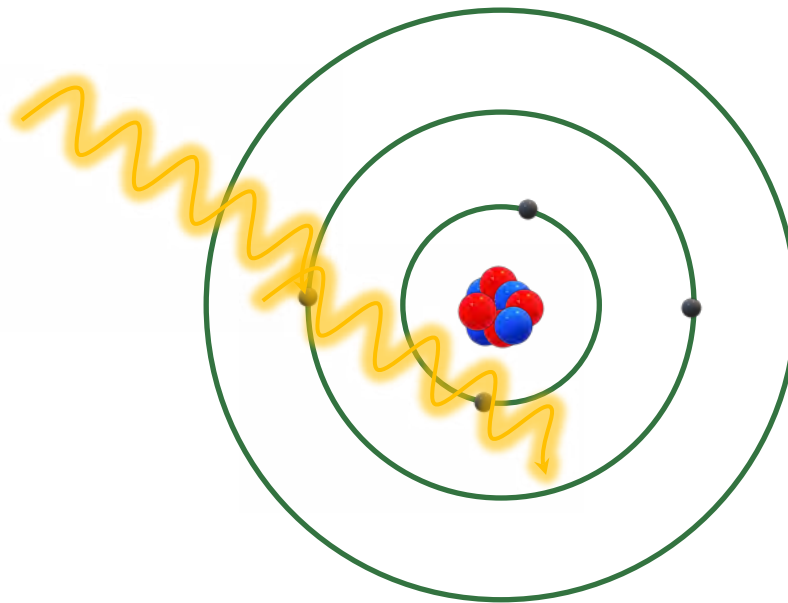
Light

Amplification by

Stimulated

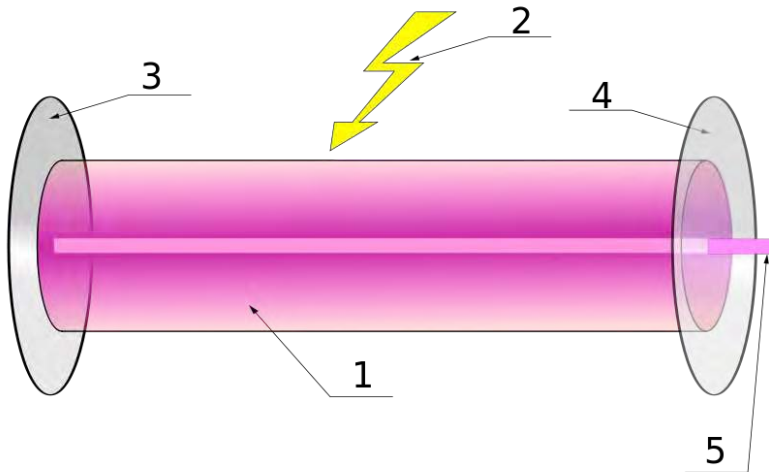
Emission of

Radiation

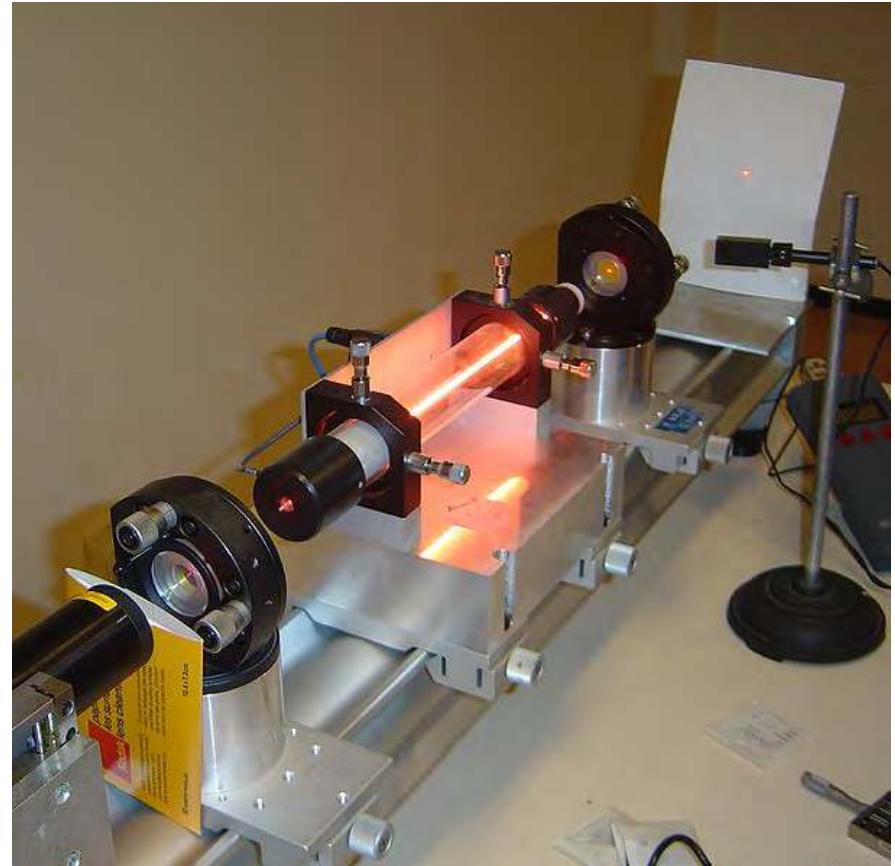




Tatoute, CC BY-SA 3.0



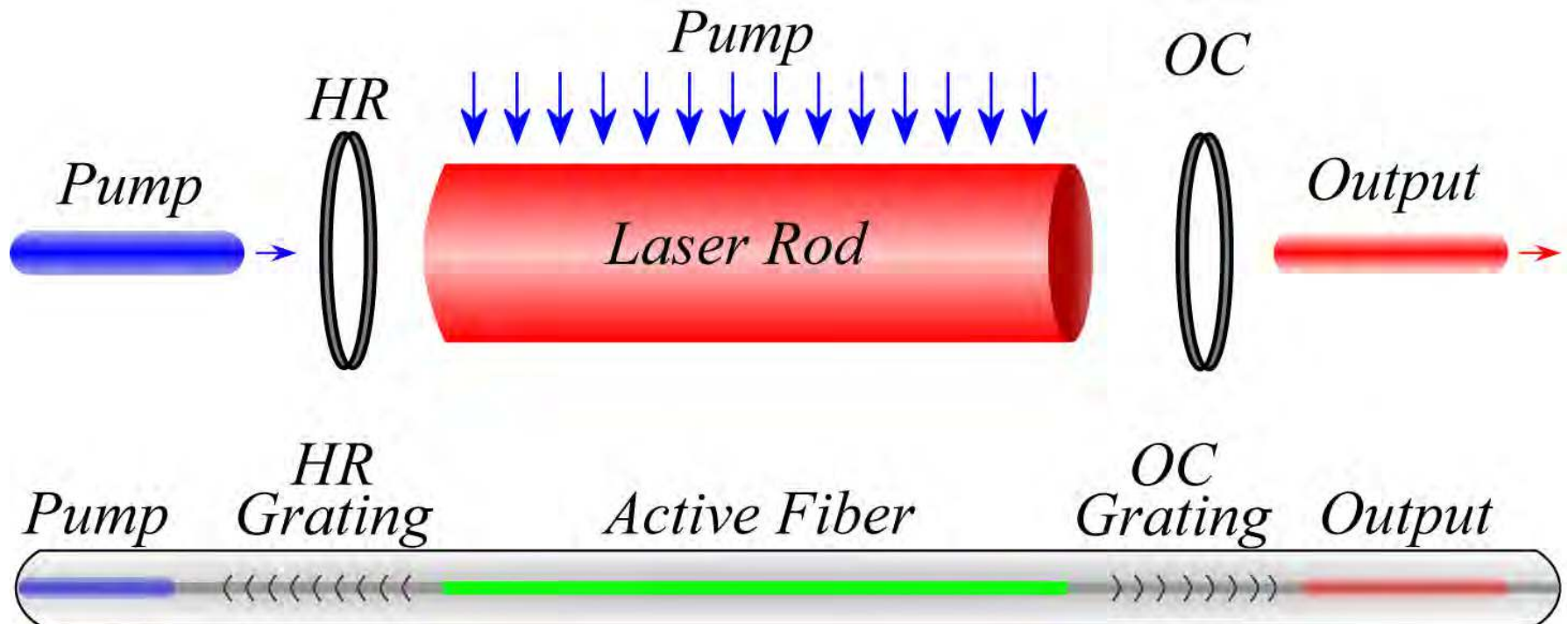
1. Gain medium
2. Laser pumping energy
3. Mirror
4. Semi-transparent mirror
5. Laser beam



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Laser Components

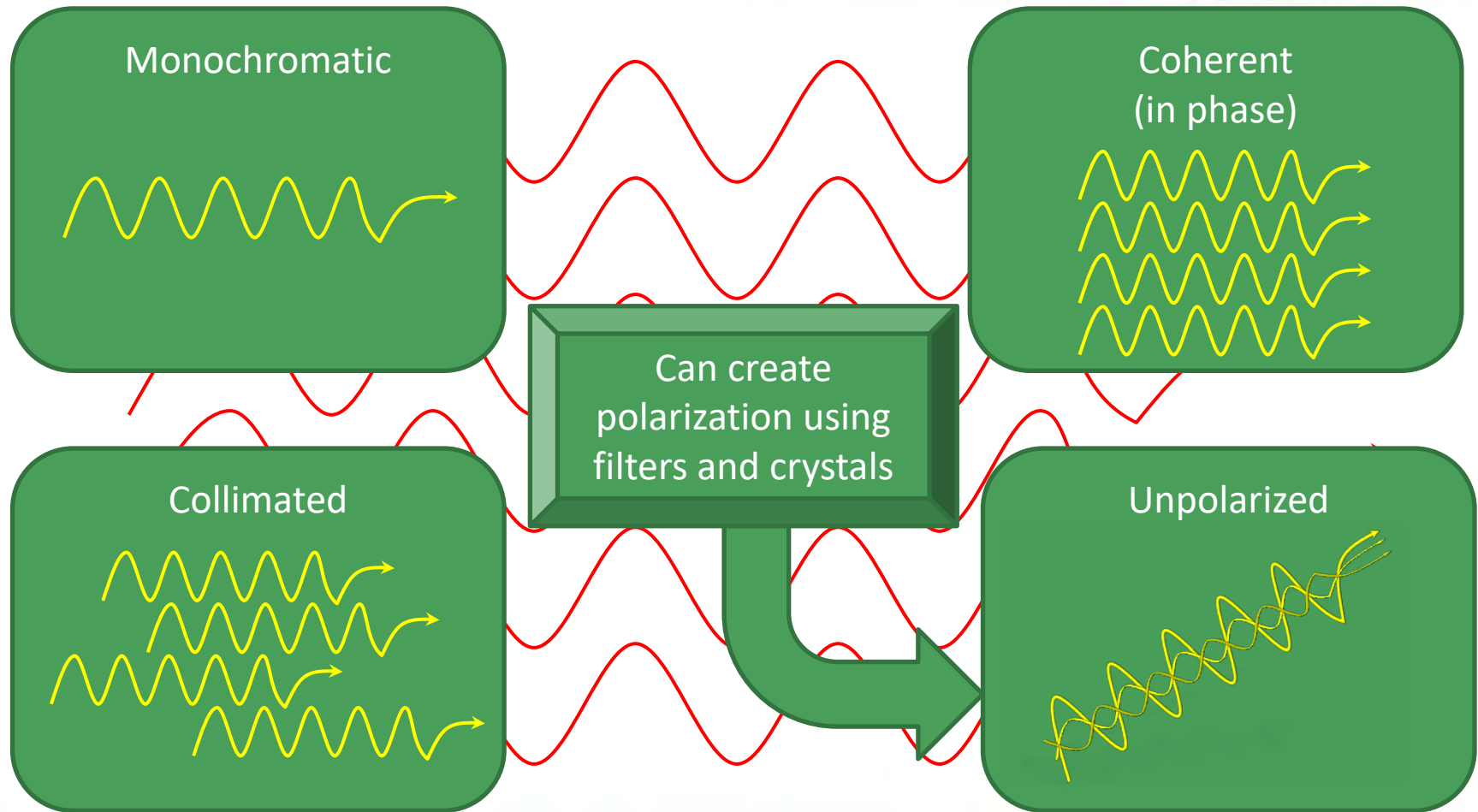


HR – Highly Reflecting; OC – Output Coupling

Matthew Leigh, CC BY 3.0

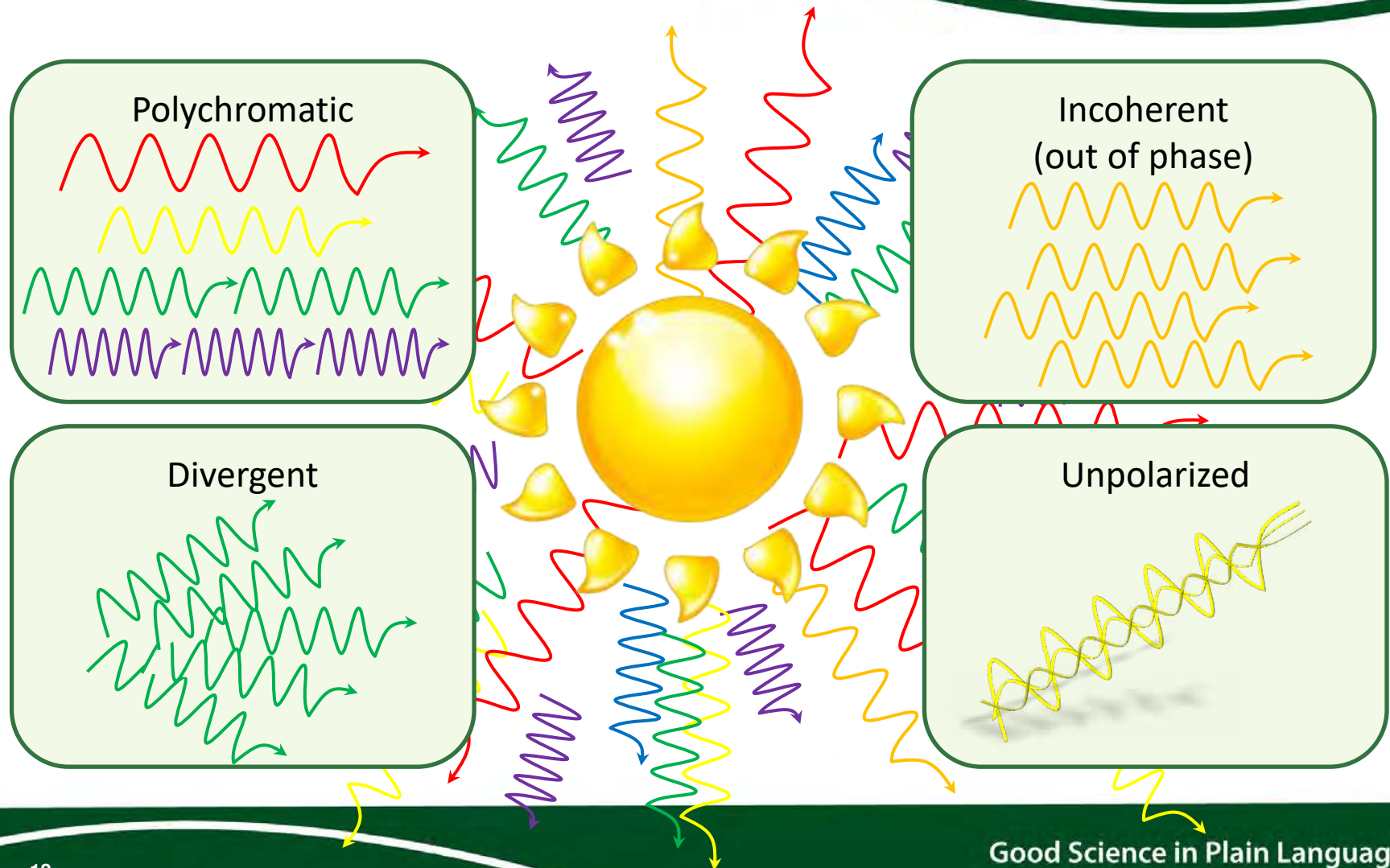


Light Waves from a Laser



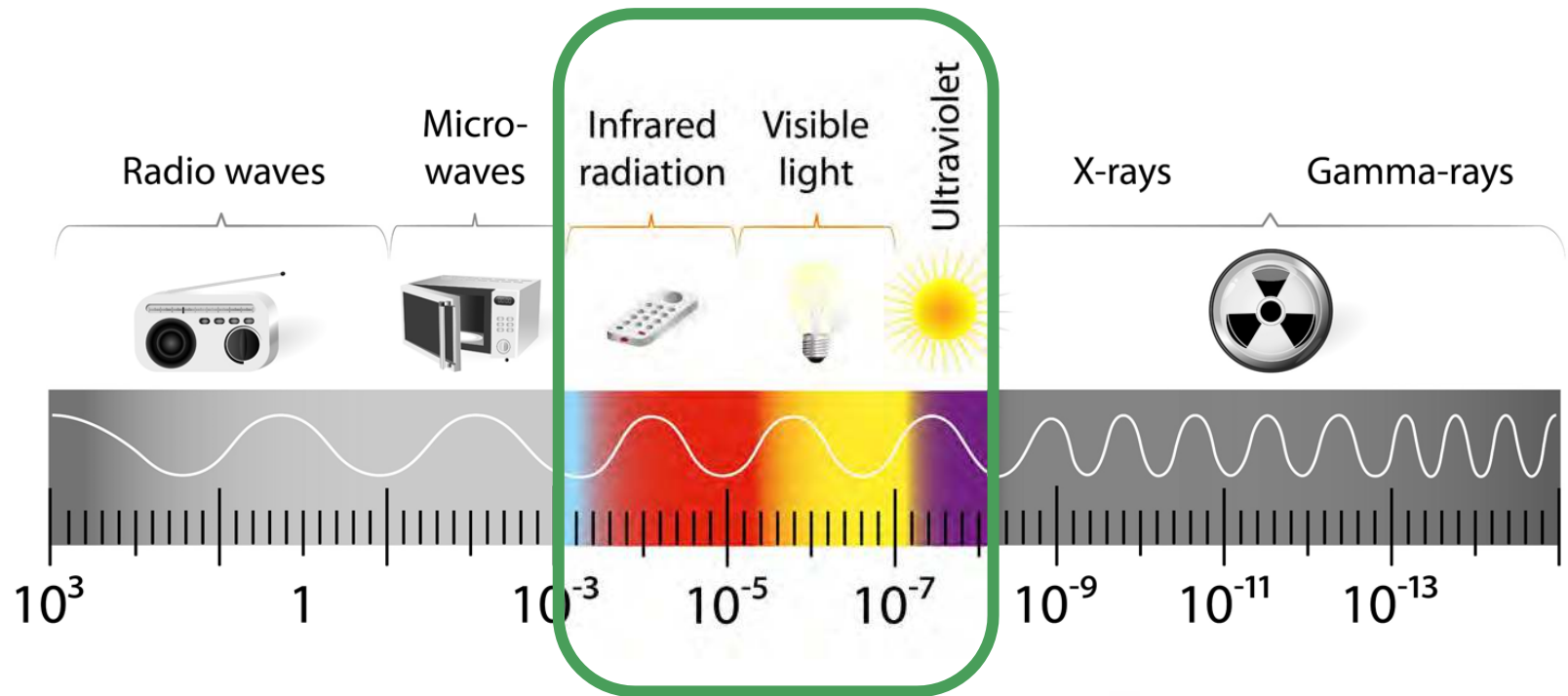


Typical Light Waves





THE ELECTROMAGNETIC SPECTRUM





ЛазерЛеди, CC BY-SA 3.0

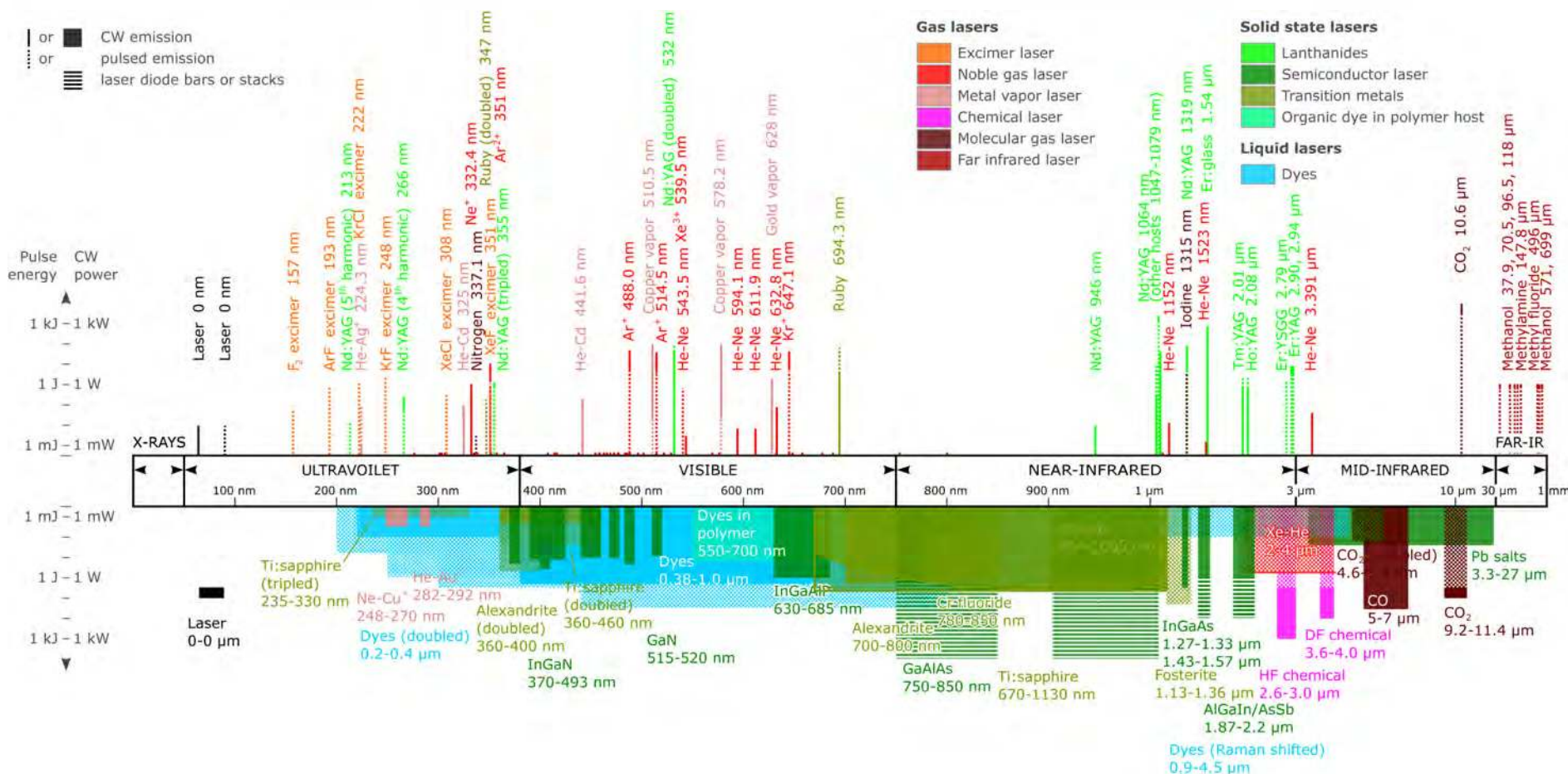
- Uses many
 - Electronics
 - Tools
 - Research
 - Dermatology
 - Tattoo & hair removal
 - Surgery
 - Holography
 - Weapons
 - Communications



Type	Example	Output
Solid state	Nd:YAG (neodymium – yttrium aluminum garnet)	Infrared
Gas	Helium HeNe (helium-neon)	Visible light, red
Gas	CO ₂	Far-infrared
Excimer (excited dimers)	Chlorine and fluorine mixed with argon, krypton, or xenon	Ultraviolet
Dye	Complex organic dyes like rhodamine 6G	Broad range of wavelengths
Semiconductor (diode)	Small and low power, laser printers, pointers, CD players	Range of wavelengths

Laser Frequencies

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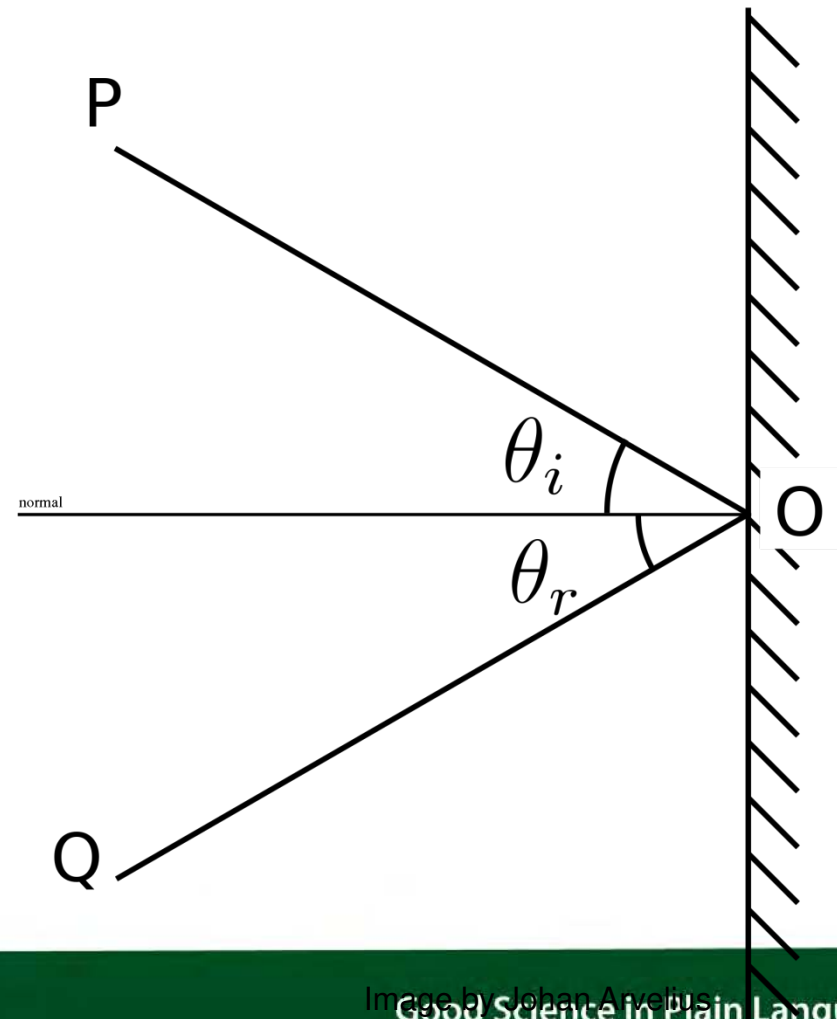
Laser Classes

ANSI	US FDA	Description
Class 1	Class I	Any laser or laser system containing a laser that cannot emit laser radiation at levels that are known to cause eye or skin injury during normal operation.
Class 2	Class II	Visible lasers considered incapable of emitting laser radiation at levels that are known to cause skin or eye injury within the time period of the human eye aversion response (0.25 seconds).
Class 3a	Class IIIa	Lasers similar to Class 2 with the exception that collecting optics cannot be used to directly view the beam.
Class 3b	Class IIIb	Medium powered lasers (visible or invisible regions) that present a potential eye hazard for intrabeam (direct) or specular (mirror-like) conditions. Class 3b lasers do not present a diffuse (scatter) hazard or significant skin hazard except for higher powered 3b lasers operating at certain wavelength regions.
Class 4	Class IV	High powered lasers (visible or invisible) considered to present potential acute hazard to the eye and skin for both direct (intrabeam) and scatter (diffused) conditions. Also have potential hazard considerations for fire (ignition) and byproduct emissions from target or process materials.



Specular Reflection

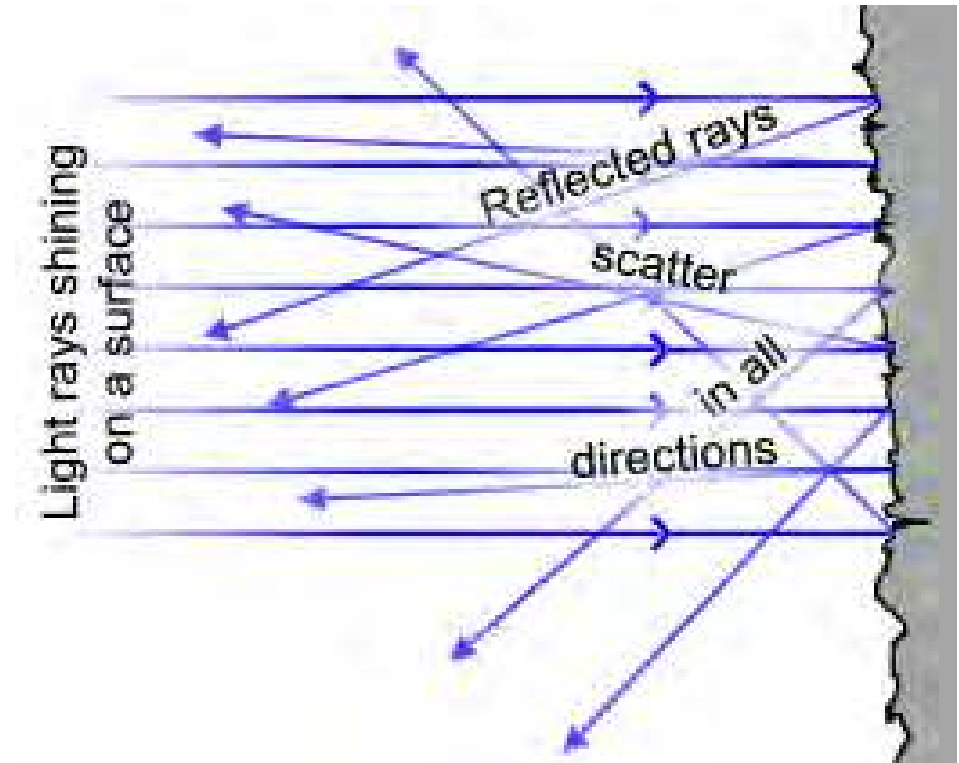
- Reflection from a smooth surface





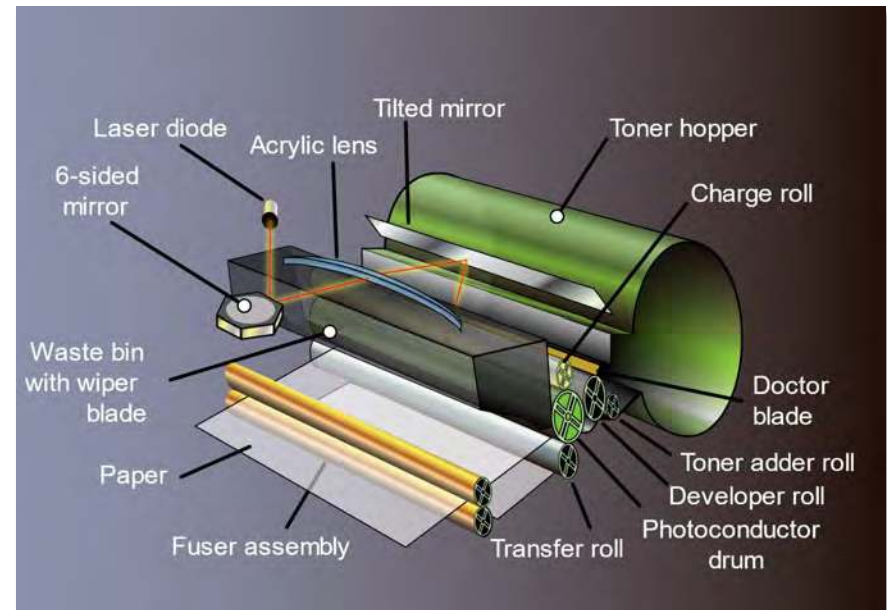
Diffuse Reflection

- Reflection from a rough surface





- Class 1
 - Incapable of causing damage
- Class 1M
 - Can cause damage if magnified
- Class 1 working environment
 - A higher class laser in a cabinet with interlocks
- Examples
 - DVD player
 - Laser printer
 - Geological survey equipment



KDS4444, CC BY-SA 4.0



- Maximum power of 1 mW CW
- Visible light emission
- Eyes protected by blink response
- Example
 - Bar code scanner



- 1 mW to 500 mW
- Eye hazard, but not a skin hazard
- Class 3R
 - 1 mW to 5 mW
 - Potentially hazardous direct beam and specular reflection
 - Some would be Class 2 but are not visible
- Class 3B
 - > 5mW
 - Hazardous direct beam and specular reflection
 - Generally not a diffuse reflection hazard
 - Not a fire hazard
- Example
 - Laser pointer



Jastrow, CC BY 2.5

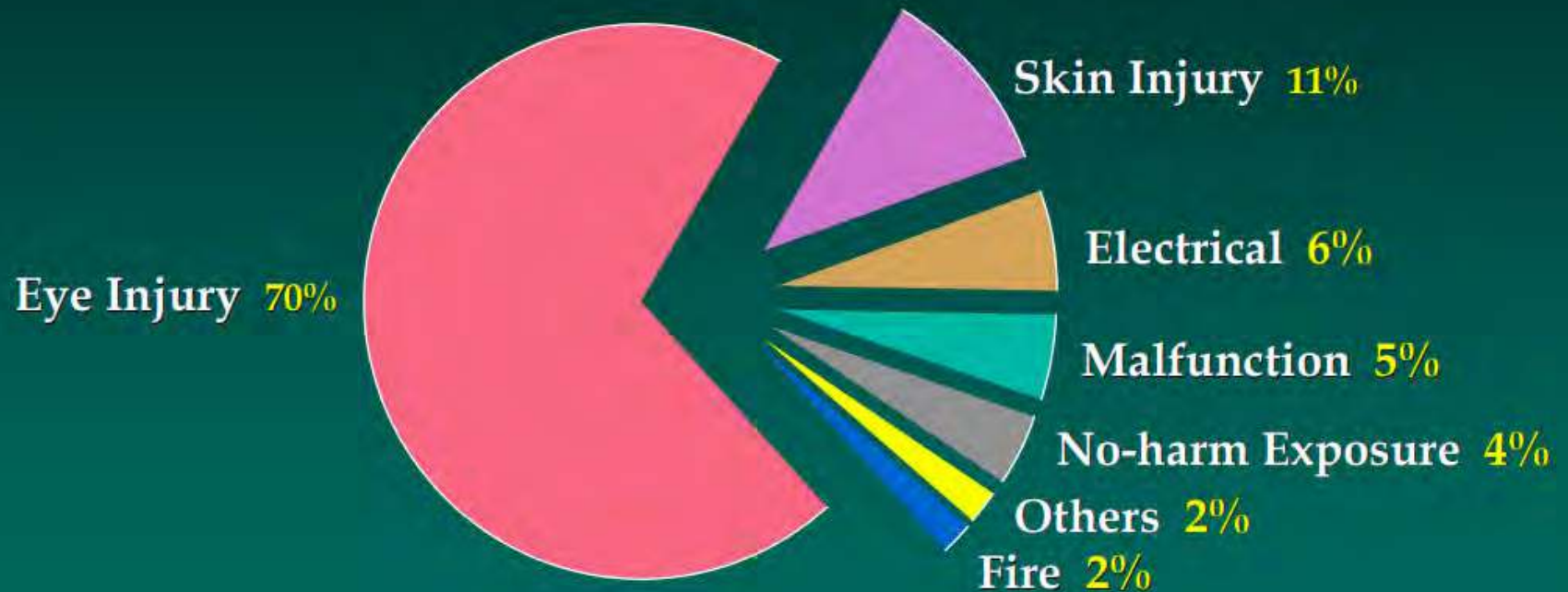


christopher friese from UK, CC BY 2.0

- Class 4
 - Eye and skin hazard
 - Damage from direct beam, specular, diffuse reflection
 - Possible fire hazard
 - Possible LGAC or plasma radiation hazards
- Class 4 examples:
 - Laser light show projector
 - Industrial lasers
 - Research
 - Eye surgery laser



Typical Laser Accident Breakdown





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Laser Properties Contribute to Hazards

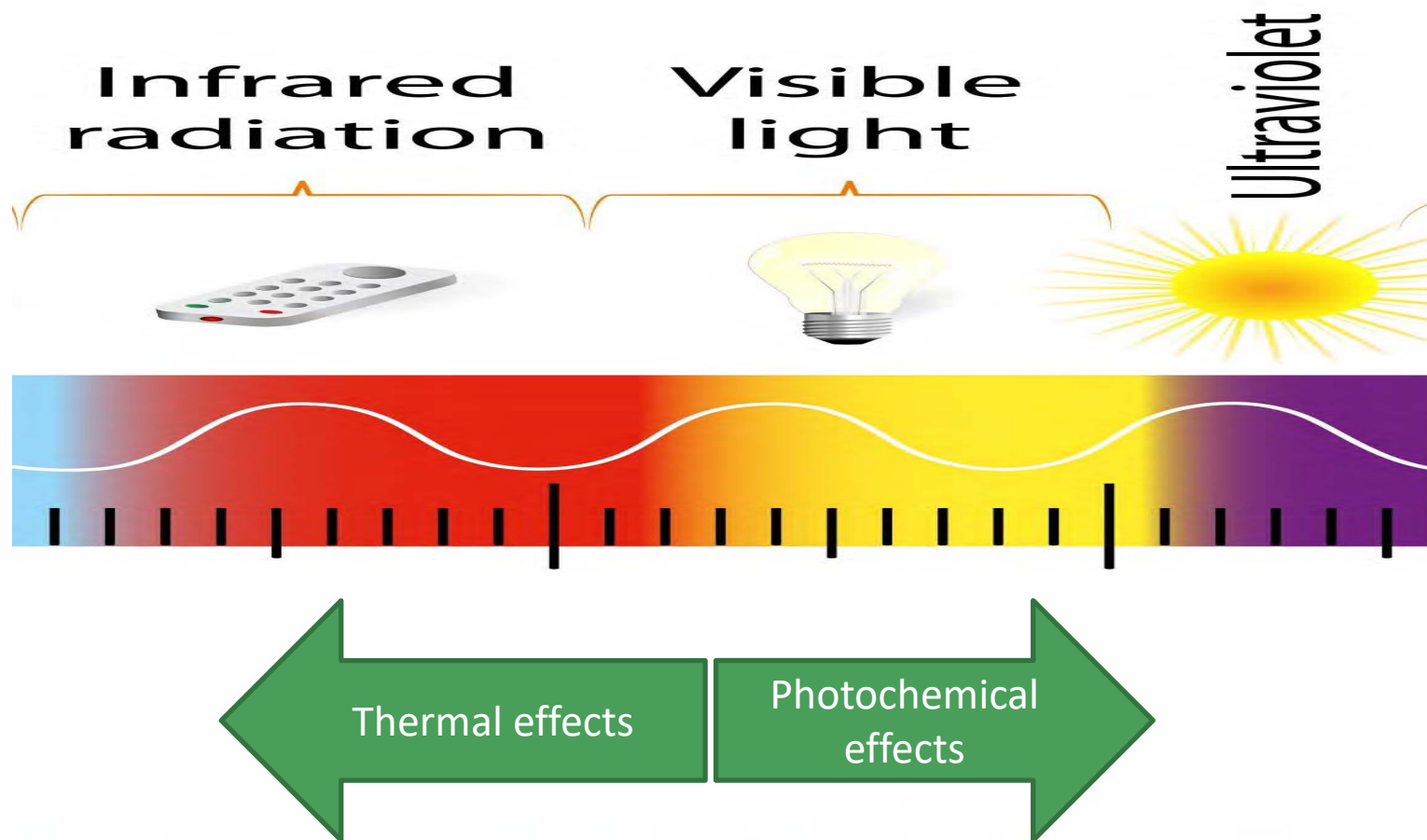
- Light must enter eye to see it
- Laser light travels straight in clean air
- Beam is invisible in many cases
 - Infrared and UV always
- Energy is concentrated

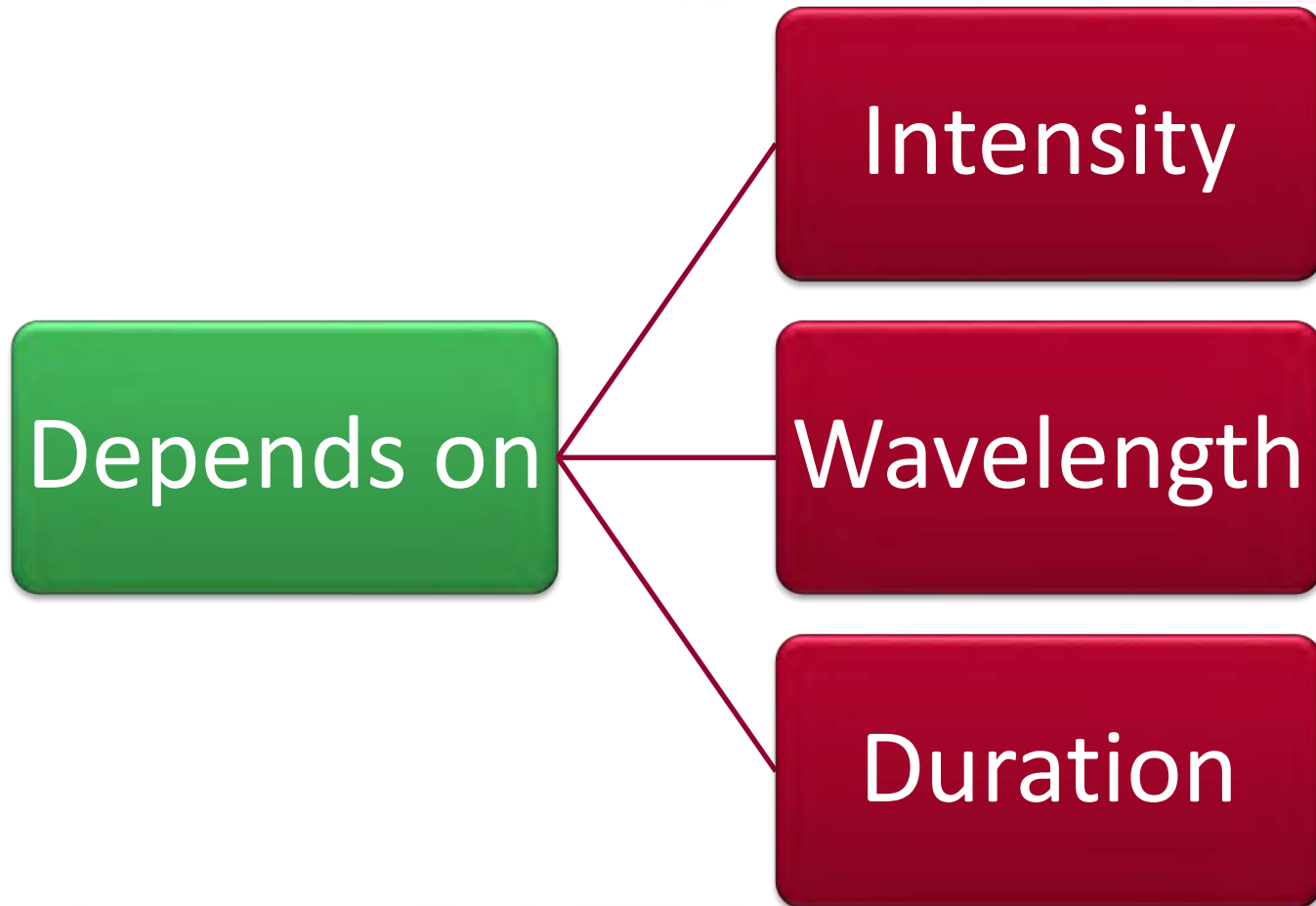


Laurie, CC BY 4.0



Wavelength Dependence

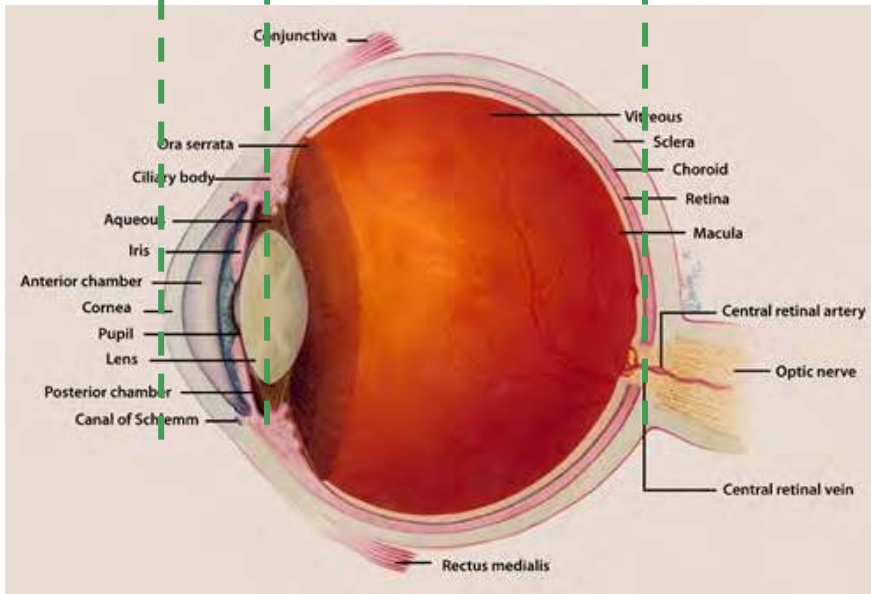






UVC UVB
UVB UVA
IRB IRA
IRC IRB

Visible
IRA

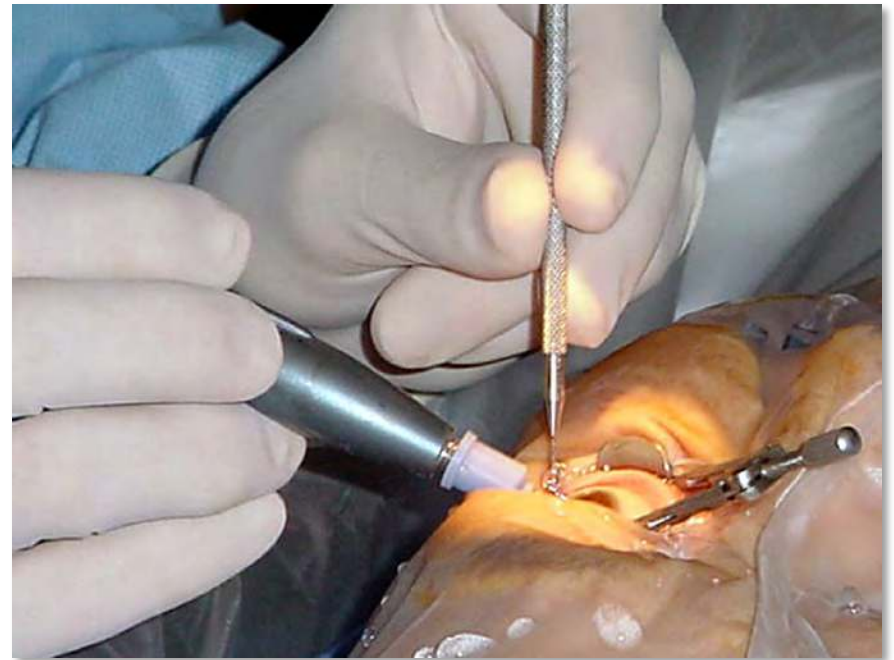


- Cornea
 - Photokeratitis
 - Thermal injury
- Lens
 - Cataracts
- Fovea
 - Central vision impairment
- Retina
 - Photoretininitis
 - Thermal injury



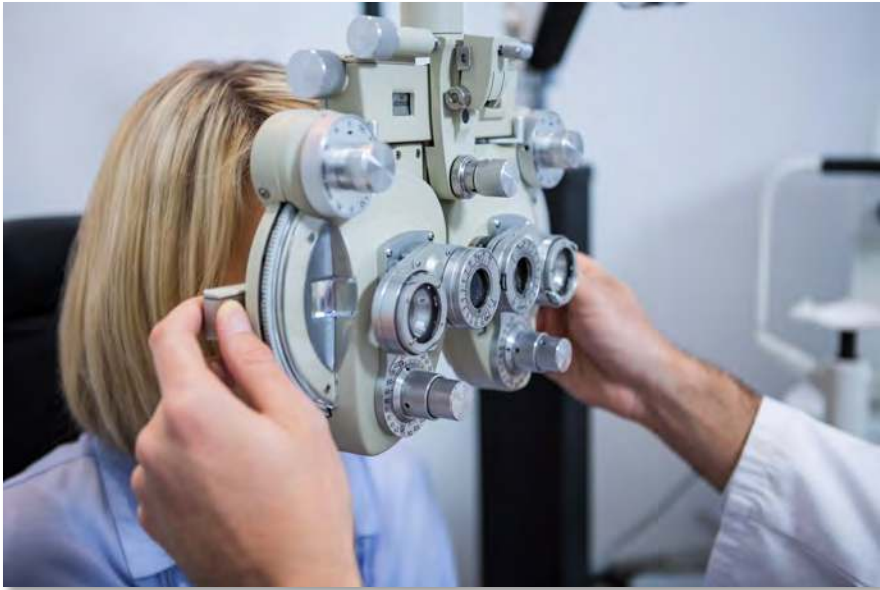
Symptoms of Eye Damage

- Popping sound from explosion on retina
- Very sore eye
- Headache
- Excessive watering of eye
- Sudden appearance of “floaters”
- Black spot in field of view





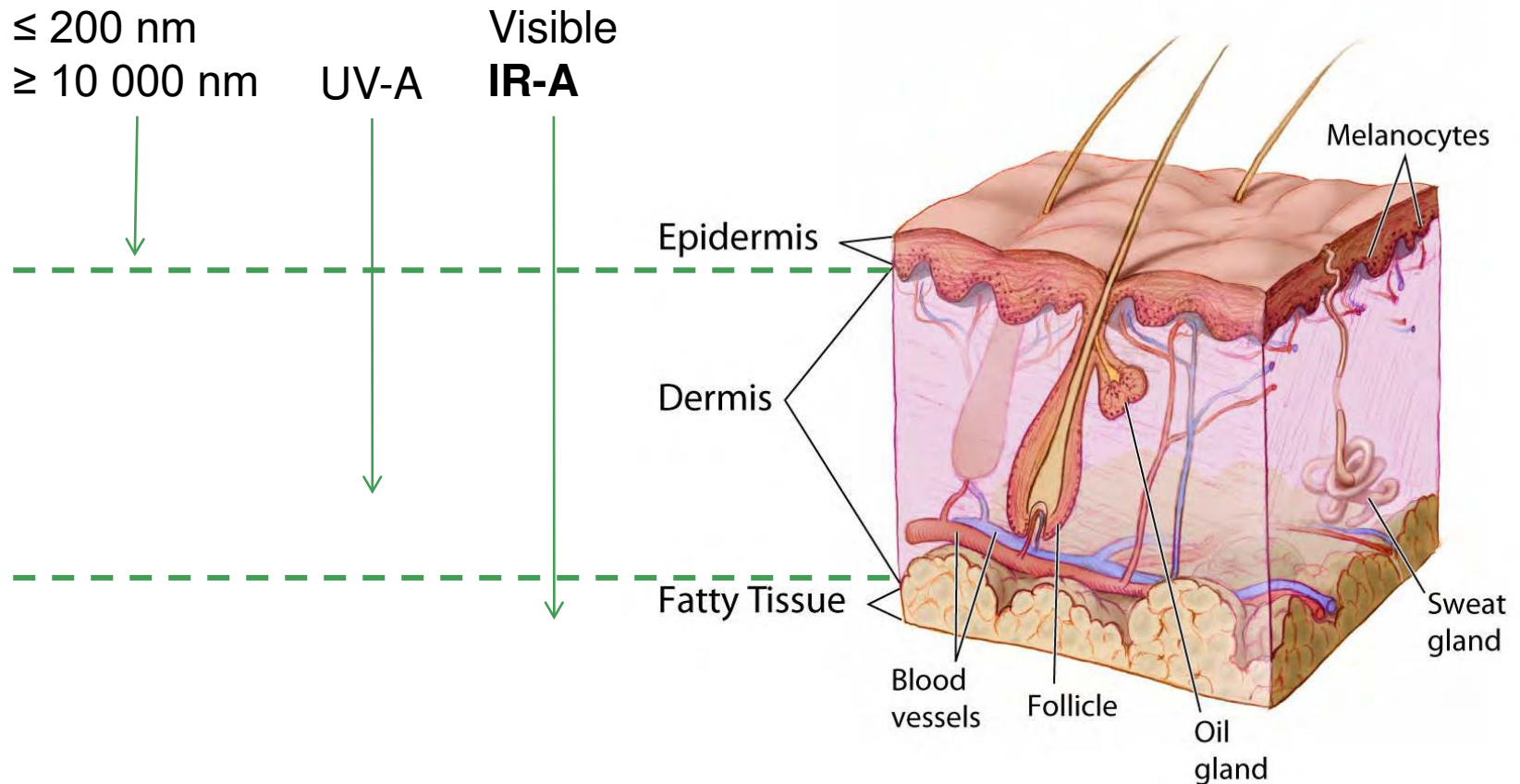
Medical Eye Evaluation



- Eye exam prior to working
- Baseline
- Comparison for assessing any possible damage
- If you suspect an injury, assess within 48 hours



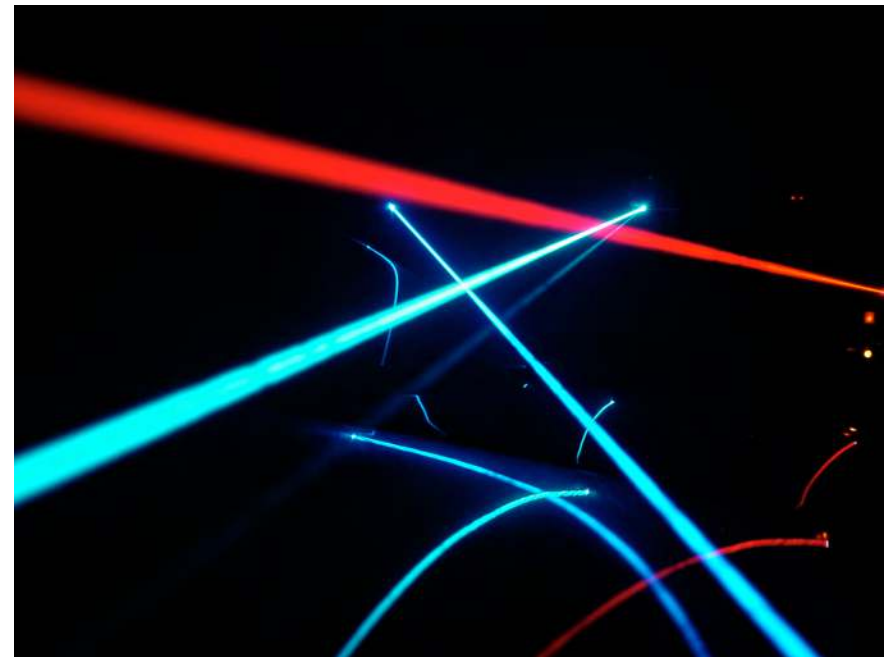
Laser Hazards to Skin



Credit: Don Bliss for the National Institutes of Health



- Physical
- Chemical
- Biological
- Mechanical
- Ergonomics and human factors



Jeff Keyzer from San Francisco, CA, USA, CC BY 2.0

Regulations

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Province/Territory	Laser Legislation/Regulations
Alberta	Radiation Protection Regulation, Alta Reg 182/2003, (Radiation Protection Act)
British Columbia	Occupational Health and Safety Regulation, BC Reg 296/97, (Workers Compensation Act)
Manitoba	Workplace Safety and Health Regulation, Man Reg 217/2006, (Workplace Safety and Health Act)
New Brunswick	General Regulation, NB Reg 91-191, (Occupational Health and Safety Act)
Newfoundland and Labrador	Occupational Health and Safety Act, RSNL 1990, c O-3
Northwest Territories	Occupational Health and Safety Regulations, NWT Reg 039-2015, (Safety Act)
Northwest Territories	Mine Health and Safety Regulations, NWT Reg 125-95, (Mine Health and Safety Act)
Nova Scotia	Occupational Health and Safety Act, SNS 1996, c 7
Nunavut	Occupational Health and Safety Regulations, Nu Reg 003-2016, (Safety Act)
Ontario	General duty clause 25(2) (h) of the Occupational Health and Safety Act (OHSA)
Prince Edward Island	Occupational Health and Safety Act General Regulations, PEI Reg EC180/87, (Occupational Health and Safety Act)
Quebec	Act Respecting Occupational Health and Safety,
Quebec	Act Respecting Industrial Accidents and Occupational Diseases, CQLR c A-3.001
Saskatchewan	Radiation Health and Safety Regulations, 2005, RRS c R-1.1 Reg 2, (Radiation Health and Safety Act, 1985)
Yukon	Radiation Protection Regulations, YOIC 1986G/164, (Occupational Health and Safety Act)



CMRF Crumlin, CC BY 2.0

- Laser standards
- Laser class
- Engineering controls
- Administrative controls
- Standard Operating Procedures (SOP)
- Personal Protective Equipment (PPE)



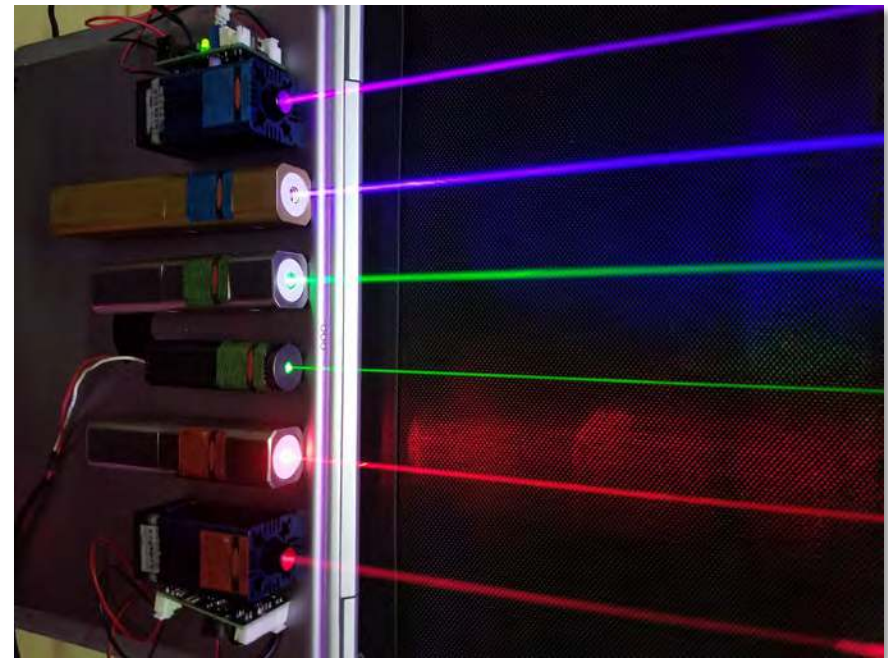
- Ideal
 - All lasers operate as Class 1
- Reality
 - Enclose beam as much as possible
 - Beam stays in a controlled area
 - Ensure beam not directed at eyes



Etan J. Tal, CC BY 3.0



- Class 1
 - Protective housing
 - Label
- Class 2
 - Class 1 measures
 - “Caution” signs
 - “Do not stare into beam” signs
 - Indicator light
- Class 3 and 4
 - Extensive engineering controls
 - Administrative controls
 - Protective eyewear
 - “Danger” signs



彭嘉傑, CC BY 2.5



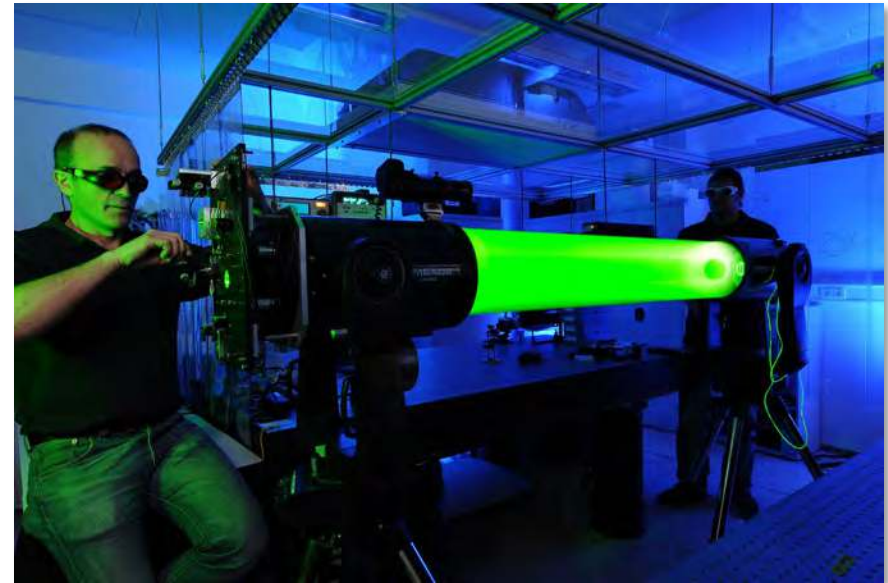
Stanislav Liubauskas, CC BY 4.0

- Built in methods or structures with the purpose to minimize a hazard
- Examples for laser
 - Warning signs and labels
 - Protective housing
 - Interlocks
 - Secure location/controlled access
 - Warning systems/emission delay
 - Remote control
 - Beam stops and attenuators
 - Location of path
 - Defined and enclosed control area
- Class 4
 - Emergency stop
 - Entry barrier





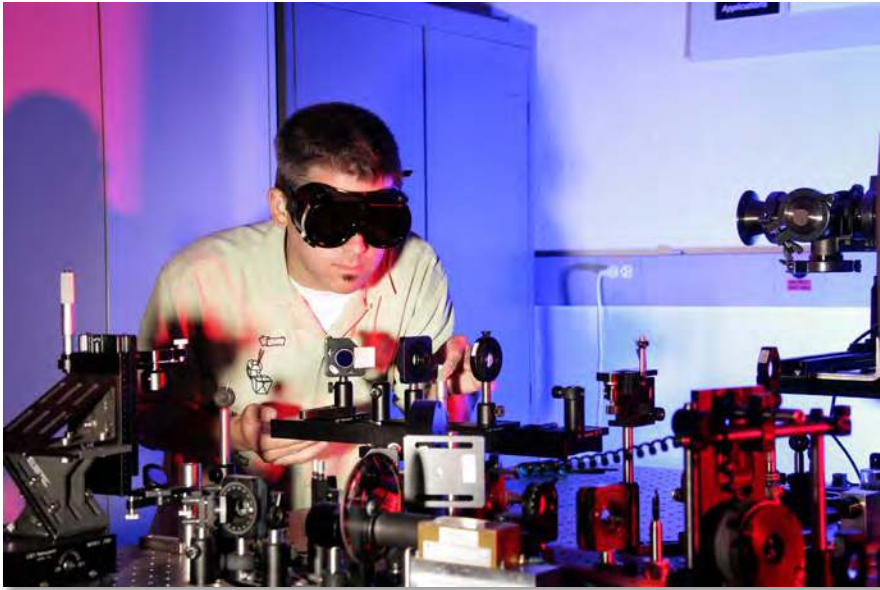
- Procedures, policy, and training to reduce risk
 - Authorize workers for laser use
 - Limit access to authorized workers
 - Proper training for workers
 - Operation and maintenance only by authorized workers
 - Develop standard operating procedures (SOP)
 - Instructions for cleaning, maintenance, and servicing
 - Emergency procedures
 - Use minimum required emission levels
 - Require use of protective equipment such as protective eyewear



DLR German Aerospace Center, CC BY 2.0



PPE: Protective Eyewear



Idaho National Laboratory, CC BY 2.0

- Last resort of protection after engineering and administrative controls
- Worn by operator and anyone else who may be exposed
- **MUST** be for the appropriate wavelength
 - Wrong wavelength is no protection
- Ensure they are the correct optical density
- Consider fit over prescription glasses



PPE: Protective clothing



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- Protective clothing
 - Necessary when risk for skin damage
 - Masks to deal with LGAC
 - Ear protection for noise



Minimize Reflection Hazards



yellowcloud from Germany, CC BY 2.0

- Remove jewelry
- Cover reflective surfaces
- Walls must be dark colour and rough texture



Control of Non-Beam Hazards

- Clean area
- Cleared space
- Secure cables and power cords, avoid tripping hazards
- Appropriate lighting
- Properly secure any gas tanks
- Flammable substances must be limited in laser area
- Provide water and/or extinguishers for controlling fires
- Ensure adequate ventilation
- Protective equipment for LGAC, noise, etc.



Metaveld BV, CC BY-SA 3.0



Thctamm, CC BY-SA 3.0

- Class 3B and 4
 - Designate LSO
 - Authorize personnel
 - Laser safety training
 - Emergency procedures training
 - Ensure standards are met
 - Ensure SOP and regulations followed
 - Maintain records
 - Perform inspection



- The Radiation Safety Institute of Canada is an independent, not-for-profit organization specializing in radiation safety.
- For further information on all types of radiation contact us at:

1-800-263-5803

info@radiationsafety.ca

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