Laser Science and Safety

Lee Collins, Westmead Hospital, Sydney
NZ GP CME meeting, Rotorua, June 2010

June 2010 *With thanks to Penny Smalley for the use of some material* 1

L ight **A** mplification **by** **S** timulated **E** mission **of** **R** adiation

Visible or Invisible — Intense — The physical principle of a laser

The word "LASER" is an acronym, divided into three parts, describing : the nature of the beam, its extreme brightness, and the reason why a laser works.

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Understanding of the operation of a laser and tissue effects is
CRUCIAL
to safe and effective laser use.

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Basic Laser Physics

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Albert Einstein proposed the theory behind lasers in 1916, but it wasn't made reality until 1960!

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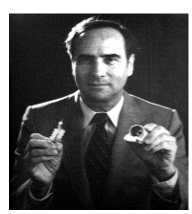
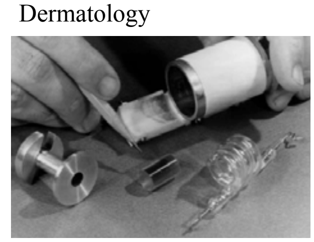
Theodore Maiman Invents the First Laser - 1960



- Ruby Crystal – 694nm
- First Used in Ophthalmology and Dermatology



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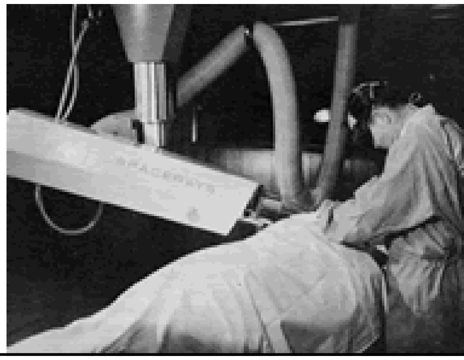
Ruby Laser in Use, 1971 (IEEE Virtual Museum)



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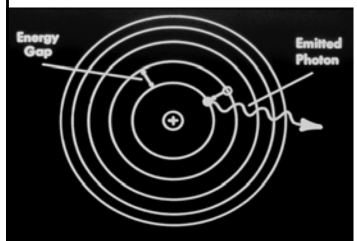
Spontaneous Emission



An external energy source raises the atoms to a higher energy state.

When the atom drops to the ground state, energy is emitted as a PHOTON

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Spontaneous Emission

Photons of all wavelengths, emit randomly from all energy levels of atoms, resulting in white light.

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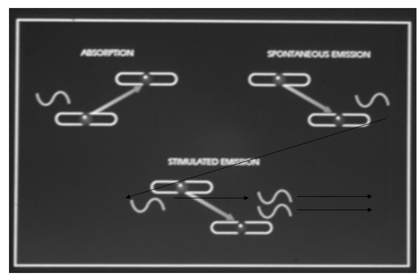
Stimulated Emission Of Radiation



A photon bombards a single energy level in an excited atom, resulting in release of two identical photons, having identical properties.

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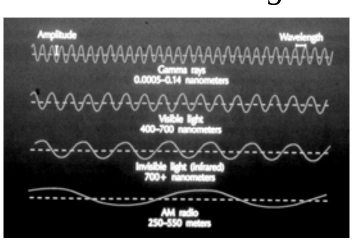
What is Wavelength?



- The wavelength (λ) of light is measured in nanometres or microns
- 1 micron (μ) = 1000 nanometres (nm) = 0.000 001 m
- Wavelength = "colour"

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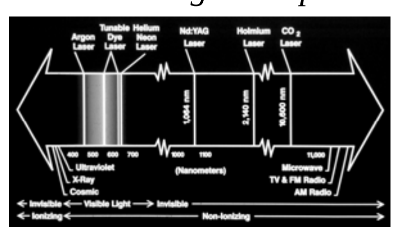
Electromagnetic Spectrum



Medical lasers operate between far infrared (10,600nm) and far ultraviolet (193nm).

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Types of Lasers

- Solid
  eg. the YAG family, diode lasers
- Gas
  eg. carbon dioxide, argon
- Liquid
  eg. dye lasers

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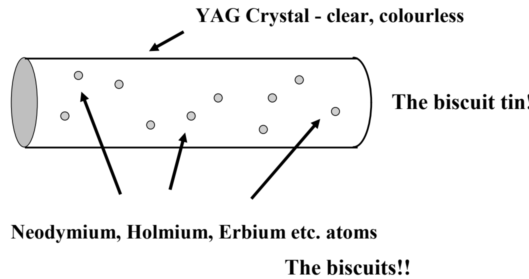
YAG (Yttrium Aluminium Garnet) Crystals



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Some Common Lasers

Laser	*Wavelength (nm)*
Carbon dioxide	10,600 (far IR)
Erbium(Er):YAG	2,940 (far IR)
Erbium Chromium YSGG	2,790 (far IR)
Holmium(Ho):YAG	2,140 (far IR)
Erbium fibre	1,550 (Fraxel)
Neodymium(Nd):YAG	1,064 (near IR)
Alexandrite:YAG	755 (red)
Diodes	473 – 1670 (vis.-near IR)
“Greenlight”	532
Argon(Ar)	490 – 510 (visible)
Excimer (Ar F)	193 (far UV)

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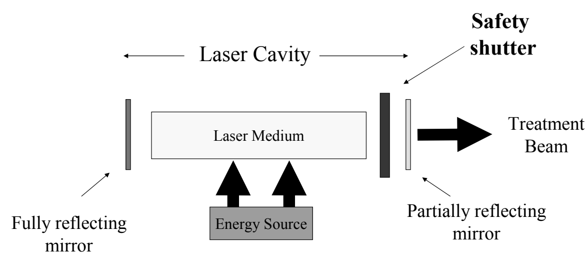
The basic components of a laser
(but NOT diode lasers……they look like a transistor!)



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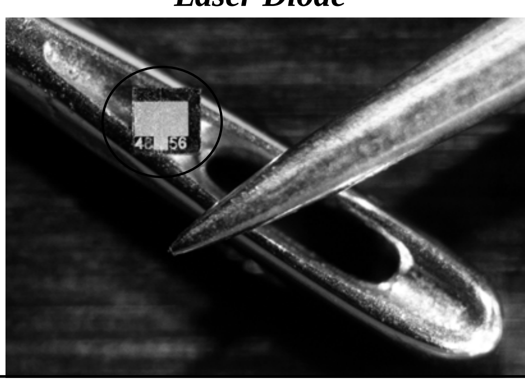
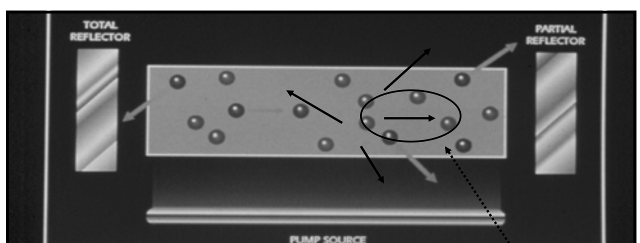
Laser Diode





When the power is turned on, individual atoms undergo spontaneous emission, in random directions. One of these emissions, purely by accident, is in the axis of the two mirrors, and it causes a stimulated emission.

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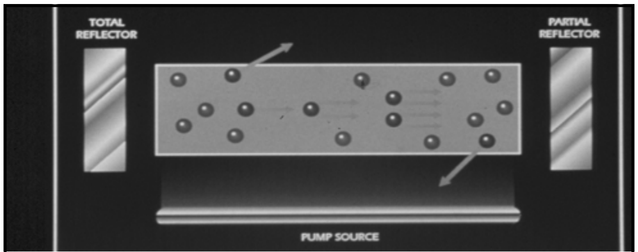

There are now two photons, which in turn cause four more stimulated emissions - all in the same direction.
The amplified beam moves towards a mirror, when it reflects back to the second mirror, continuing the amplification.

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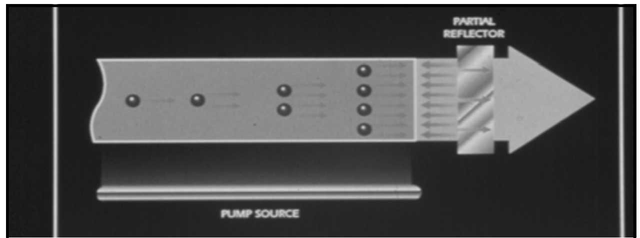

Even though spontaneous emission still occurs randomly, the great majority of the beam power is on the axis of the mirrors, as it bounces back and forth.
All the time, a small percentage of the beam can pass through one mirror - this is our useful beam.

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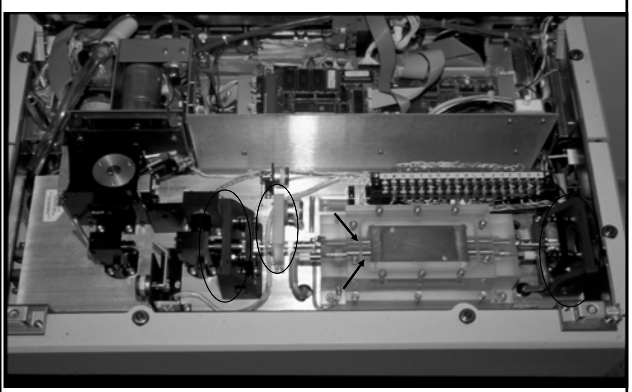

Properties of Lasers

- ***Wavelength (monochromaticity)***
- *Collimation*
- *Intensity*
- *Coherence*

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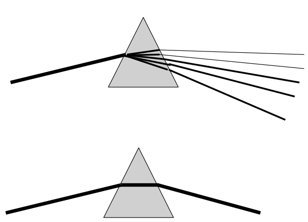
Monochromaticity



White light is made up of many colours – the rainbow

Laser light has one pure colour only

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Properties of Lasers

- *Wavelength (monochromaticity)*
- ***Collimation***
- *Intensity*
- *Coherence*

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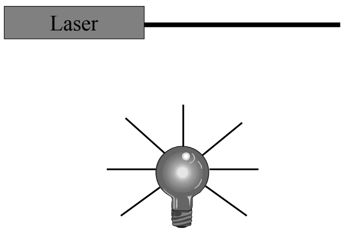
Collimation / Divergence



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Collimated beam – lunar laser ranging

- Round trip takes ~2.5 seconds
- Accuracy ~1mm!!

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Properties of Lasers

- *Wavelength (monochromaticity)*
- *Collimation*
- ***Intensity***
- *Coherence*

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More Jargon

- Now we need to think about the parameters of the treatment beam - power, power density, energy and energy density.
- The laser user MUST understand what these are - and know what parameters are required for the particular application.

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Power

- This just describes the raw laser beam, and is measured in ***Watts (W).***
- Think of the sun - its “brightness” can be thought of as power. This tells you nothing about its effect.

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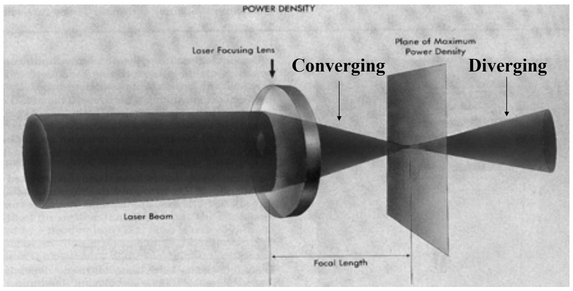
Power Density

- Now divide the power by the area of the beam - this is power density, measured in ***Watts/cm^2***
- The sun is bright (power), and it feels warm (power density) - but you still don’t know if you’ll get burnt.
- Power density is rapidly increased with a focussing lens - try the sun and a magnifying glass!

Power Density and Focussing



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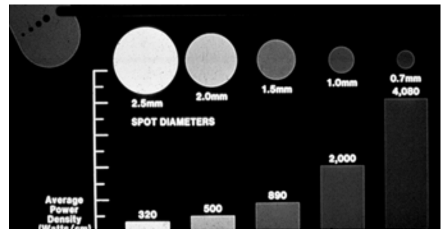
Power Density

Watts ÷ spot size = watts/cm^2



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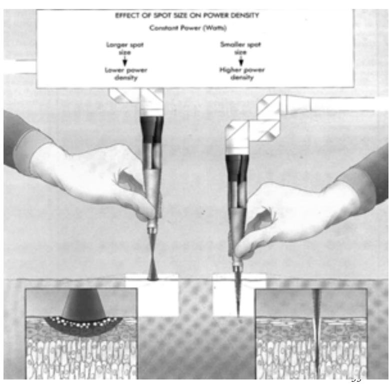
Spot Size and Power Density



Aiming Beams

- Many lasers provide a low power ***SAFE*** laser "aiming beam" to show the user where the high power treatment laser beam will go
- No eye risk, but never look into any laser beam
- Aiming beam usually red or green, and will be circular and appear uniform

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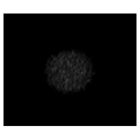
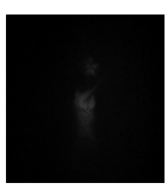
Spot Size Affects Power Density



Good

Bad



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Energy and Energy Density

- Now, if we multiply the power (density) by the exposure time, we will get energy (density), measured in ***Joules (Joules/cm^2)***
- And of course we know that too long an exposure to a bright and warm sun can cause sunburn!
- The same principles apply to laser effects on tissue - it is, after all, just another source of light.
- 1J = energy released by dropped mobile phone!

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Energy

Joules = watts x time

………………………..

100 joules = 1000 watts x 0.1 sec

OR 100 joules = 1 watt x 100 sec

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Properties of Lasers

- *Wavelength (monochromaticity)*
- *Collimation*
- *Intensity*
- ***Coherence***

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COHERENT

White light photons are disordered, and are emitted in all directions, with no two photons being identical in phase or direction.

Laser photons are in phase in both time and space - they travel in the same direction, and are "in step", like soldiers marching.

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Modes of Operation of a Laser Continuous Wave - CW

- Very simple - the beam is emitted as long as the footswitch is depressed. The power usually is a maximum of about 120 watts.

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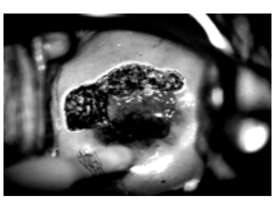
CONTINUOUS MODE



- Shutter open when footswitch is activated
- No interruption in power delivery
- Used for vaporization, coagulation, excision
- Produces carbon on the tissue

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Pulsed CW

- Also simple - the beam is turned on and off electronically. It may be a single exposure (or pulse), or a repeated series of exposures, with a fixed or variable gap in between.
- If repeated, the sequence may go on as long as the footswitch is depressed.

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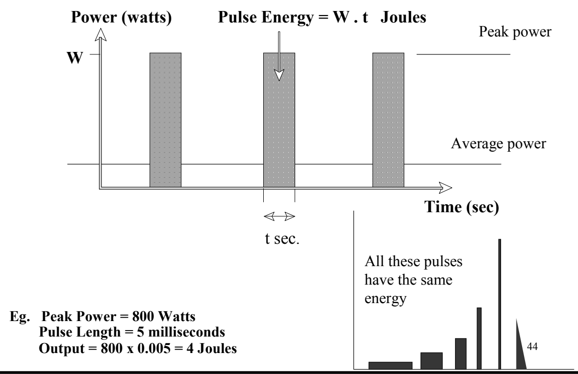
Pulsed Modes

Not so simple - there are various modes :

- Naturally pulsed lasers (eg. Er:YAG)
- Medium to long pulse (<1ms to >200ms)
- Q-switched (microseconds or less)
- "superpulse" - or "ultrapulse", or many other names (CO_2 lasers, where laser can be turned on and off quickly)



Duty Cycle

- The duty cycle is simply a measure of how long in each second the laser beam is "on"
- A duty cycle of 1:10, 0.1 or 10% means the beam is on for 10% of the time and off for 90%
- A short duty cycle means the average power is low compared to peak power

Repetition Rate

- Some lasers eg. Ho:YAG and Er:YAG operate naturally in a pulsed mode
- What we can change is the pulse repetition rate in Hertz (Hz), where 1 Hz = 1 pulse per second, and the pulse energy
- Typically in urology we will use about 7 Hz and 1 Joule per pulse

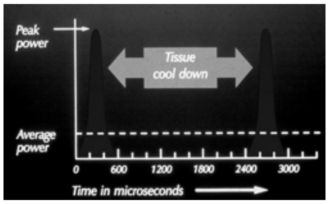
Repetition Rate

- The product of the pulse energy and rate is the "average power" as displayed on some lasers
- eg. 7 Hz and 1J = 7W "average power" (depends on duty cycle)
- The average power is important as there are limits to how much power a fibre can transmit without damage – **especially fibres for Ho:YAG lasers**
- The smaller the fibre diameter, the lower the average power limit

"Superpulse"

- A common term, but different manufacturers have different names.
- Basically, we turn the external energy source on and off rapidly. This allows a higher pulse power (say 1,000W), and a short gap between pulses.
- Can also be simulated by rapidly moving the beam with a mirror.

(SUPER)PULSED MODE



- Pulse allows for intermittent heating / cooling
- Reduces carbon on the tissue
- Used for cutting, delicate tissues, excision
- Minimal coagulation

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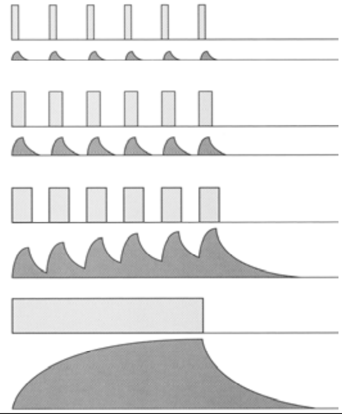

More realistic relationship between pulse length and tissue heating/cooling

Laser on

Temperature

Image courtesy of Iridex

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"Real Life" Pulses

- Lasers canot be made to produce squared-off pulses like the idealised pulses shown
- They usually rise to a peak then fall off somewhat, then fall to zero
- The effect is that the peak power may be higher than desired with the risk of overtreatment

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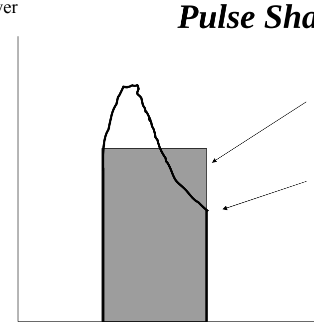
Pulse Shape

Power



Time

(Ideal) square pulse has uniform peak power

"Real" pulse means higher peak power needed to achieve desired effect

High peak power = higher temperature

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Other Pulses

- A squared pulse can be simulated by moving a continuous beam so that each point on the tissue is "swept" by the beam
- The beam can be swept in various patterns to allow degrees of overlap to account for the beam profile

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Q-Switched

- In a Q-switched laser, think of BOTH mirrors being fully reflecting - then make one fully transmitting.
- The entire energy inside the laser comes out in a huge (maybe 100,000 W), and very short (maybe 0.000 000 1"), pulse.
- Now "replace" the mirror, and start again.

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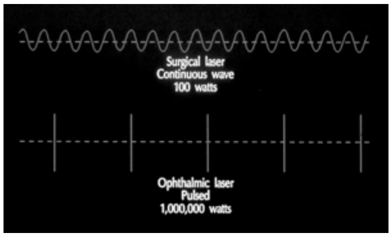
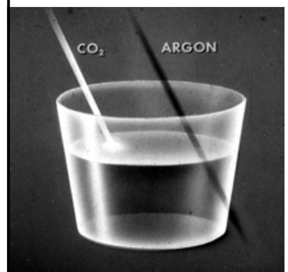
Q-Switched Nd:YAG Posterior Capsulotomy





Is our laser wavelength :

Absorbed in water
or
Transmitted through water?

…and what effect does this have?

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Delivery Systems - Getting the Beam to the Tissue

- *For wavelengths* ***absorbed*** *in water:*
  - Hollow tube with mirrors
  - Rigid endoscopes
  - Handpiece, scanner, micromanipulator
- *For wavelengths* ***transmitted*** *by water:*
  - Optical fibres
  - All endoscopes

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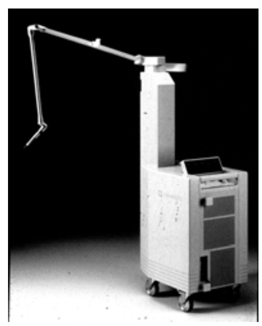
CARBON DIOXIDE



- 10,600 nm (10.6 micron)
- Water absorber
- Very shallow penetration (<0.1 mm)
- Rigid, hollow, mirrored delivery systems
- milliwatts to1000 watts

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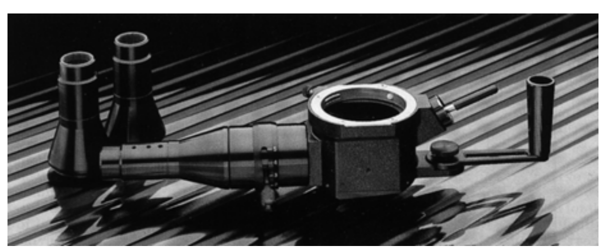
CO_2 Handpieces

CO_2 Micromanipulator



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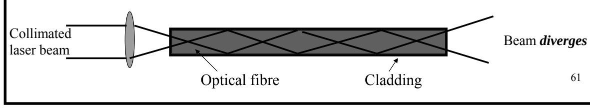
Optical Fibres

- Useable up to ~2100 nm
- Flexible
- Diameter from ~100 μ up to 1000 μ
- Light "bounces" within the fibre, causing it to diverge at the end



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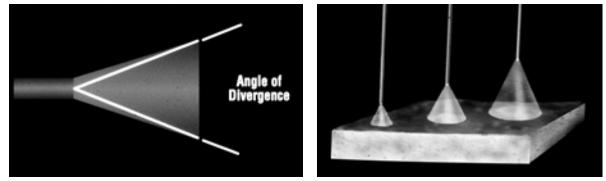

- Fibers have no lens - the beam diverges rapidly
- Fibers must be held close to target to maintain power density
- Spot size is determined by the fibre size
- 600 μ fiber = 600 μ spot size at the end of the fibre

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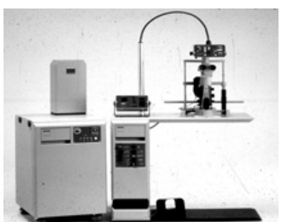

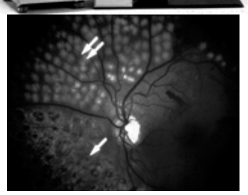

VISIBLE LASERS

- 755 nm – 488 nm
- Water transmitters
- Penetrate 2-3 mm
- Absorbed in chromophores
- Fibre / endoscopic delivery systems

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Nd:YAG

- 1064nm
- Water transmitter
- Non-specific absorption
- 4-6mm penetration (more in unpigmented tissue)
- Fibreoptic delivery
- Contact/non-contact modes

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Holmium:YAG Lasers

- Wavelength 2,100 nm
- Pulsed (for stones), or effectively continuous wave (for soft tissue)
- Shallow penetration in tissue
- Effectively water absorber
- Fibre (low OH content) transmission

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Diode Lasers

- Wavelengths - various eg. 532, 810, 940, 980, 1450 nm
- Power - up to 150 W, and higher coming
- Various absorption (depending on wavelength)
- Delivery - fibre

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Laser - Tissue Interactions

OUCH!!

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Now we've dealt with the basics, let's think about how lasers work on tissue.

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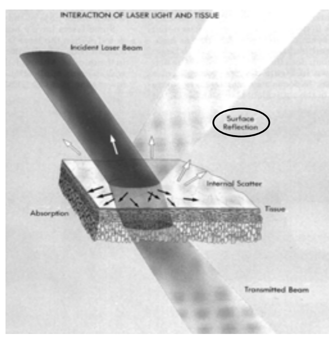
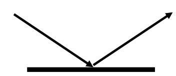
When the Beam Meets A Target….

- You'll hear more about this later, but like any form of light, when the laser beam strikes any target, four effects can occur
- The amount of each depends on many factors

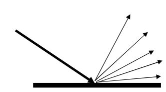


Reflection

- Specular, or mirror-like
  - Near perfect reflection, like a mirror
  - Power density preserved



- Diffuse
  - Reflection "spreads out"
  - Power density greatly reduced



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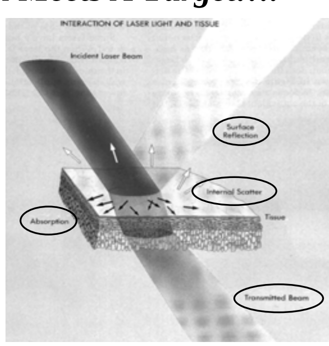

Scatter

- Scatter in general increases as wavelength decreases (this is why the sky looks blue!)
- However as green light is so strongly absorbed by Hb, the effect in tissue is less scatter than for red light

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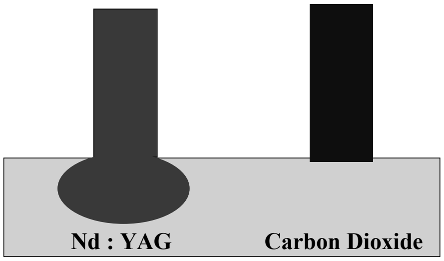
Scatter and Absorption



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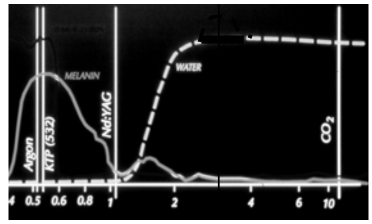

Absorption (rough graph)

- CO_2 and Er:YAG are absorbed in the intracellular water.
- Shorter wavelengths are absorbed in chromophores, including the three main tissue components

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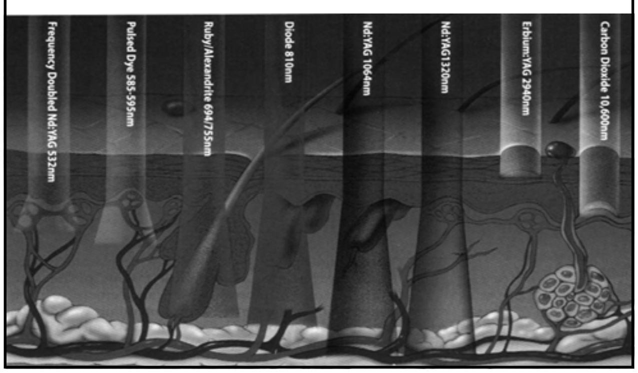
Depth of Penetration



Chromophore Absorption

- Visible light reacts with coloured pigments - chromophores
- Most near IR does not react with colour, only shade (darkness)
- Far IR has no relationship (water absorber only)

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Two Approaches to Absorption...

- Target discrete chromophores
  - visible, near visible wavelengths
- Target water only
  - far infrared wavelengths
- *Can also target chromophores and water simultaneously*
  - *near infrared*

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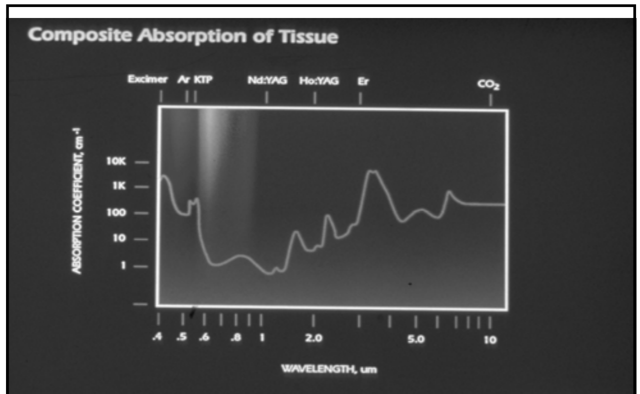

Biological Effects of Lasers

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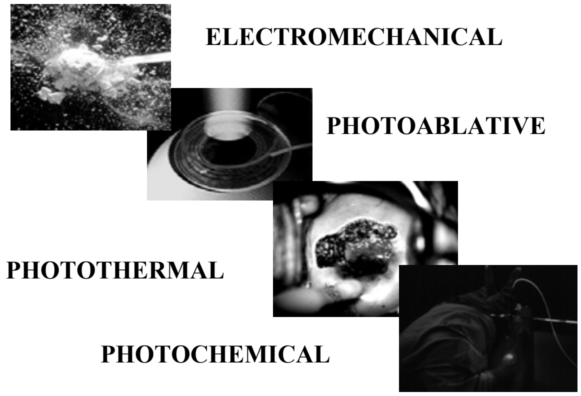
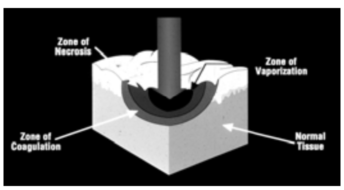


ELECTROMECHANICAL

PHOTOABLATIVE

PHOTOTHERMAL

PHOTOCHEMICAL

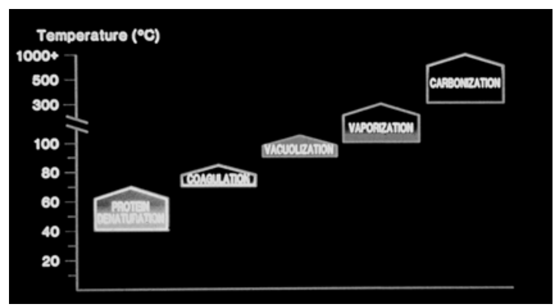


PHOTOTHERMAL

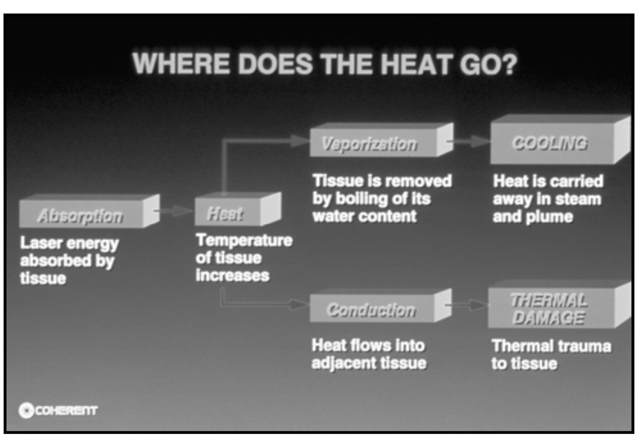
CO_2	Tunable Dye
Argon	KTP
Nd:YAG	Diode

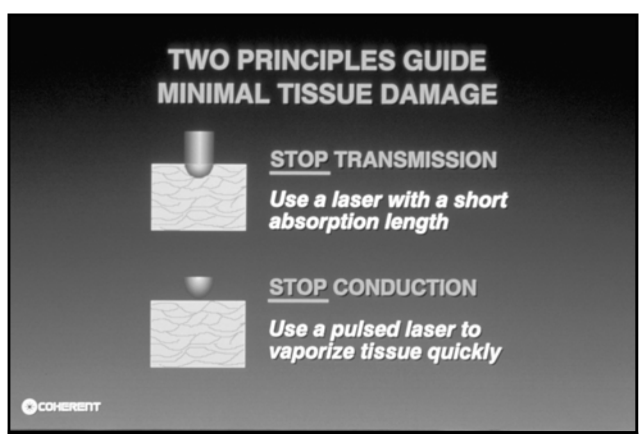
81

Absorptive Heating in Tissue

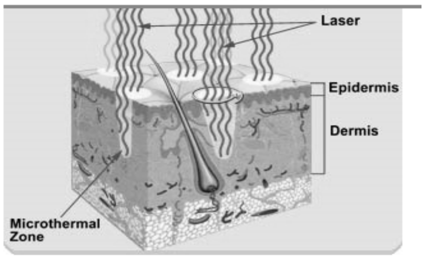


82



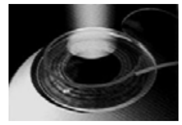


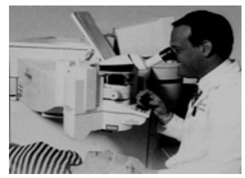
Fractional Photothermolysis (1550 nm)



85

PHOTOABLATION



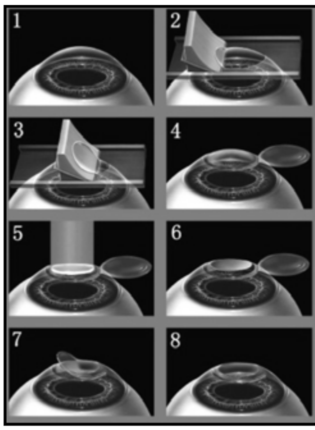


Excimer

108 – 308 nm

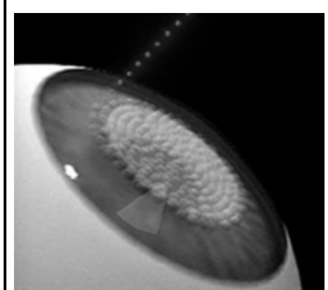
193 nm for PRK/LASIK

86



LASIK using microkeratome

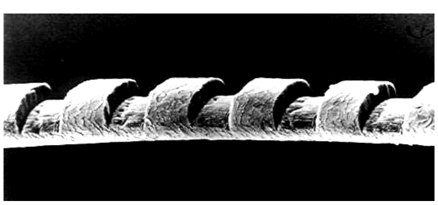
87

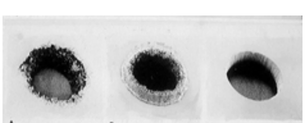


Corneal flap with Intralase – 1053µ wavelength, 3µ spot size Femtosecond pulses create microbubbles, leaving flap 100µ thick

88

Photoablative Tissue Effects





From the work of Dr. R. Srinivasan

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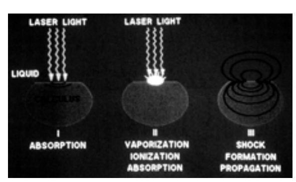
Electromechanical



- Q- switched Nd:YAG
- Q - switched ruby
- Flash lamp dye
- ***Holmium:YAG***
- Alexandrite

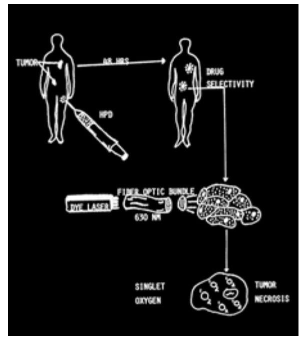
90

Photochemical

- Low power lasers (physiotherapy, acupuncture)
- Photodynamic therapy
- Low power, long irradiation time

91

PHOTODYNAMIC THERAPY



Photosensitizers Clear From Normal Tissues and Are Selectively Retained in Target Cells.

400nm Light Causes Florescence of Tagged Cells.

Selective Laser Wavelengths Absorb in Tagged Cells, and a Photochemical Reaction Occurs, Causing Release of Singlet Oxygen, and Individual Cell Death.

92

LOW LEVEL LASER APPLICATIONS

- Pain Relief
- Wound Healing
- Herpetic Lesions
- Sports Injuries
- Scars
- Hyperpigmentation
- Repetitive Stress Injury / Carpal Tunnel

93

IPL

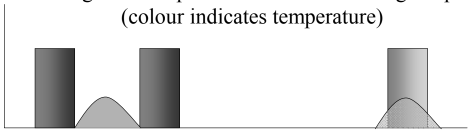
- Intense pulsed light sources - not lasers
- polychromatic light (515 - 1200 nm)
- wide range of fluence and pulse properties
- allow vascular and pigmented lesion treatment
- require epidermal cooling
- have similar safety issues to lasers

94

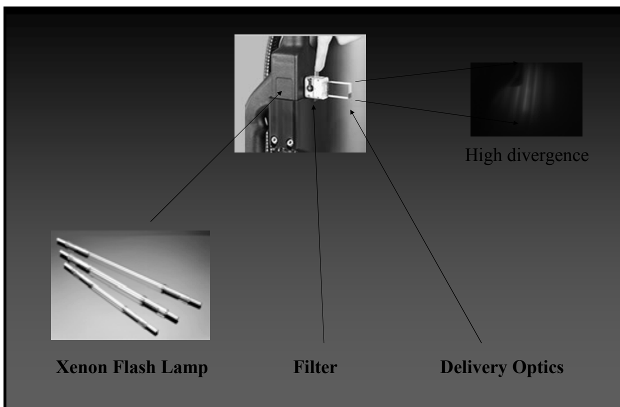
Epidermal Cooling

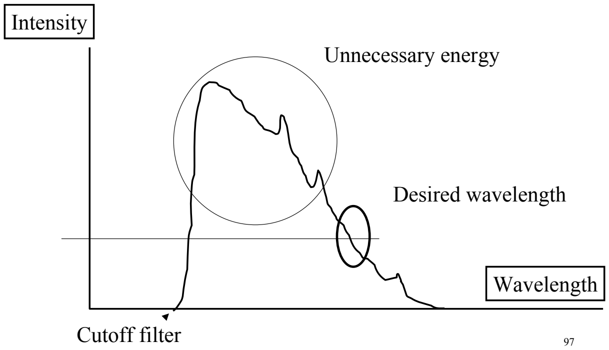
- Where the skin surface temperature could increase to the point of permanent damage or ablation (eg. darker skinned patients, IPL systems, long IR wavelengths), surface cooling may minimise this risk

Cooling between pulses During the pulse
(colour indicates temperature)

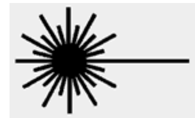


95





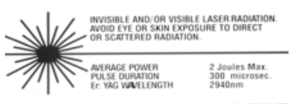
97



Laser Safety

98

Laser safety is covered by Australian Standards AS/NZS2211 (general safety) and AS/NZS4173 (medical lasers), as well as legislation in some states.



Laser accidents can and do happen. Fortunately they are rare. Many can be minor, but most are serious. In Australia we have had patient deaths, operator blindness, fires, and unexpected (and unwanted) tissue effects.

100

Dangers of lasers revealed

By ANNA PATTY
Health Reporter

SAFETY controls are urgently needed to regulate the use of popular laser therapies for cosmetic procedures such as hair removal, medical professionals warned yesterday.

The call comes as dermatologists report an increasing number of patients with serious burns from lasers used by untrained beauty therapists and hairdressers.

Alison [redacted], 26, of North Sydney yesterday said she had suffered serious burns under her arms after undergoing laser therapy at a beautician's salon.

"The impression they gave me was that it was a simple procedure like waxing — that I'd be in and out, that it would save me money," she said.

"No one explained the risks or the medical aspects of the treatment.

"I had about five minutes before the treatment to sign a form with a lot of small print and jargon. I skim-read it and nothing jumped out at me to say it could be dangerous."

After the procedure Ms Variet felt like fainting.

"I felt burnt. I had to have ice packs under my arms," she said.

Ms [redacted] GP, Dr Sharron Phillipson, was so concerned about the burns that she took photographs.

Dr Phillipson, who chairs the laser subcommittee of the Cosmetic Surgery Credentialling Counsel said there were no controls in NSW on beauty therapists using intense pulse lights and laser therapies.

"We are getting cases of burns and pigment changes in patients who have been to beauticians," Dr Phillipson said.

"Beauty therapists are not trained to deal with such complications and, with minimal training to use these machines, the risk increases.

"I know of a beautician offering free melanoma diagnosis — you need medical expertise to diagnose these conditions."

Dr Phillipson has repeatedly written to NSW Health, the Therapeutic Goods Administration and NSW Health Minister Morris Iemma warning of the dangerous practices.

"I've had no reply," she said.

The Cosmetic Surgery Credentialling Council was established after the State Government held an inquiry into the cosmetic surgery industry in 1998.

Sydney dermatologist Dr James Walter has also raised concerns about the misuse of laser therapy.

"Many beauty therapists and hairdressers are buying these instruments with no regard to the competence of the people who will operate them," he said.

"I have seen a number of patients with complications from intense light pulse machines and lasers used by people with no qualifications."

Helen McCabe: Page 38

Sydney Morning Herald 101

Examples of eye damage

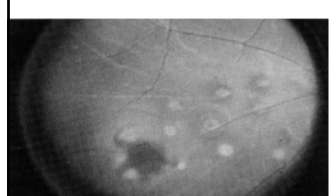
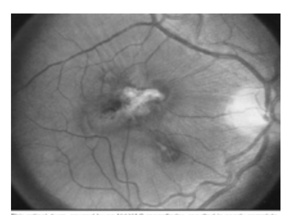


Figure 7. Multiple small laser burns with minimal hemorrhage.



This retinal burn, caused by an Nd:YAG rangefinder, resulted in nearly complete vision loss.

Experience has demonstrated that most laser injuries go unreported for 24–48 hours by the injured person. This is a critical time for treatment of the injury.

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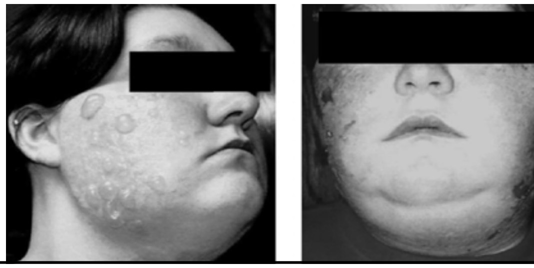
Vesicobullous eruption post IPL

(Dermatol Surg 2005;31:345-349)

Excessive fluence (J/cm^2) used, leading to thermal injury



03

7. Blistering and subsequent hypopigmentation following laser hair removal treatment.

104

Laser Safety Classification

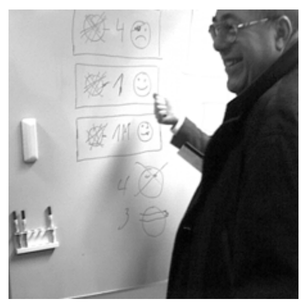
Virtually all surgical lasers are Class 4

Indicative power limit	Class	
	Class 4	Unsafe for eyes, skin + fire hazard
0.5 W		
	Class 3B	Unsafe for eyes, OK for skin
0.005 W		
	Class 3A	As Class 2, but no magnification
0.001 W		
	Class 2	Safe with aversion response
0.0005 W		
	Class 1	Safe

Note : All except class 4 have recently changed, but not significantly

105

New IEC Classifications



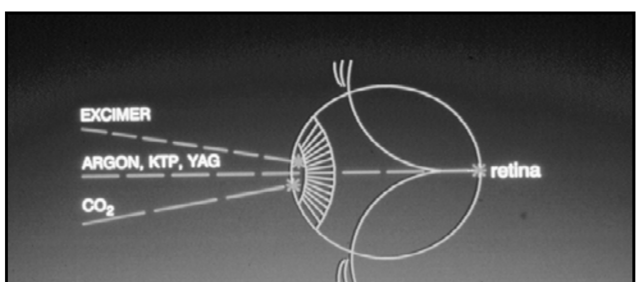
- **Class 1**
- **Class 1M**
- **Class 2**
- **Class 2M**
- **Class 3R**
- **Class 3b**
- **Class 4**

106

Hazards of Medical Laser Use

- ***Eye damage***
  - Visible and near infrared radiation can reach retina and cause catastrophic damage
  - Longer and shorter wavelengths can damage lens/cornea
- Smoke (plume) inhalation
- Fire
- Skin burns

107



Those wavelengths which can pass through the lens are focussed by a factor of around 100,000 - the power density can be enormous.

108

Lasers are not toys!!

Laser pointers are not toys either!

- Hand-held, battery powered diode lasers producing blue, green or red light
- Can easily be Class 3B, but mostly Class 2, 2M or 3R
- All states and Commonwealth ban possession and use of >Class 2 pointers (>1mW) without permit or “good cause”
- Hazard more dazzling/flash blindness than permanent injury, except at high powers

110

Safety glasses MUST be used, and designed for the laser being used – check the wavelength markings!

111

It’s not just the direct beam…..!

GreenLight KTP laser in use

Courtesy LaserScope

Laser Safety Eyewear

- There are two different marking schemes in use, but both require the filtered wavelength(s) to be marked, normally in nanometres (nm).
- ***BEWARE*** - two goggles may look the same, but can be for very different wavelengths.
- ***CHECK THE MARKINGS BEFORE USE***

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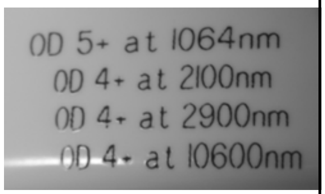
Laser Safety Eyewear

- Older eyewear show the Optical Density - a measure of how well a wavelength is filtered.
- An OD of 4 to 5 is normally adequate (depending on wavelength), but check the laser manual first!
- Newer eyewear (to the UK and European standards) has more complex markings - I suggest taking advice!

114

Laser Eyewear Labels

Old system (still in use)



OD = optical density,
logarithmic scale
NOT like sunglasses

115

New Marking System (AS 1336)

D = use with CW laser
I = use with pulsed laser
R = use with Q-switched laser
no letter = use with all types
plus wavelength (in nm)
plus scale number (L1 to L10) giving level of protection
plus optional mechanical strength mark

eg. D 2100 L5

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This can mean that there are different L values for different modes of operation. Can be confusing!!

OLD SCHEME	*NEW SCHEME*
OD>7 5000-11000 nm	DR 1064 L6
OD>7 850-1080 nm	DR 850-1070 L4
OD>5 750-850 nm	D 750-850 L4
OD>3 710-750 nm	D 488-515 L5
OD>7 520-532 nm	DR 355 L7
OD>9 90-520 nm	D 193-520 L3
	DR 532 L6

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IPL Systems Are NOT *Lasers*

- Not governed by Standards or Regulations - YET!!
- Can be hazardous to staff and patient (burns, photic stimulation, eye damage)
- Mode of action should not be confused with lasers
- Require appropriate education, training, and safety controls
- Regulated in the UK since April 2002, Tasmania since June 2006

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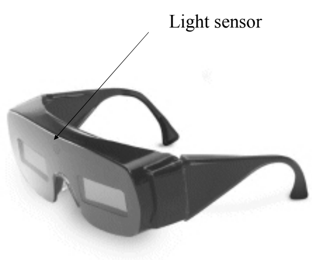
IPL Glasses



119

Take Care Of Safety Eyewear

<u>DO NOT USE CLEANSERS THAT CONTAIN ALCOHOL</u>

- **NO Abrasive Materials**
- **Avoid Extended Light Exposure**
- **Store in Protective Covers**
- **Inspect Before Use**

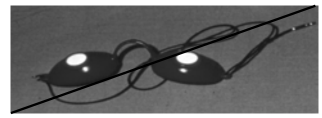
120

Patient Eye Protection

When patients are awake (local or no anaesthesia) safety goggles are worn throughout the laser procedure.

121

Never use foil, plastic, reflective, or unlabelled devices

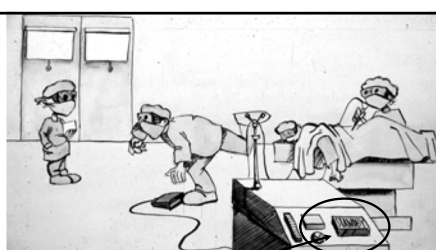


Eye Protection for the Patient Under General Anaesthesia

123

No extra protection is needed with the CO2 Laser on a microscope.

Be sure the correct eye safety filter is installed properly with any fiberoptic laser.



The "Standby" switch is a major safety feature which disables the footswitch – use it when the laser is not required.

125

Some laser procedures create a smoke plume, which can contain viral material, and toxic gases (as well as smelling awful!)

Protect yourself and staff by using a smoke evacuator which removes particles down to 0.1 micron

126

Laser-induced fires ARE possible, especially with CO_2 lasers.

Know how you would deal with a fire.

127

Endotracheal Tube Fire Demonstration

128

Medtronic Laser-Shield Tube (CO_2 or KTP)

129

Signs and Warnings

- A laser warning sign must be placed at every entrance to a room where a laser is is use.
- It must also show the wavelength.
- No-one should be allowed to enter without wearing protective eyewear (keep spare goggles outside).
- Some sites also use an illuminated warning.

130

Windows

- CO_2 and Er:YAG lasers can be safely used behind ordinary window glass - the water (OH) in the glass is a good absorber.
- Ho:YAG in most cases could be safe with ordinary window glass – but risk analysis may be necessary
- Other laser wavelengths will be transmitted partly or completely through glass, therefore windows must be covered.

131

Doors

- Although all medical lasers allow for a switch connected to the door to turn off the laser when the door is opened, this is not recommended. And NEVER lock the door from the inside!
- Make sure however that the door is shut during a laser procedure.

132

133

Training

- Most accidents can be prevented - training of all staff using lasers and assisting is vital, and becoming mandatory under state legislation.
- This includes writing protocols and procedures where appropriate. For example, a good airway fire protocol has saved a patient's life more than once.

134

Smoke Evacuators vs Laser Masks

- Filtration must be to at least 0.1 micron, and >99.99% efficient
- Masks are secondary protection only, and are intended as particle filters – not odour filters!
- Smoke evacuators the most efficient method

135

Is smoke from a laser procedure safe….?

- It is offensive!
- Studies have shown that there may be live viral material and noxious gases in the plume
- Be safe….use a smoke evacuator

136

Lasers and Pregnancy

- Laser light is not able to reach the foetus (even Nd:YAG only penetrates ~6mm)
- The light is not carcinogenic – in comparison x-rays potentially are, and shielding is required
- The foetus is not at risk from laser use

137

Basic Safety Precautions

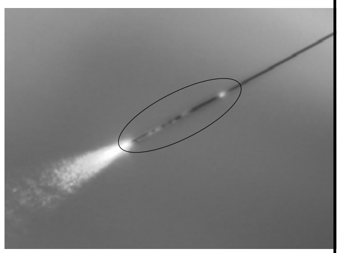
Equipment

- Master key (never left in laser!)
- Use of "Standby"
- QA (esp. power, beam alignment where possible)
- Keep log of procedures
- Draw up and follow procedures for laser and associated equipment use

138

Fibre and Ureteroscope Damage

- Fibres - especially re-useable fibres - can develop stress points due to the frequent flexing at the tip of the ‘scope.
- This can sometimes be seen as little flecks of light from the aiming beam near the fibre tip.



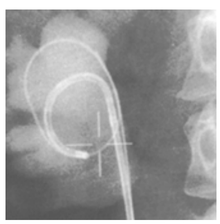
139

Fibre and Ureteroscope Damage

- Stress can lead to sudden fibre breakage
- To avoid this, always cleave the fibre 10 cm from the tip, where stress is unlikely.
- Ureteroscopes can also be damaged, either by firing the beam when the fibre tip is inside the ‘scope, or by puncturing the wall.
- ALWAYS put the laser on “Standby” when the fibre can no longer be seen on the monitor.

140

Re-inserting a fibre into a flexed ‘scope can easily cause wall penetration - straighten the ‘scope first.



141

Before the serviceman gets called...

- There are a few easily fixed, and sometimes common, problems that should be checked if the laser is not working

142

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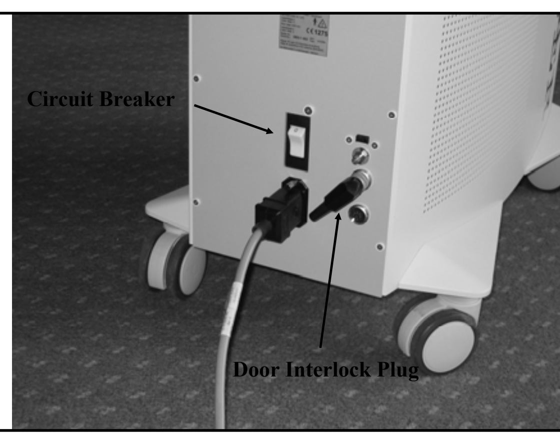

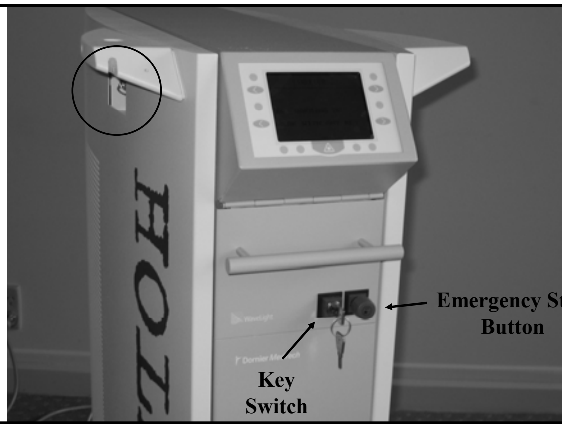

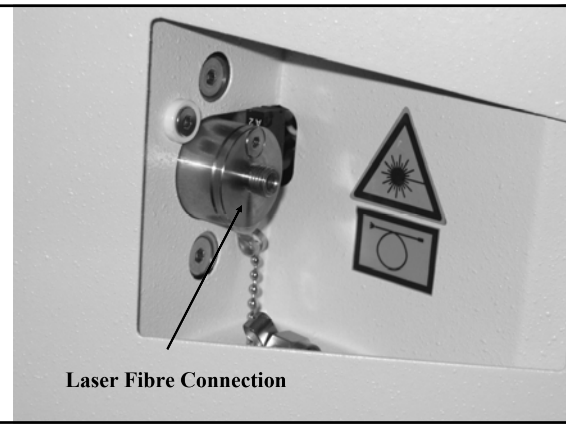

Quality Assurance

- The operator cannot do much QA except for CO_2 lasers, but :
  - check emergency stop operation regularly
  - check all cables and footswitch
  - check interlocks
  - check fibres and accessories
  - check aiming beam quality and homogeneity
  - check eyewear

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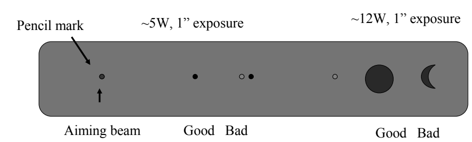
Quality Assurance - CO_2 Lasers

- Check articulated arm for damage
- check coincidence of aiming beam and treatment beam using wet tongue depressor
- check homogeneity of treatment beam



148

Basic Safety Precautions

Environment

- Protection of the laser room
- Fire beam only when aimed at target
- **No fluids near laser**
- Fire precautions
- Check footswitch cable
- Know your responsibilities and role
- Protect non target tissues where appropriate

149

Basic Safety Precautions

Staff

- Safety eyewear (incl. patient)
- Warning signs
- Room protection
- Training

150

Some examples of safety badly done…………..

(courtesy Penny Smalley)

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Australian Standards


AS/NZS 4173:2004

Australian/New Zealand Standard™

Guide to the safe use of lasers in health care

STANDARDS AUSTRALIA

- **NOT REGULATORY (unless referenced by laws)**
- **Benchmark for National Level of Safe Practice**
- **Committee membership represents hospitals, industry, research, regulators and professional bodies**

154

AS/NZS 2211 (1998)

- Technical (very!!)
- Applies to all types of lasers
- Referenced by AS/NZS 4173

155

AS/NZ 4173 (2004)

- **Applies to *ALL* Medical Lasers and Practice Settings**
- **Referenced By ACORN, State And Regulatory Agencies**
- **Procedural and Operational Body of Knowledge**

156

What’s In AS/NZS 4173 ?

Scope
Laser Properties
Delivery Systems
Bioeffects
Hazards / Safe Practices
Equipment
Administration
QA / Acceptance Testing
Appendices

157

Hazard Controls

ADMINISTRATIVE

ENGINEERING

PROCEDURAL

158

Lasers and the Law

159

Legal Requirements

- WA, Qld., and Tas have regulations covering (class 3B and) 4 lasers and in some cases, IPLs
- Mostly, users need to be licensed, and/or the laser equipment has to be registered.
- Other states and NZ currently do not have controls over laser/IPL use
- Australian Commonweatlh regulator (ARPANSA) is developing uniform controls – will NRL in NZ follow?

160

So………...

- Laser safety is as much a state of mind as a science
- It’s easy…provided the basic rules are followed
- The consequences of bad safety practices to patient and staff can be rather nasty...

161