

## LASER THERAPY



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## Lecture Objectives

- Identify the different types of lasers
- Appreciate the physical principles used to produce laser light
- Understand the therapeutic applications of lasers in wound & soft tissue healing, oedema reduction, inflammation & pain
- Understand the application techniques of low power lasers
- Describe the classification of lasers
- Be aware of the safety considerations in the use of lasers, the contraindications and precautions for low-power lasers

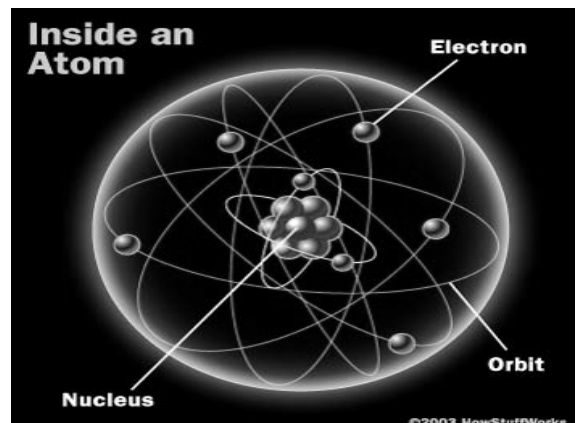
## LASER

- **L**ight **A**mplification for the **S**timulated **E**mission of **R**adiation
- History
  - Einstein 1916
  - Townes & Schawlow 1955, MASERs (microwave amplification of stimulated emission of radiation)
  - Theodore Maiman 1960, optical MASERs
  - 1965, term LASER substituted for optical MASER

## The physics..

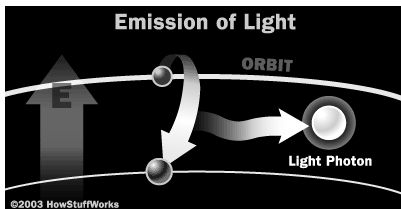
- Light = electromagnetic energy that has wavelengths between 100 & 10,000 nanometers within the electromagnetic spectrum
- Visible light ranges from 400 (violet) to 700nm (red)
- Beyond red portion of the visual range = infrared & microwave region
- Beyond violet portion of the visual range = ultraviolet, x-ray, gamma & cosmic ray regions

- Light travels through space as waves that contain tiny “energy packets” called **photons**.
- Each photon contains a definite amount of energy depending on its wavelength (colour)
- Atomic theory explains laser generation
  - Atom is smallest particle of an element
  - Atoms contain neutrons, protons & electrons
  - Neutrons & protons form nucleus of atom
  - Negatively charged electrons (= to no. of protons) orbit the nucleus at distinct energy levels



- If an atom gains or loses an electron it becomes a negatively or positively charged **ion**, respectively.
- Polarity difference between positively charged nucleus & negatively charged electrons  $\Rightarrow$  electrons orbit nucleus at distinct energy levels
- An electron will always remain in its ground state unless it absorbs enough energy to move to higher level.

- If a photon of enough energy collides with an electron of an atom  
 $\Rightarrow$  electron will change level (atom in "excited state")
- Atom in excited state momentarily & releases identical photon (energy level) to the one it absorbed
- By releasing this energy  
 $\Rightarrow$  returns to ground state
- This process = SPONTANEOUS EMISSION



## Stimulated emissions

- Postulated by Einstein
- Photon released from an excited atom would stimulate another similarly excited atom to de-excite itself by releasing an identical photon.
- The 'triggering' photon would continue unchanged, and subsequent photon released would be identical in frequency, direction & phase.
- These 2 photons would promote release of additional identical photons in the presence of other excited atoms.

## Stimulated emissions rely on..

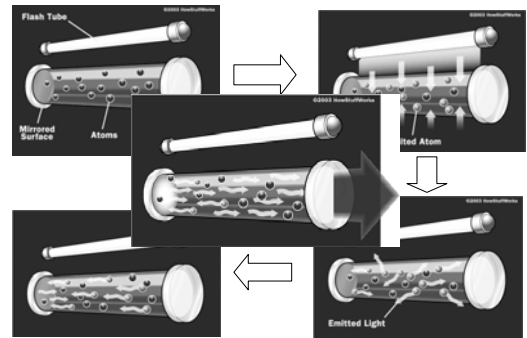
- "Population inversion"
  - Environment with unlimited excited atoms
  - I.e. More atoms in excited state than in ground state
  - Produced by applying external power source to 'lasing medium'.
- To contain excited atoms use mirrors at either end of a chamber
  - 1 totally reflective
  - 1 semipermeable

- Photons reflected within chamber
- Amplifies light & stimulates emission of other photons from excited atoms
- Eventually, abundance of emitted photons (energy) that chamber cannot contain
- When specific level of energy is attained, photons of particular wavelength are ejected through the semipermeable mirror.

Thus,

- Amplified light through stimulated emissions (LASER) is produced!!

### Stimulated emission – The Ruby Laser



### Laser light - characteristics

- Coherence
  - All photons of light emitted from ind. gas molecules are of same wavelength & ind. light waves are in phase with one another
  - Normal light composed of many wavelengths that superimpose their phases on one another.

- Monochromaticity
  - Only 1 characteristic wavelength or 'colour' of light is emitted.
- Collimated
  - Minimal divergence of photons
  - Photons move in parallel fashion
  - Leads to concentrated beam of light

### Types of LASERS

- Classified according to nature of material placed b/n 2 mirrors
- Lasing mediums
  - Crystal & glass (solid-state)
  - Gas
  - Semiconductor
  - Chemical
  - Liquid dye

- High-power lasers (Hot lasers)
  - Generate thermal responses
  - Medically, surgical cutting & coagulation, ophthalmologic, dermatologic, oncologic & vascular specialties
- Low-power lasers (Cold lasers)
  - Produces no thermal change
  - Wound healing & pain management (relatively new area of application of lasers)
    - Tendon/ligament injury, oedema management, soft-tissue injury, ulcer & burn care, scar tissue inhibition, arthritis, acutherapy

## Laser Generators

- Lasers need
  - Power supply
  - Lasing medium
  - Pumping device
  - Optical resonant cavity to contain lasing medium
- Helium Neon (HeNe) & Gallium Arsenide (GaAs)



- HeNe Lasers
  - Laser in red portion of electromag. Spectrum
  - Wavelength = 632.8nm
  - Power output = 1.0 – 10.0mW
- GaAs Lasers
  - Uses a diode to produce infrared (invisible) laser
  - Wavelength = 904nm



## Treatment techniques

- Lasing techniques
  - Gridding
    - Treatment area divided into grid of square centimetres
    - Each square centimetres stimulated for specified time
    - Most frequently employed & preferred technique
    - Don't draw on skin

- Scanning
  - No contact between laser & skin
  - Laser tip held 5-10mm from wound
  - Beam divergence
    - Dec. in energy as distance from target inc.
  - Difficult to calculate delivered dose
- Wanding technique
  - Grid area bathed with laser in oscillating fashion for designated time
  - Difficult to calculate delivered dose

## Dosage

$$T_A = (E/P_{av}) \times A$$

$T_A$  = treatment time for a given area  
 $E$  = mJ of energy per cm<sup>2</sup>  
 $P_{av}$  = Average laser power in mW  
 $A$  = beam area in cm<sup>2</sup>

- Laser may be delivered continuously or pulsed
- Dosage (or energy density) of laser is reported as Joules per square centimetre (J/cm<sup>2</sup>) (1 Joule = 1 Watt/sec.)
- Dosage dependent on
  - Output of the laser in mW
  - Time of exposure in sec
  - Beam surface area of the laser in cm<sup>2</sup>
- Treatment guidelines have been developed for specific injuries and conditions

## Depth of penetration

- Energy applied to the body may be
  - Absorbed
  - Reflected
  - Transmitted
  - Refracted
- Biological effects result only from ABSORPTION
  - If more absorbed at point of application, less available for deeper or adjacent tissues
  - Laser's depth of penetration depends on type of laser energy
    - HeNe absorbs rapidly in superficial tissues, esp. first 2-5mm
    - Direct effect vs. Indirect effect (eg. For HeNe is on tissues up to 8-10mm from surface)

## Effects on body tissues

- Primarily occur at cellular level
- Very few controlled studies in the lit.
- Documented case studies & empirical evidence
  - lasers effective in reducing pain and aiding wound healing
  - Mechanism of action uncertain
  - Proposed physiological effects inc.
    - Increased collagen synthesis, decrease in microorganisms, increase in vascularisation, reduction of pain & anti-inflammatory action

## Wound healing

- Increased fibroblastic activity
  - Increased connective tissue production
- Increased synthesis of nucleic acids & cell division
- Laser effect on rate of healing varies amongst studies
- Increased tensile strength of lased wounds reported several times
- Increased phagocytosis by leukocytes
- Decreased prostaglandins
  - Reduced oedema
  - Reduced inflammation

- Less scar tissue (subjective analysis)
- Improved cosmetic appearance (subjective analysis)

## Pain

- Rockhind et al (1987)
  - Crush injuries in rats
  - 10 J/cm<sup>2</sup> of HeNe
  - Demonstrated improved activity of sciatic nerve to normal level preinjury by 1 yr.
  - Controls did not reach normal levels after 1yr.
- Chronic pain
- Subjective nature of pain??

## Other suggested therapeutic indications

- Bone & articular cartilage lesions
- Pain assoc. with arthritic conditions

## Safety considerations

- Low-power lasers considered non-hazardous to the body or only hazardous if a viewer stares continuously into the source
- Avoid direct contact with eyes
- Patients & operators must wear protective glasses

## Contraindications

- Tumourous cells may proliferate if stimulated
- First trimester of pregnancy (although no adverse reactions documented)
- Small percentage of patients – syncope during treatment
- Eyes
- Others
  - Pacemakers (over or near), male genitals

## References

- Prentice W E. *Therapeutic Modalities for Physical Therapists*. 2<sup>nd</sup> Edn. McGraw-Hill. USA. 2002.