PH 301

ENGINEERING OPTICS

Lecture_Optical Sources_18

Laser Applications

- Scientific,
- Military,
- Medical,
- Industrial applications, &
- Commercial applications

Scientific Applications

- Interferometric techniques
- Spectroscopy & Raman spectroscopy
- Atmospheric remote sensing
- Investigating nonlinear optics phenomena
- Holographic techniques
- Laser-based light detection & ranging (LIDAR)
- Adaptive optics telescopes
- Material processing
- Photochemistry
- Laser cooling (atom trapping)
- Nuclear fusion
- Microscopy

Military Applications

- Target Designator & Range Finder
- Defensive IR Countermeasures
- Systems use lasers to confuse the seeker heads on heat-seeking anti-aircraft missiles.

- Communications
- High Power Lasers (e.g., 100 KW) to destroy cruise missiles, artillery, rockets
- STARWARS
  - Ground-based or space-based laser systems can destroy incoming intercontinental ballistic missiles.

- Laser Dazzlers
  - This unit illuminates an opponent with harmless low-power laser light & can have effect of dazzling or disorienting the subject or causing him to flee.

Laser Target Designator

Revolver equipped with a Laser Sight mounted on the trigger guard

Medical Applications

- **Cosmetic surgery: removing Tattoos, Scars, Stretch marks, Sunspots, Wrinkles, Birthmarks, Hairs (laser hair removal).**

Lasers in Dermatology: **Ruby (694 *nm*), pulsed diode array (810 *nm*), Nd:YAG (1064 *nm*), Ho:YAG (2090 *nm*), Er:YAG (2940 *nm*).**

- **Eye surgery & Refractive surgery**
- **Soft tissue surgery: CO_2, Er:YAG laser**
- **Laser scalpel: general surgery, gynecological, urology, laparoscopic**
- **Photobiomodulation: Laser therapy**
- **“No-touch” removal of tumors, especially of brain & spinal cord**
- **Dentistry: Tooth whitening, Oral surgery**

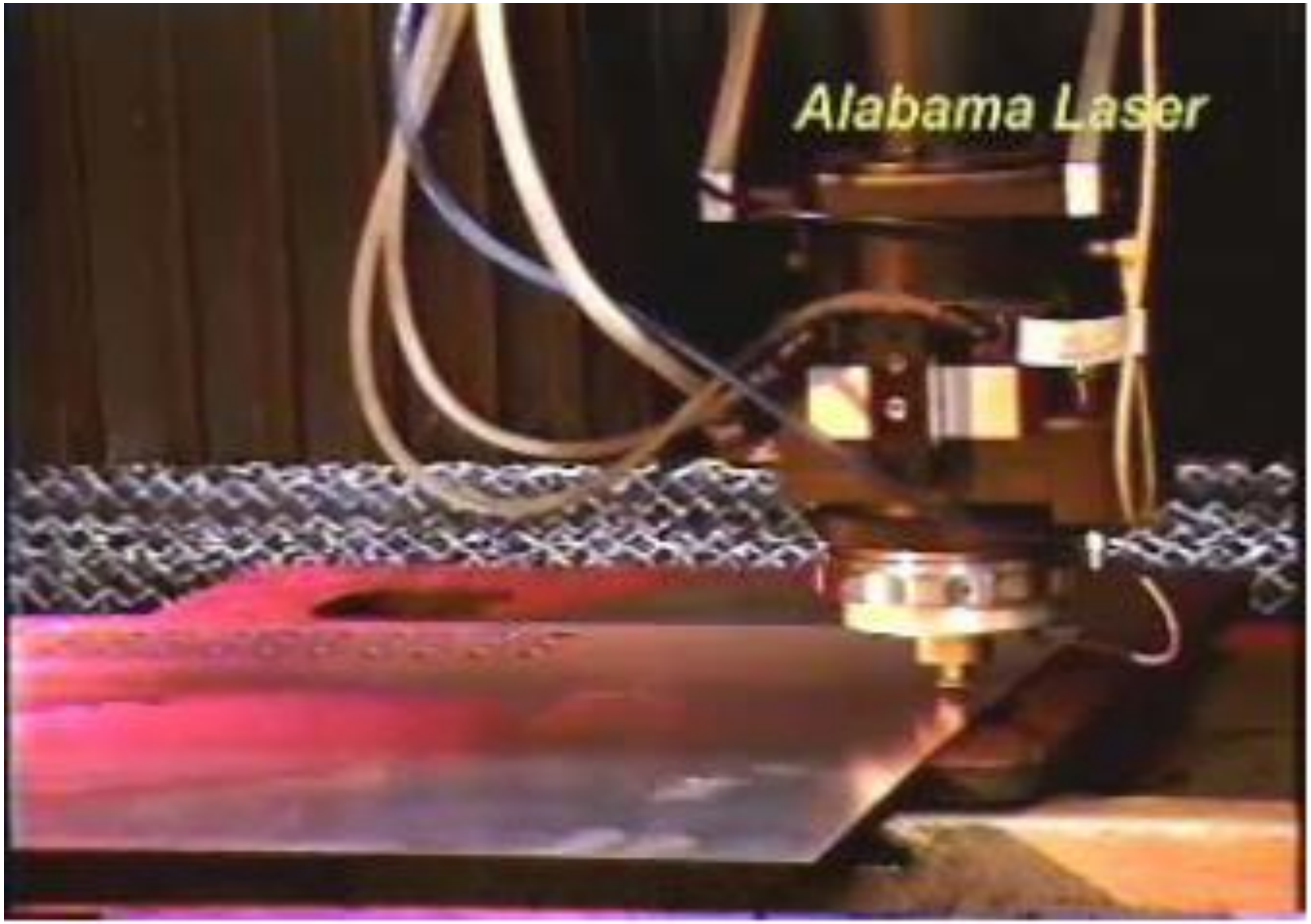
Laser therapy: **Application of electromagnetic wave 600-1100 *nm* over injuries or lesions to improve wound / soft tissue healing & give relief for both acute & chronic pain.**

Industrial & Commercial Applications

- Cutting & peening of metals & other materials, welding, marking
- Guidance systems (e.g., Ring Laser Gyroscopes)
- Range finder/surveying
- LIDAR/pollution monitoring
- Barcode readers, laser pointers, laser printers, laser scanners, CD readers/writers
- Laser bonding of additive marking materials for decoration & identification
- Photolithography
- Optical communications (optical fiber)
- Optical tweezers

Laser Light Show: lasers used for visual effects during a musical performance.

Leveling of ceramic tiles floor with a Laser Device.



Metal cutting

Holography

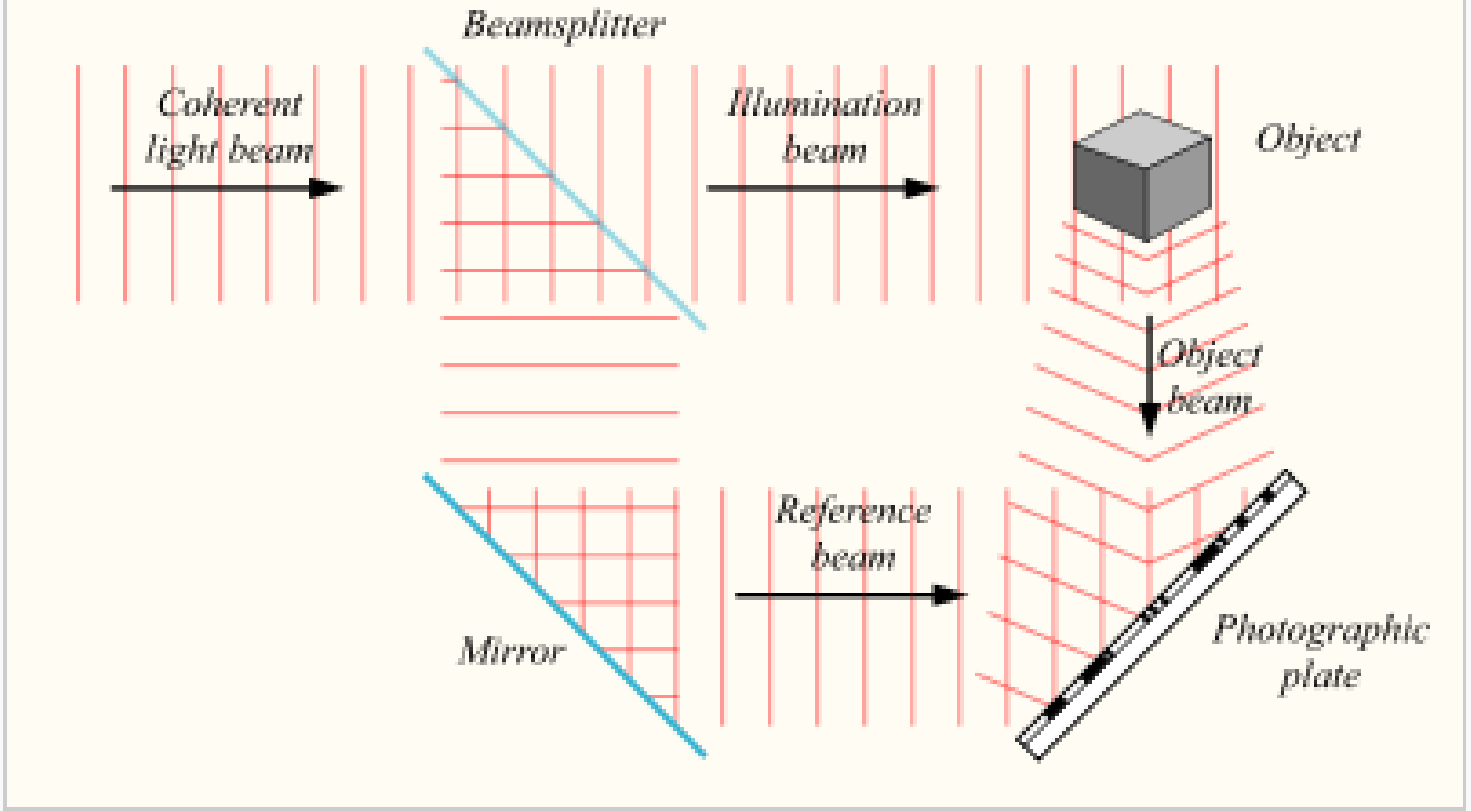
Invention: 1948

Nobel Prize: 1971

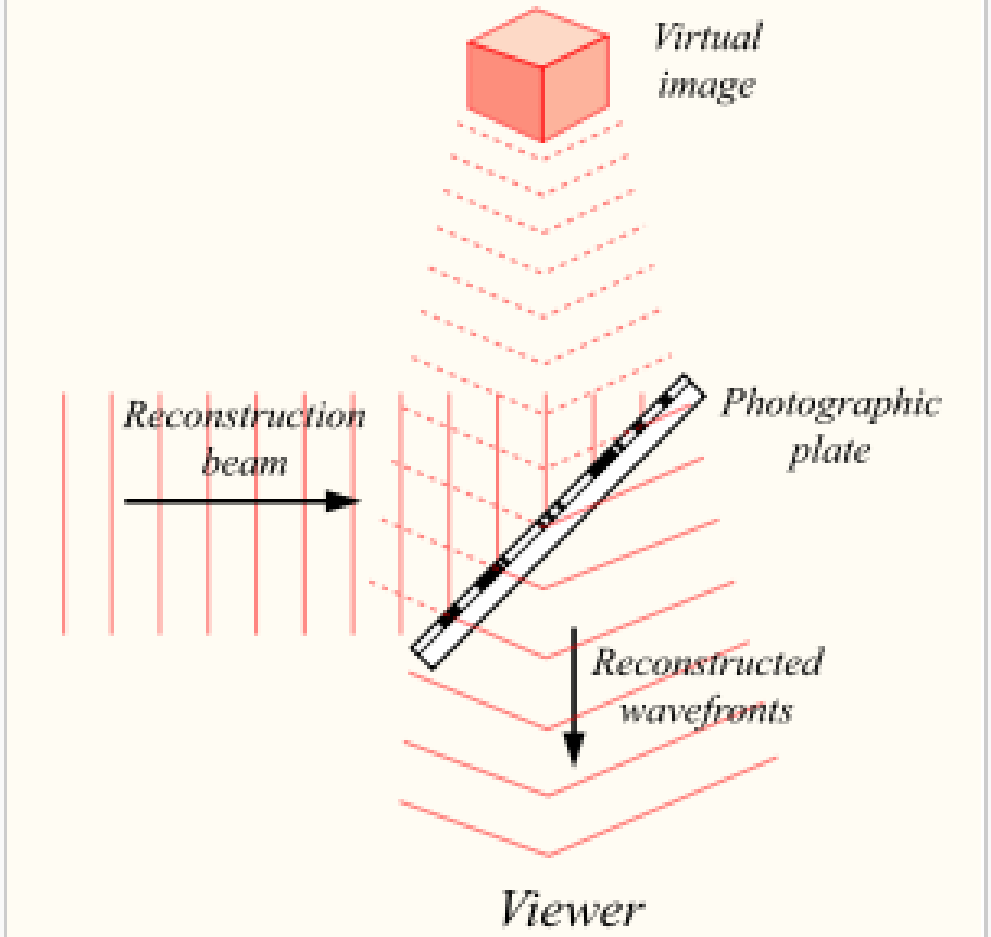
Dennis Gabor

05.06.1900 – 08.02.1979

Hungarian/British



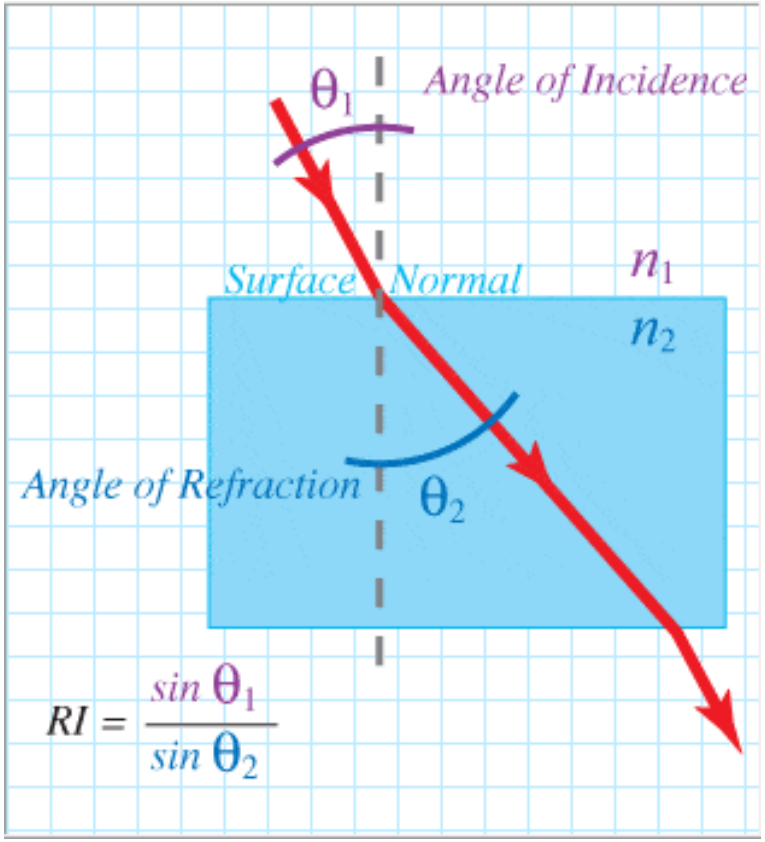
Holographic recording process



Holographic reconstruction process

Three-dimensional laser hologram of a toy train

Refractive Index



Light travels through different substances at different speeds.

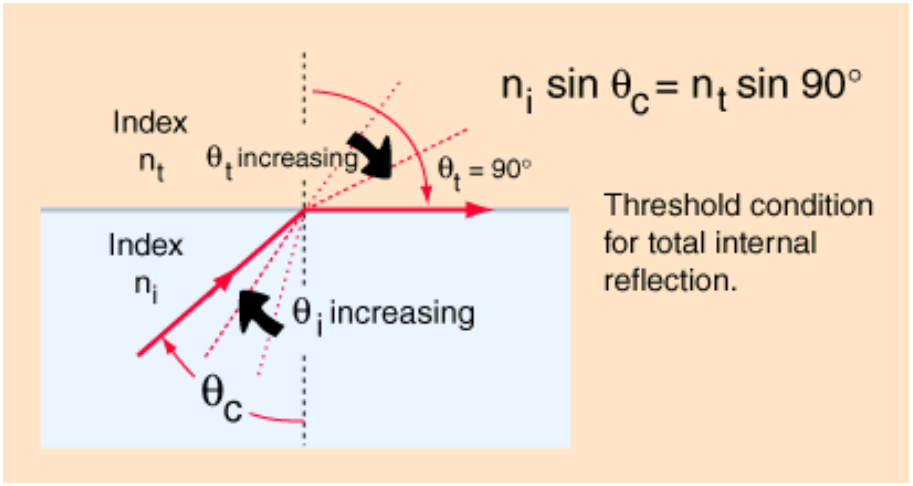
When light enters a substance at an angle, this change in velocity causes the ray to be deflected, or bent. This bending is called **Refraction**.

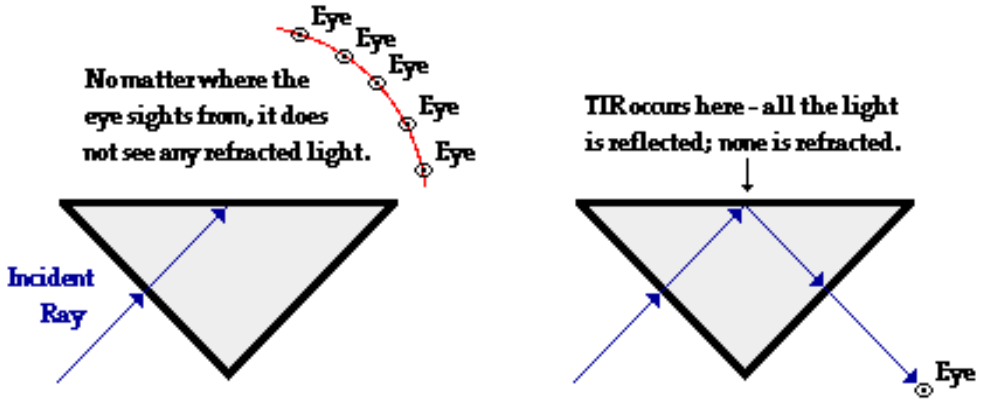
The amount that the substance bends light is its **Refractive Index**. It is determined by using **Snell's law**.

Because of the RI for a given substance at a given temp & pressure is a constant, RIs are used in the real world to determine everything from the percentage of water in a sample of honey to the composition & purity of gemstones.

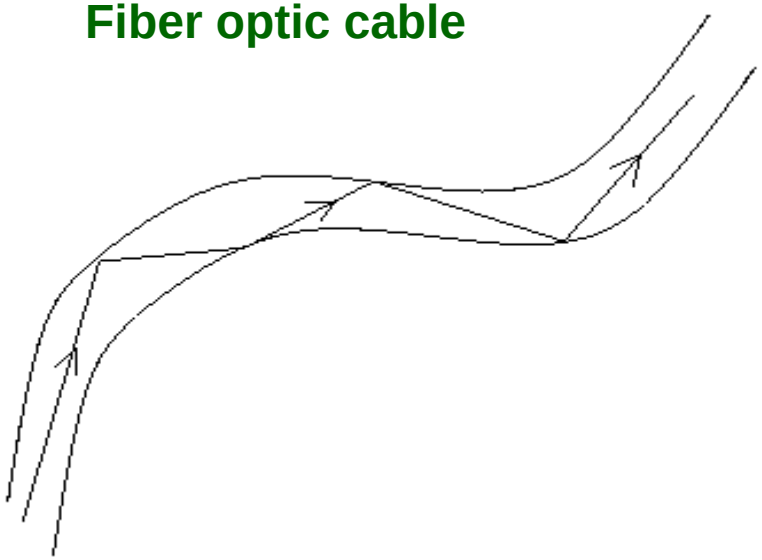
Total Internal Reflection

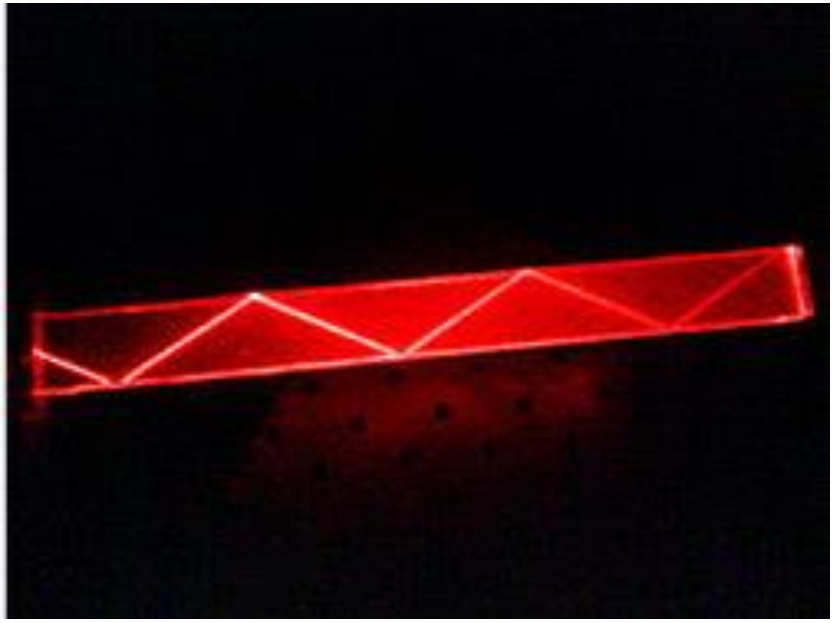
TIR: When a ray of light strikes a medium boundary at an angle larger than the critical angle with respect to the normal to the surface. If the refractive index is lower on the other side of the boundary no light can pass through, so effectively all of the light is reflected. The critical angle is the angle of incidence above which the total internal reflection occurs.





Fiber optic cable





TIR is used in telephone & TV cables to carry signals.

Light as an information carrier is much faster & more efficient than electrons in an electric current. Also, since light rays don't interact with each other (whereas electrons interact via their electric charge), it is possible to pack a large number of different light signals into the same fiber optics cable without distortion.

This physical property makes optical fibers useful & binoculars possible. It is also what gives diamonds their distinctive sparkle, as diamond has an extremely high refractive index.

Nobel Prizes; Optics & Photonics

Year & Prize	Recipients	Research
1964 Physics	**Charles Townes, Nikolai Basov, Alexander Prokhorov**	**MASER & LASER**
1971 Physics	**Dennis Gabor**	**Holography**
1981 Physics	Nicolaas Bloembergen, Arthur Schwlow	Laser spectroscopy
1997 Physics	Steven Chu, Claude Cohen-Tannoudji, William Phillips	Laser trapping & cooling of atoms
1999 Chemistry	Ahmed Zewail	Chemical reaction dynamics on femtosecond time scales
2000 Physics	Zhores Alferov, Herbert Kroemer	Heterostructures for high-speed optoelectronics

Contd…

Year & Prize	Recipients	Research
2001 Physics	Eric Cornell, Carl Wieman, Wolfgang Ketterle	Producing Bose-Einstein condensates, sometimes called “atom lasers”
2005 Physics	Roy Glauber, John Hall, Theodor Hansch	Quantum theory of optical coherence & Ultraprecise laser spectrosocpy & frequency-comb generation
2009 Physics	**Charles Kao**	**Light transmission in optical fibers for telecommunications**
2014 Physics	**Isamu Akasaki, Hiroshi Amano, Shuji Nakamura**	**Blue LED**
2018 Physics	**Arthur Ashkin, Gerard Mourou, Donna Strickland**	**Optical tweezers & generation of high-intensity ultra-short optical pulses**