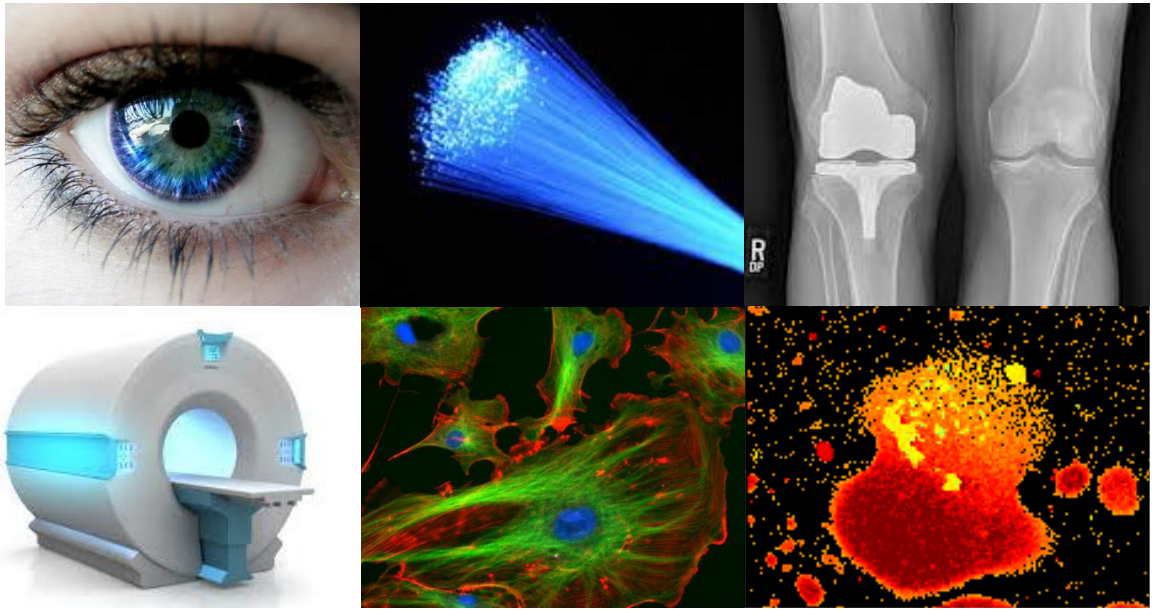
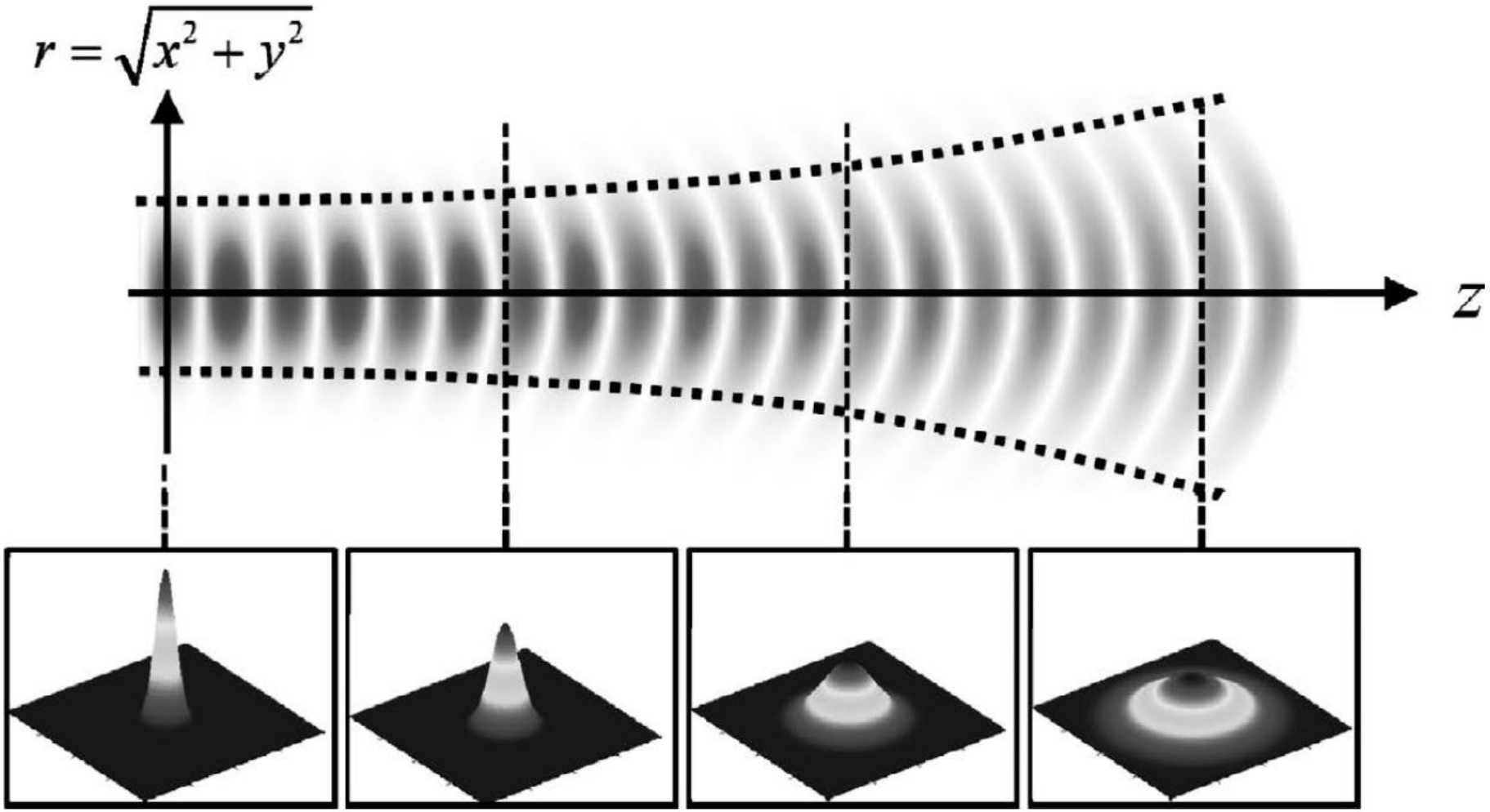
Lasers e Ótica Biomédica



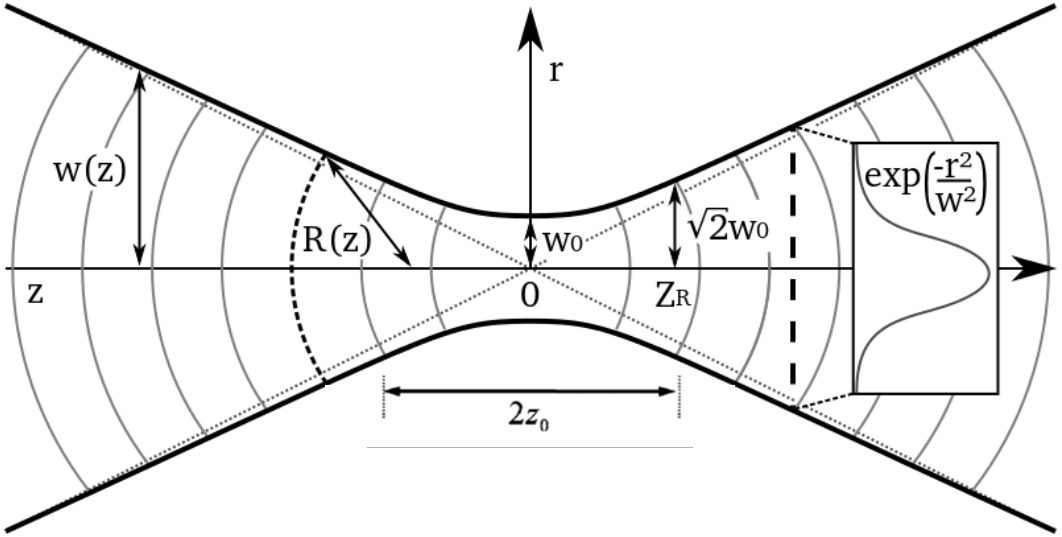
Pedro Jorge

Propagation of a Laser beam – Gaussian beam



Gaussian beam

When considering the effects of diffraction, an ideal Laser beam behaves like a “Gaussian beam”.



w_0=beam waist (radius)

Z_0 or Z_r =Raleigh distance

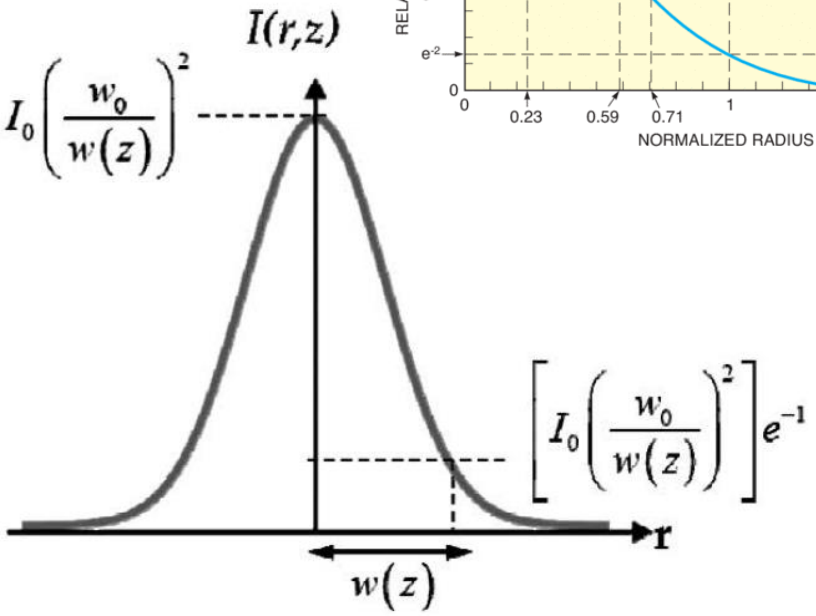
$w(z_0)= \sqrt{2}w_0$

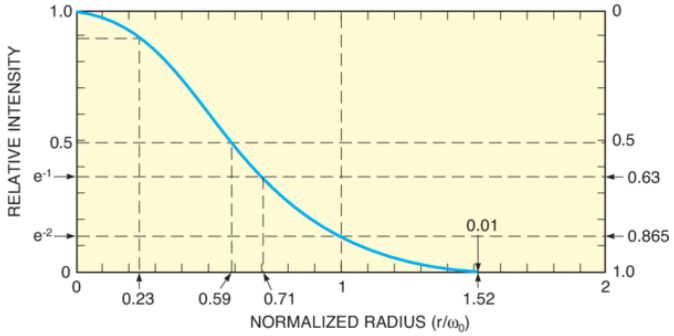
$$2z_0 = \frac{2\pi n w_0^2}{\lambda}$$

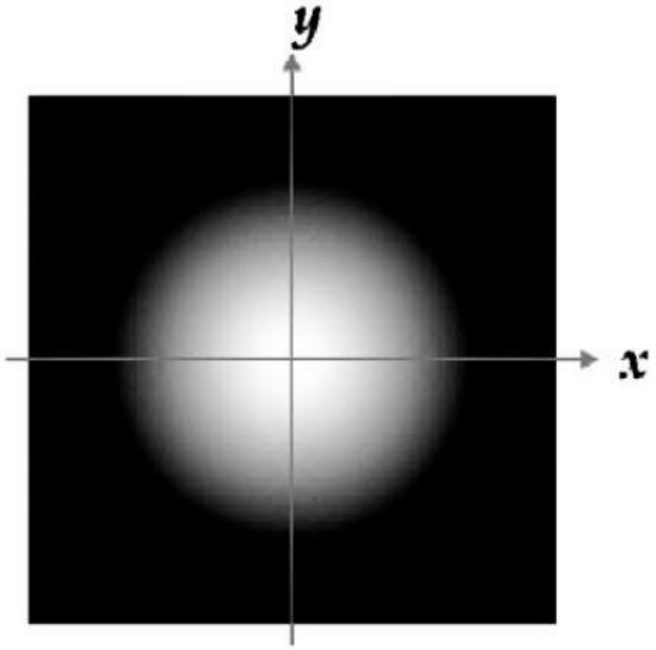
$$I(r,z) = I_0 \left(\frac{w_0}{w(z)} \right)^2 \exp\left(-\frac{2r^2}{w(z)^2} \right)$$

self-Fourier Transform characteristic of the Gaussian beam

Gaussiano Beam



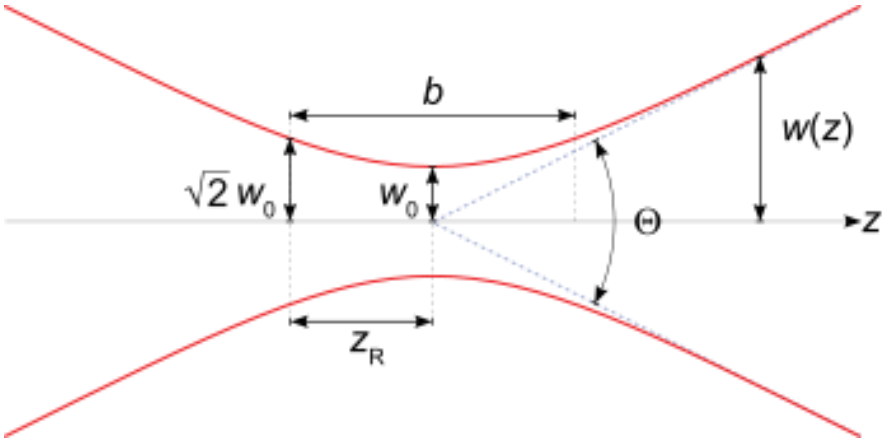




$$w(z)^2 = w_0^2\left[1+\left(\frac{z}{z_0}\right)^2\right] \qquad 2z_0 = \frac{2\pi n w_0^2}{\lambda}$$

https://www.newport.com/n/gaussian-beam-optics

Gaussian beam



Divergence

$$\theta \simeq \frac{\lambda}{\pi w_0}$$

$$\Theta = 2\theta$$

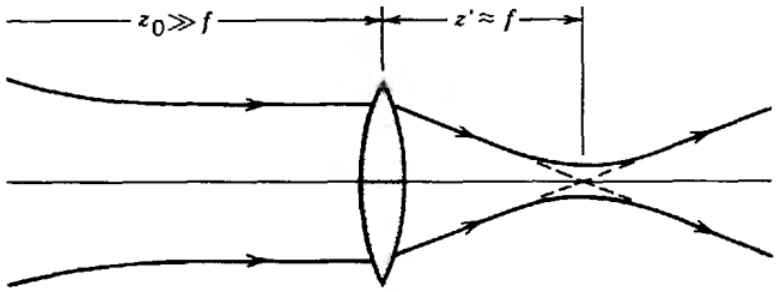


Figure 3.2-4 Focusing a collimated beam.

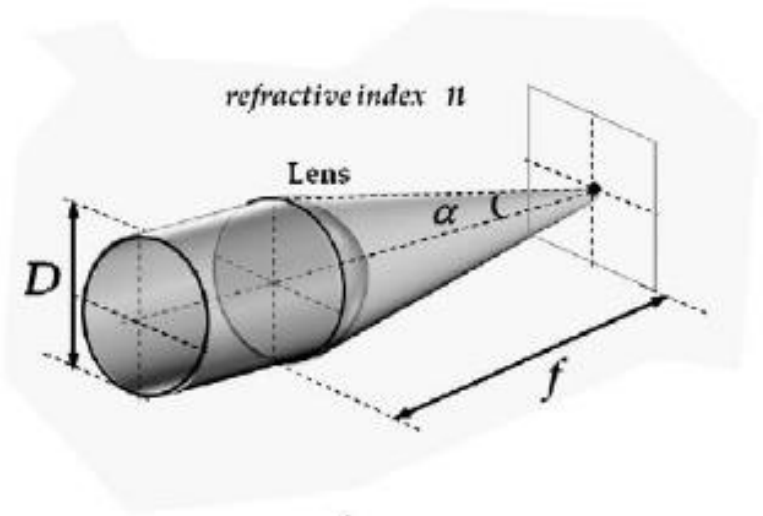
Divergence

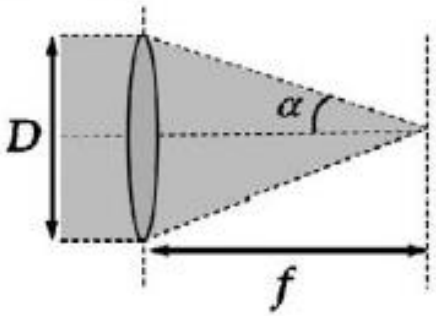
$$2w_0 = \frac{4\lambda}{\pi}\frac{f}{D} = 1.27\lambda\ f_{/\#}$$

Calculate the waist of a beam from an HeNe Laser, with 1 mm of diameter, after being focused by a lens with f=10 mm.

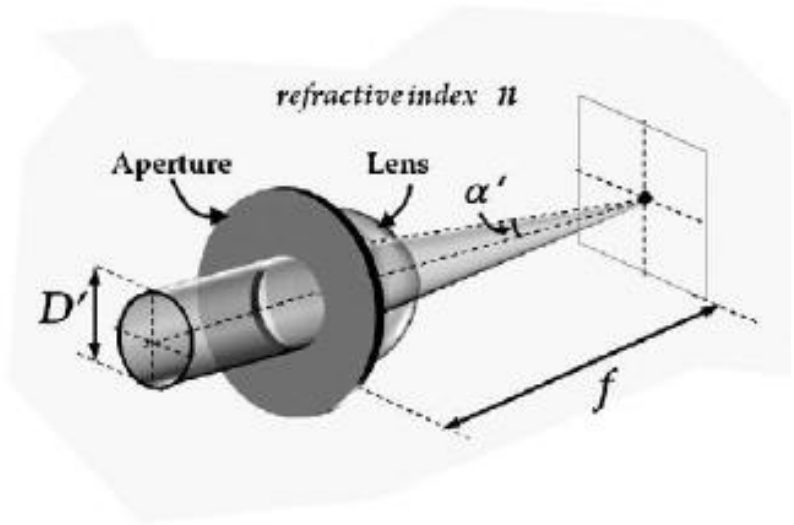
$$w = \sqrt{w_0^{\,2} + (\theta_L z)^2}$$

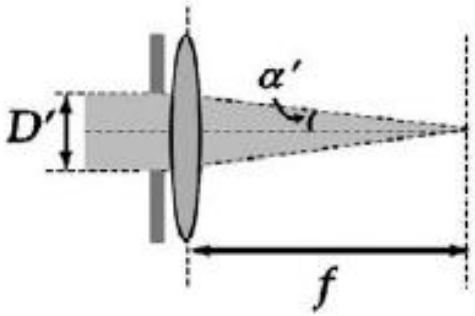
Numerical aperture of a lens





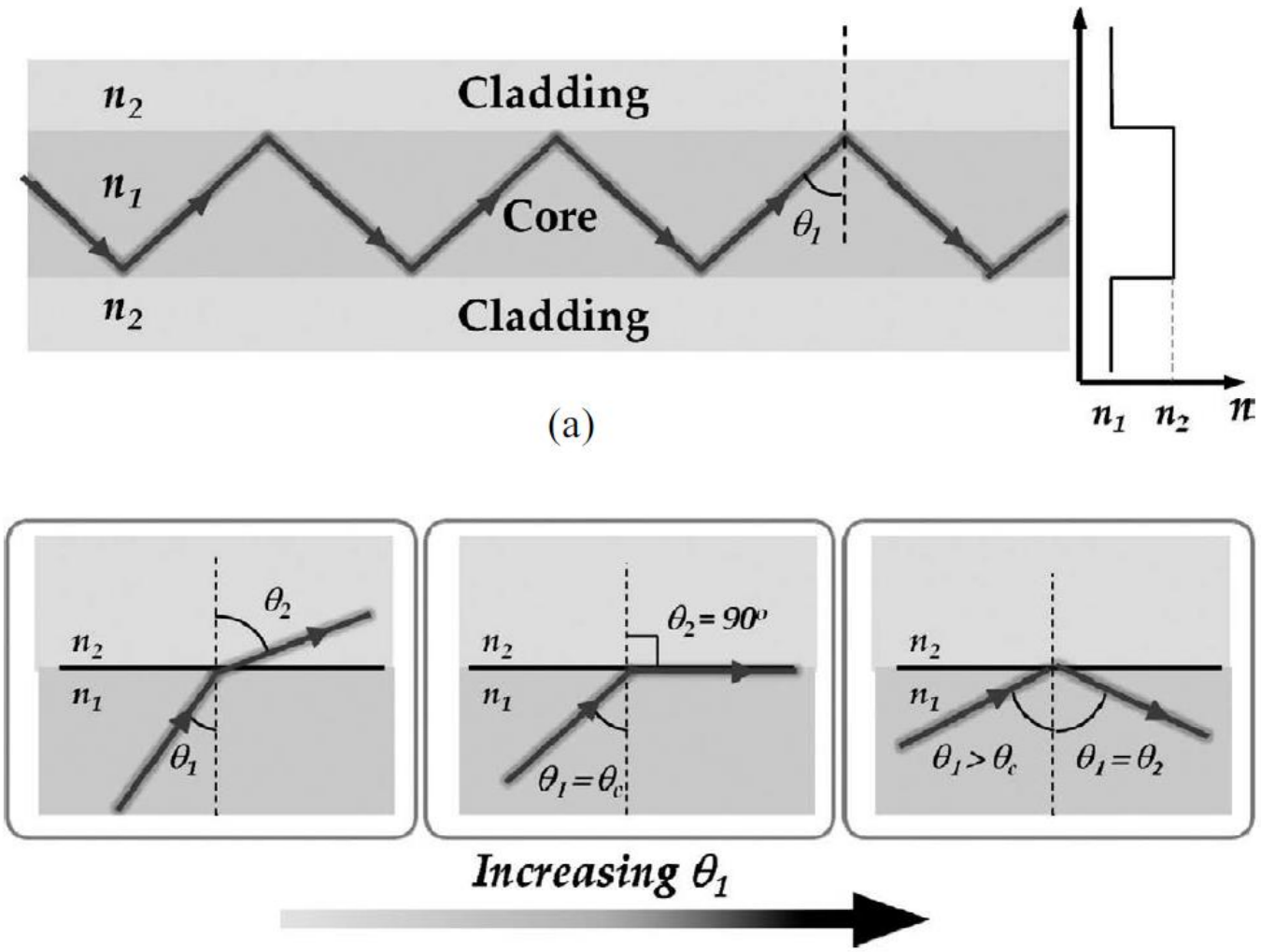
$$NA = n\sin\alpha \approx \frac{nD}{2f} = \frac{n}{2(f/\#)}$$





$$NA' = n\sin\alpha' \approx \frac{nD'}{2f} = \frac{n}{2(f/\#)'}$$

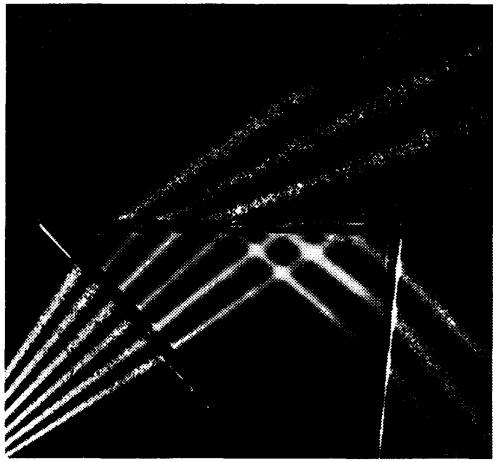
Guided Optics

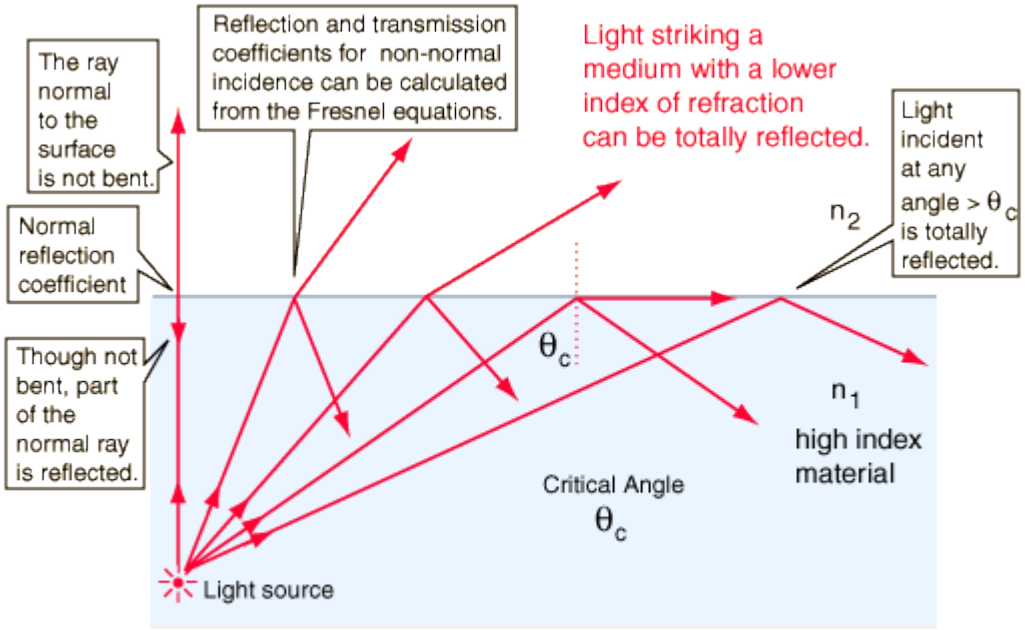


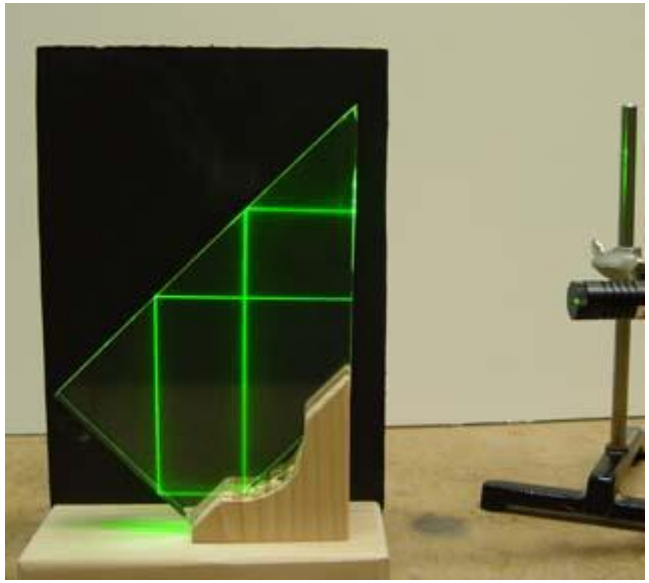
Critical angle: Total Internal reflection

$$n_i > n_t \qquad \theta_t = 90^\circ$$

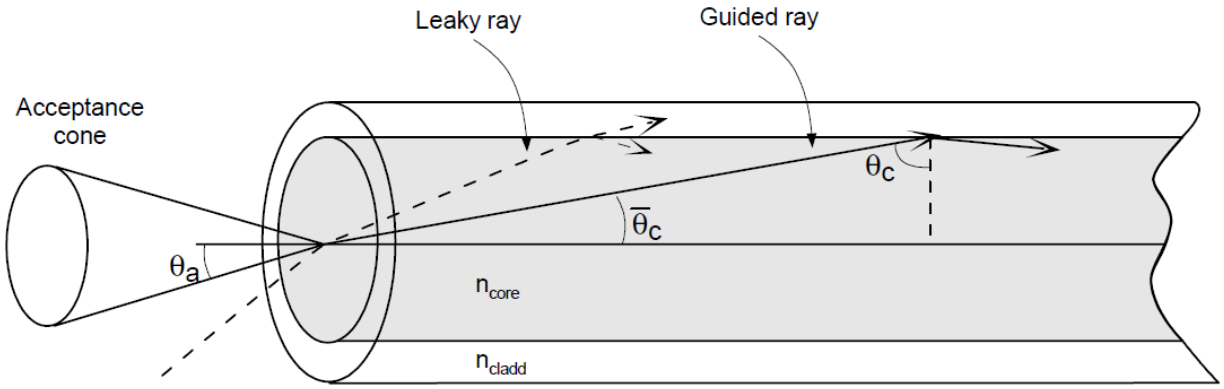
$$\sin\theta_t = \frac{n_t}{n_i}\sin\theta_t \qquad \theta_c = \theta_i = \arcsin\left(\frac{n_2}{n_1}\right)$$

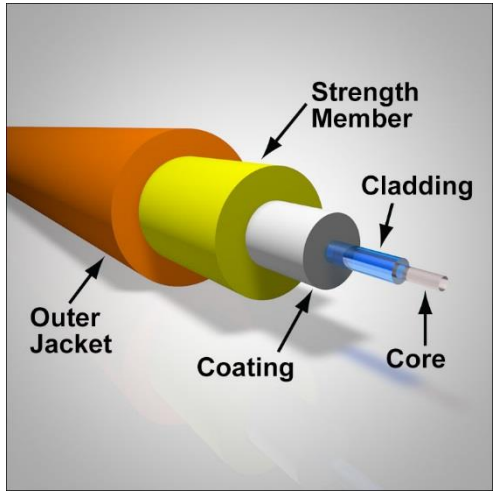






Optical Fibres





Numerical Aperture and acceptance angle

$$\theta_a = \sin^{-1}[NA]$$

$$NA = \left(n_{co}^2 - n_{cl}^2\right)^{1/2}$$

Typical values

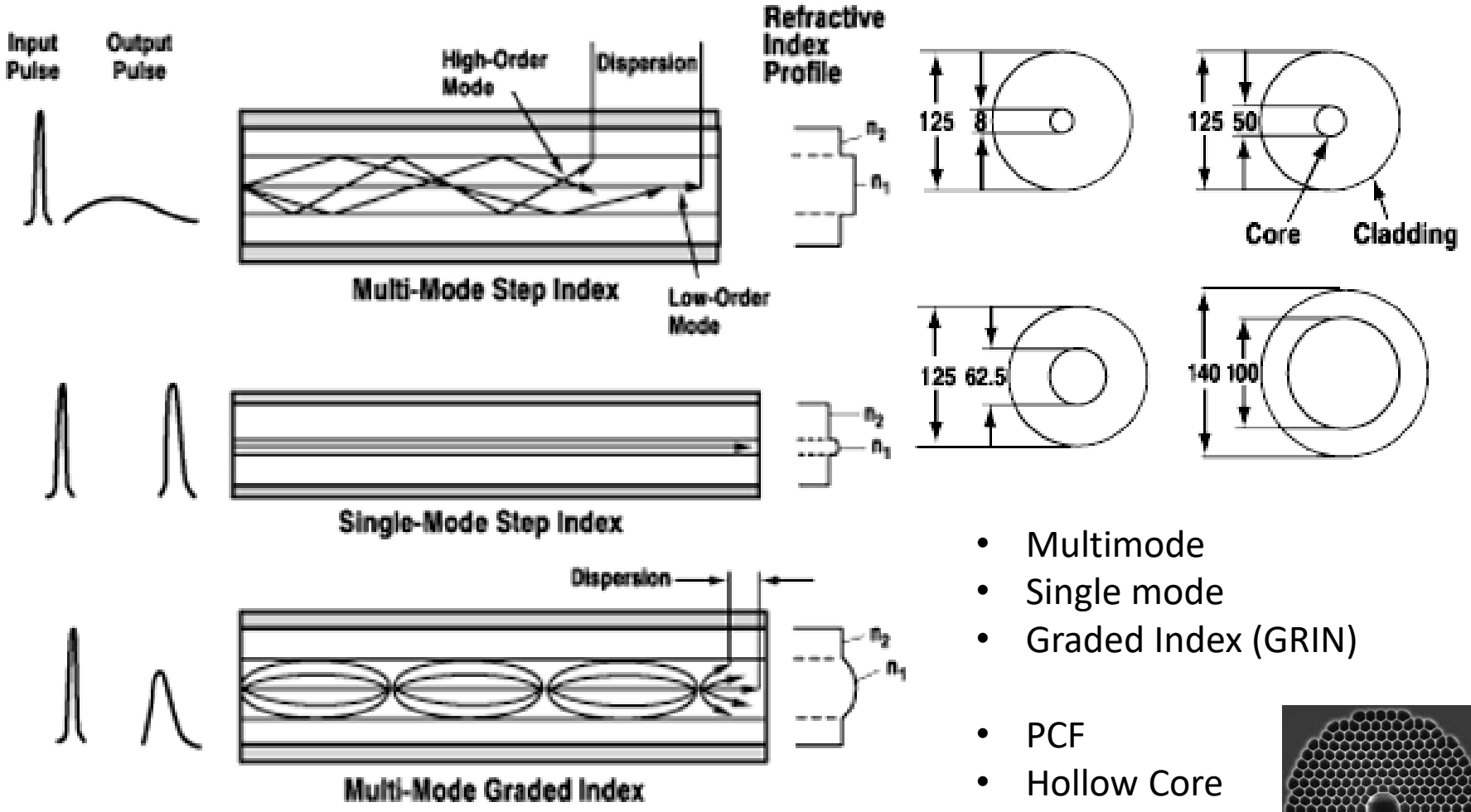
MM

NA de 0.1 a 0.5

SM

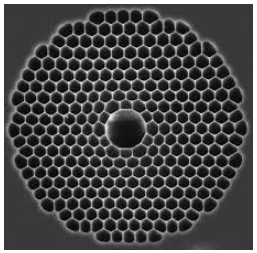
NA 0.12 (de 012 a 0.35)

Types of fibres



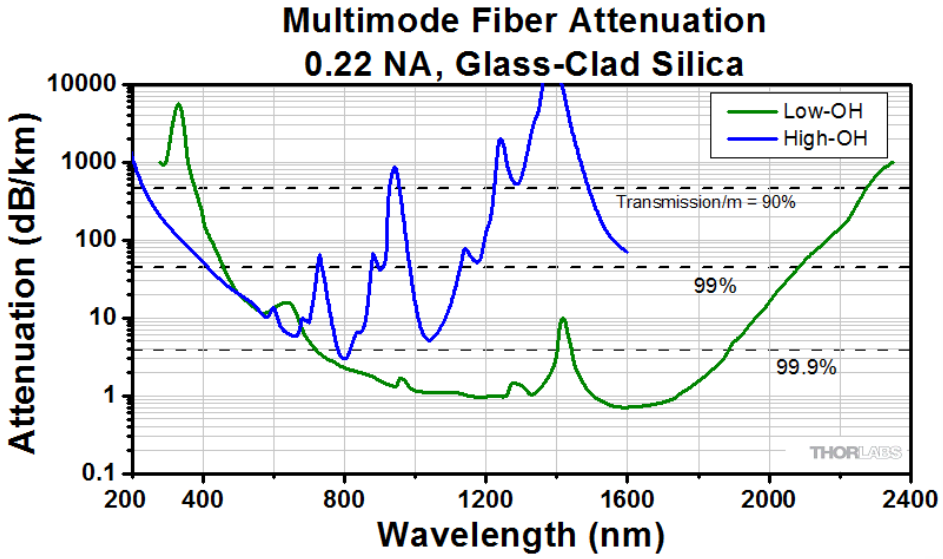
- Multimode
- Single mode
- Graded Index (GRIN)

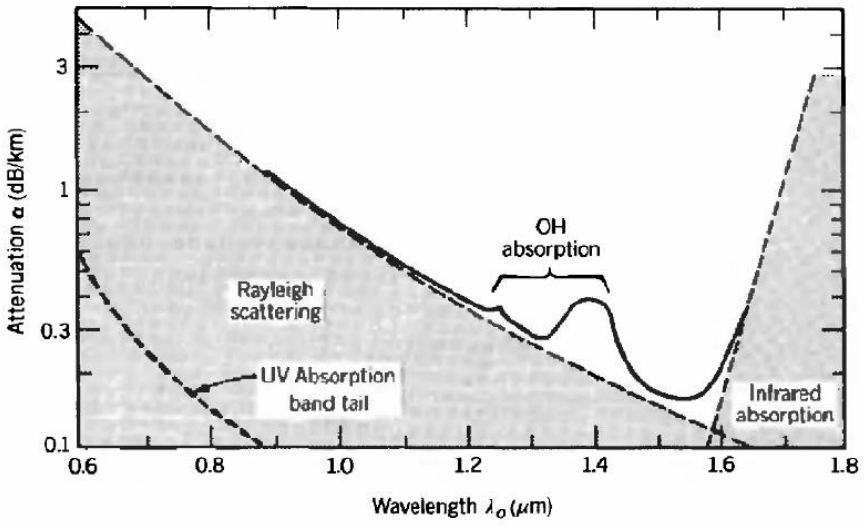
- PCF
- Hollow Core
- Plastic
- Double Clad



Attenuation

- Fiber to use in each application depend on the Laser wavelength, its energy and the working power.
- Type of material and its purity determine absorption.(Quartz, pure Silica, polymers…)
- For high energies, small defects can lead to catastrophic failures.





https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=6840

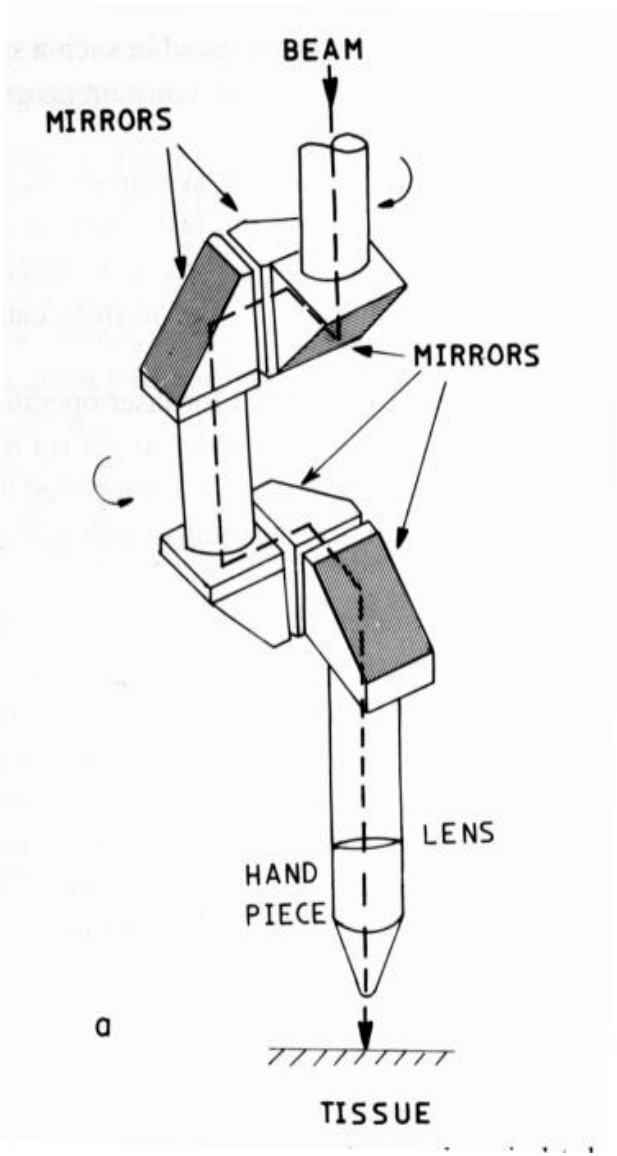
Articulated arm

Set of mirrors and/or prism in articulated supports

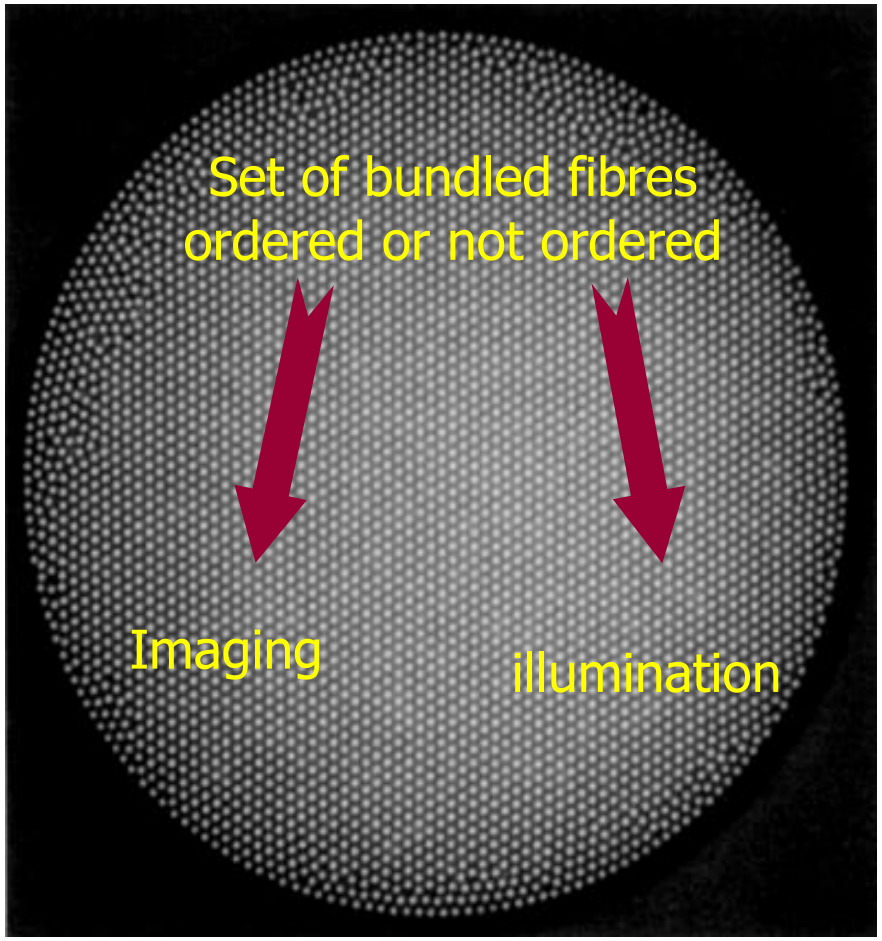
Used whenever optical fibers are not adequate for the transport of the laser radiation. (eg. too much energy)

Disadvantages

- dimensions
- limited movement ability
- rigid structure
- Diameter of the arm ~ 15-50 mm



Bundles


Set of bundled fibres
ordered or not ordered
Imaging
illumination

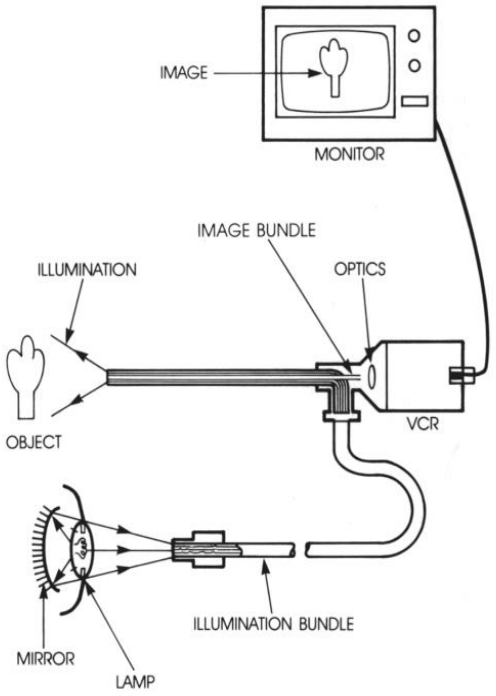
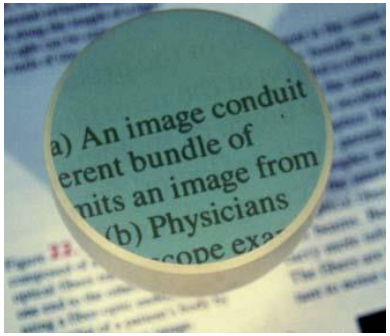


IMAGE
MONITOR
IMAGE BUNDLE
ILLUMINATION
OPTICS
VCR
OBJECT
ILLUMINATION BUNDLE
MIRROR
LAMP

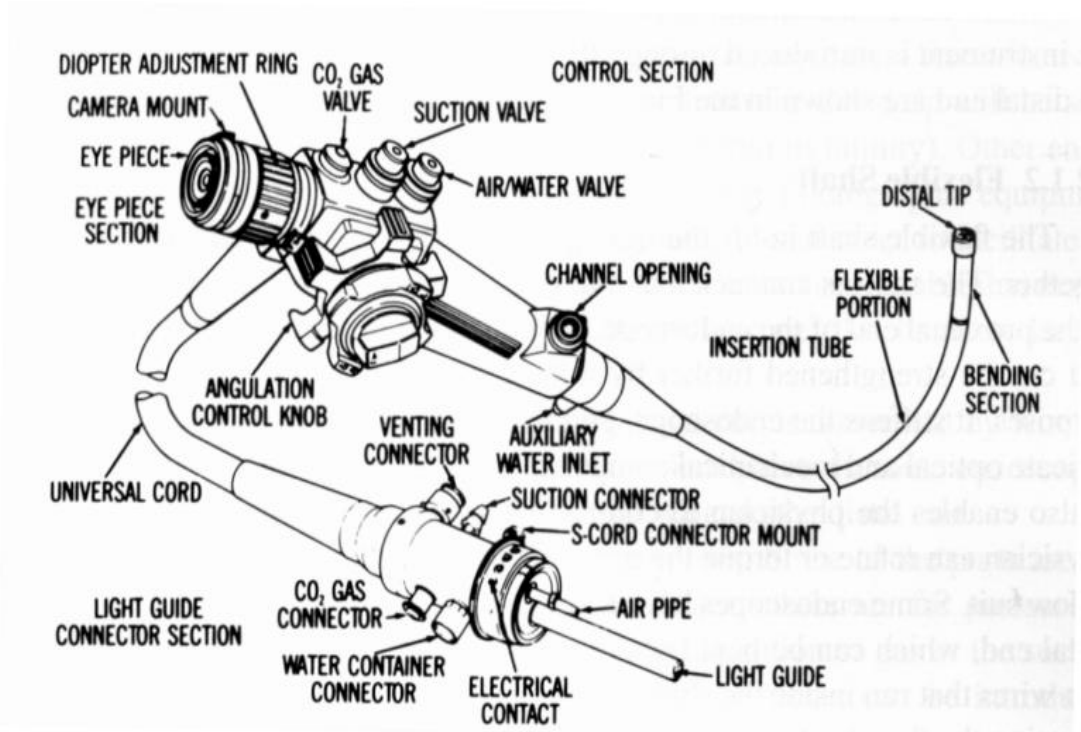

a) An image conduit
erent bundle of
nits an image from
(b) Physicians

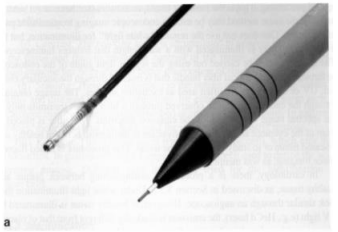
Laser endoscope

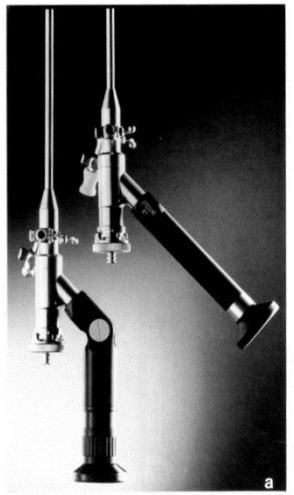
A tool for (simultaneous diagnostic & therapy

dimensions

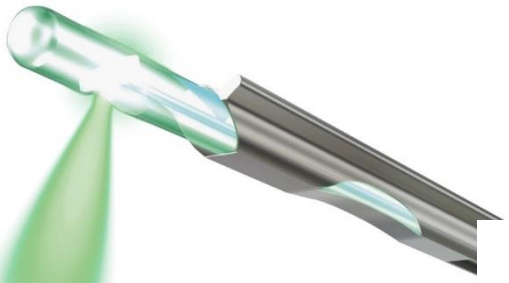
versatility

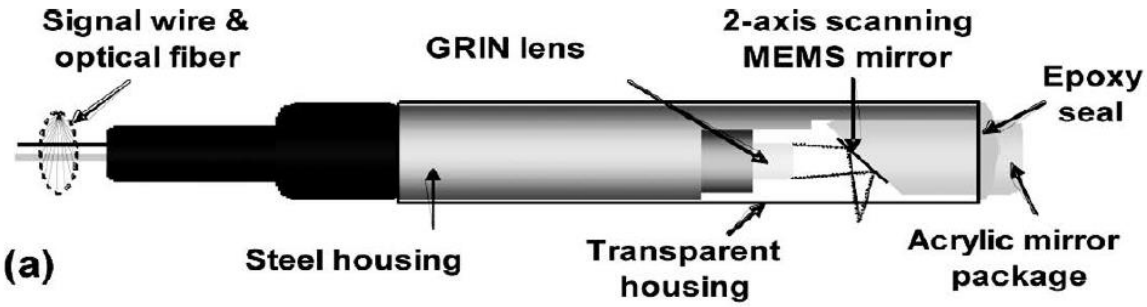






Laser Endoscope





http://www.richard-wolf.com/no_cache/products.html?tx_snetrwproducts_pi1%5Bproduct%5D=139&tx_snetrwproducts_pi1%5Baction%5D=show&tx_snetrwproducts_pi1%5Bcontroller%5D=Product

Hand pieces

type

Fixed focus

Variable focus

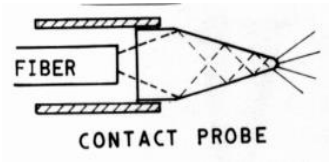
sapphire

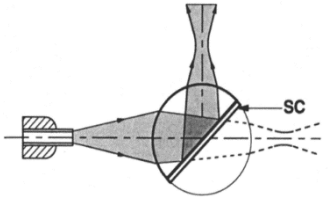
deflectors

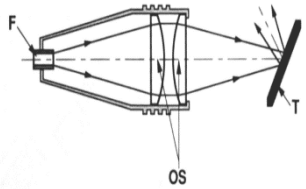
diffusor

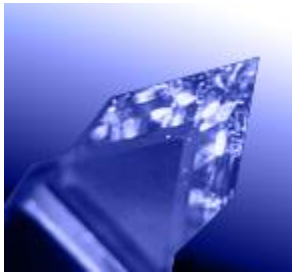
Hot spots

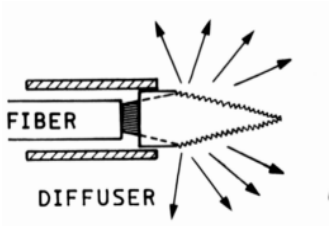
Fiber protection

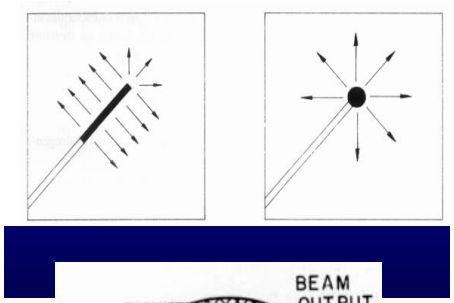


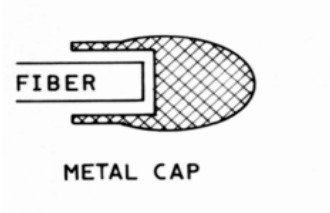


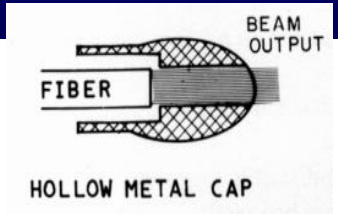


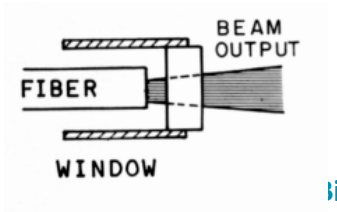


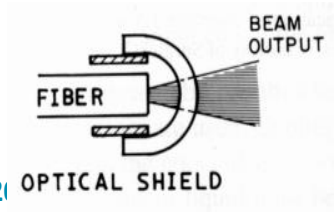












micromanipulators

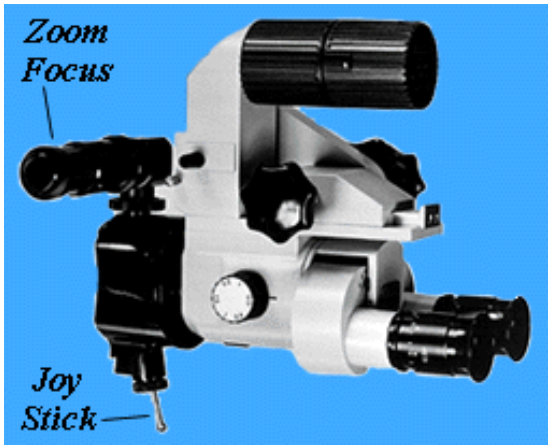
- Shifts the LASER beam without affecting the microscope
- When coupling light into the system, the LASER should not interfere with the field of view of the microscope.

zoom:

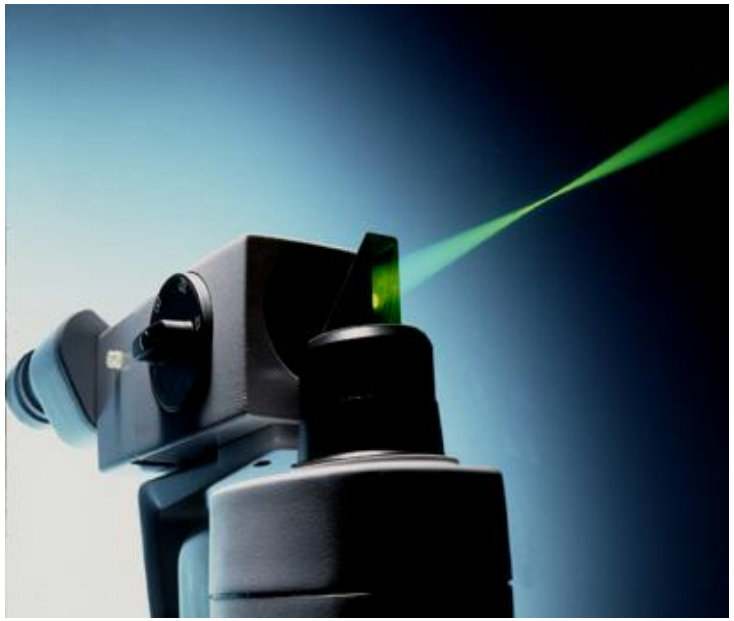
allow different focal distances to be used

(short focal distances) *focusing* for cutting

(long focal distances) Unfocusing *for* coagulation



Laser biomicroscope



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https://www.youtube.com/watch?v=1UF9fJtZHAY

http://www.genesis.net.au/~ajs/projects/medical_physics/endoscopes/

			Tsia chapts	Niemz	Hecht
18/2	Semana 2	**Gaussian optics: laser beam manipulation and calculations. Optical systems for beam maniipulation.** Geometric optics basics.image formation, beam expander;	1.8,1.2.1 .3 1.9, 7		5.1-2, 5.2.3, 5.4.2, 5.6, 5.7.1-2