Bharathidasan University

Tiruchirappalli – 620 024, Tamil Nadu, India

Programme: M. Sc., Physics

Course Title : Lasers and Nonlinear Optics

Course Code : 22PH401

Unit V

Nonlinear Optics: Experiment and Applications

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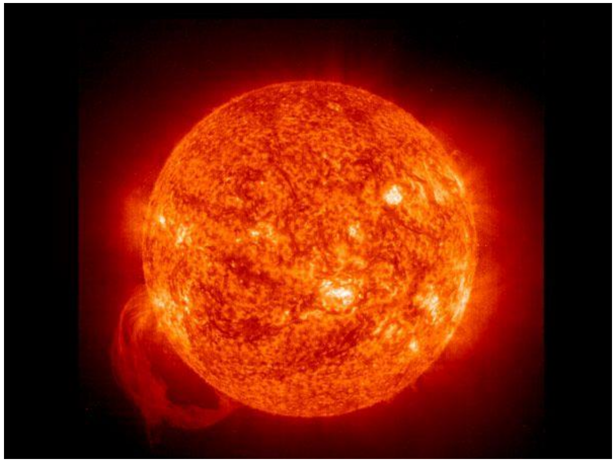
Department of Physics

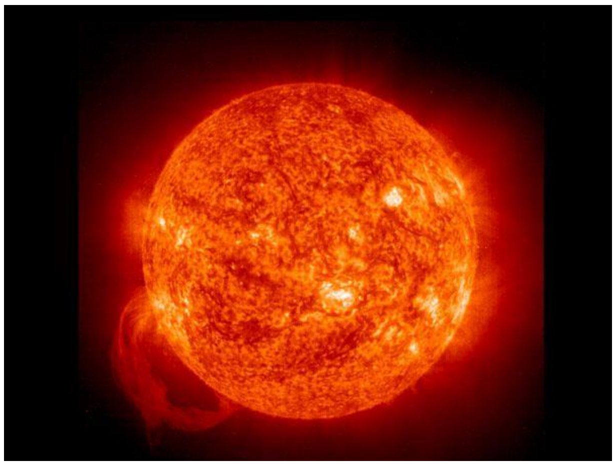
Which source of light is more dangerous to human?

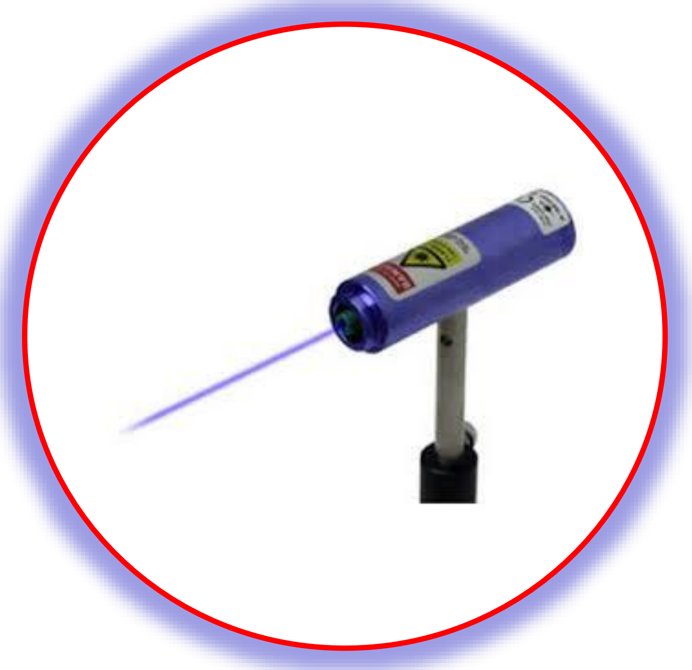
Sun or **100 W Lamp** or **1 mW laser** ?



WHY ARE THE LASERS RISKY?

Intensity …. ?



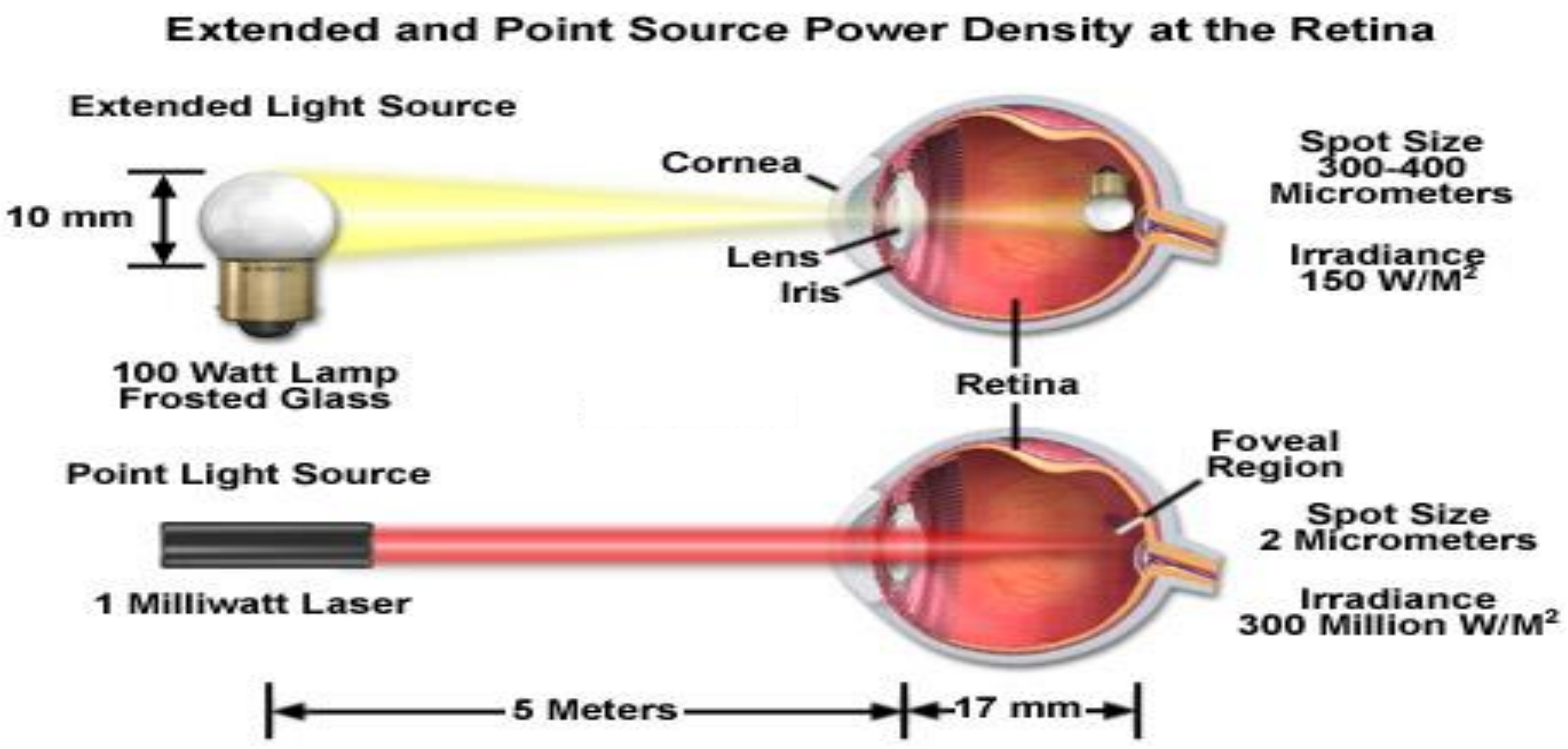


Source	SUNLIGHT	LAMP	LASER
Maximum intensity at ground level (mW/mm^2)	1	1	1
Power density on the retina (W/mm^2)	0.1	0.15	300
Potential Hazard Level	1	1.5	300

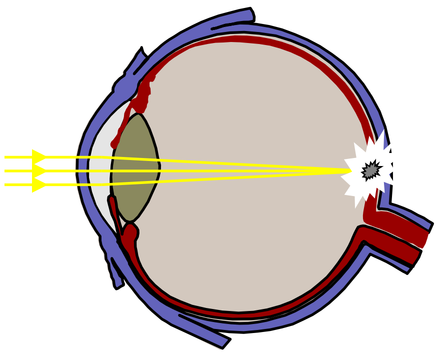
Mechanism involved in both situations are the same

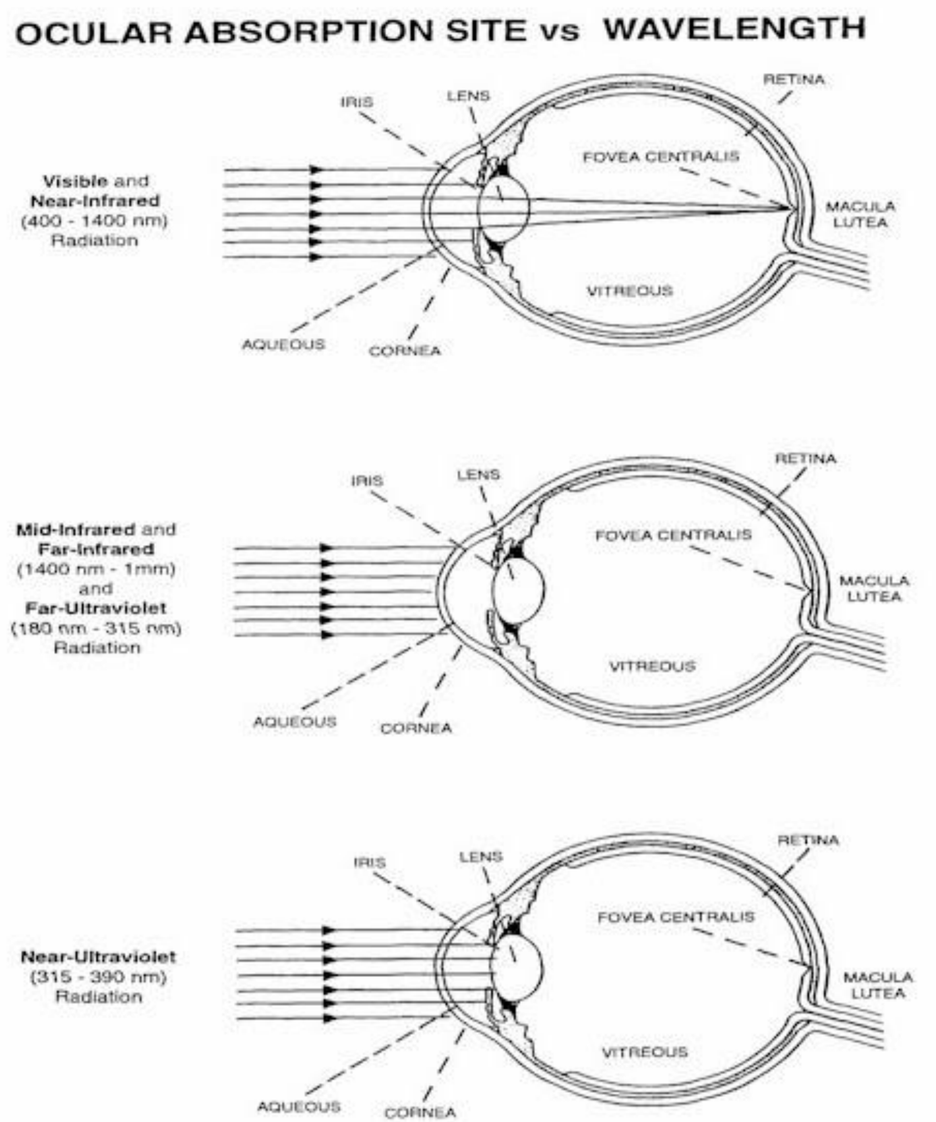
WHY ARE THE LASERS RISKY?

Intensity …. ?



WHY ARE THE LASERS RISKY?

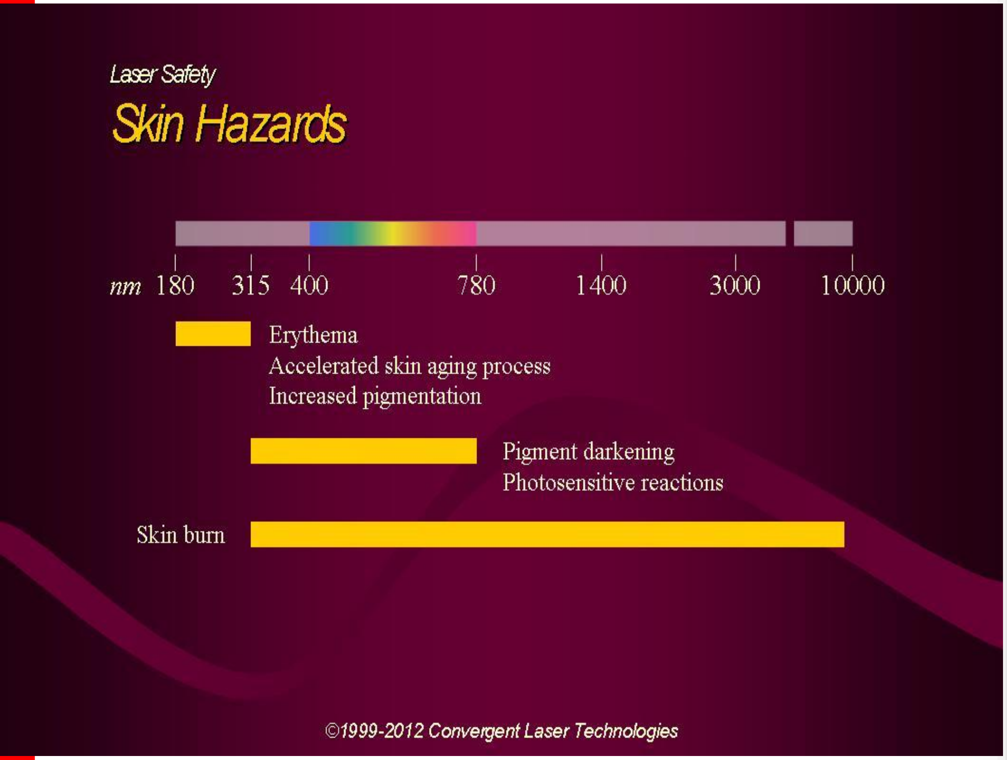


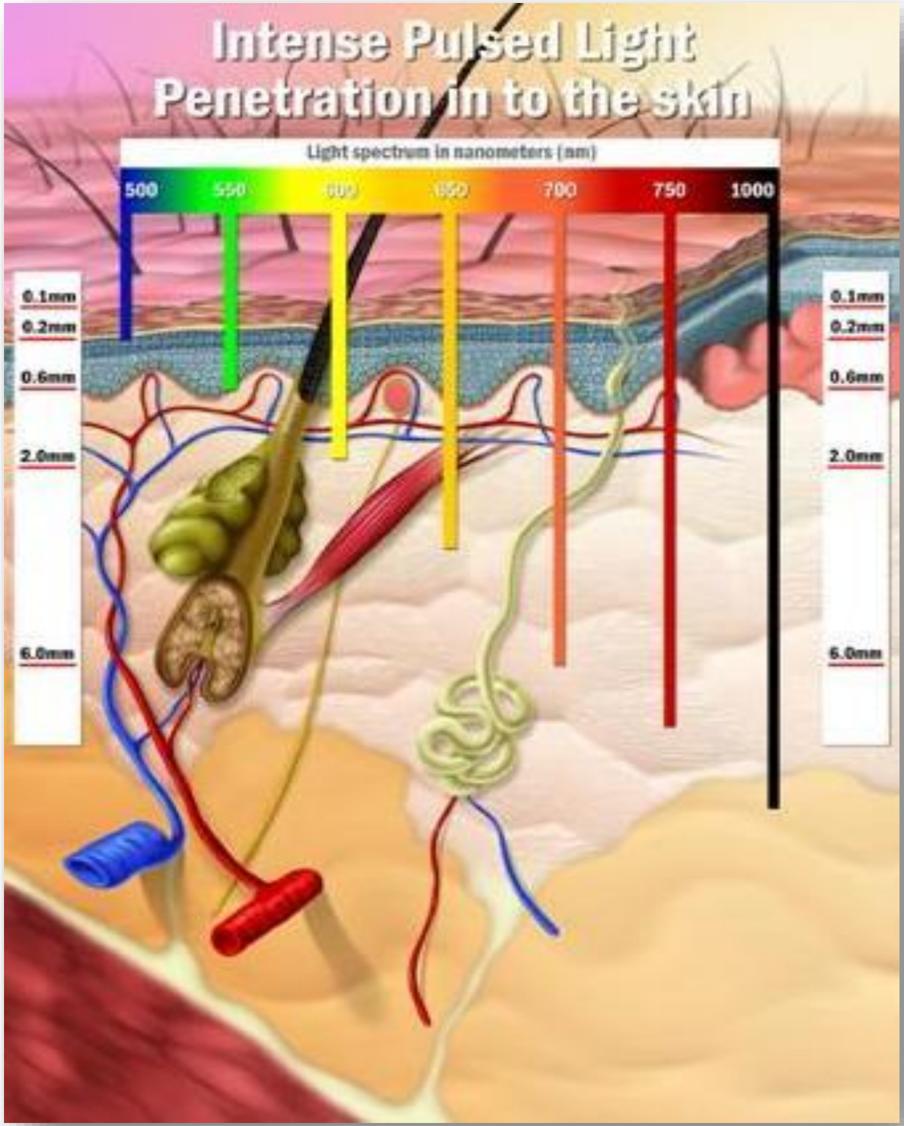


Wavelength …. ?

Wavelength	Ocular Damage
Visible and NIR	Retina
UV and FIR	cornea and lens
Near UV	Lens

WHY LASERS ARE RISKY?



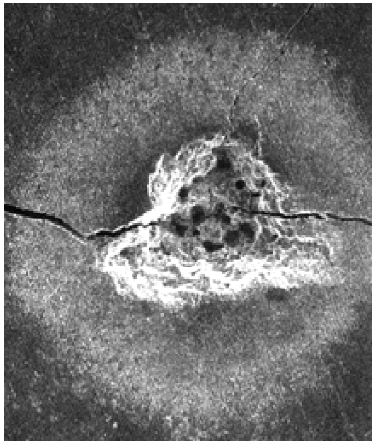


Survey of Ophthalmology, 44,6,2000, 459-478

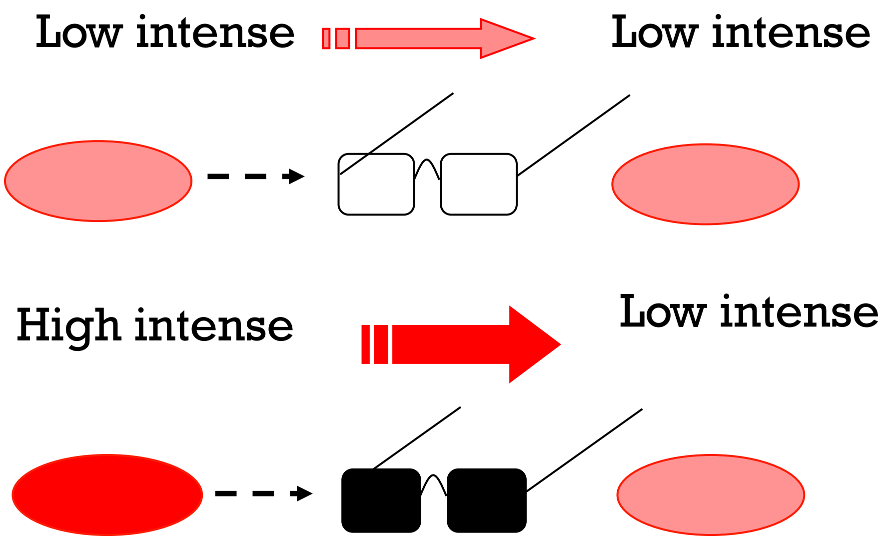
Laser Accidents

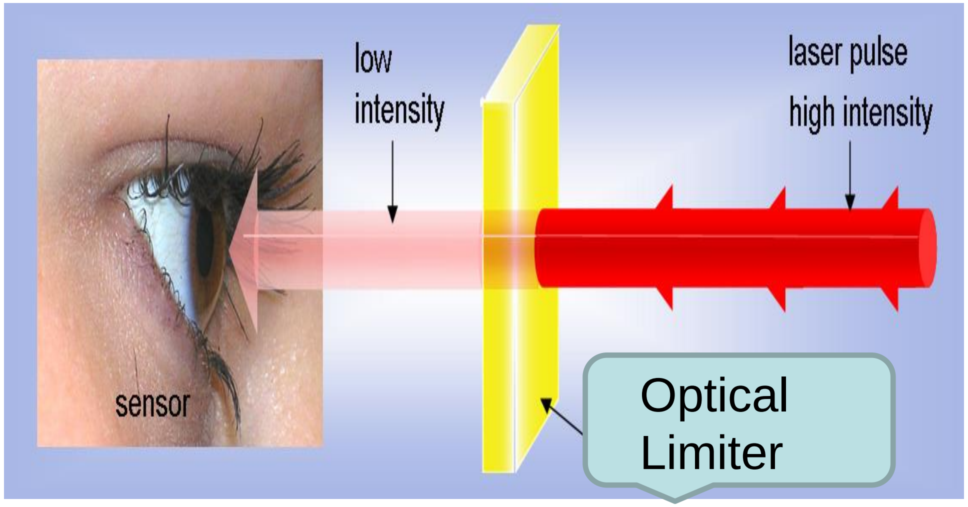
Monkey cornea immediately (left) and six weeks (right) following ablation **of a 3.1** mm^2 disk in the cornea with the excimer laser at 193 nm.

Normal Human Skin with burn and teeth enamel due to the irradiation of infrared lasers (1064 nm, 100 mJ, 10 ns).

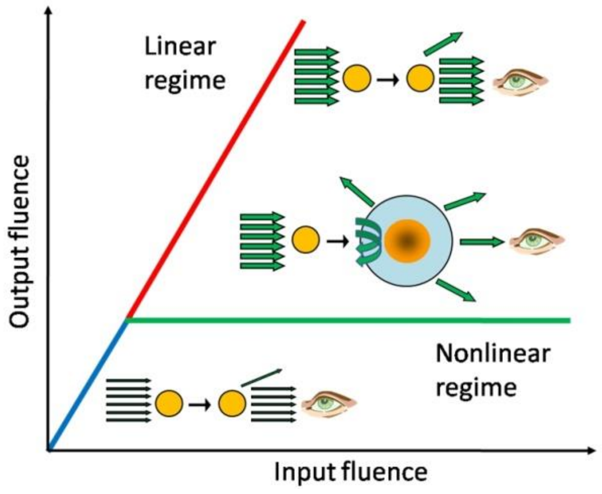


Optical Limiters

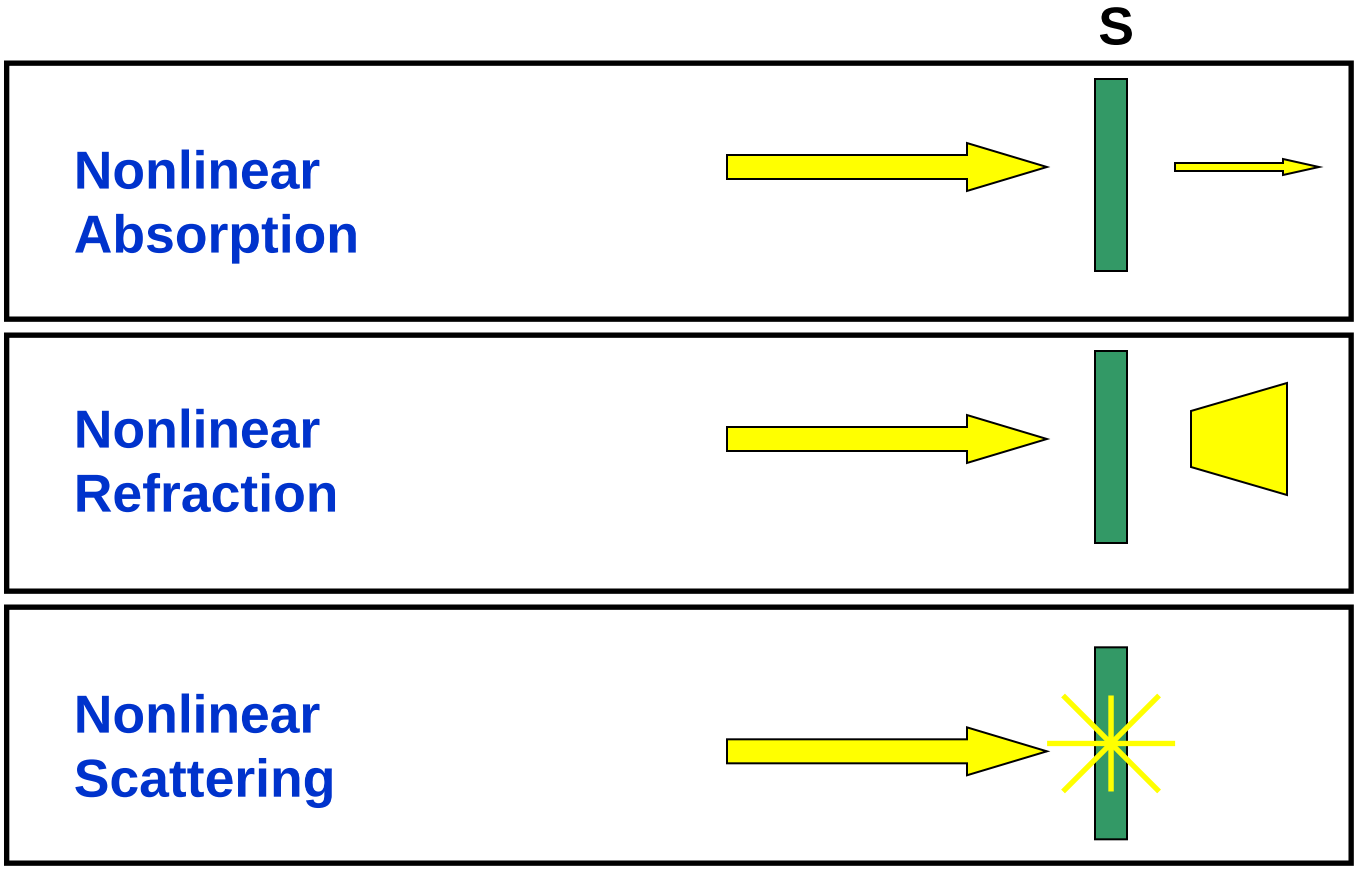




Optical limiters are SMART MATERIALS designed to have high transmittance for low level inputs while blocking the transmittance for high intensity laser beams.

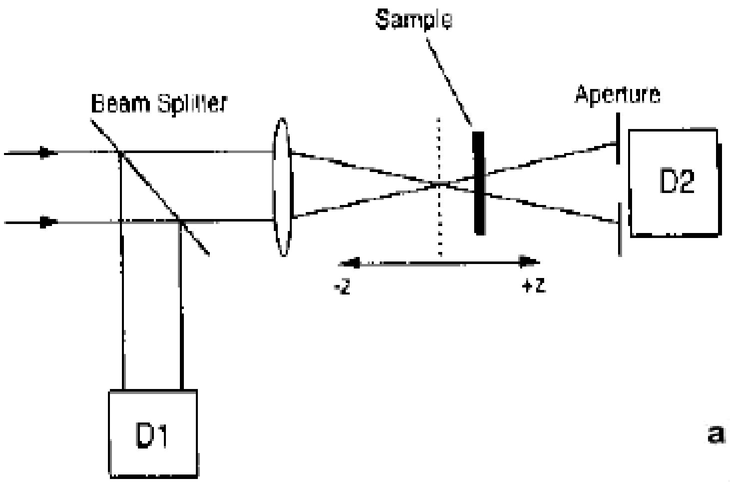


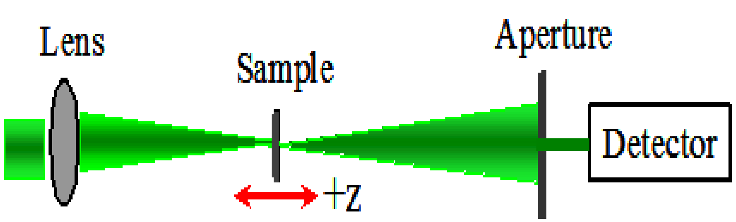
Physical processes causing optical limiting effects



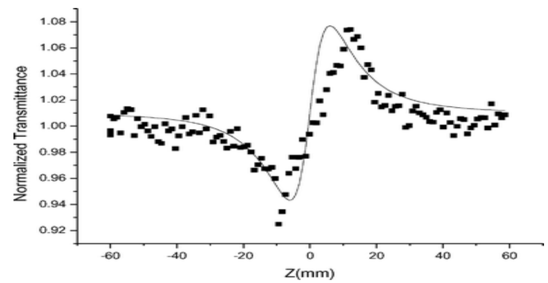
Z-Scan Technique

Optical Limiter

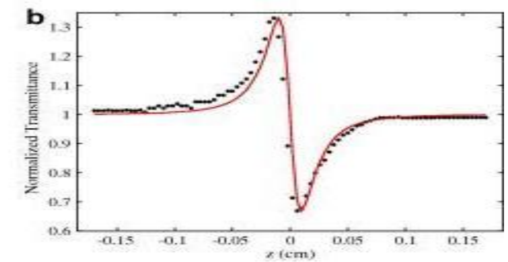




Closed Aperture – NLR

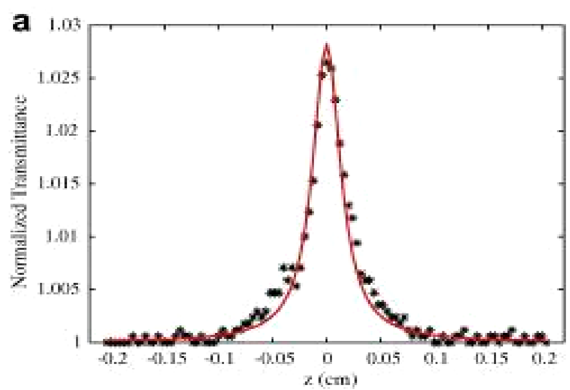


Positive nonlinearity
Self-focusing

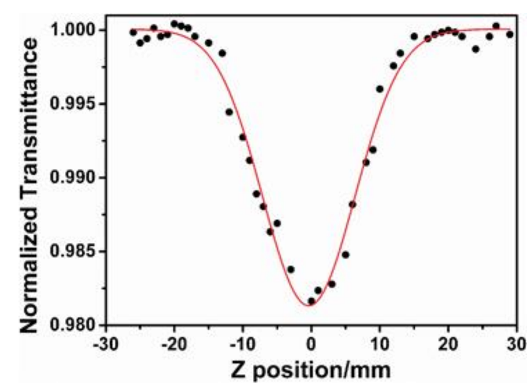


Negative nonlinearity
Self-defocusing

Open Aperture – NLA

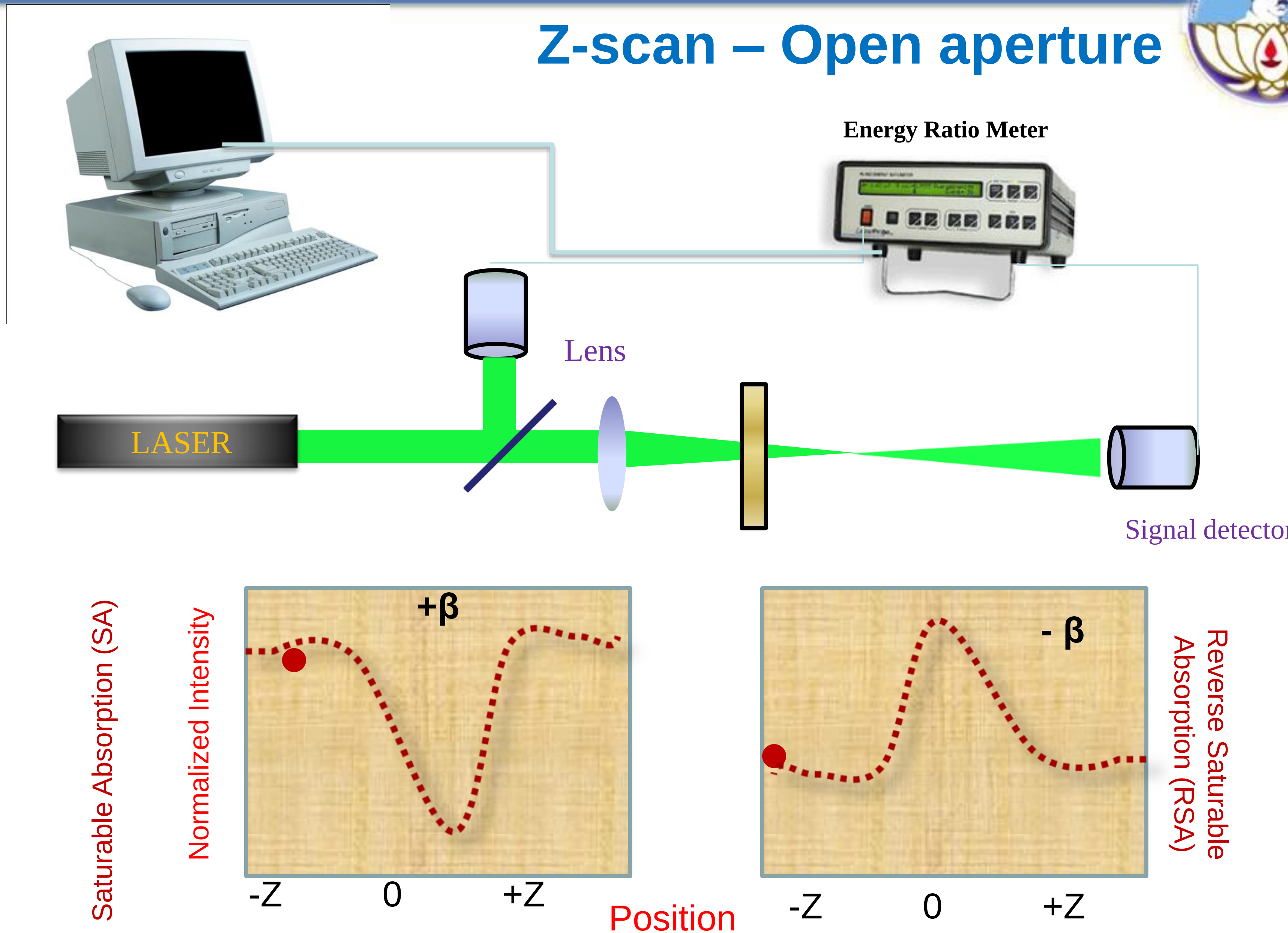


Saturable Absorption (SA)



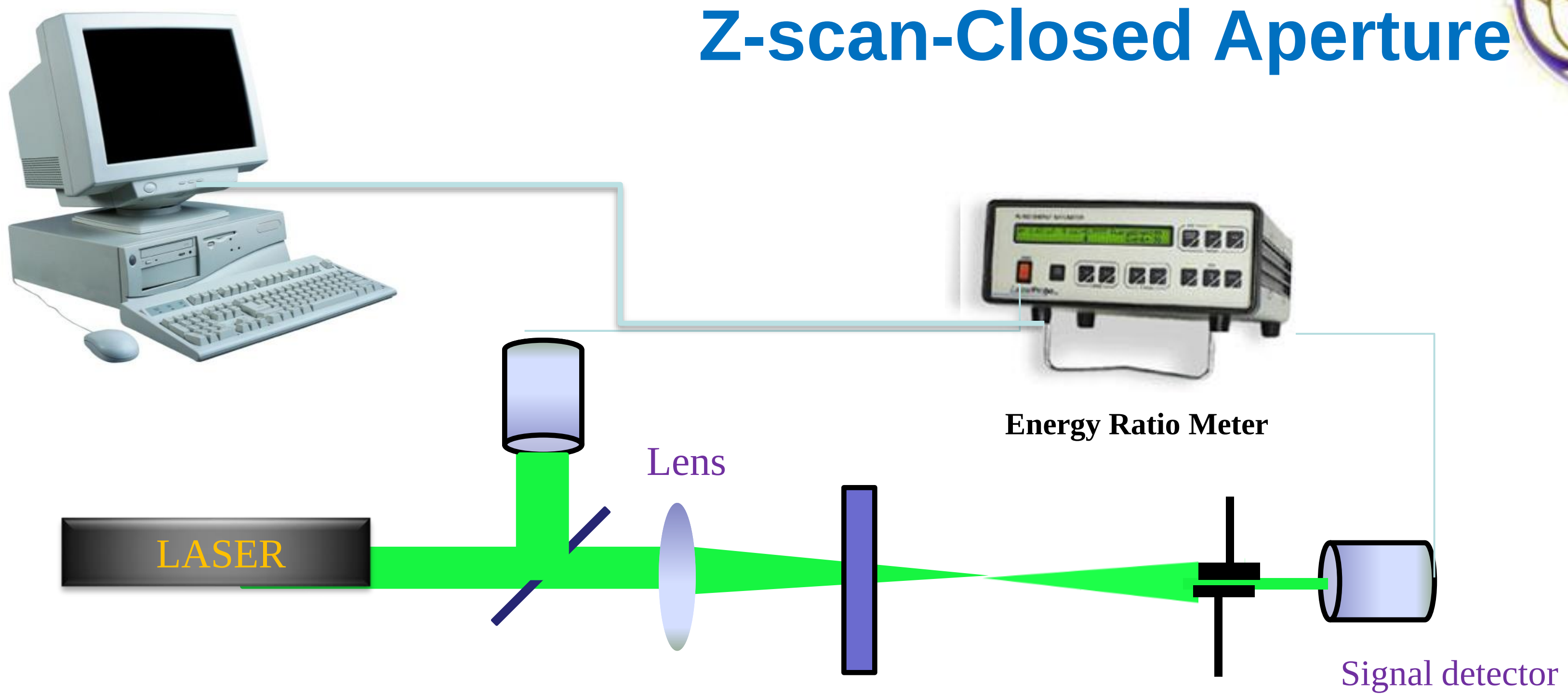
Reverse Saturable Absorption (RSA)

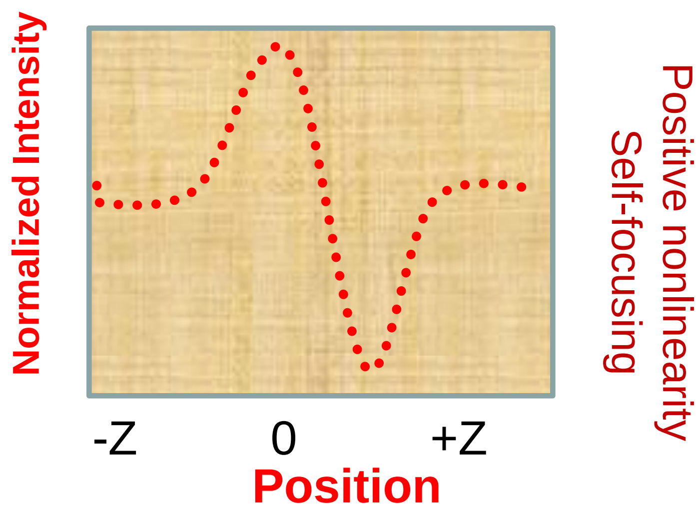
Z-scan – Open aperture

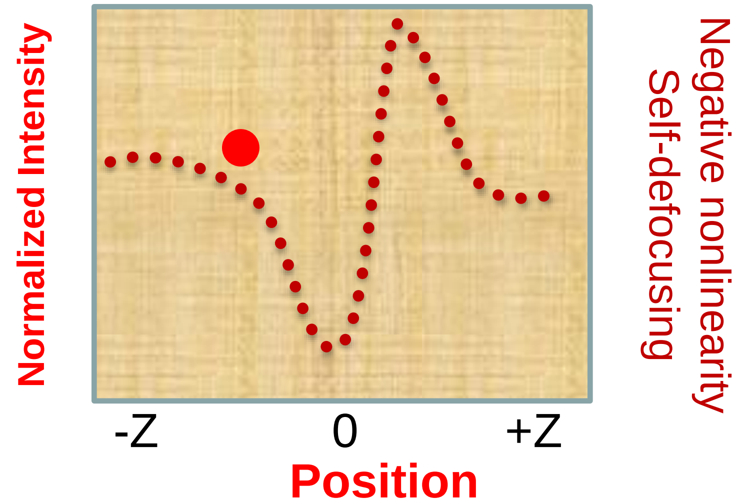


M. Sheik Bahae et . al. IEEE J.Quantum Electron,vol.21, pp.26,760(1990)

Z-scan-Closed Aperture

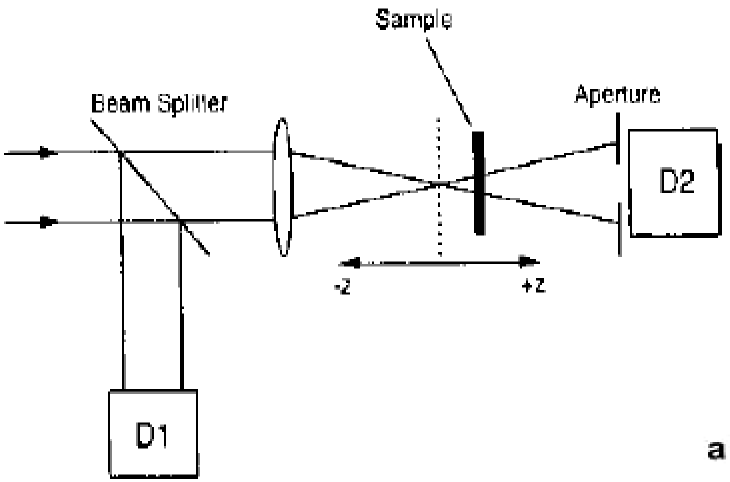


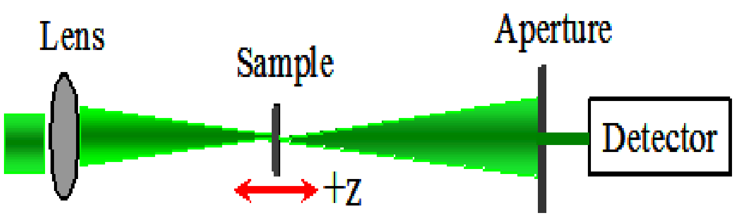




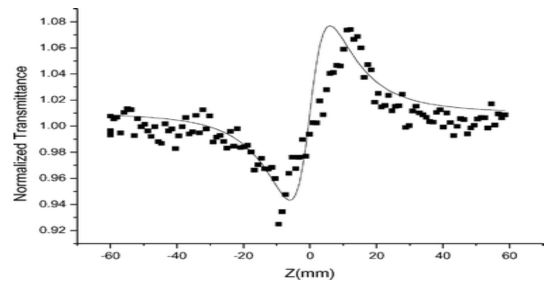
Z-Scan Technique

Optical Limiter

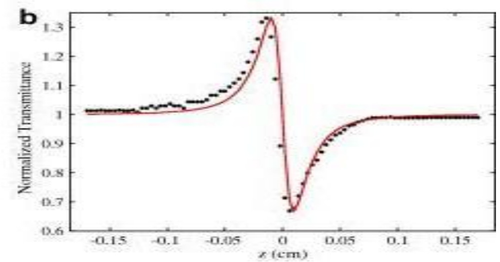




Closed Aperture – NLR

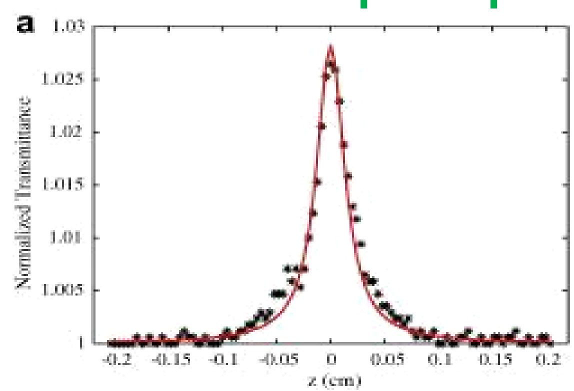


Positive nonlinearity
Self-focusing

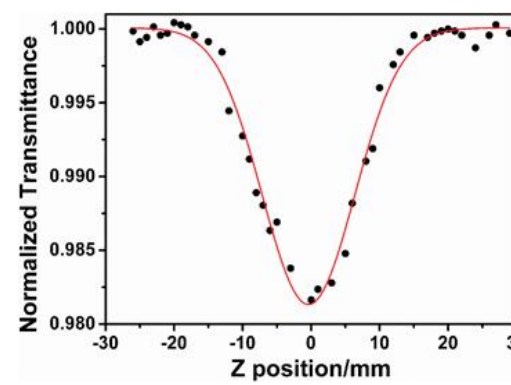


Negative nonlinearity
Self-defocusing

Open Aperture – NLA



Saturable Absorption (SA)

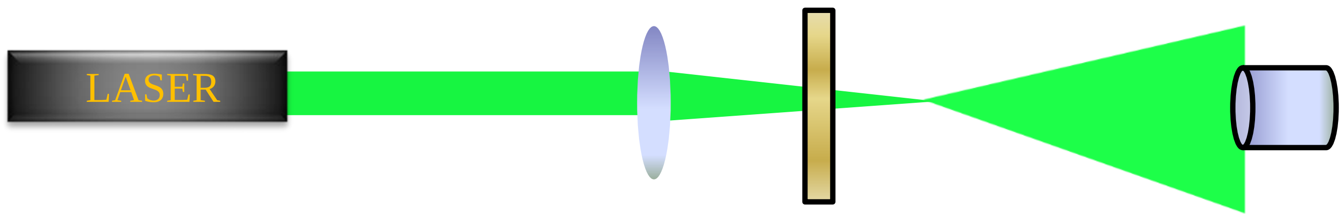


Reverse Saturable Absorption (RSA)

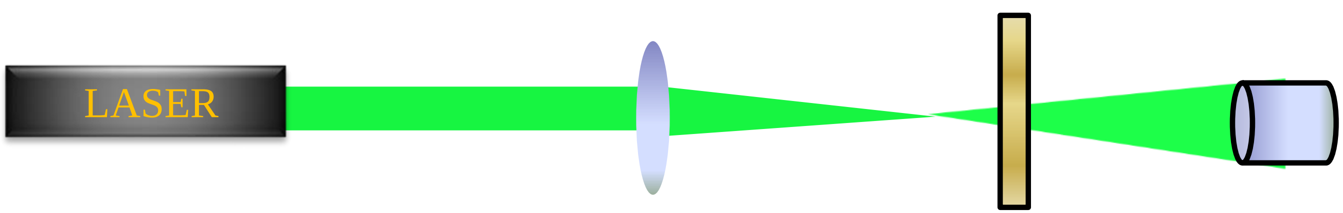
Z-Scan Technique – NLR Mechanism

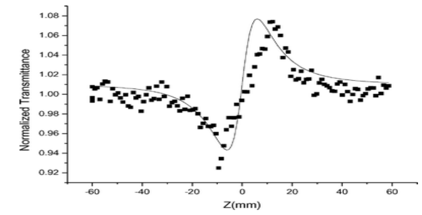
Sample is far from the focus - intensity in the sample is small - energy transmitted through the aperture - approximately constant.

Imagine, a sample with positive lensing effect. For z < 0; this lensing causes the beam to come to focus earlier, so that it diverges more rapidly in the far field. The result is that the aperture transmittance decreases.



On the other hand, for z > 0; the positive lensing causes the beam divergence to decrease, resulting in an increased aperture transmittance. The net Z-scan yields a dispersion-shaped transmittance valley-peak curve.





Obviously, a negative n_2 material will produce a similar curve, but with the peak and valley reversed about z = 0, that yields a peak-valley curve.

Books for Study:

1. **K.R. Nambiar**, Lasers: *Principles, Types and Applications* (New Age Inter-national Publishers Ltd, New Delhi, 2014).
2. **B.B. Laud**, *Lasers and Nonlinear Optics,* 3rd Edn. (New Age International Pvt. Ltd., New Delhi, 2011).
3. **Ralf Menzel**, *Photonics* (Springer-Verlag Berlin Heidenberg, New York, 2007)

Books for Reference

1. **Richard L. Sutherland**, *Handbook of Nonlinear Optics*, (Marcel Decker Inc, New York, 2003)
2. **R.W. Boyd**, *Nonlinear Optics, 2nd* Edn. (Academic Press, New York, 2003)
3. **W.T. Silfvast**, *Laser Fundamentals* (Cambridge University Press, Cambridge, 2003)
4. **Y.R. Shen**, *The Principles of Nonlinear Optics*, (Wiley & Sons, New Jersey, 2003)