The Axicon

Proteep Mallik

OPTI 696bx

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College of Optical Sciences
The University of Arizona

Outline

- What is an axicon?
  - Its history
- Its many uses
  - Optical alignment
  - Generation of diffraction free beams
  - Corneal surgery
  - OCT
  - Atom traps
  - Acoustic testing

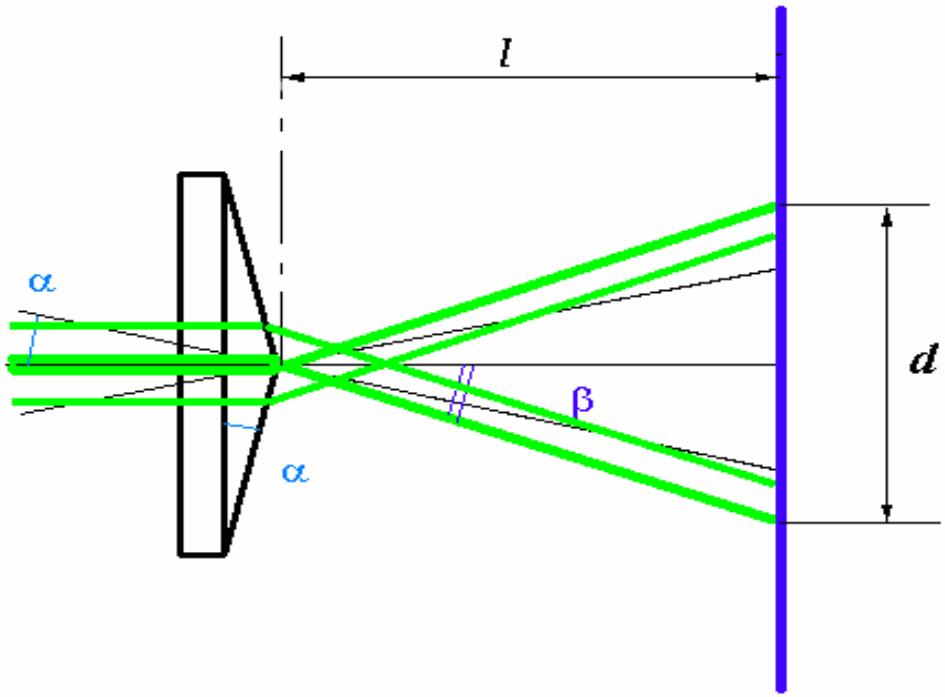
  … the list is endless!
- Modeling an axicon- ZEMAX

What is an Axicon?
-History

- Term coined by J.H. McLoed in 1954
- Greek: “axis image”
- A point imaged onto a line segment
  - Pinhole camera
  - Poisson spot/Arago spot

What is an Axicon?

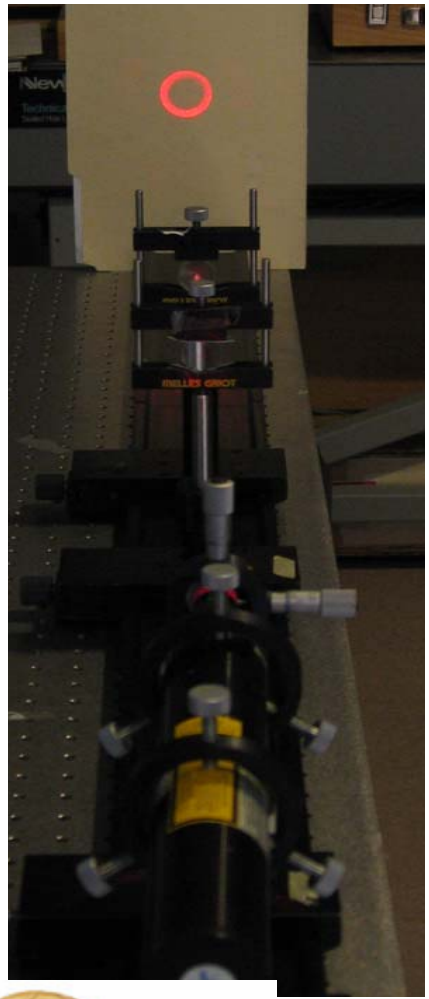
- Many definitions
- Conical lens or rotationally symmetric prism
- Cone angle = $180^0 - 2\alpha$
- Produces a line focus
- Projects a ring 'spot'

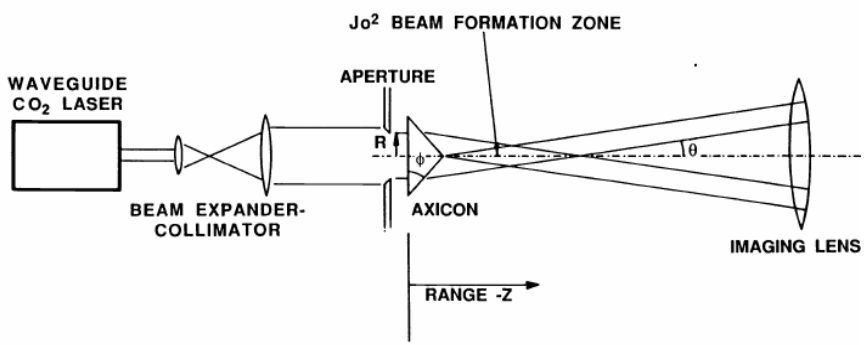


Optical Alignment

- Collimated light through axicon
- Axicon dia = 25.4mm
- Depth of focus = R/[(n-1).α] ~ 29cm, for α = 5^0 and R = 12.7mm
- Diameter of ring,

  d = 2.l.tan [(n-1).α]
- Line segment width (central peak) ~ λ/R



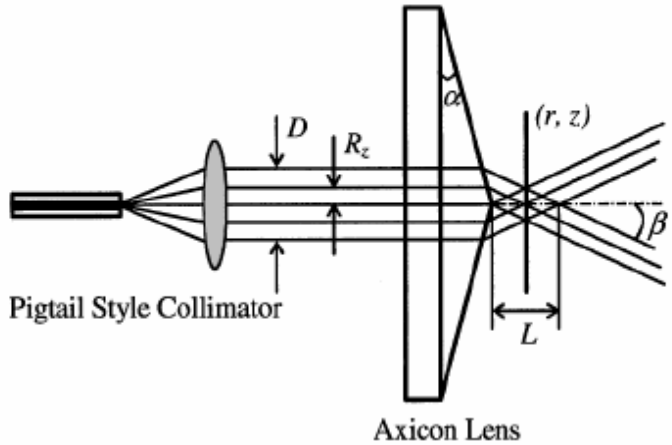


Diffraction Free Beam

•Irradiance behind axicon given by:

$$I(r,z) = E^2(R_z)R_z \frac{2\pi k \sin\beta}{\cos^2\beta} J_0{}^2(kr \sin\beta),$$

$$R \le D/2, \qquad z \le L$$



where, r = radial coordinate on observation plane

J_0 is a zero order Bessel function

E is the energy of the beam at R_z

•J_0 is a function of transverse coordinates

•Remains unchanged for z <= L

•Used where long interaction lengths are needed

- atom traps, Compton scattering etc.

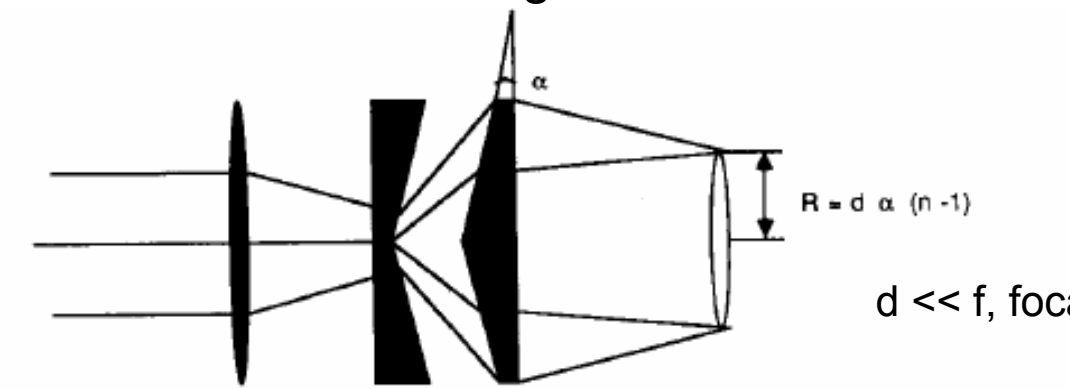
Corneal Surgery

Qiushi Ren, Reginald Birngruber, IEEE Journal of Quantum Electronics, Vol 26, No 12, 1990

- Uses negative and positive axicons to change diameter of ring for ablating corneal material
- Diameter of ring directly controlled by separation of axicons
- R = d.α.(n-1), d = axicon separation

  α = axicon angle

  R = radius of ring

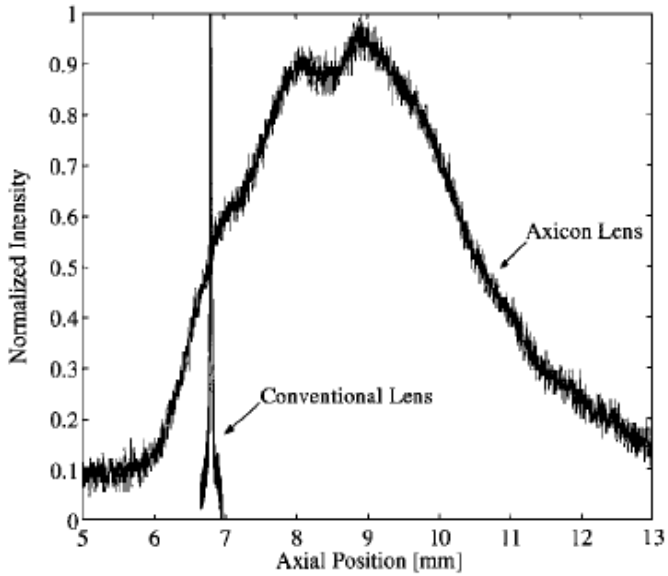


d << f, focal length of lens

Optical Coherence Tomography

Zhihua Ding et al, Optics Letters, Vol 27, No 4, 2002

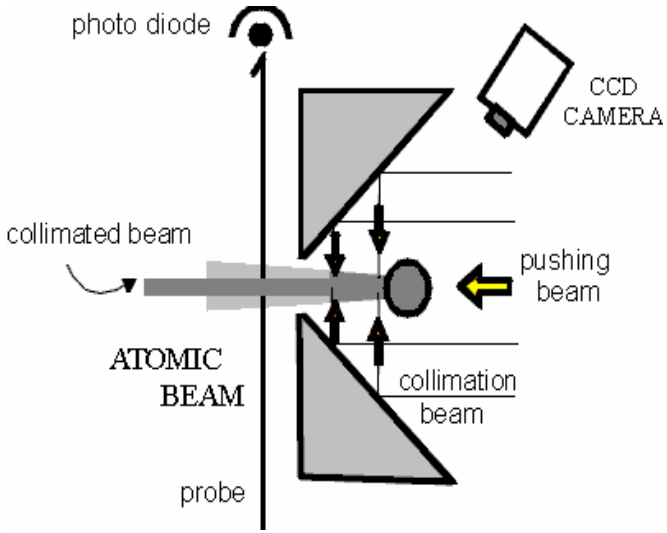
- Focus depth increased w.r.t. conventional lens
- Better than 10μm lateral resolution over 6mm axial position
- Comparable Gaussian beam has axial range of only 0.25mm
- Disadvantage: less light at focus point



Atom Traps

Ki-Hwan Kim et al, Technical Digest- Intl. Quantum Electronics Conference, Vol 7, 1998

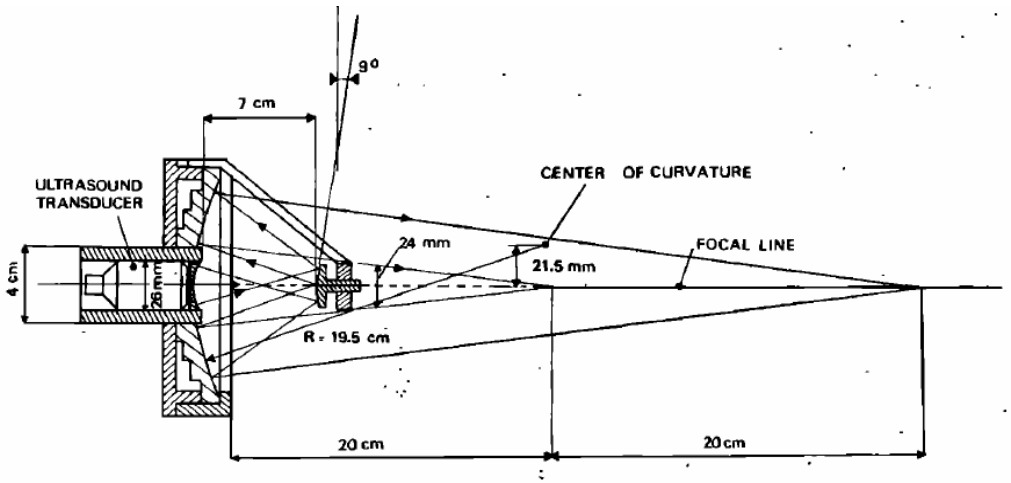
- Axicon mirror with hole in the middle
- Pushing beam pushes atoms towards hole
- Counter-propagating beam through hole
- Turning counter-propagating beam on/off
- Creates pulsed atom beam through hole



Acoustic Testing

C.B. Burckhardt et al, J. Acoustical Soc. Of Am., Vol 54, No 6, 1973

- Transducer creates ultrasonic beam
- Focused by plexiglass lens, incident on a conical mirror
- Divergent beam incident on large axicon (cone + sphere)
- Axicon focuses acoustic beam over a large range
- Test material defects

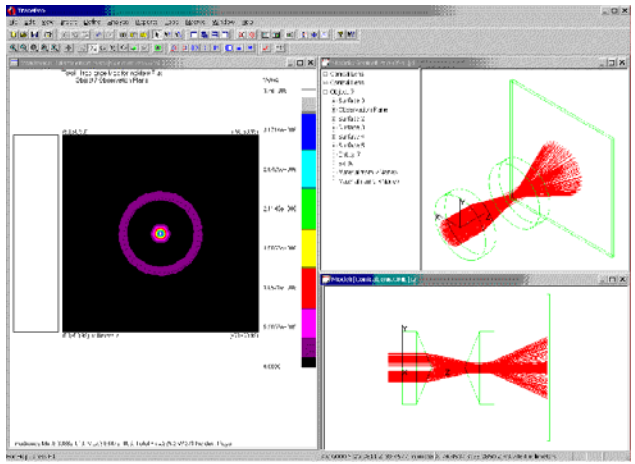


Other Applications

- Solar concentrators
- Axicon resonators in lasers
- Breakdown in light filaments
- Gradient index, grating axicons
- Illumination

Modeling an Axicon

ZEMAX Application Note



- Axicon defined by single parameter, θ
- θ = 0, plane parallel plate
- Surface sag, z = r.tanθ, r = radial coordinates in lens units

Standard Surface Model	Odd Asphere Surface Model
■set roc to small value, several times smaller than smallest radial aperture, conic < -1	■Set roc = infinity, param1 = tanθ
■Ex: axicon dia = 100mm, cone angle = 10^0, use conic = -33.16, roc = .1mm or less, but not zero	■Other non-sequential ways to model