ATTENUATION MECHANISM FOR THE OPTICAL SIGNALS PROPAGATING THROUGH OPTICAL FIBER

ATTENUATION

- Attenuation is the loss of light intensity as it travels in the optical fiber, is also called as fiber loss. the losses or attenuation may be due to light absorption, scattering and extensive fiber bends.

Expression for attenuation coefficient

The loss of power suffered by an optical signal as it propagates down the fiber is called attenuation.

Attenuation coefficient $$\alpha = -\frac{10}{L}\log_{10}\left[\frac{P_{out}}{P_{in}}\right]$$

Generally α is expressed in decibel/km (dB/km),

where **L** is the length of the fiber in **km**, $\mathbf{P_{out}}$ is output power and $\mathbf{P_{in}}$ is input power in Watt.

Absorption losses:

Absorption losses occur due to absorption of photons associated with signal by the fiber material.

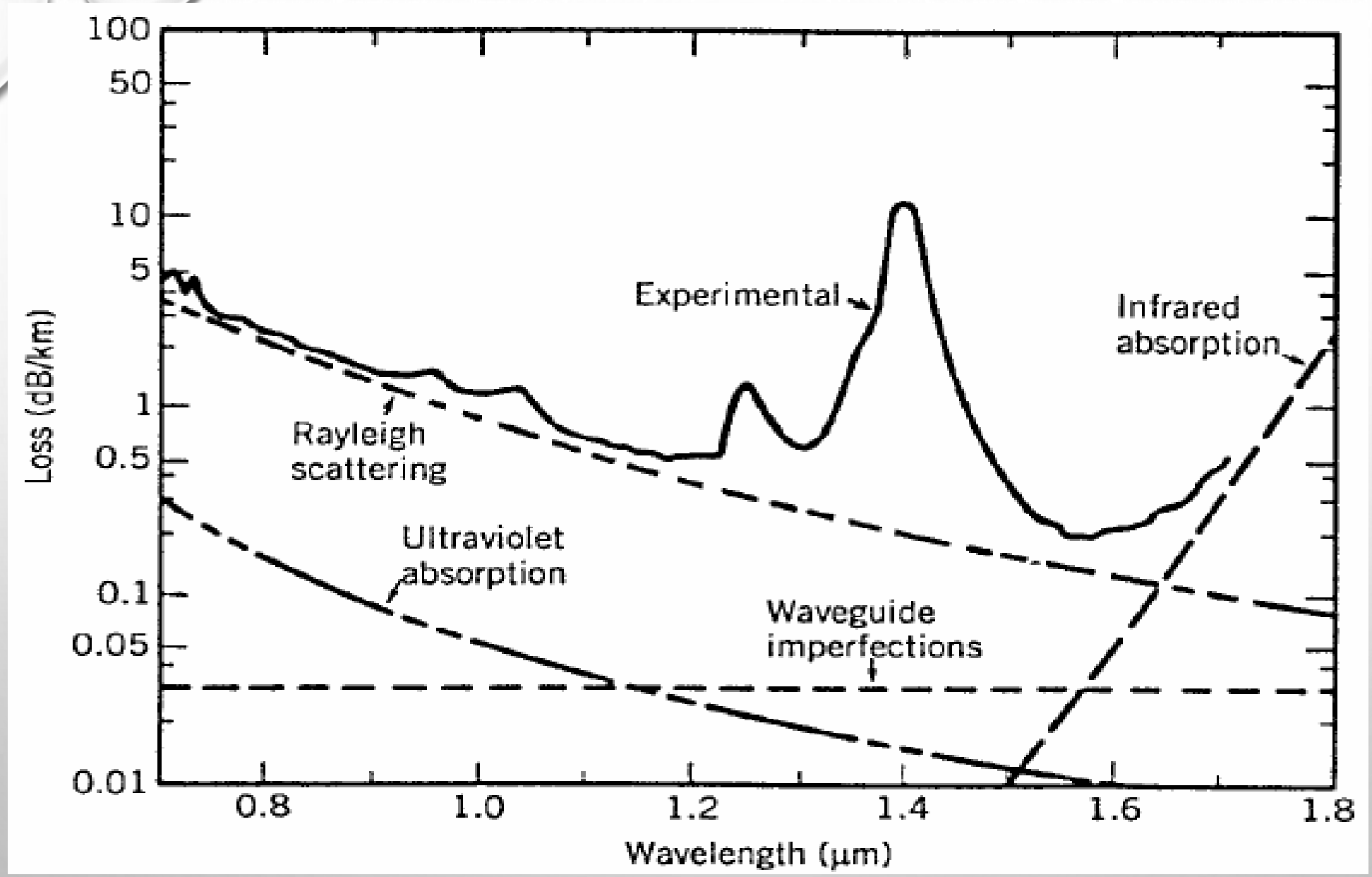
Intrinsic absorption

I. **In silica fibers, SiO_2 is the main constituent which can absorb part of the optical signals and is called intrinsic absorption.**

II. **Along with intrinsic absorption, there may be impurity absorption.**

Extrinsic Absorption

- **Generally impurities present are transition metal ions, OH(hydroxyl) ions which will absorb photons during the propagation of light signals.**
- **However by reducing impurity concentrations during the fabrication of fibers, we can reduce impurity absorption but intrinsic absorption cannot be avoided which sets the lowest limit for absorption loss.**


100
50
10
5
1
0.5
0.1
0.05
0.01
Loss (dB/km)
Experimental
Infrared
absorption
Rayleigh
scattering
Ultraviolet
absorption
Waveguide
imperfections
0.8
1.0
1.2
1.4
1.6
1.8
Wavelength (μm)

SCATTERING LOSSES.

- **Scattering losses occur due to inhomogeneities and structural defects present in the fiber.**
- **While the signals travel in the fiber, the photons may be scattered because of sharp changes in refractive index values inside the glass over distances that are small compared to wavelength of light.**
- **These regions of dimensions less than the wavelength of light acts as a scattering agents, as a result of which Photon changes its direction and can escape out of the fiber without undergoing total internal reflection and thus loss in optical signals occurs.**
- **This kind of scattering is called rayleigh's scattering and the rate of scattering is inversely proportional to fourth power of light wavelength used.**
- **To reduce this type of scattering losses, Generally lights of longer wavelengths will be used for communication purpose.**

Mie scattering

Non perfect cylindrical structure of the fiber and imperfections like irregularities in the core-cladding interface diameter fluctuations, trapped gases bubbles, unreacted starting materials etc-May create scattering which is termed as mie scattering.

BENDING LOSSES.

Bending loss or radiative loss:

Occurs due to bending of a fiber.

There are two types in bending

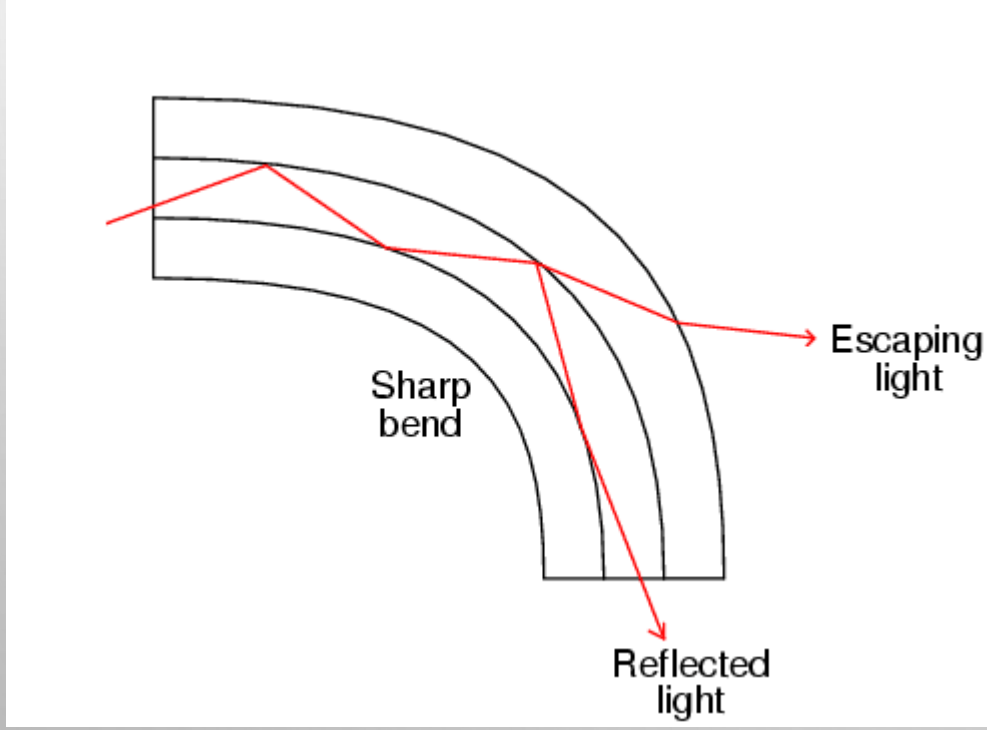
- Macroscopic bending
- Microscopic bending.

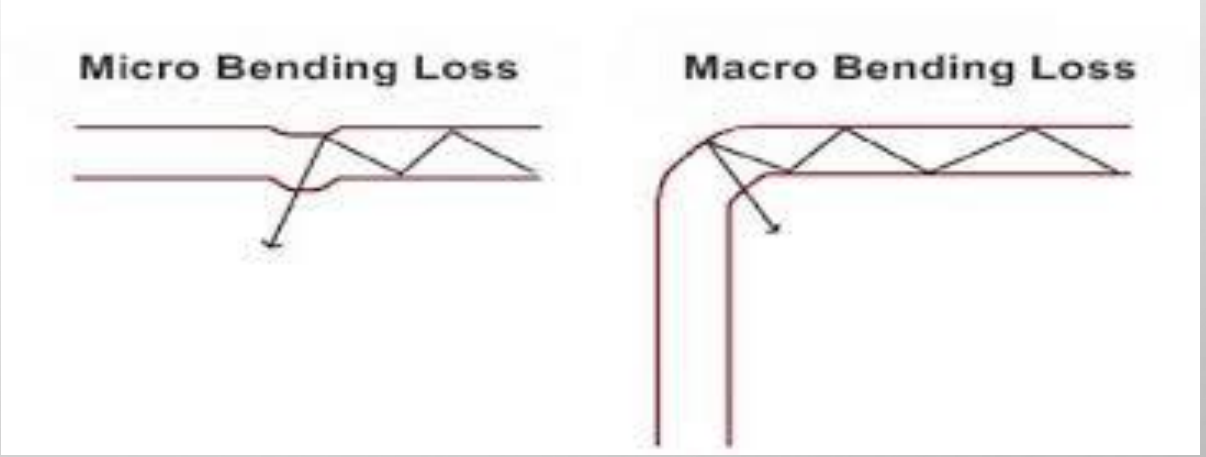
Macroscopic bends

Bends having radius that are much larger compared to the fiber diameter which occur during turning the fiber around the corner while laying it. **Light ray encountering this sharp bend fails to get total internally reflected due to change in angle of incidence at the boundary separating core and cladding.**

This kind of losses can be avoided by avoiding sharp bends in the fibers during installation.

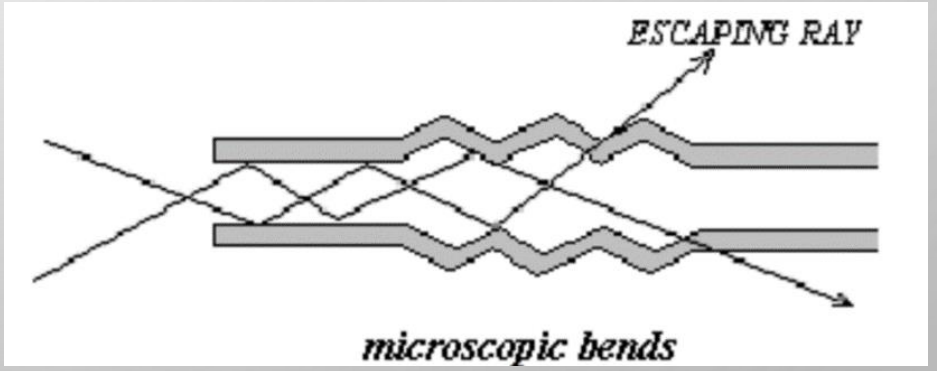
MACRO AND MICRO BENDS





GEOMETRICAL LOSSES OR MICROSCOPIC BENDING.

- ✓ These losses refer to repetitive small scale fluctuations in the linearity of the fiber axis due to non uniformities in the manufacturing the fiber or due to the non-uniform lateral pressures created during The cabling of the fibers.
- ✓ The micro bends cause irregular reflections and some of them then leak through the fiber.
- ✓ Wrapping or coating compressible jackets over the fiber so that external pressure effects in fiber can be avoided, can minimize signal losses due to geometric losses.



Splicing or coupling losses.

- For some applications, the optical fibers have to be laid over very large distances then it becomes necessary to interconnect two fibers which are usually of kilometer length.
- When the fibers are interconnected, losses occur due to mechanical misalignment.
- This is called splicing or coupling losses.