EE2025
Why Study Electromagnetics?

Uday Khankhoje & Deepa Venkitesh
Electrical Engineering
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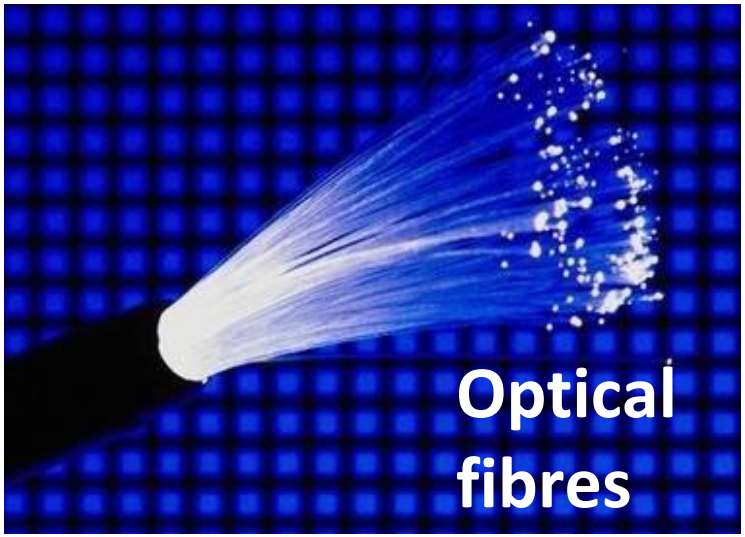
Why Study Electromagnetism?



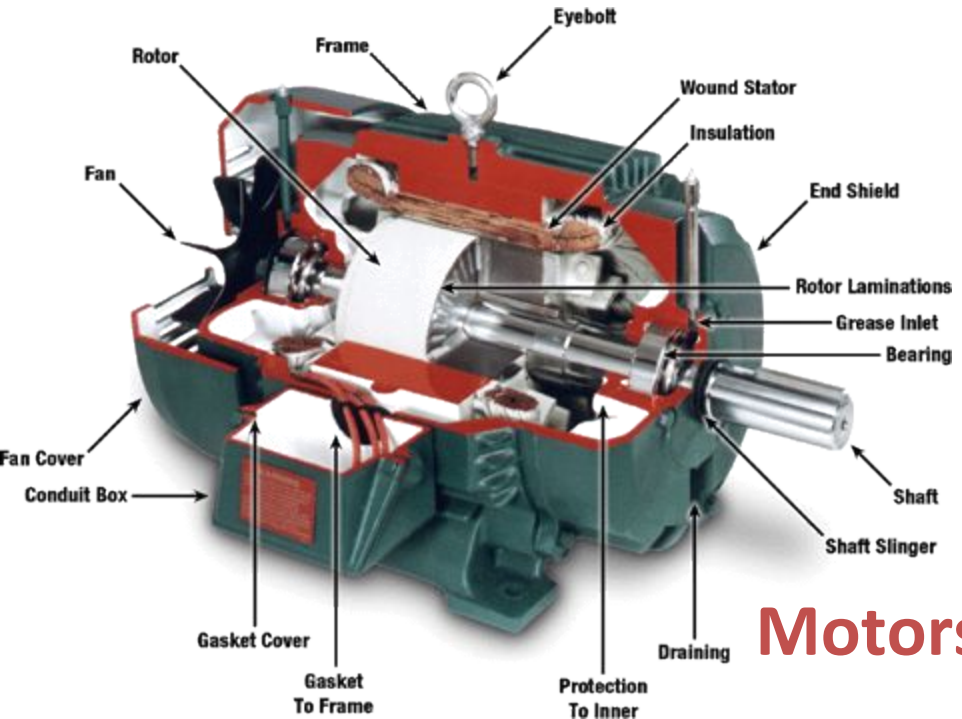
Mobiles & Cell towers

Why Study Electromagnetism?

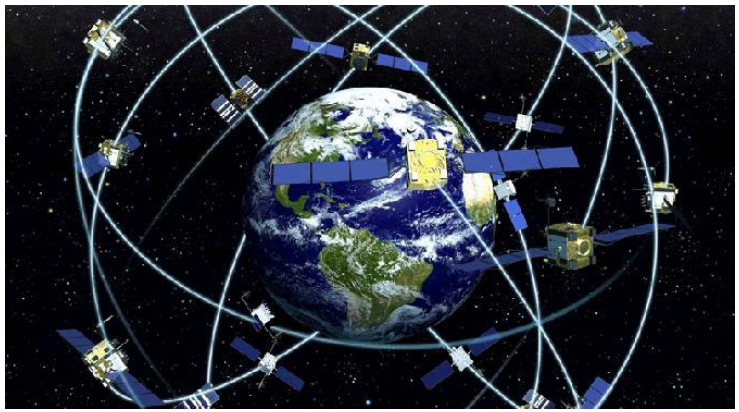
Radio astronomy

LCD screens

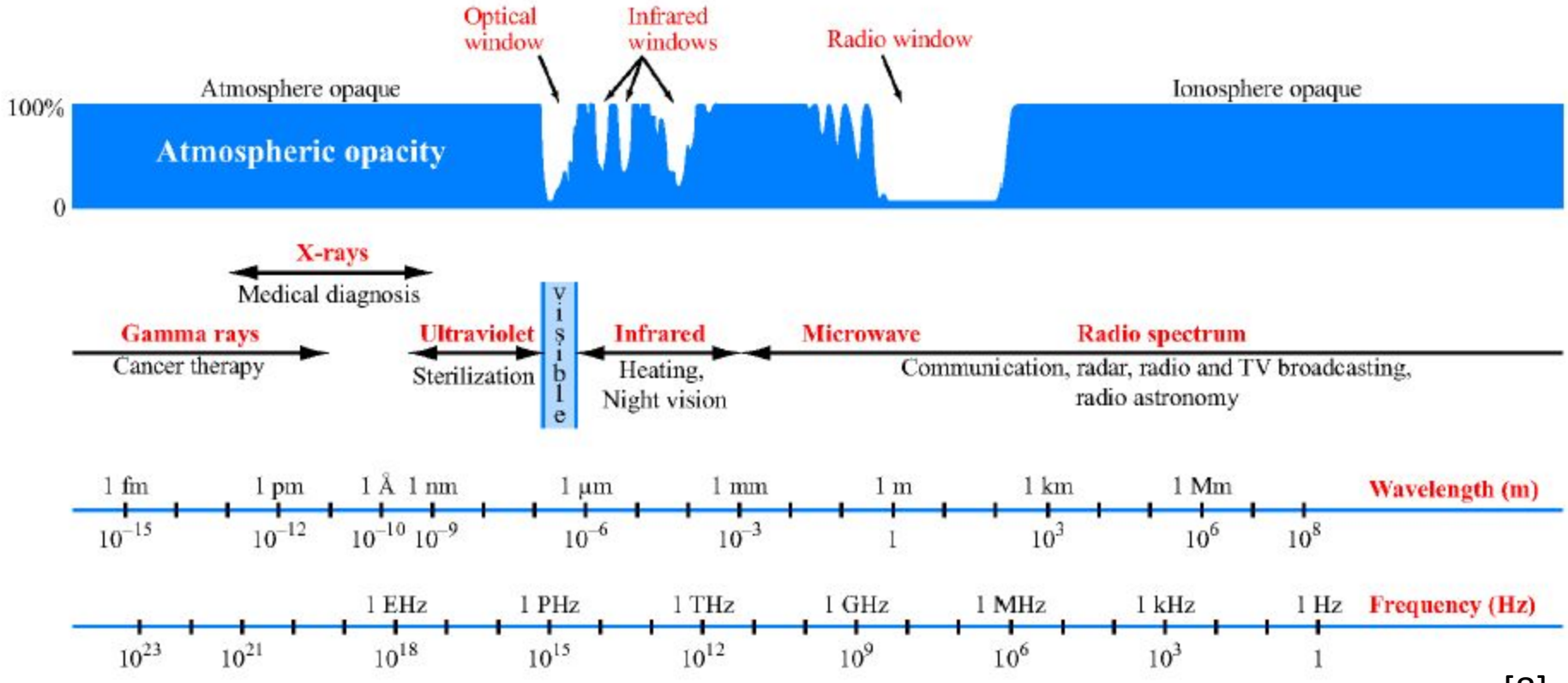
GPS



Motors



Electromagnetic Spectrum

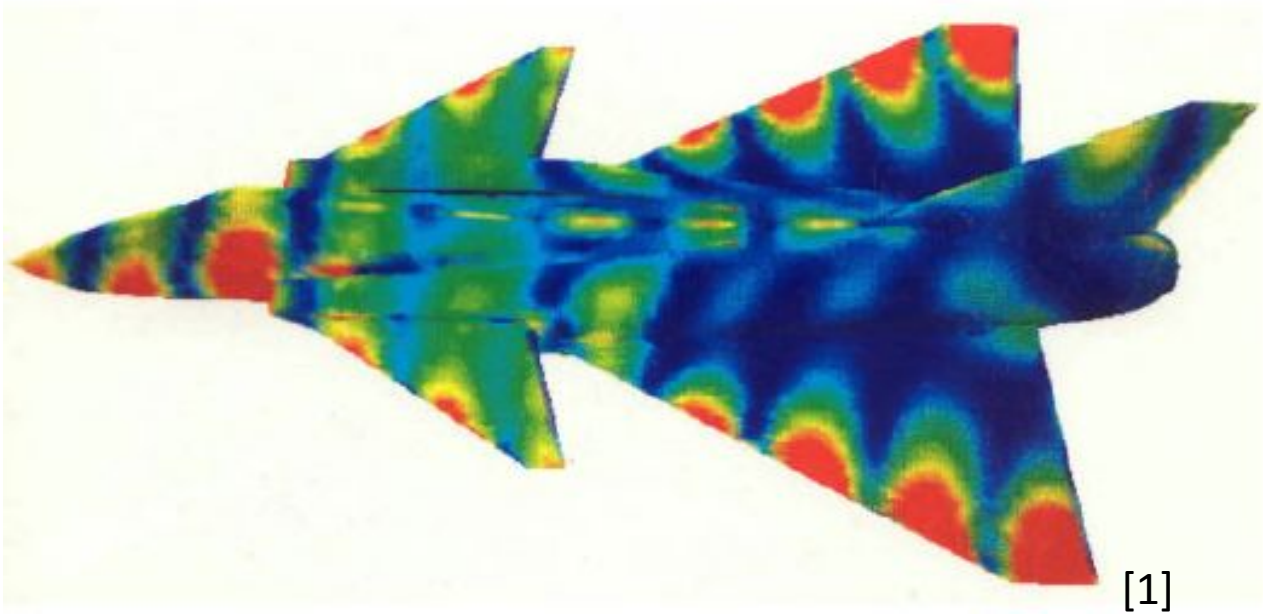


[8]

EM Applications over time

- 1900 – 1990s: Dominated by military applications – Radar, stealth technology, electromagnetic weapons, etc.
- 1990s – today:
  - Computing
  - Communication
  - Imaging (bio-medical, remote-sensing, ground-penetrating radar, oil well exploration….)

Military applications



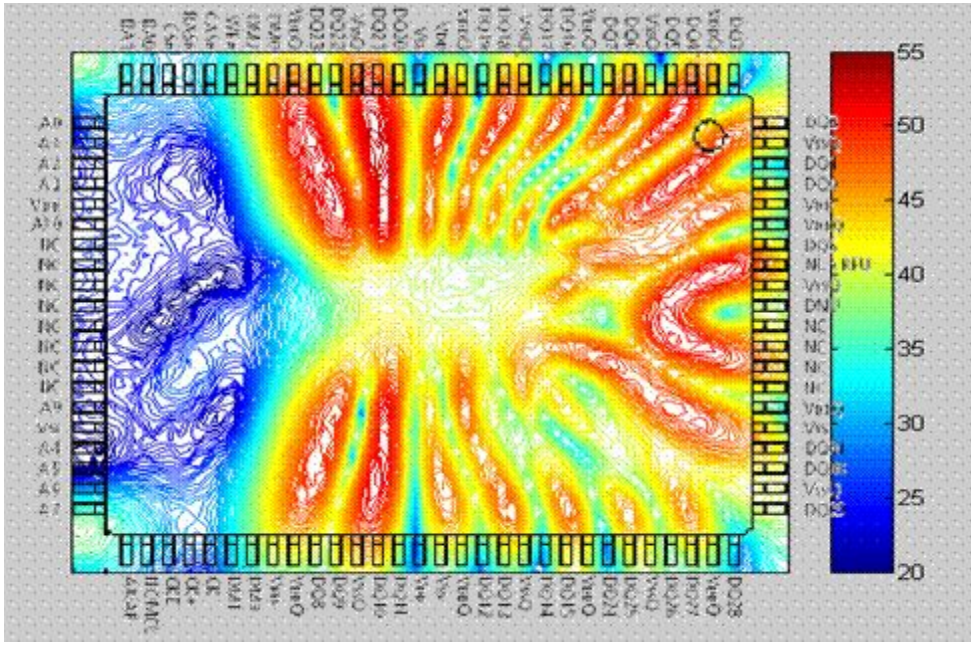
[1]

100 MHz radar wave interacts with a fighter jet. False colours correspond to induced surface currents which re-radiate EM energy

High-speed circuits

Circuit theory is actually a *subset* of electromagnetic field theory:

At high switching speeds, signals are ***not*** confined to circuit paths! Kirchhoff's laws fail !!

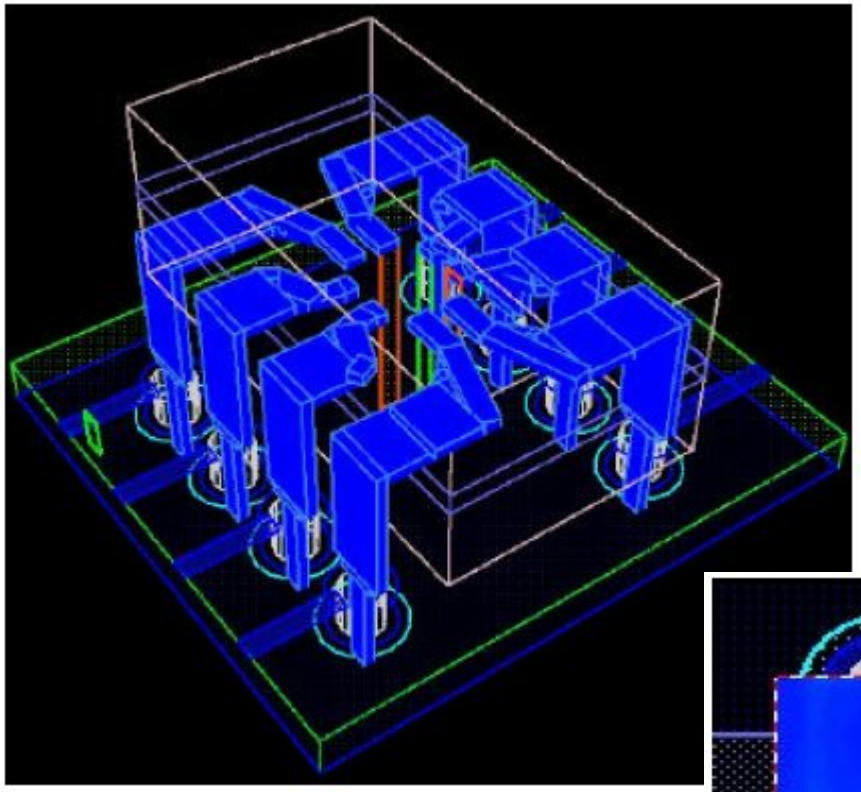


Shrinking circuit size **+** high speed operation

=> Higher coupling between circuit elements via EM

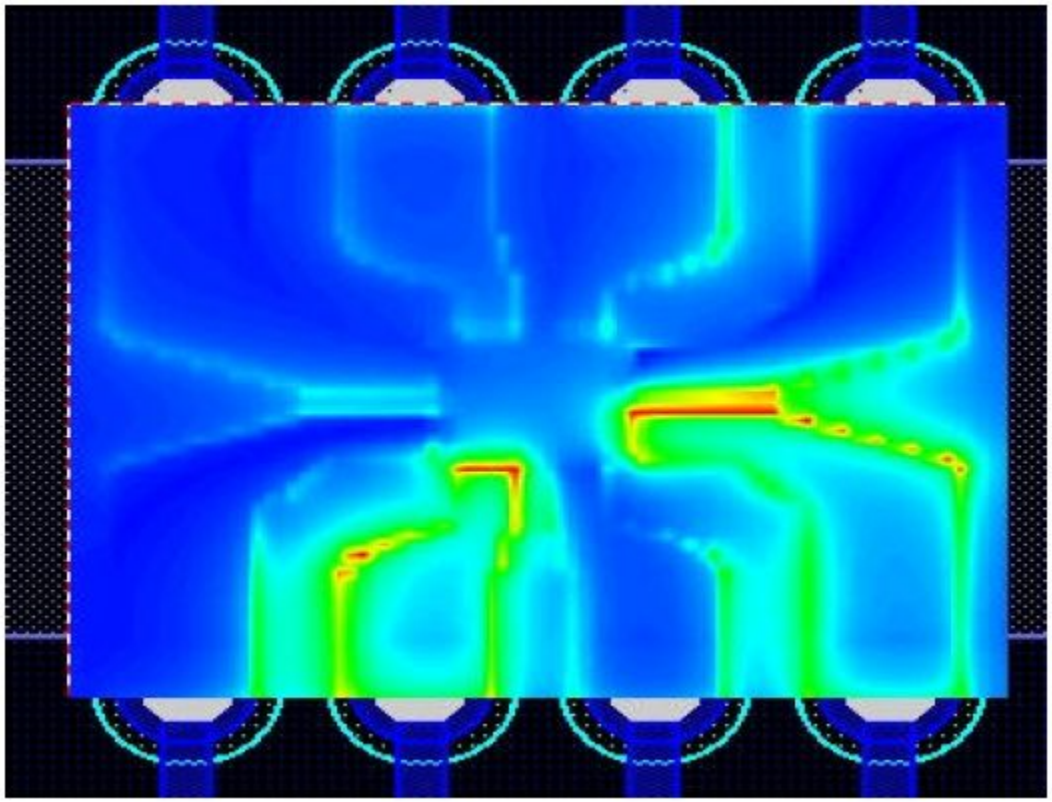
Near magnetic field above a packaged integrated circuit.[2]

High-speed circuits



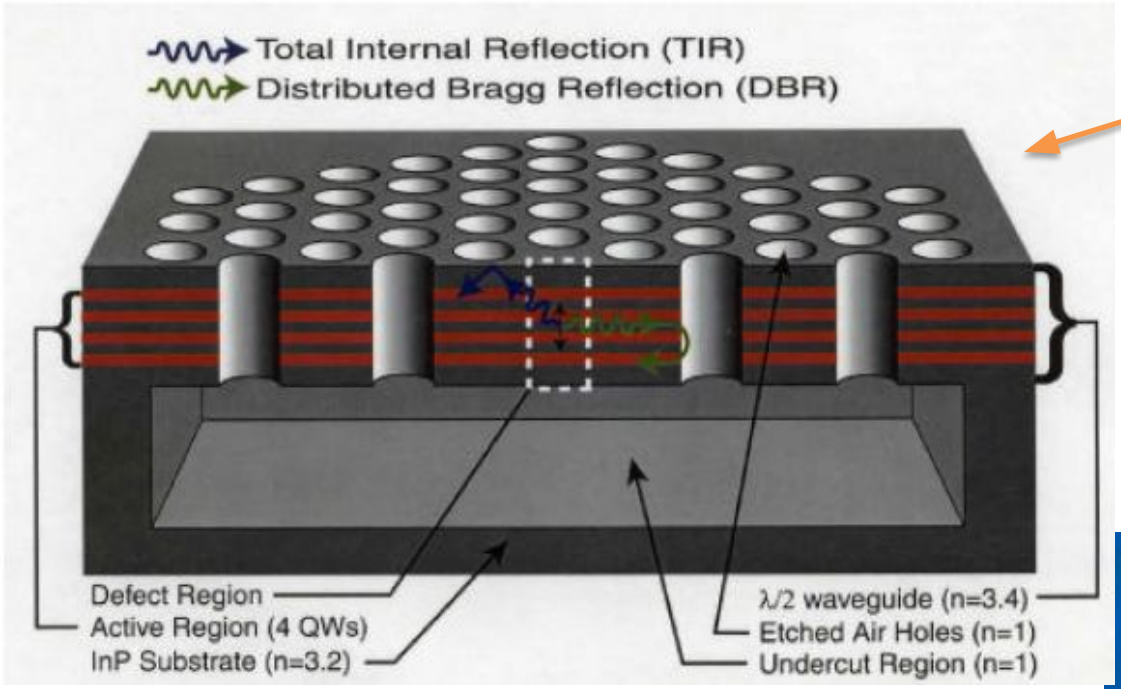
Microchip embedded within a dual inline IC

[1]



Fields associated with a logic pulse are not confined to metal paths

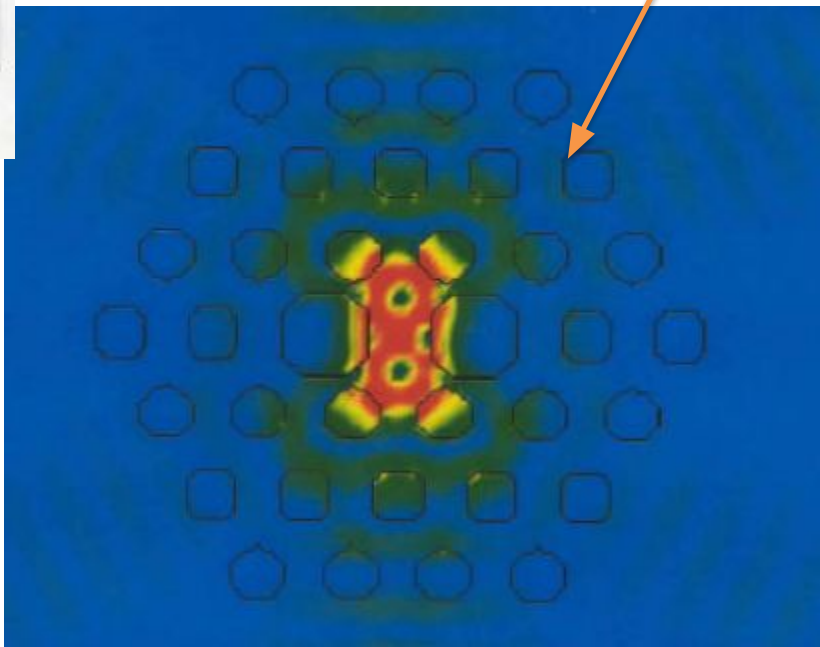
Micro-cavity Laser Design



Periodic air holes in a slab – *Photonic Crystal*

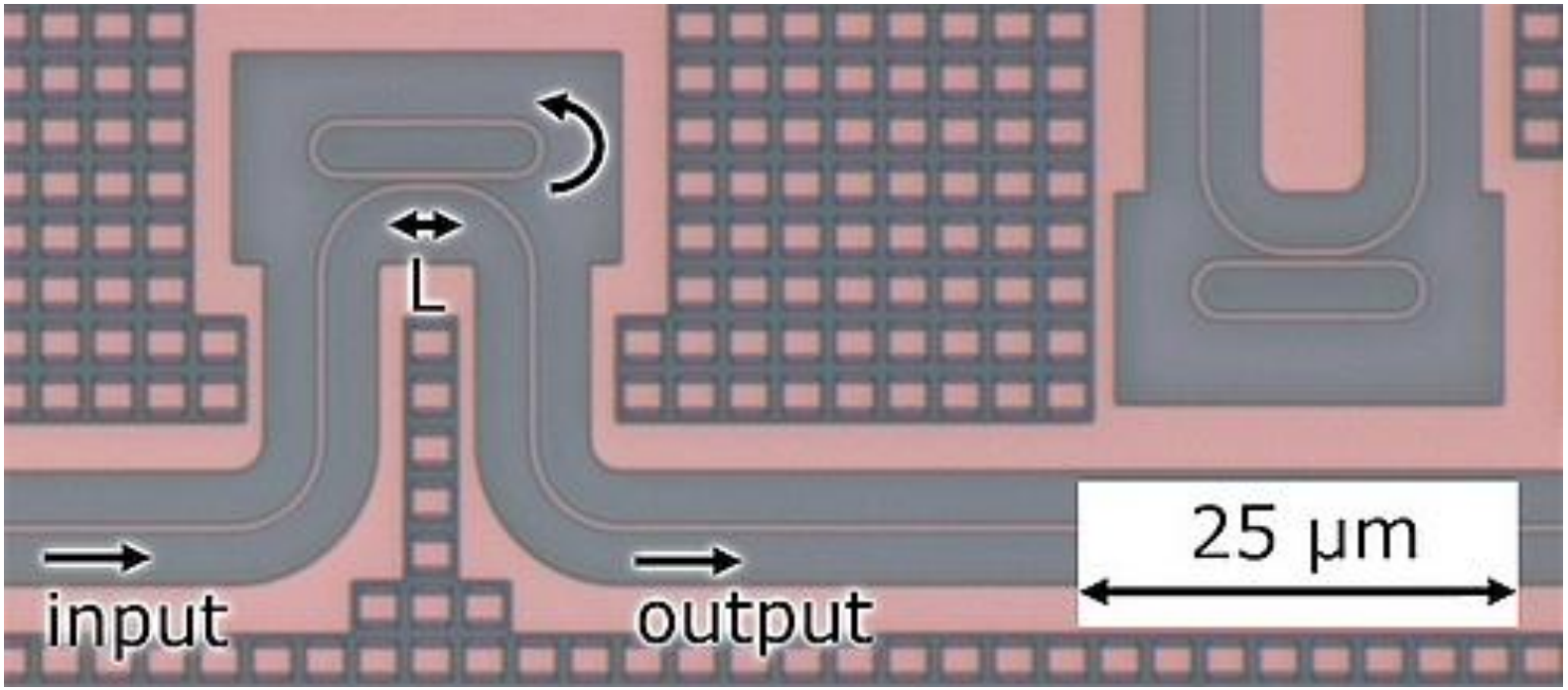
Simulation showing trapped electro-magnetic fields

[7]



Used for making ultra-compact lasers, quantum-entanglement devices, etc.

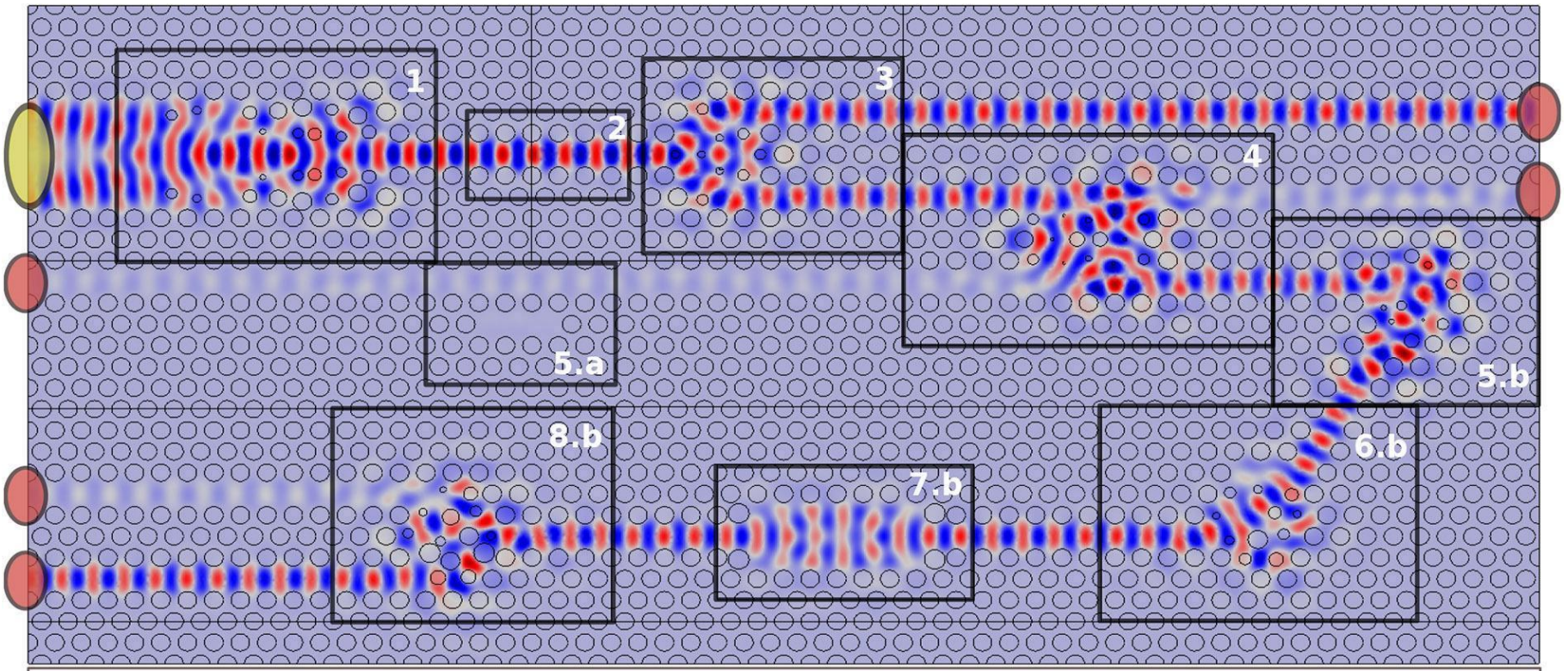
Photonic integrated circuits



[5]

Circuits for light : simple example of a wavelength dependent filter. At the resonance frequency of the loop, output drops off.

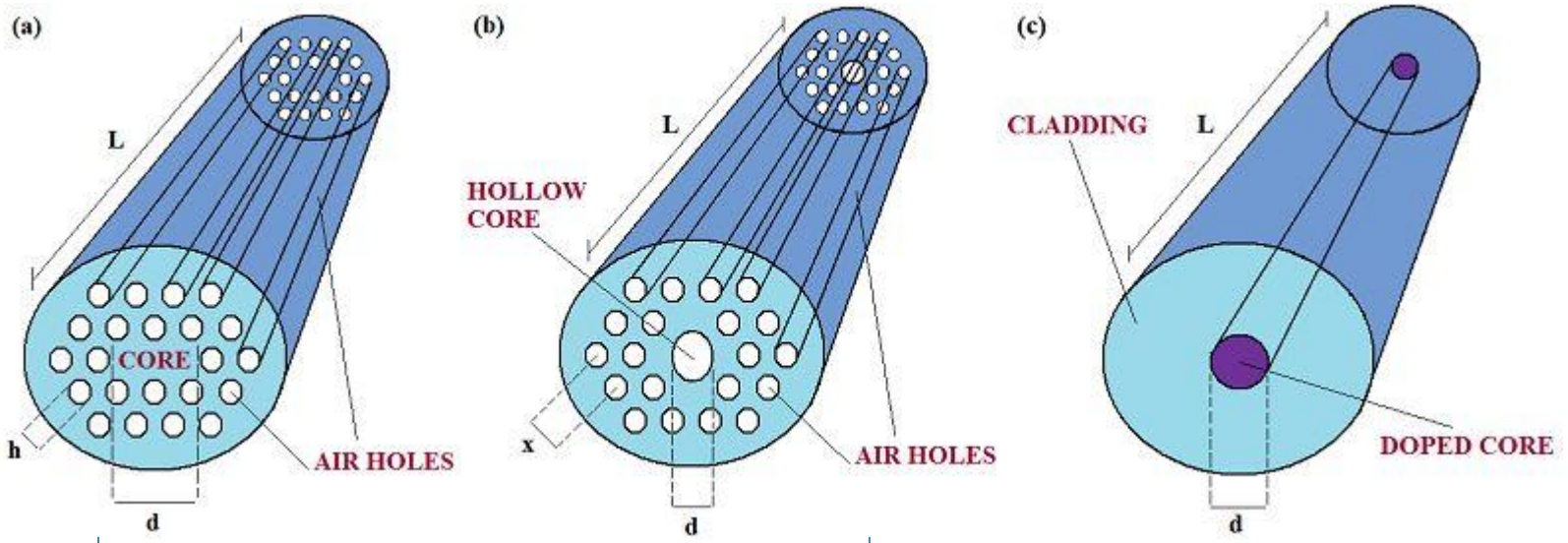
Photonic integrated circuits



Input port	2-Regular PCWG	5.a-Optical resonator	7.b-Delay line/phase shifter
Output port	3-Power beam splitter	5.b-120 degree bend PCWG	8.b-Wavelength multiplexer
1-PCWG mode coupler	4-Optical cross-connect	6.b-60 degree bend PCWG	

[6]

Optical Fibres



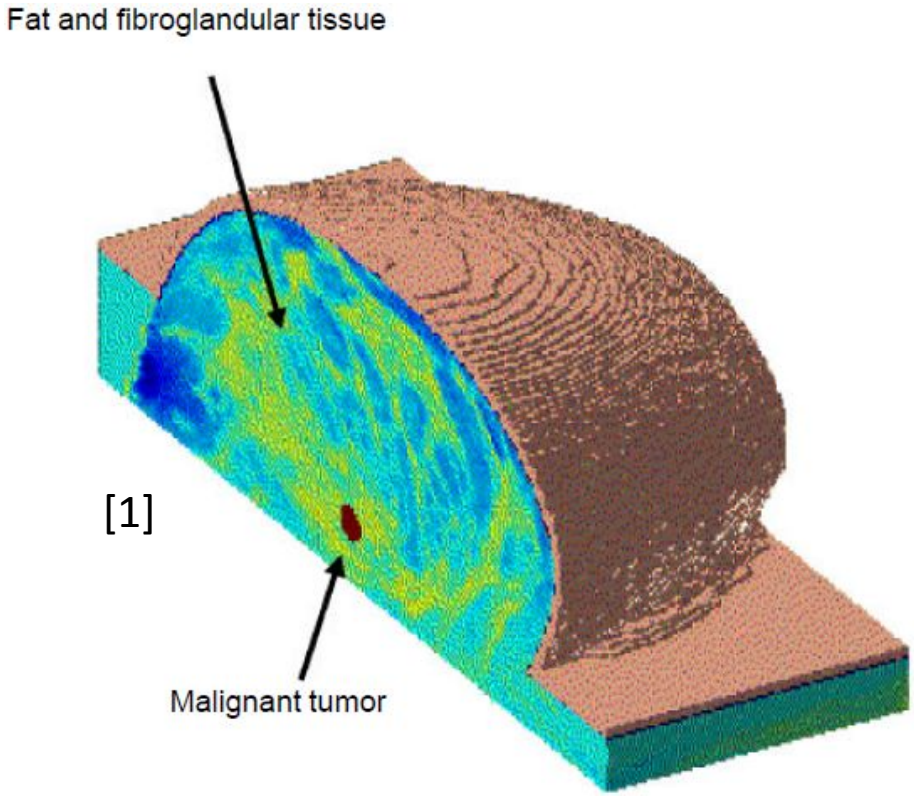
[4]

Photonic crystal fibres

Conventional fibres

In addition to simply guiding light, gives control over dispersion, polarization properties, non-linear effects, etc.

Human Body Imaging : medicine

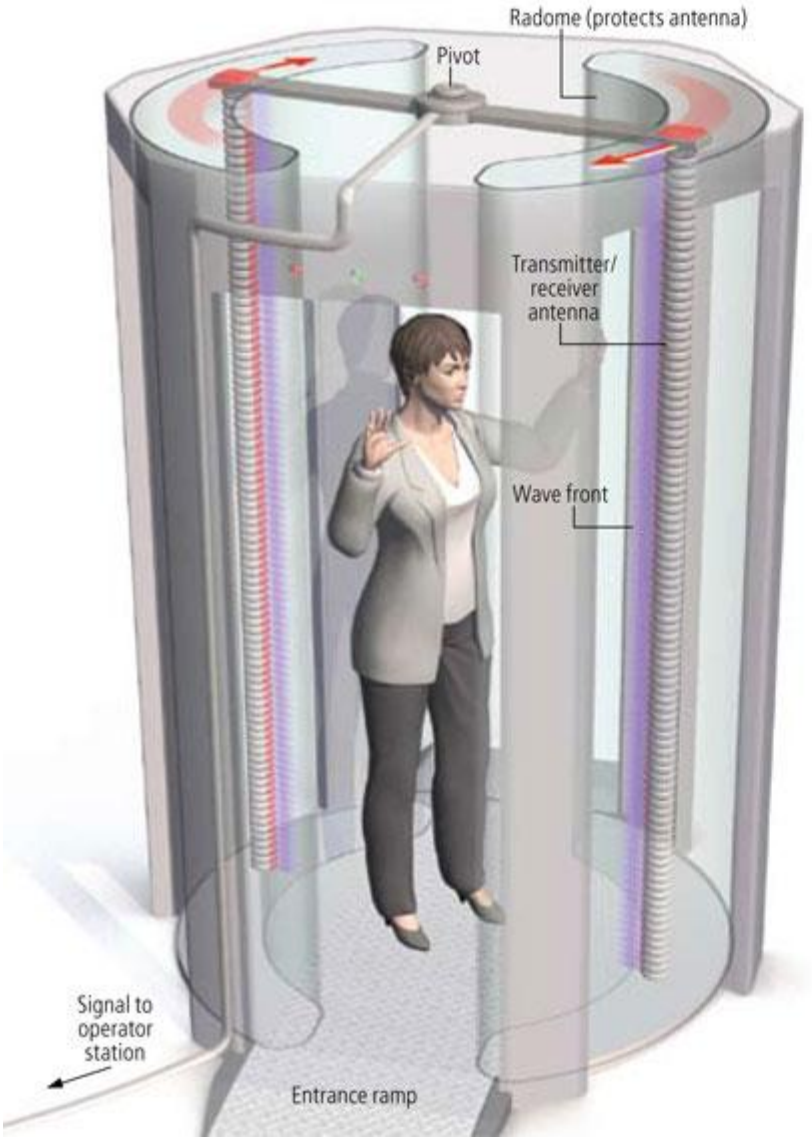


Tumour region has different refractive index as compared to surrounding fatty tissue

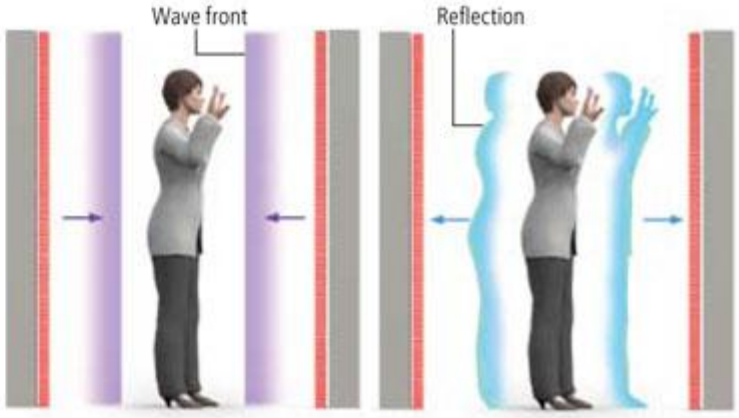
Surround the tissue by antennas: properties of the scattered electro-magnetic energy depends on refractive index distribution

Reconstruct refractive index profile based on scattered electro-magnetic fields

Human Body Imaging : security



Very active area of research : terahertz frequency (millimetre wavelength) sources and detectors.



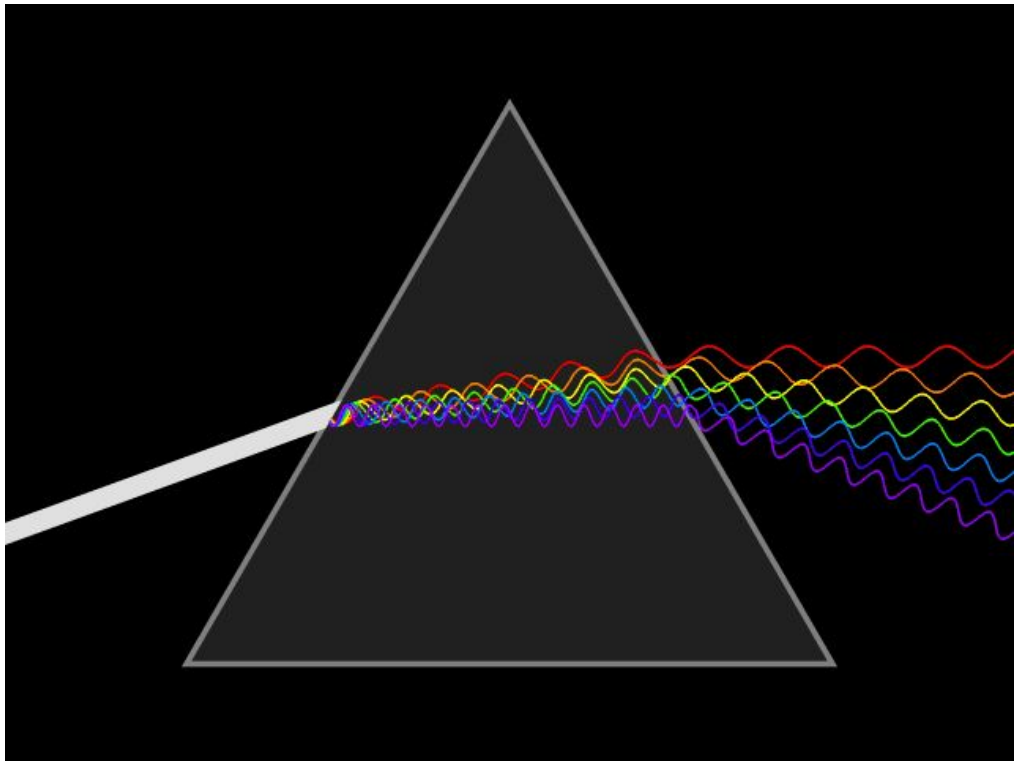
MILLIMETER-WAVE IMAGING

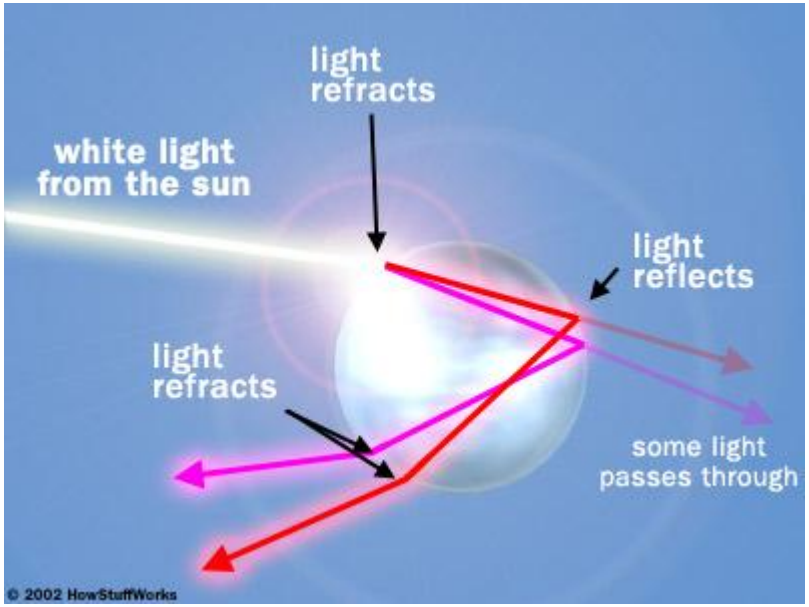
A passenger steps inside. Two vertical banks of transmitter/receivers pivot in tandem, each emitting a wave front that penetrates clothing and reflects off the person's body and any concealed objects. For privacy, the security operator viewing the resulting image sits at a remote location.

Scan time = 10 seconds
Beam frequency = 24–30 GHz
Beam power density = 6×10^{-6} mW/cm^2

[3]

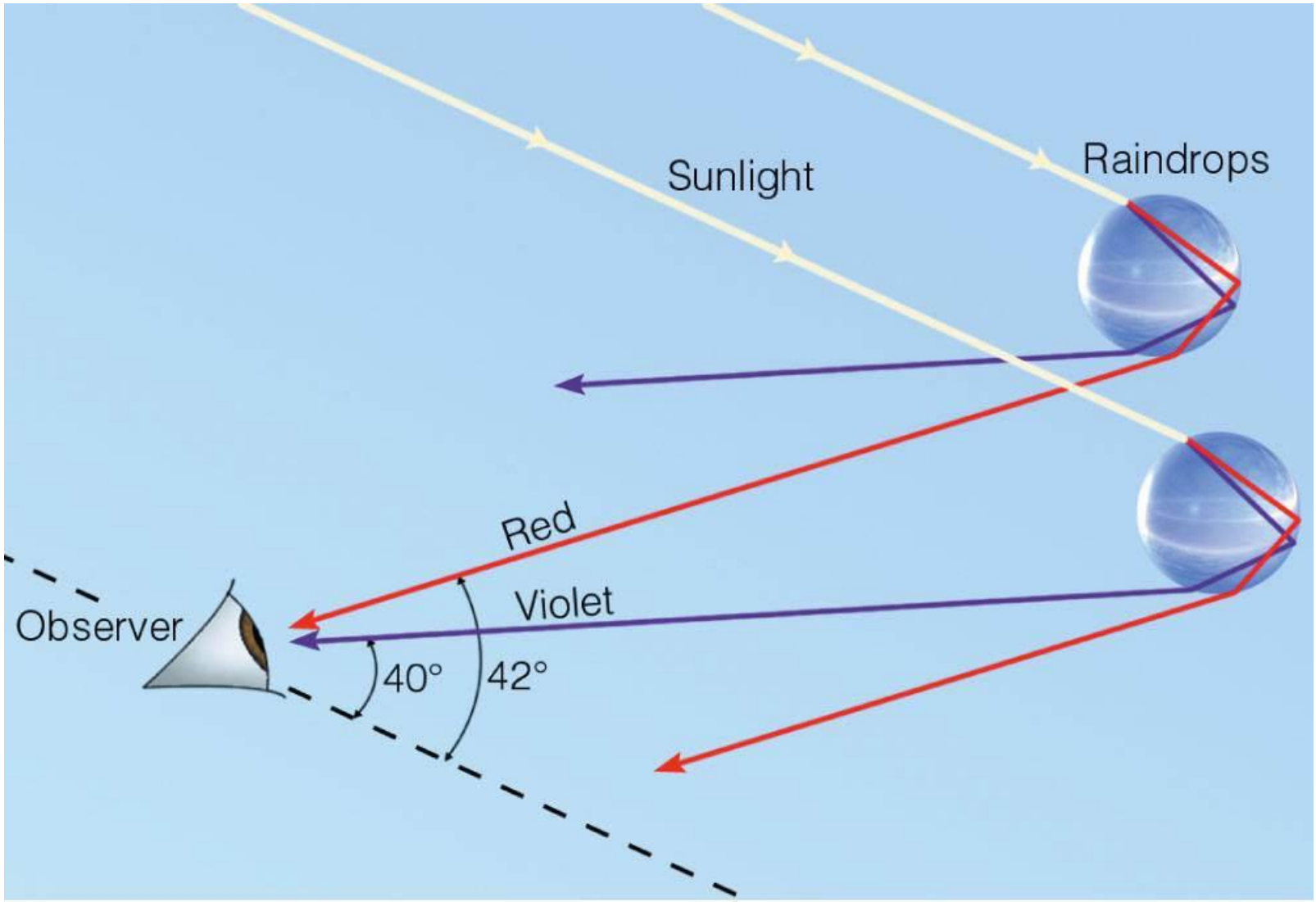
Natural Phenomena: rainbow!





http://www.srh.noaa.gov/jetstream/clouds/color.htm
http://www.naturphilosophie.co.uk/rainbows-rainbows-everywhere/
http://science.howstuffworks.com/nature/climate-weather/storms/rainbow2.htm

Natural Phenomena: rainbow!



Conclusions

- Study of EM is fundamental to most applications of computing, circuit design, and communications

- Many prominent future technologies are highly dependent on a sound understanding of EM: quantum computing, high-speed optical inter-connects, wireless power transfer

References

[1] Taflove, Allen. "Why study electromagnetics: the first unit in an undergraduate electromagnetics course." *Antennas and Propagation Magazine, IEEE* 44.2 (2002): 132-139.

[2] http://www.cvel.clemson.edu/emc/ic_emc/ic.html

[3] http://projektas-kalejimai.blogspot.in/2011_11_01_archive.html

[4]http://www.intechopen.com/books/advances-in-photonic-crystals/photonic-crystals-for-optical-sensing-a-review

[5]http://www.tnw.tudelft.nl/en/about-faculty/departments/imaging-physics/research/researchgroups/optics-research-group/research/integrated-photonics/

[6] Imanol Andonegui and Angel J. Garcia-Adeva. “Designing integrated circuitry in nanoscale photonic crystals” http://spie.org/x104683.xml

[7] O. Painter, R. K. Lee, A. Scherer, A. Yariv, J. D. O’Brien, P. D. Dapkus, and I. Kim, “Two-dimensional photonic band-gap defect mode laser,” Science, vol. 284, June 11, 1999, pp. 1819–1821.

[8] Ulaby, Michielssen, Ravaioli, “Fundamentals of Applied Electromagnetics”, Pearson 6th ed.

Course Topics

1) Transmission Lines – how electricity travels like a wave
2) The simplest electromagnetic waves – plane waves
3) What happens when waves meet matter
4) How to confine and guide waves – waveguides
5) How to transmit electromagnetic energy – Antennas

Course Outline

Components

1. Exams 1,2,3,4: 15% (each) (no quiz1,2)
2. End Sem: 25%
3. Poster Day : 10%
4. Tutorials: 5%

- ➢ Regular tutorials every 7-10 days
- ➢ 85% attendance req.

- Exams will be closed notes, but "cheat" sheets will be allowed.
- Attending tutorials essential to doing well
- Severe penalties for plagiarism/cheating
- Immediate expulsion from classroom if found using electronic devices

Frequently Asked Questions

- How are the exams?

old style JEE, i.e. conceptual in nature, difficult if you mug last minute!

- How to meet me if you have doubts?

Office hours will be announced. Posting doubts on Moodle forums encouraged.

- Course information?

The course website/Moodle will be constantly updated.

- Recommended books?

Electromagnetic Waves by Shevgaonkar
(Please purchase the low cost edition)

Teaching Assistants - your first point of contact

~ Ten students report to one TA

Details will be put up in moodle

Tutorial questions will be put up in moodle in advance

Attempt to solve Tut qns before the Tutorial Session

Use Tutorial Session to discuss with peer, with TA

Single tutorial note book to be maintained

Textbook:

1. Electromagnetic waves - R K Shevgaonkar

References :

1. Principles of Electromagnetics - Sadiku
2. Elements of Engineering Electromagnetics – NN Rao
3. Field and Wave Electromagnetics – David. K. Cheng

Follow up courses :

RF and Photonics

Photonics (Minor)

Computational Electromagnetics

Fiber Optic Communication Technology