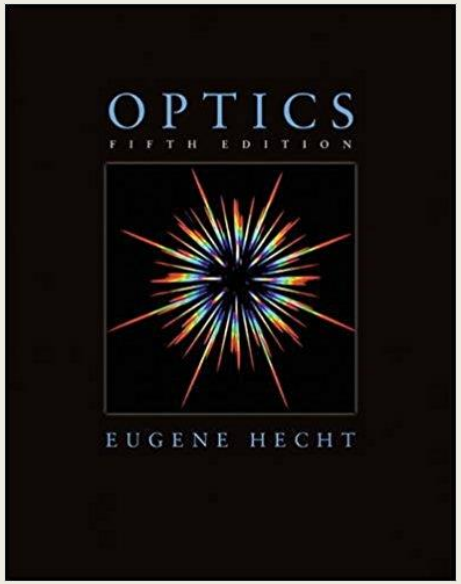
INTRODUCTION TO OPTICS

P47 – Optics: Unit 1

Iraqi Dinar – Ibn al-Haytham ("Father of Optics", 965-1040)



Course Outline

Unit 1: Electromagnetic Waves
Unit 2: Interaction with Matter
Unit 3: Geometric Optics

Unit 4: Superposition of Waves
Unit 5: Polarization
Unit 6: Interference

Unit 7: Diffraction
Unit 8: Fourier Optics
Unit 9: Modern Optics

Grading

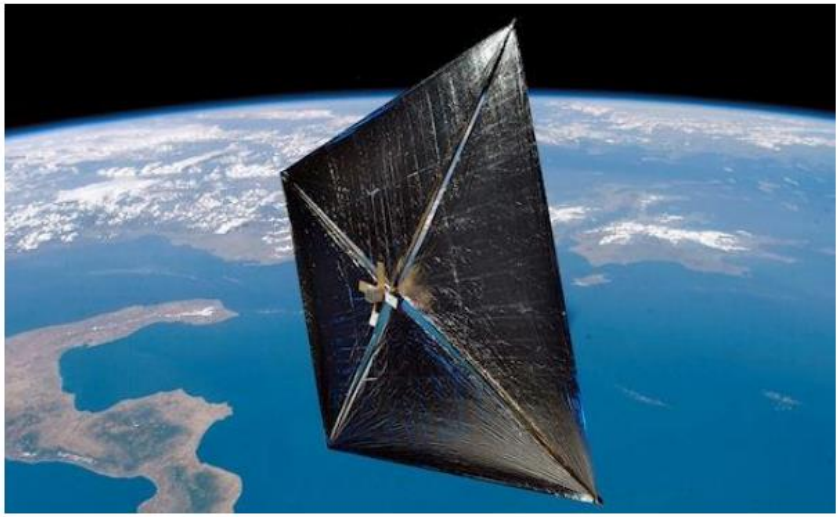
- 35% Homework
- 5% Reading Quizzes
- 30% Labs
- 30% Exams (3)

Overview of Wave Mechanics and Electrodynamics

- the differential wave equation
- phase and phase velocity
- complex representation of waves
- plane waves (1D and 3D)
- EM waves in free space
- energy and momentum of EM waves

Electromagnetic Energy and Momentum

3 kW fiber-based cutting laser
(Hypertherm)

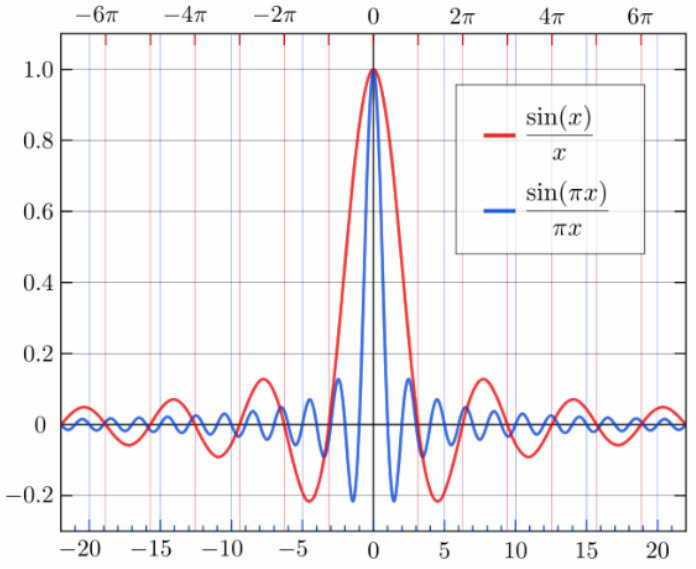


Nano-Sail D, First solar sail in earth orbit
(NASA)

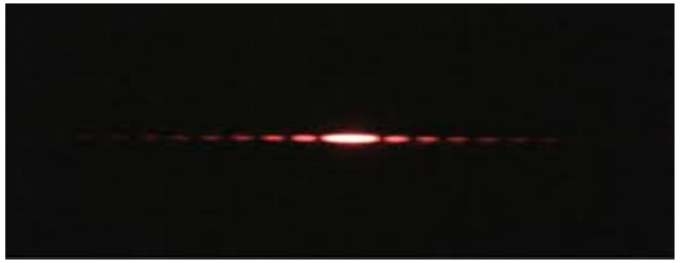
sinc(x) shows up all the time in optics (and Fourier analysis)

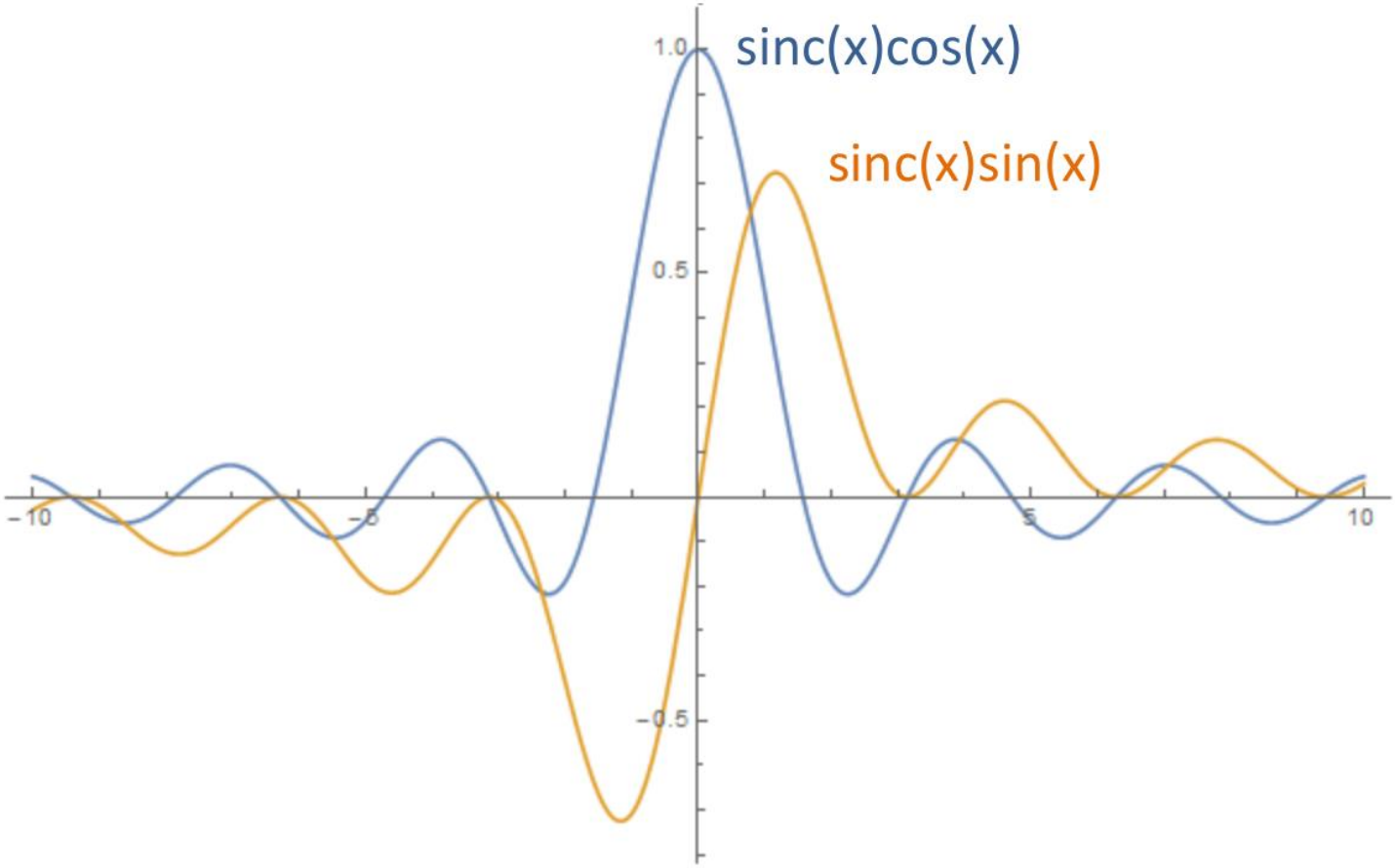
$$\mathrm{sinc}(x) = \frac{\sin(x)}{x}$$

The name is a contraction of "cardinal sine"

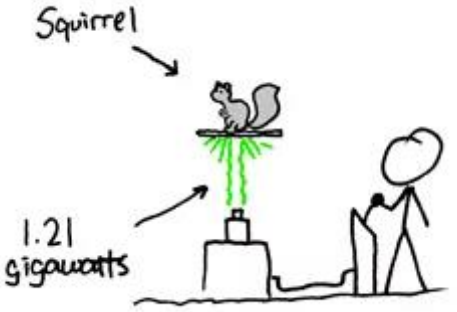


Example:
Pattern of diffraction from a slit…




sinc(x)cos(x)
sinc(x)sin(x)
1.0
0.5
−0.5
−10
−5
5
10

Momentum of EM Waves!



credit: xkcd

Measurement of light pressure in 1901-1903 (just down the hall! – Wilder 115)

Ernest Fox Nichols and Gordon Ferrie Hull

nature photonics

LETTERS

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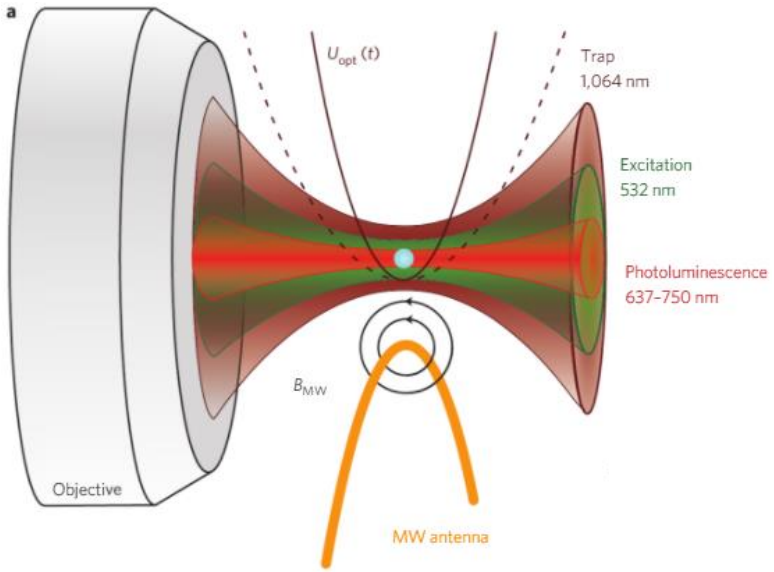
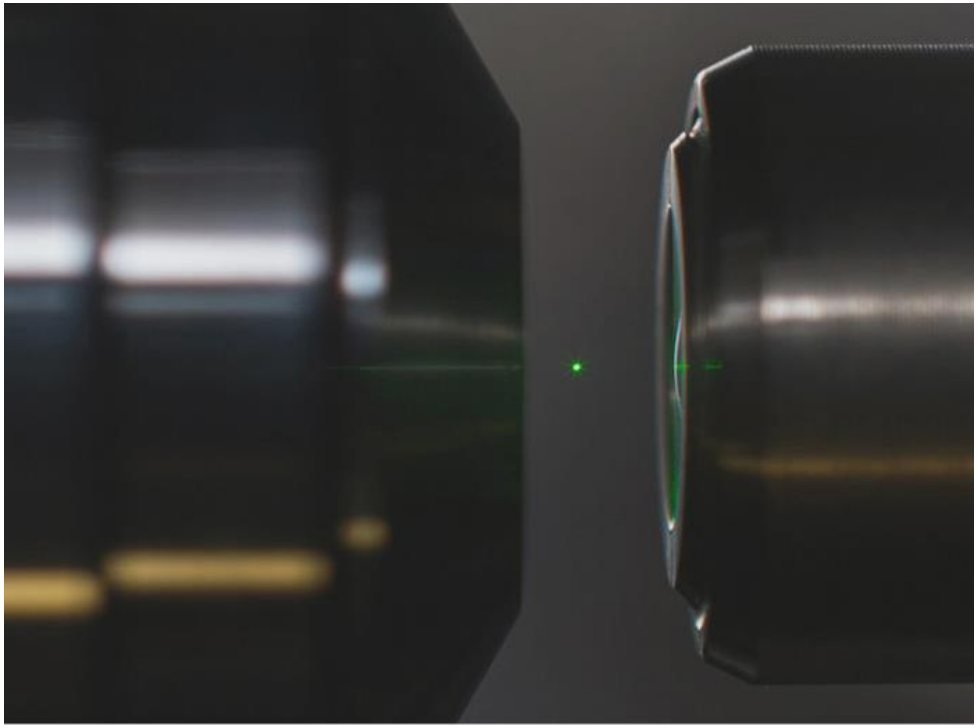
Multi-dimensional single-spin nano-optomechanics with a levitated nanodiamond

Levi P. Neukirch[1,2]*, Eva von Haartman[3], Jessica M. Rosenholm[3] and A. Nick Vamivakas[2,4]*





The Andromeda Study: A Femto-Spacecraft Mission to Alpha Centauri

Andreas M. Hein, Kelvin F. Long, Dan Fries, Nikolaos Perakis, Angelo Genovese, Stefan Zeidler, Martin Langer, Richard Osborne, Rob Swinney, John Davies, Bill Cress, Marc Casson, Adrian Mann, Rachel Armstrong

(Submitted on 11 Aug 2017)

Abstract

This paper discusses the physics, engineering and mission architecture relating to a gram-sized interstellar probe propelled by a laser beam. The objectives are to design a fly-by mission to Alpha Centauri with a total mission duration of 50 years travelling at a cruise speed of 0.1c. Furthermore, optical data from the target star system is to be obtained and sent back to the Solar system. The main challenges of such a mission are presented and possible solutions proposed. The results show that by extrapolating from currently existing technology, such a mission would be feasible. The total mass of the proposed spacecraft is 23g and the space-based laser infrastructure has a beam power output of 15GW. Further exploration of the laser – spacecraft trade-space and associated technologies are necessary.

Table 0-8: Dielectric multi-layer sail material properties

Material	Reflectivity [-]	Density [kg/m^3]	Emissivity [-]	Max. Temperature [K]	Max intensity [W/m^2]
Ag, SiO2, TiO2 5 layers	0.9961	1400	0.03	1235	1.0 10^6
Ag, SiO2, TiO2 15 layers	0.9999535	1400	0.03	1235	8.5 10^7
Cu, SiO2, TiO2 15 layers	0.9999294	1400	0.07	1360	1.9 10^8