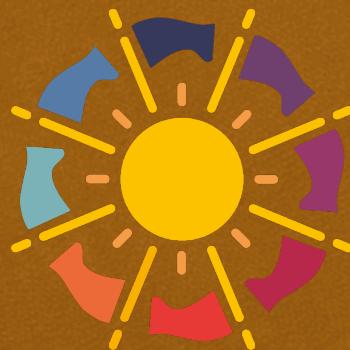


PHYS 3038 Optics

Lecture 1 Introduction



Shengwang Du



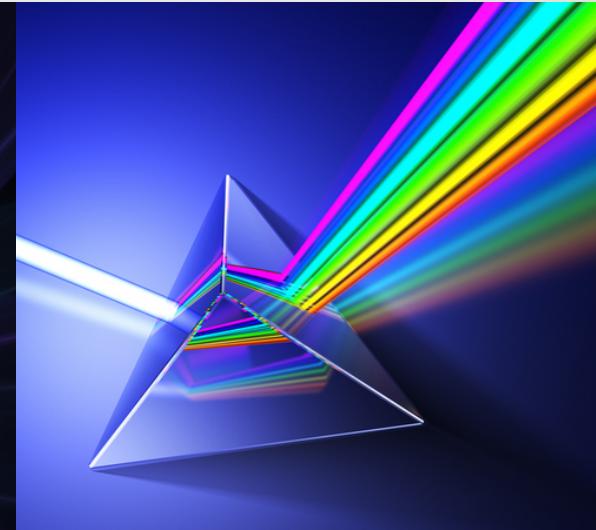
2015, the Year of Light

Optics : Light



❖ **Optics** is the branch of physics which involves the behavior and properties of **light**, including its interactions with matter and the construction of instruments that use or detect it.

(<https://en.wikipedia.org/wiki/Optics>)



2015: The International Year of Light

<http://www.light2015.org>



United Nations

A/RES/68/221



General Assembly

Distr.: General
12 February 2014

Sixty-eighth session
Agenda item 21 (b)

Resolution adopted by the General Assembly on 20 December 2013

[on the report of the Second Committee ([A/68/440/Add.2](#))]

**68/221. International Year of Light and Light-based Technologies,
2015**

2015: The Year of Light



<http://www.light2015.org>



Recognizing the importance of light and light-based technologies in the lives of the citizens of the world and for the future development of global society on many levels,

Stressing that enhanced global awareness of and increased education in the science and technologies of light are vital for addressing challenges such as sustainable development, energy and community health, as well as for improving the quality of life in both developed and developing countries,

Considering that the applications of light science and technology are vital for existing and future advances in, *inter alia*, medicine, energy, information and communications, fibre optics, agriculture, mining, astronomy, architecture, archaeology, entertainment, art and culture, as well as many other industries and services, and that light-based technologies contribute to the fulfilment of internationally agreed development goals, including by providing access to information and increasing societal health and well-being,

Considering also that technology and design can play an important role in the achievement of greater energy efficiency, in particular by limiting energy waste, and in the reduction of light pollution, which is key to the preservation of dark skies,

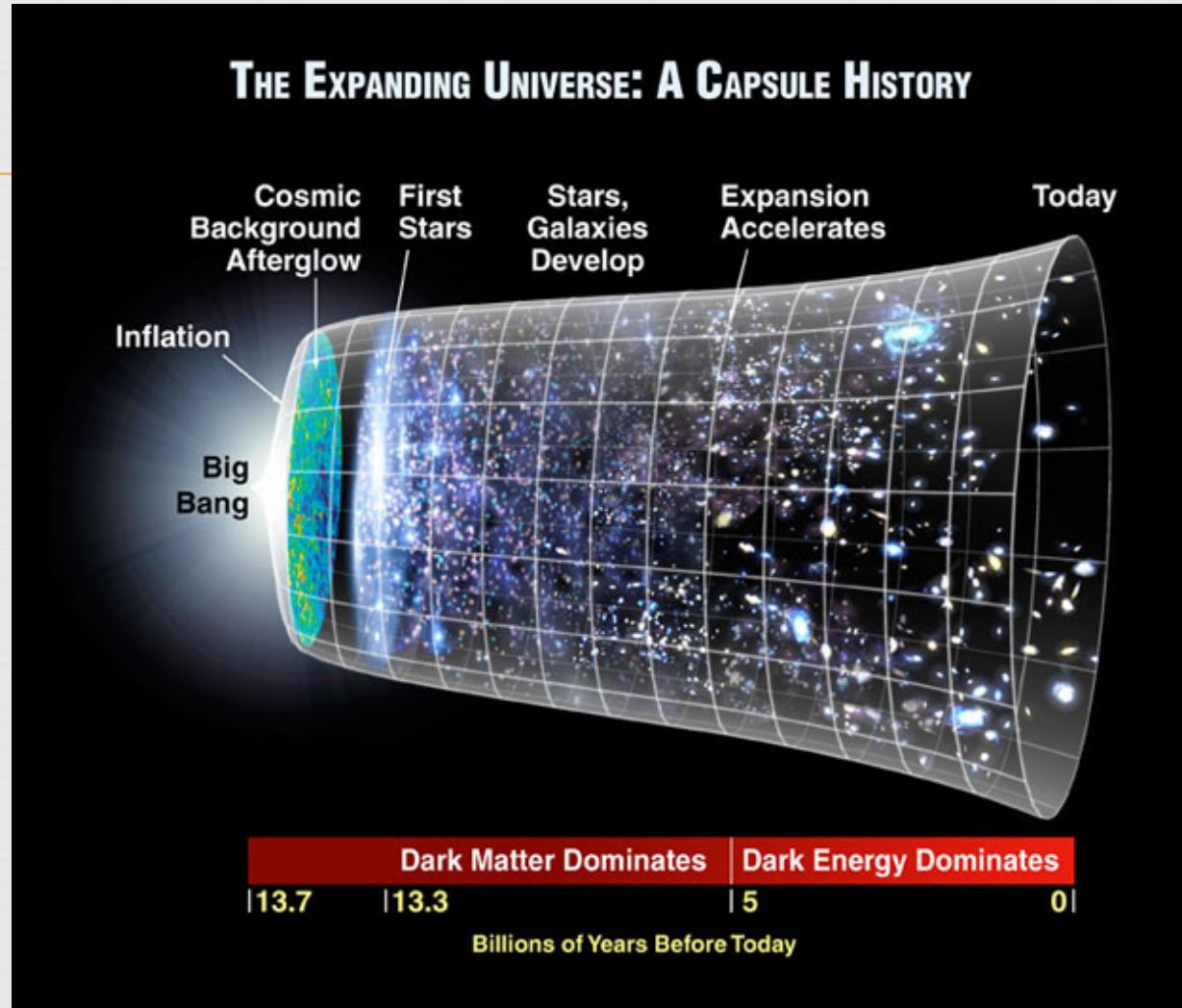
2015: The Year of Light



Noting that 2015 coincides with the anniversaries of a series of important milestones in the history of the science of light, including the works on optics by Ibn Al-Haytham in 1015, the notion of light as a wave proposed by Fresnel in 1815, the electromagnetic theory of light propagation proposed by Maxwell in 1865, Einstein's theory of the photoelectric effect in 1905 and of the embedding of light in cosmology through general relativity in 1915, the discovery of the cosmic microwave background by Penzias and Wilson and Kao's achievements concerning the transmission of light in fibres for optical communication, both in 1965,

<http://www.light2015.org>

A Brief History of Light

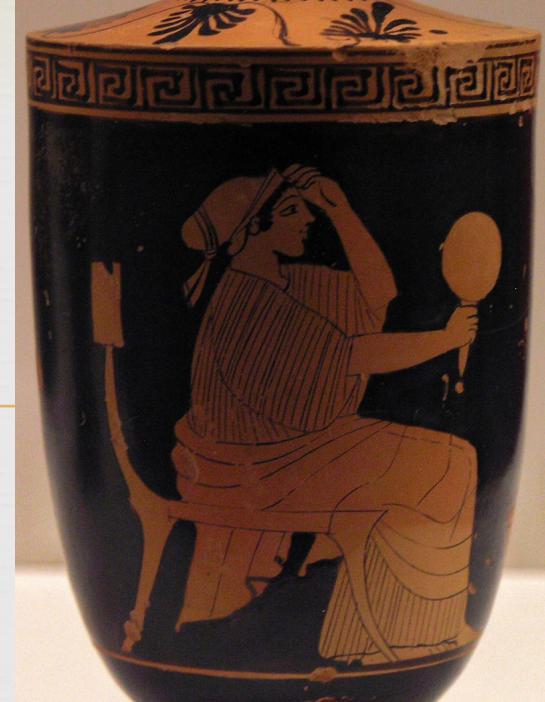


And God said, Let there be light; and there was light. [Bible-Genesis 1:3]

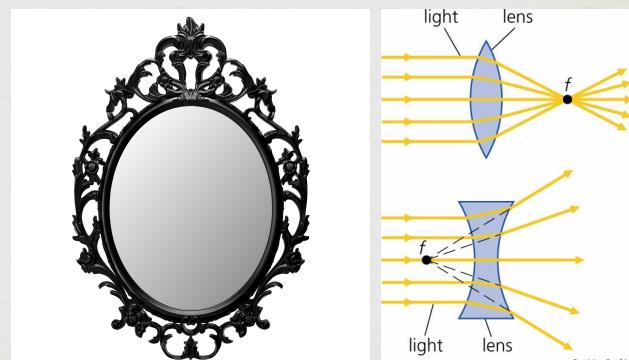
From the First Mirror to Lens (Geometric Optics)



- ❖ Anatolia (Turkey, 6000BC): polished stone
- ❖ Egypt (1900 BC): polished copper
- ❖ Bible Exodus 38:8 (1200 BC)
- ❖ Alhazen (1000 AD): law of reflection
- ❖ Franciscan Roger Bacon (1215-1294)
 - the 1st scientist in the modern sense
 - lens
- ❖ 16th century: positive and negative lens



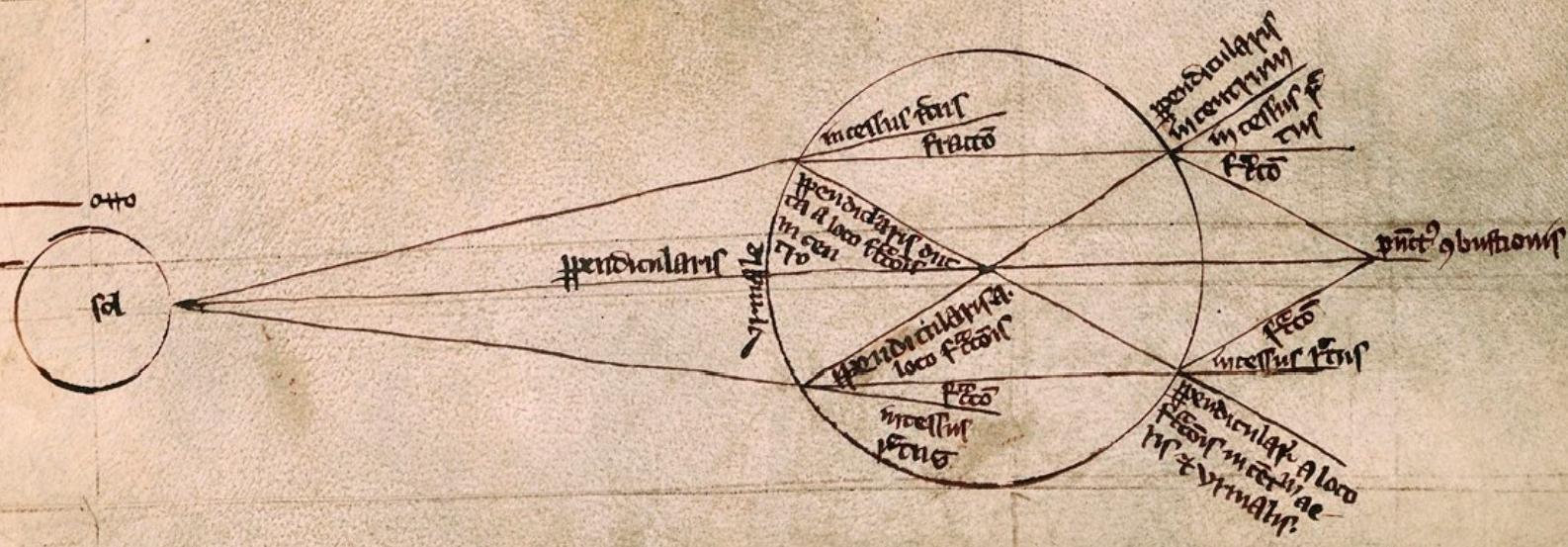
Seated woman holding a mirror.
Ancient Greek Attic red-figure
lekythos, ca. 470-460 BC, National
Archaeological Museum, Athens.



Bacon's idea of Telescope



temp
io appensu distan^a. A stellari polo erit minor cū finit i midionali linea
nisi exinde. Cu. ut finit i linea midio in loco a est p^{ro}priior p^{ro}p^{to}. d est
fini cap*o* minor; Sic i ipsa loco dehinc eadistans eq*uo* nati*o* maior i p*ro*xi*m*
aco minor. q*uod* actio p*ro* extre*m*e radu q*uod* sit i superficie q*uod* debet i n*on* a*cti*
o*n*o*m*o*r*o*s*.



17th - 18th Century

(Geometric Optics)



- ❖ 1608, Hans Lippershey: Invention of telescope
- ❖ Dutchman Zacharias Janssen (1588-1632):
Invention of microscope
- ❖ Antony Van Leeuwenhoek (1632-1723):
The first practical microscope
- ❖ Johannes Kepler (1571-1630)
Total internal reflection
- ❖ Willebrord Snel (1591-1626): Law of Refraction (1621)
→ Modern applied Optics

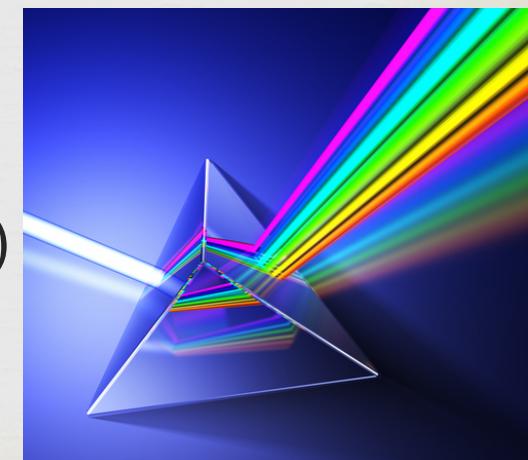


17th - 18th Century

(Wave/Particle Optics?)



- ❖ Maria Grimaldi (1618-1663, Bologna): diffraction
- ❖ Robert Hooke (1635-1703, London): Interference (1665)
 - Wave Optics: What kind of wave?
“every pulse or vibration of the luminous body will generate a sphere”
- ❖ Isaac Newton (1642-1727): Dispersion experiment
 - Light is particle (emission).
- ❖ Christian Huygens (1629-1695):
 - Wave theory
- ❖ Dane Ole Christensen Romer (1644-1710)
 - speed of light $2.3\text{--}2.4 \times 10^8$ m/s



19th Century: Wave Optics



❖ Thomas Young (1773-1829)

- Double-slit interference
- Transverse wave

❖ Augustin Jean Fresnel (1788-1827)

❖ Polarization: Newton (*Opticks*) , Huygens

❖ Speed of light: 3.153×10^8 m/s

❖ Electricity & Magnetism: Michael Faraday (1791-1867)

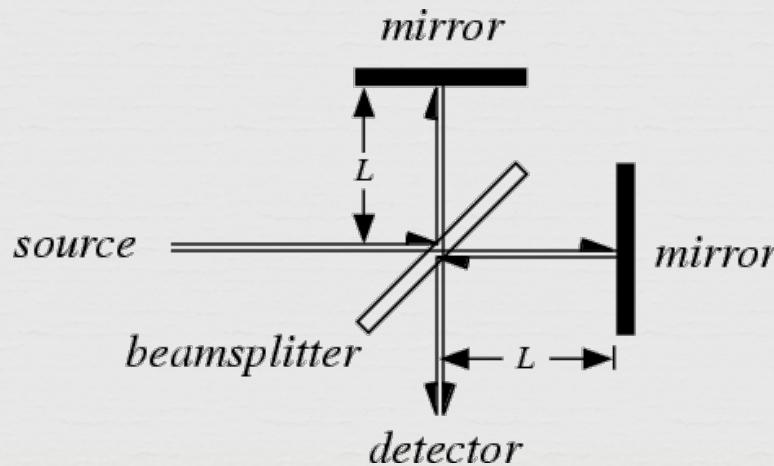
❖ James C. Maxwell (1831-1879): Maxwell Equations

$$c = 1 / \sqrt{\epsilon_0 \mu_0} \quad \rightarrow \quad \text{Light is EM wave!}$$

19th Century: Wave Optics



- ❖ 1888: EM waves generated, Heinrich Hertz
- ❖ Medium of light: Aether (a wrong concept)
- ❖ 1887: Michelson-Morley experiment
 - Aether does not exist → Light speed is constant



20th Century

Relativity & Quantum Theory of Light



- ❧ 1900, Plank distribution: quantum of light
- ❧ 1905, Albert Einstein: Special Relativity, $c = \text{constant}$
PE effect: light is particle
- ❧ 1923, Compton scattering
- ❧ 1925-26, Quantum mechanics
- ❧ 1953, Maser (Charles. Townes)
- ❧ 1960, Laser (T. H. Maiman)
- ❧ 1950-1960, Quantum theory of light → Quantum Optics
- ❧ 1962, Holography (Yuri Denisyuk)
- ❧ 1965, Fiber optical communication
- ❧