

*Optics & Photonics*  
*Introduction*

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- 1 Some History
  - Achievements in optics during the centuries
  - The Fizeau experiment (1849)

# Literature

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# Introduction to Optics

## Some History

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## Some History

### In the beginning

- Exodus 38:8 ca. 1200 B.C., "the **looking-glasses** of the women"
- 1900 B.C., specimens from ancient Egypt, a **mirror** in perfect conditions was unearthed
- Greek philosophers Pythagoras, Democritus, Empedocles, Plato, Aristotle and others developed several **theories of the nature of light**
- 424 B.C., the **burning glass** was alluded to by Aristophanes
- 50 A.D., **refraction** was studied by Cleomedes and later in 130 A.D. by Ptolemy
- 3 B.C. - 65 A.D., Roman philosopher Seneca identified a water-filled glass globe has **magnifying properties**

# Introduction to Optics

## Some History

### In the beginning (2)

- *during the **Dark Ages** in Europe, the center of scholarship shifted to the Arab world (Alhazen, 1000 A.D., elaborated the law of refraction, studied mirrors, description of the human eye)*
- 1215-1294, Roger Bacon, initiated the idea of using **lenses to correct vision** and to **combine lenses to form a telescope**
- 1452-1519, Leonardo da Vinci described the "camera obscura"

# Introduction to Optics

## Some History

### From the seventeenth century

- Hans Lippershey (1587-1619), first patent on a **refracting telescope**
- Galileo Galileo (1564-1642), heard about the invention and built his own instrument
- Zacharias Janssen (1588-1632), invention of the **compound microscope**, improved by Francisco Fontana (1580-1632)
- Johannes Kepler (1571-1630) changed the telescope by means of the detection of **total internal reflection** and evolved a **treatment of first-order optics for thin-lens systems**
- Willebrord Snel (1591-1626) discovered the "**law of refraction**" (1621)
- René Descartes (1596-1650), formulation of the "**law of refraction**" **in terms of sines**

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## Some History

### From the seventeenth century (2)

- Pierre de Fermat (1601-1665), law of refraction derived from his "**principle of least time**"
- Francesco Maria Grimaldi (1618-1663) denotes the **phenomenon of diffraction** the first time
- Robert Hooke (1635-1703) first studied the coloured **interference patterns** generated by thin films
- Sir Isaac Newton (1642-1727) concluded that **light is a mixture of a whole range of independent colors**. Theory of an aether which is excited by light to characteristic vibrations. Experiments on dispersion and chromatic aberrations. Rejected the wave theory as rectilinear was not explained at this time by the propagation of waves



# Introduction to Optics

## Some History

### From the seventeenth century (3)

- Christiaan Huygens (1629-1695) extended the wave theory as he correctly concluded that **light slows down when entering optically dens media**. He explained the law of refraction and reflection as well as double-refraction using **wave theory**. He discovered the phenomenon of **polarization**
- Ole Christensen Römer (1644-1710) concluded the position of the Jupiter moon Io arising from the assumption of a **finite speed of light**
- Leonhard Euler (1707-1783) proposed that chromatic aberrations might be compensated by achromatic lenses, built a similar way than the human eye. Samuel Klingenstjerna (1698-1765) determined Euler's theory to be in error

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## Some History

### From the seventeenth century (4)

- John Dollond (1706-1761) combined two elements in 1758 to perform an **achromatic lens**. His work was preceded by the unpublished work of Chester Moor Hall (1703-1771)

# Introduction to Optics

## Some History

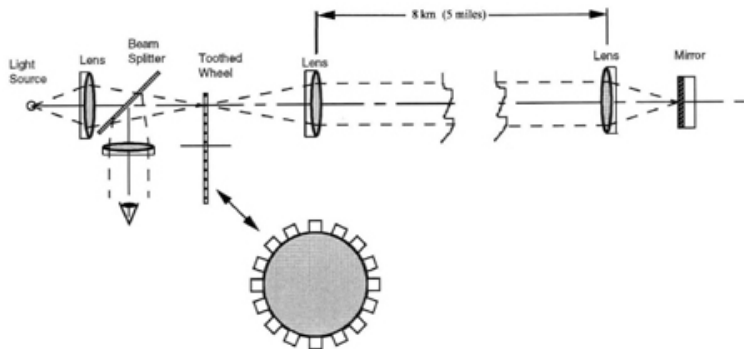
### The nineteenth century

- Thomas Young (1773-1829) extolled the wave theory and added the fundamental **concept of interference**
- Augustin Jean Fresnel (1788-1827) synthesized the concept of Huygens wave description and the interference principle by the view of **secondary wavelets**
- Etienne Louis Malus (1775-1812) discovered that the **polarization of light also arises upon reflection** and that the phenomenon was not inherent to crystalline media. This observation was inexplicable within the framework of longitudinal waves. Thomas Young proposed the **concept of transverse waves** as it occurs on a string
- Armand Louis Fizeau (1819-1896) performed the first **terrestrial determination the speed of light**. Jean Bernard Foucault (1819-1868) was involved in this experiment

# Introduction

## History

### The Fizeau experiment (1849)



**Figure :** Fizeau's experiment to measure the speed of light. Fizeau measured 301.000 km/s (Source: Optimedia SPIE press books open for reference)

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### The nineteenth century (2)

- Michael Faraday (1791-1867) established the **interrelationship of electromagnetism and light**
- James Clerk Maxwell (1831-1879) summarized and extended all the empirical knowledge on the subject in a single set of equations, the **Maxwell equations**. The speed of light was now formulated in terms of electric and magnetic properties of the medium it traverses
- Heinrich Hertz (1857-1894) verified the conclusions of Maxwell's equations by experiment, i.e. "light is an electromagnetic disturbance in the form of waves"

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### Twentieth century optics

- Jule Henry Poincare (1854-1912) observed the significance of the experimental inability to observe any effect of motion relative to the aether and therefore **put the aether theory in question**
- Albert Einstein (1879-1955) introduced his "**Special Theory of Relativity**" which independently rejected the aether theory. Former experiments were explained quite naturally in **Einstein's relativistic kinematics**. Since then, light was seen as a self-sustaining wave, able to propagate through free space
- Max Planck (1858-1974) introduced the beginnings of the **Quantum Mechanics**, a theory on submicroscopic phenomena. Based on these ideas, Einstein proposed a new form of the corpuscular theory in which he asserted that light consists of globs or "particles" of energy, each such a **quantum called a "photon"**

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### Twentieth century optics (2)

- **Classic optical theory was brought together with the Fourier theory**
- Fourier Optics introduced the concept of spatial frequencies, image filtering, evaluation and formation as well as the concept of transfer functions
- **First laser** in 1960
- Single and multilayer anti-reflection coatings
- **use of the infrared spectrum** for surveillance systems and laser missile guidance
- **Fibre optics** for digital communication systems
- **Electro-optic** and **acousto-optic** modulators
- **Wavefront reconstruction** technique (holography)