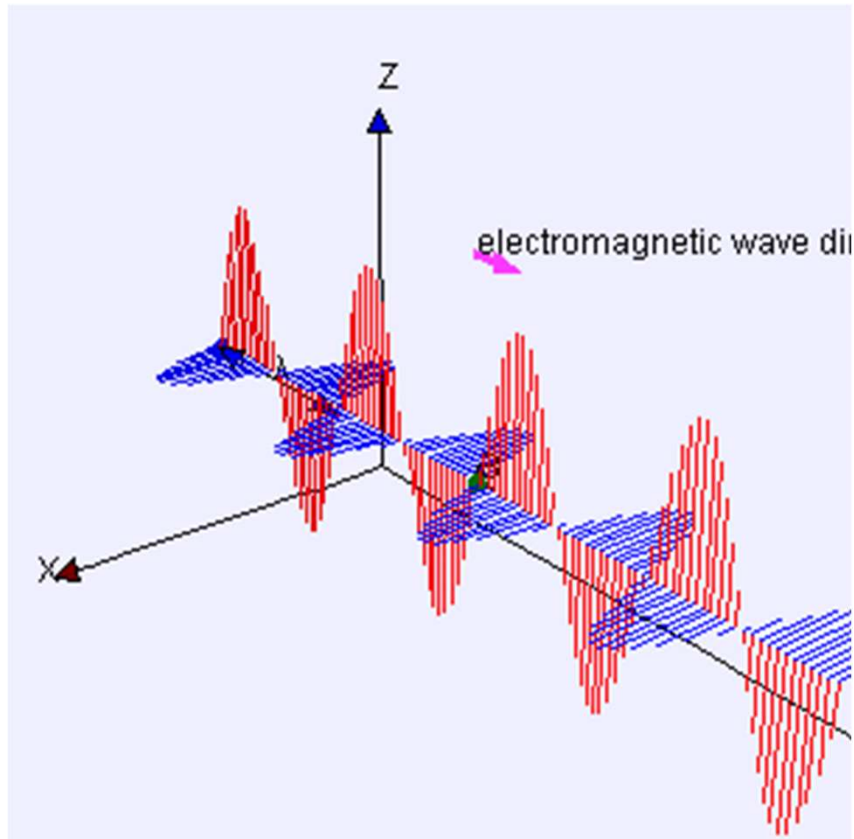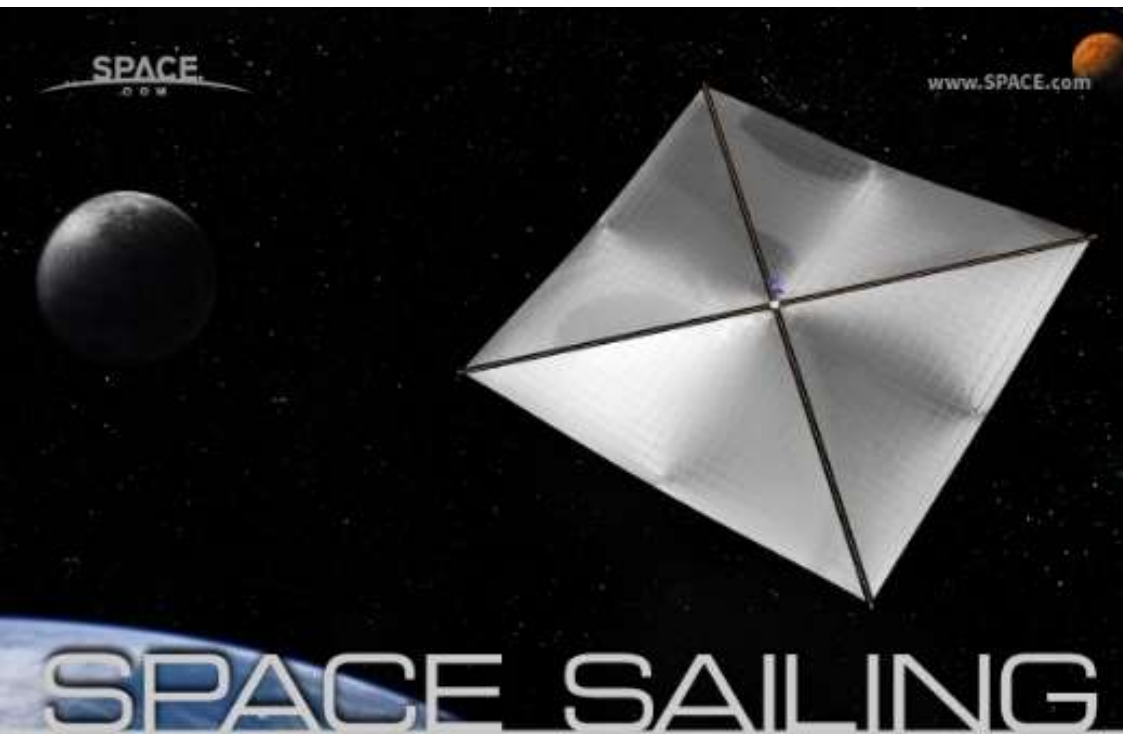# Electromagnetic Waves

electromagnetic wave di...

James Clerk Maxwell
Scottish Theoretical Physicist
(1831–1879)

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$$

$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I + \epsilon_0 \mu_0 \frac{d\Phi_E}{dt}$$
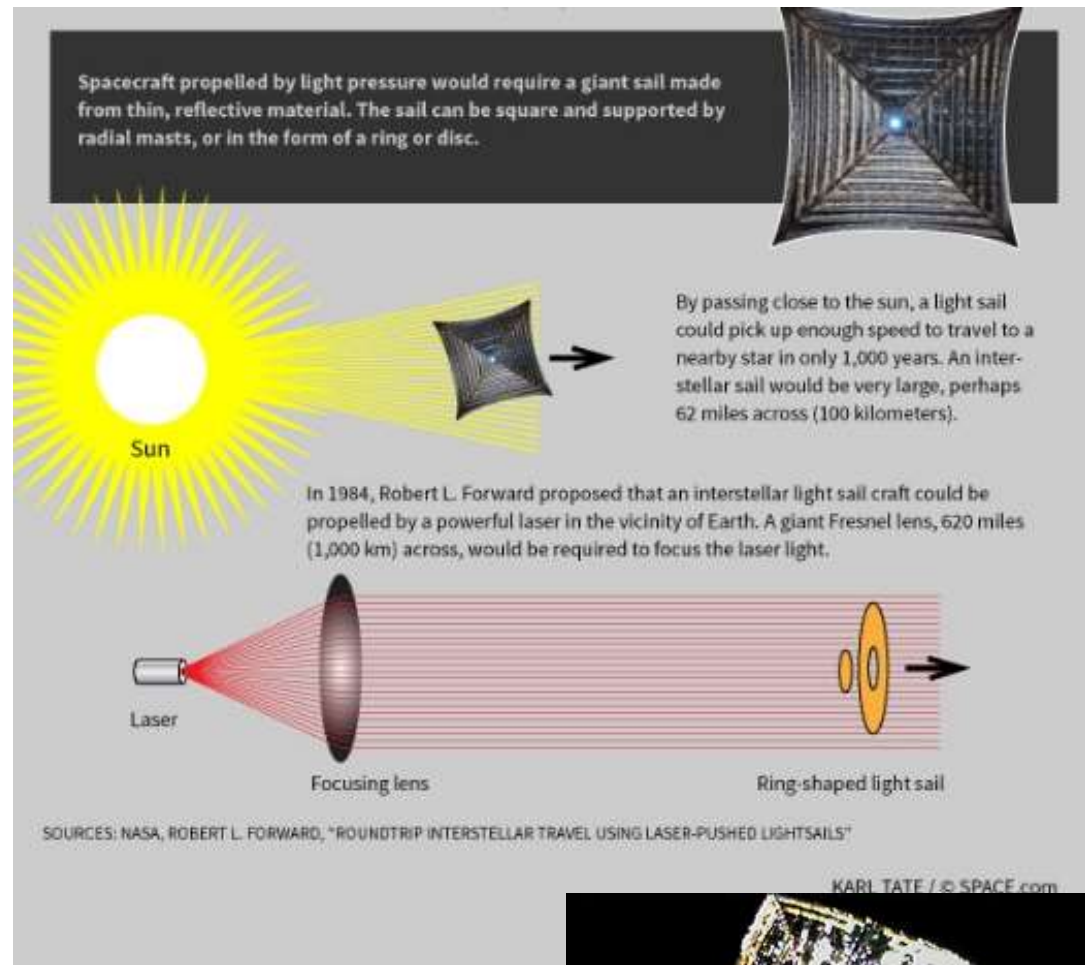
SPACE SAILING

Light exerts pressure on objects on which it shines. If collected on a large enough surface, the pressure of light can be used for space propulsion. Light sail craft have already been tested in Earth orbit, and could also be used for interplanetary or interstellar travel.
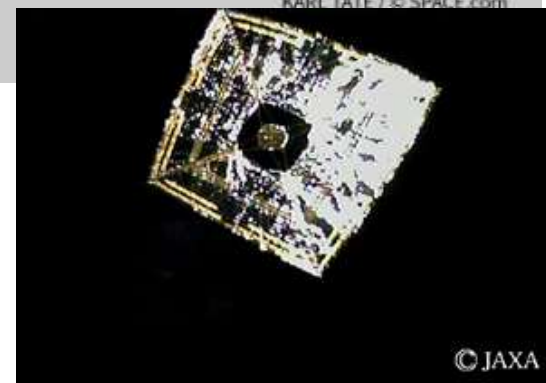
PHOTO: A71 STIXENDORF / MICHAEL JÄGER

German astronomer Johannes Kepler noticed in the early 1600s that a comet's tail points away from the sun, and he hypothesized that the pressure of the sun's light might be responsible.

Spacecraft propelled by light pressure would require a giant sail made from thin, reflective material. The sail can be square and supported by radial masts, or in the form of a ring or disc.

Sun

By passing close to the sun, a light sail could pick up enough speed to travel to a nearby star in only 1,000 years. An interstellar sail would be very large, perhaps 62 miles across (100 kilometers).

In 1984, Robert L. Forward proposed that an interstellar light sail craft could be propelled by a powerful laser in the vicinity of Earth. A giant Fresnel lens, 620 miles (1,000 km) across, would be required to focus the laser light.

Laser

Focusing lens

Ring-shaped light sail

SOURCES: NASA, ROBERT L. FORWARD, "ROUNDTRIP INTERSTELLAR TRAVEL USING LASER-PUSHED LIGHTSAILS"

KARL TATE / © SPACE.com

IKAROS project (2010)

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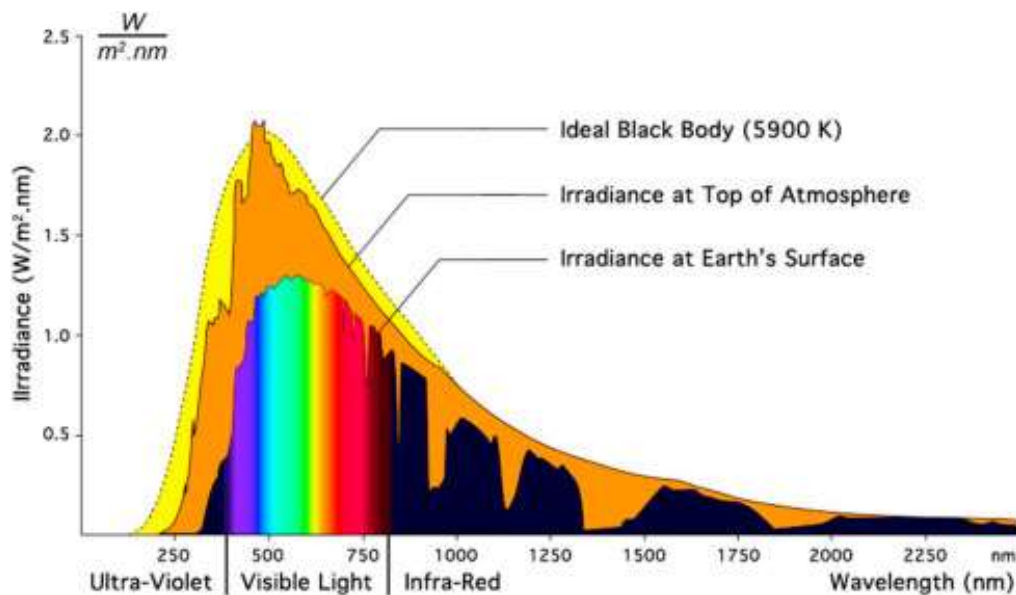# The Spectrum of Electromagnetic Waves

Solar spectrum