Telescopes across the electromagnetic spectrum
Maxwell’s Equations

Electric field
\[ \oint_S \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0} \]
\[ \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_M}{dt} \]

Magnetic field
\[ \oint_S \vec{B} \cdot d\vec{A} = 0 \]
\[ \oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enc}} + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} \]

\[ E \propto -\mu_0 \epsilon_0 \frac{d^2 E}{dt^2} \]
Whenever a charge *accelerates* a kink is created.
Color
Color
Why can’t I see other waves?
Increasing wavelength

Increasing energy

Gamma rays
X rays
Ultraviolet
Infrared
Microwaves
Radio

Wavelength (m)

Frequency (s⁻¹)

Visible

Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).

Visible Light observable from Earth, with some atmospheric distortion.

Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).

Radio Waves observable from Earth.

Long-wavelength Radio Waves blocked.
Unnatural sources of light
Radio
Synchrotron light source
Synchrotron light source
Natural Light Sources
Optical telescopes in Hawaii
Solar spectrum
Solar optical telescope
Infrared Venus & Trifid Nebula (cold)
Spitzer satellite
Planetary disk (very cold)
Atacama Large Millimeter Array
Cosmic Microwave Background (2.7 K)
Radio galaxy
VLA
Moon to scale

2 minutes of data, dark field, signal dominated
Ultra-violet sun (hot)
X-rays (very hot)
NuSTAR
NASA's new satellite telescope

The Columbia-designed optic that will concentrate X-rays on the NuSTAR telescope.

X-rays converge at a focal point.

X-rays, invisible to the eye, enter the NuSTAR telescope.
gamma-ray sky
Fermi telescope