Infrared Astronomy
In 1800 William Herschel discovered “invisible light”

It’s energy with all the same characteristics as visible light, but is not sensed by the human eye

The light Herschel discovered was just beyond the red part of the spectrum. So it was named “infrared”
The Spectrum of Light

- Visible light is a tiny fraction of the Electromagnetic Spectrum
- Gamma rays—billions of waves per inch
- Radio waves—up to miles-long wavelengths
The Physics of Light

- All objects in the Universe emit light depending on their temperature.
- Cool objects emit primarily long wavelength light.
- Hot objects emit primarily short wavelength waves.
The Physics of Light

Objects emit light depending on their temperature.

Cool objects emit primarily long wavelength light

- Human
  - Infrared
  - 33°C (306 Kelvin)

- Electric Stove
  - Red Light
  - 4,130°C (4,400 Kelvin)

Hot objects emit primarily short wavelength light

- Spot Light
  - White Light
  - 5,230°C (5,500 Kelvin)

- Lightning Bolt
  - Ultraviolet Light
  - 30,000°C (30,273 Kelvin)

Hot objects emit primarily short wavelength light.
Infrared light lies just beyond the red portion of the visible spectrum ("below red"). Infrared wavelengths are about 0.7 to 350 microns.

(a micron is one-millionth of one meter, or about 1/50th the width of a human hair).
## The Range of Infrared Light

<table>
<thead>
<tr>
<th>SPECTRAL REGION</th>
<th>WAVELENGTH RANGE (microns)</th>
<th>TEMPERATURE RANGE (degrees Kelvin)</th>
<th>WHAT WE SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near-Infrared</td>
<td>0.7 – 5</td>
<td>740 – 5,200</td>
<td>Cooler red stars</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Red giants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dust is transparent</td>
</tr>
<tr>
<td>Mid-Infrared</td>
<td>5 – 40</td>
<td>93 – 740</td>
<td>Planets, comets and asteroids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dust warmed by starlight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Protoplanetary disks</td>
</tr>
<tr>
<td>Far-Infrared</td>
<td>40 – 350</td>
<td>11 – 93</td>
<td>Emission from cold dust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Central regions of galaxies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very cold molecular clouds</td>
</tr>
</tbody>
</table>
Getting the WHOLE picture

An object can look radically different depending on the type of light collected from it:

Since shortly after Herschel discovered infrared light astronomers have been observing astronomical objects in Infrared Light to get a more complete picture.
Why Study Infrared?

- **Visible**: dark nebula, heavily obscured by interstellar dust (“Horsehead Nebula”)
- **Near-Infrared**: dust is nearly transparent, embedded stars can be observed forming
- **Mid- and Far-Infrared**: glow from cool dust is directly observable
Why Study Infrared?

- Cool objects--like newly forming stars and solar systems--emit almost exclusively in the Infrared
Infrared penetrates intervening dust clouds, allowing us to see through or into them.
But there’s a Challenge...

- Earth’s atmospheric water vapor absorbs almost all incoming infrared radiation
- Even mountain-top observatories get a limited view of the infrared universe

Infrared telescopes need to observe from high altitude or in space
NASA’s Infrared Missions

Spitzer Space Telescope

WISE

SOFIA

James Webb Space Telescope
Visible Light
Constellation Orion

Mid Infrared Light

IRAS
Trifid Nebula

Visible Light

NOAO
Trifid Nebula

Infrared Light

Spitzer
Orion Nebula

Visible Light
Orion Nebula

Infrared Light

Spitzer
Sombrero Galaxy

Visible Light

HST
Sombrero Galaxy

Infrared Light

Spitzer
The Whole Sky

Visible Light - Axel Mellinger
The Whole Sky

Near Infrared Light - 2MASS Survey
The Whole Sky

Mid/Far Infrared Light - IRAS Survey