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”
• “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
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>
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<td></td>
<td></td>
<td></td>
<td>Red giants</td>
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<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>
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<td></td>
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<td></td>
<td>Dust warmed by starlight</td>
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<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>
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.
Constellation Orion

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

Near Infrared Light - 2MASS Survey
The Whole Sky

Mid/Far Infrared Light - IRAS Survey
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

Dust Ring Around Young Star

HR4796A

Ring Width
1.6 Billion Miles

Ring Diameter
13 Billion Miles
Why Study 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
WISE will map the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the Universe.

WISE will deliver to the scientific community:

- Over 1 million images covering the whole sky in 4 infrared wavelengths
- Catalogs of ≈ 500 million objects seen in these 4 wavelengths

wise.astro.ucla.edu
Two decades ago IRAS gave us what is still our best view of the mid-infrared sky.
WISE will map the entire sky with resolution comparable to the view shown here.
WISE will be launched in late 2009.

It will orbit Earth cartwheeling once per orbit to always stay pointing straight up and will always keep its solar panels to the Sun.

As Earth orbits the Sun, WISE’s orbit also rotates to maintain the spacecraft’s orientation to Earth and Sun.
Each image exposure will last 11-sec and is matched to the orbit.

Each orbit, a circular strip of the sky is imaged.

As the orbit itself rotates, a slightly different strip is imaged.

In 6 months, the entire sky is imaged.

There will be 8 or more exposures at each position over more than 99% of the sky.
WISE will survey the sky in two near infrared channels: 3.3 and 4.7 μm

WISE will survey the sky in two mid-infrared channels: 12 and 23 μm
WISE will detect most of the Main Belt asteroids larger than 3 km, providing reliable diameters for them.
A simulated composite WISE image demonstrates how the motion of an asteroid will be easily detected.

WISE’s Education Program will allow students to search for asteroids themselves.
WISE Science: Cool Stars

WISE will find the coolest and closest stars to the Sun
Red and Brown Dwarf stars are the most common type of star. They have lowest masses and are the coolest stars. They emit most of their energy in infrared light and are faint.
Known Stars within 25 light-years
WISE Science: Cool Stars

WISE Stars within 25 light-years
WISE Science: The Milky Way

Centaurus Tangent Region
from the Spitzer-GLIMPSE Survey

WISE will image the entire Galactic Plane
WISE Science: Extragalactic

WISE will image all nearby galaxies

Composite 3.6-24 microns

Galaxy M81
2MASS Surveyed Large Scale Structure out to 1.3 Billion Light-years (z ~ 0.1)
WISE will survey out to 6.7 Billion Light-years (z ~ 0.5)
WISE will find the most luminous galaxies in the Universe: Ultra-luminous Infrared Galaxies (ULIRGs)

ULIRGs are merging galaxies whose collisions lead to dust-enshrouded bursts of star formation.
WISE Mission: Spacecraft

A cold 40 cm telescope in Earth orbit
Enabled by new megapixel infrared detector arrays

By being in space, the 40 cm WISE telescope is as powerful as 6,000 8-meter telescopes on the ground!
Uses solid hydrogen to cool optics and detectors down to near absolute zero.
WISE Mission: Detectors

Mid Infrared Detector Array

Near Infrared Detector Array

1024² Si:As Detector

1024² HgCdTe Detector in Focal Plane Mount Assembly
The WISE End-to-End Optical System with Embedded Scanner

Afocal/Imager Mount Interface

Primary Mirror

Baffles and vanes minimize stray light

Spider and secondary mirror

Afocal Structure

Entire assembly mounts at a single cryostat interface ring

Aluminum baffle tube

Scanner mounts to imager optics module

Imager module provides common imaging optics for all 4 channels
WISE will use a scan mirror to stabilize the line-of-sight while the spacecraft scans the sky.
Note: the M2 and M1 baffle cones were not installed at time of photo
The WISE E/PO Program is a multifaceted enterprise bringing together a veritable who’s who of professionals in formal and informal astronomy education.

The WISE E/PO program will inspire students, teachers, and the public at large to appreciate, understand, and take part in the WISE mission.