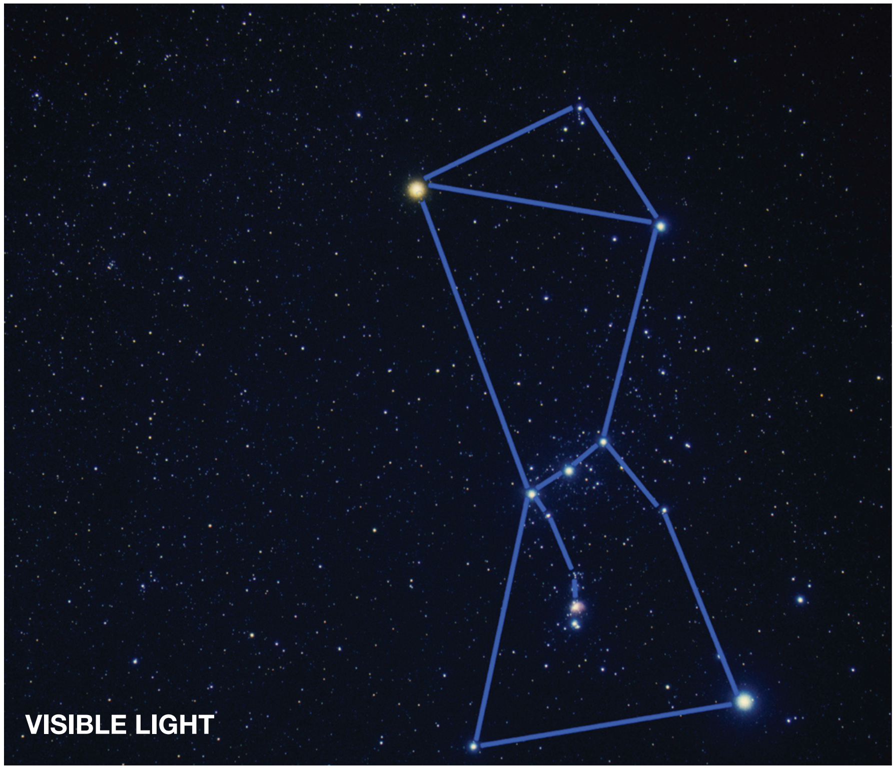
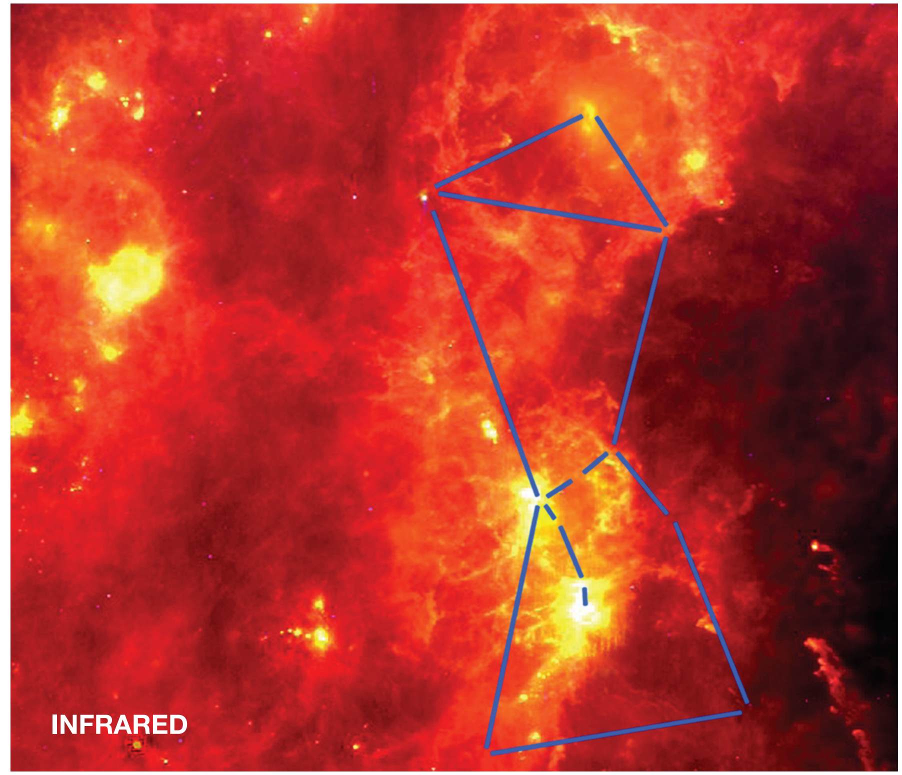
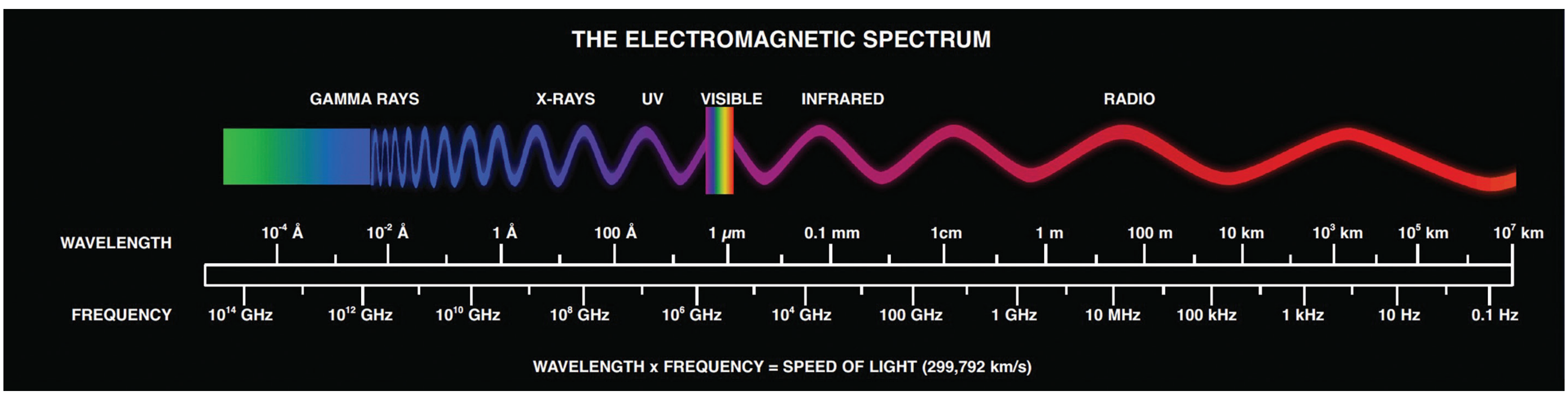
Infrared Astronomy: More Than Our Eyes Can See





These views of the constellation Orion dramatically illustrate the difference between the familiar, visible-light view and the richness of the universe that is invisible to our eyes, though accessible via other parts of the electromagnetic spectrum.



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Invisible Light. In 1800, William Herschel discovered an invisible form of radiation just beyond the red portion of the visible spectrum. He named this form of radiation infrared ("below" red). (Herschel was already world-famous for having discovered the planet Uranus.) Herschel's discovery was the first step in establishing the existence of what we now call the electromagnetic spectrum. Visible light and infrared radiation are just two of the many types of electromagnetic energy produced by objects on Earth and throughout the universe. Only by studying all of these types of radiation can we fully characterize celestial objects and gain a complete picture of the universe, its history, and its evolution.

Studying the Hidden Universe. The heat that we feel from our Sun or from a fireplace is infrared (sometimes called thermal) radiation. Even objects that we think of as being very cold, such as ice cubes, emit infrared radiation. Measuring the infrared energy arriving from astronomical objects is difficult because much of it is blocked by water vapor and other molecules in Earth's atmosphere. Therefore, most infrared astronomers use airborne telescopes, balloon payloads or space telescopes to study the thermal radiation from celestial objects. The telescopes and detectors used by infrared astronomers emit their own infrared radiation. To minimize this interference, and to be able to detect the much weaker radiation from celestial objects of interest, infrared astronomers refrigerate their instruments and even entire telescopes to temperatures as cold as –269 °C (–452 °F) — almost absolute zero!

Building New Stars. The visible and infrared images shown on the other side of this lithograph are of exactly the same region of the sky containing the constellation Orion. These images dramatically illustrate how features that cannot be seen in visible light show up very brightly in the infrared. The infrared image shows several regions of hot, dense cores within clouds of gas and dust. These are the stellar nurseries where new stars like the Sun and planets like the Earth are being born. Embedded in these molecular clouds, the young stars are difficult to see in visible light, but their presence is revealed by infrared radiation.

The interstellar medium (ISM) in our Milky Way galaxy is the dust and gas between the stars. Some of it is primordial, dating back to the origin of the universe, and some has been added by the violent deaths of massive stars in supernova explosions, or in gentler episodes when the outer layers of some stars are blown off near the ends of their lives. The ISM is the reservoir of material from which new stars form. Clouds of interstellar dust and gas are easily detected at long infrared wavelengths (about 100 times longer than visible radiation). To see the newborn stars embedded in these clouds of dust and gas, astronomers depend instead on observations made at short infrared wavelengths that penetrate the obscuring dust.

Building New Planets. In the 1980s and 1990s, using data from the *Infrared Astronomical Satellite (IRAS)* and the *Hubble Space Telescope (HST)*, astronomers discovered disks of dust around over a hundred nearby stars. These disks contain the raw materials from which planetary solar systems are formed: as such, these disks provided the first tantalizing evidence that planets orbiting stars are probably common occurrences.

Understanding Galaxies. Our view of distant regions of the Milky Way galaxy, including the galactic center, is heavily obscured by the ISM at wavelengths of visible light. The galactic center is one of the brightest sources of infrared radiation in the sky. Infrared observations show that this region consists of very dense crowds of stars and clouds of gas which orbit the galactic center unexpectedly rapidly — evidence of the gravitational influence of a massive central black hole.

Observing the Past. When we observe galaxies at distances of billions of light years, we see them as they existed billions of years ago because of the finite speed of light. Moreover, the universe is known to be expanding, producing a shift in the measured wavelength of radiation relative to the wavelength at which it was emitted. This shift of the visible radiation toward the red end of the electromagnetic spectrum is known as the "cosmological red shift." If the emitting objects are sufficiently far away (long ago), the radiation received is shifted from the visible spectrum into the infrared. Thus, infrared observations provide a glimpse of the early universe, an era when the first stars and galaxies were forming.

Infrared Astronomy. NASA has sponsored several exciting infrared research programs:

• The *Spitzer Space Telescope* (known before its launch in 2003 as the *Space Infrared Telescope Facility, or SIRTF)* completes NASA's multi-wavelength set of "Great Observatories" which also includes the *Hubble Space Telescope*, the *Compton Gamma Ray Observatory*, and the *Chandra X-ray Observatory*. *Spitzer*, with an 85 centimeter (33 inch) diameter telescope studied the universe at wavelengths from 3 to 160 microns during the 5½ year lifetime of its cryogen supply. (*Spitzer* continues to operate part of its near infrared camera, IRAC, at ambient temperature.)

• The *Stratospheric Observatory For Infrared Astronomy (SOFIA)* is a Boeing 747SP airplane modified to carry a telescope with a diameter of 2.7 meters (106 inches). Flying above 12km (39,000 feet), *SOFIA* avoids most of our atmosphere's obscuring effects and is able to study the universe using wavelengths from ultraviolet to sub-millimeter, concentrating on the far-infrared and sub-millimeter ranges enabled by its operating altitude. *SOFIA*'s scientific instruments are especially well suited for comparing how stars form in our Milky Way galaxy versus other galaxies, understanding processes by which the interstellar medium is created and evolves, and investigating the production of organic compounds in space. *SOFIA* is a joint project of NASA and the German Aerospace Center, DLR.

• The *Wide-field Infrared Survey Explorer (WISE)* is a NASA space telescope mission launched in December, 2009 that operated for 10 months until its cryogen supply was depleted. It mapped the entire sky in infrared light with 500 times greater sensitivity than previous space-borne infrared survey missions. Astronomers continue to analyze *WISE* data to study the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe.

• The *James Webb Space Telescope (JWST)* is a near- and mid-infrared space mission which will have high sensitivity and spatial resolution, giving us the best views yet of the sky in those wavelength ranges. *JWST* will be used to study the early universe and the formation of galaxies, stars and planets.

For more information:

www.spitzer.caltech.edu (Spitzer Space Telescope)
www.sofia.usra.edu (SOFIA science project)
wise.ssl.berkeley.edu (WISE space telescope)
www.jwst.nasa.gov (James Webb Space Telescope)
coolcosmos.ipac.caltech.edu (infrared light and infrared astronomy tutorial)

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SOFIA Science Project

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www.nasa.gov/sofia
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