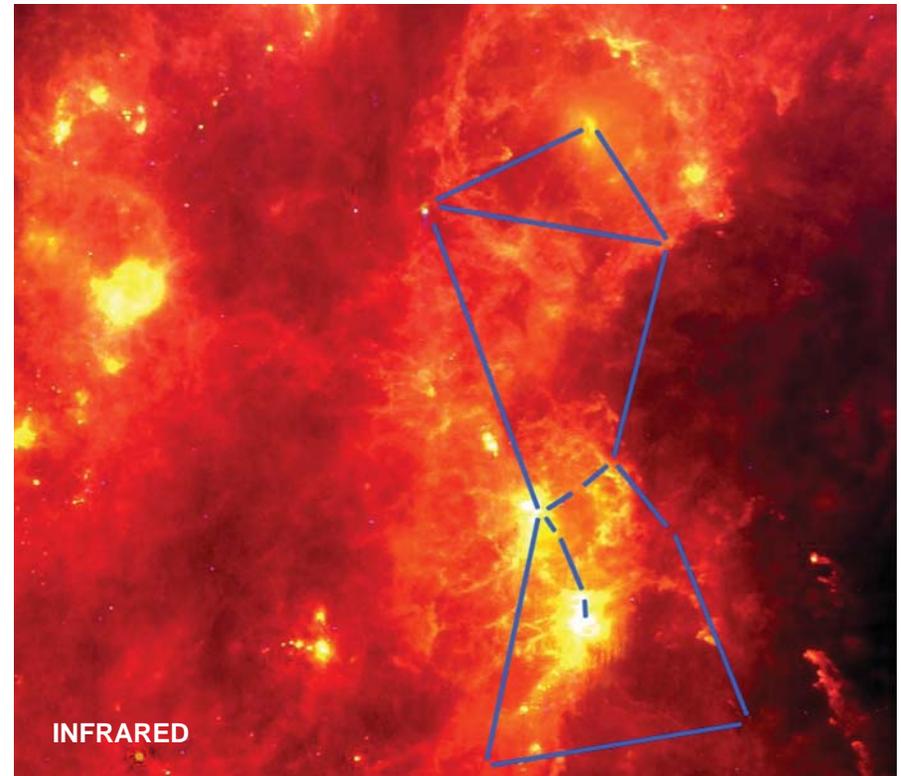
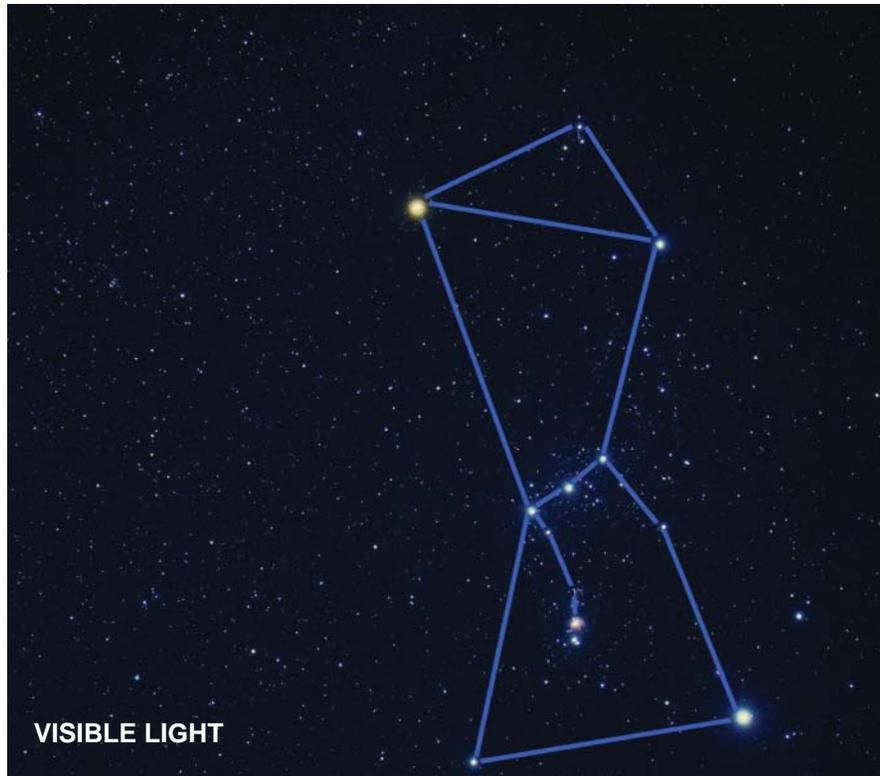


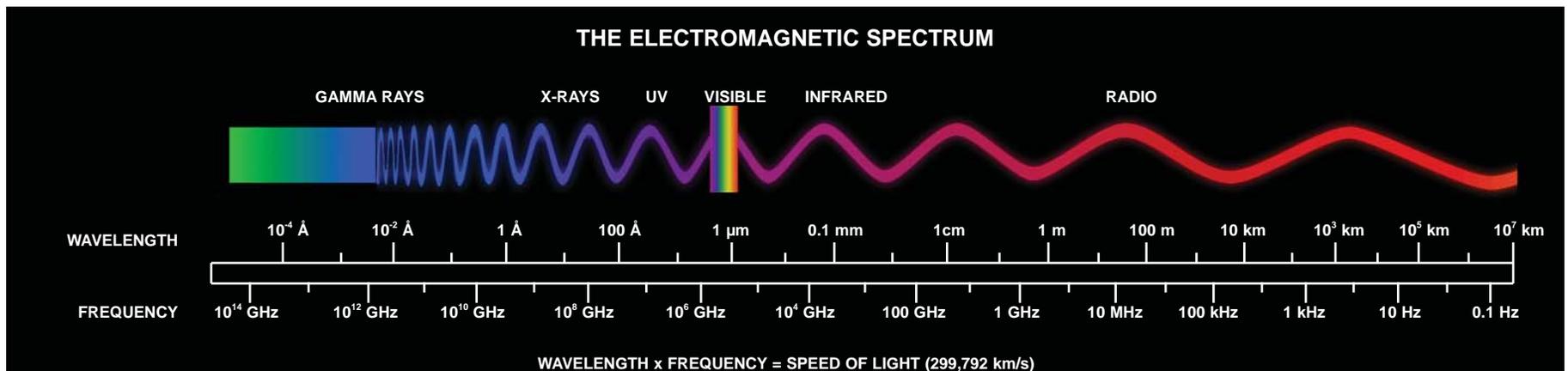


National Aeronautics and  
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## Infrared Astronomy: More Than Our Eyes Can See



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 in other parts of the electromagnetic spectrum.





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In 1800, Sir 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’s discovery was the first step in establishing what we now call the electromagnetic spectrum. Visible light and infrared radiation are just two of the many types of energy produced by all objects on Earth and throughout the universe. Only by studying all of these types of radiation can we characterize celestial objects and gain a complete picture of how the universe was formed and is changing.

**Studying the Hidden Universe.** The heat that we feel from our Sun or from a fireplace is infrared radiation (thermal energy). Even objects that we think of as being very cold, such as ice cubes, emit thermal energy. Measuring the infrared energy from astronomical objects is difficult because most of it is blocked by Earth’s atmosphere. Therefore, most infrared astronomers use spaceborne telescopes to study the thermal emission from celestial objects.

The telescopes and detectors used by infrared astronomers emit thermal energy of their own. To minimize these contaminating influences, and to be able to detect the much weaker celestial radiation of interest, astronomers typically refrigerate their telescopes and instruments to temperatures near minus 269°C (-450°F) –almost absolute zero!

**Building New Stars.** The visible and infrared images shown on the other side of this lithograph are of the exact same area in 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 are being born. Embedded in these molecular clouds, the young stars are difficult to see in visible light – but heat reveals their presence in the infrared. At long infrared wavelengths, astronomers are able to study the distribution of dust that characterizes these cocoons where star formations occur. At short infrared wavelengths, scientists can pierce through the

obscuring dust and gas to reveal the young stars in the process of being born.

The interstellar medium (ISM) in our Milky Way Galaxy is the dust and gas between the stars. It originates in either violent supernova explosions or in gentler episodes where a star’s outer layers are blown off near the end of its life. The ISM is the reservoir of material from which new stars form. The clouds of interstellar dust and gas are best revealed 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 on observations made at short infrared wavelengths which penetrate through the obscuring dust.

**Building New Planets.** Using data from the Infrared Astronomical Satellite (IRAS), astronomers discovered flat disks of dust around two dozen nearby stars. These disks are thought to 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.** Astronomers’ visible-light view of most of the distant regions of our own Milky Way Galaxy, including the Galactic Center, is heavily obscured by the ISM. At infrared wavelengths, the Galactic Center is one of the brightest sources in the sky. Infrared observations show that this region consists of very dense crowds of stars, and that gases orbit the Galactic Center very rapidly – probably due to the gravitational influence of a central black hole.

**Observing the Past.** When we observe galaxies billions of light years away, 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 (from the wavelength at which it was emitted). This shift of the visible radiation toward the end of the electromagnetic spectrum is known as the “cosmological red shift.” If the emitting objects are sufficiently distant (i.e., young) enough, the shift is beyond 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.

**Observing the Future.** Work is now in progress at NASA on several exciting new infrared programs:

- The *Two-Micron All-Sky Survey* (2MASS), a ground-based survey operating from 1997-2001, is providing new information on the large-scale structure of the local universe and the Milky Way.

- The *Space Infrared Telescope Facility* (SIRTF) – scheduled for launch in 2003 – will complete NASA’s multiwavelength tool-box of “Great Observatories” (which also includes the Hubble Space Telescope, the Compton Gamma Ray Observatory, and the Chandra X-Ray Observatory). SIRTF, with an 85-centimeter-diameter telescope and expected lifetime of up to 5 years, will study the universe over nearly the entire range of infrared wavelengths with much greater sensitivity than previous spaceborne infrared missions.

- The *Stratospheric Observatory For Infrared Astronomy* (SOFIA) is a converted Boeing 747 airplane carrying a 2.5-meter telescope. Flying above 12.2 kilometers (40,000 feet), SOFIA will avoid most of our atmosphere’s obscuring effects and will be able to study a wide range of infrared wavelengths.

- The *Next Generation Space Telescope* (NGST) is a visible and infrared space mission which will have extremely good sensitivity and resolution, giving us the best views yet of the sky in the near-mid infrared. NGST will be used to study the early universe and the formation of galaxies, stars and planets.

For more information: <http://www.ipac.caltech.edu/>

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