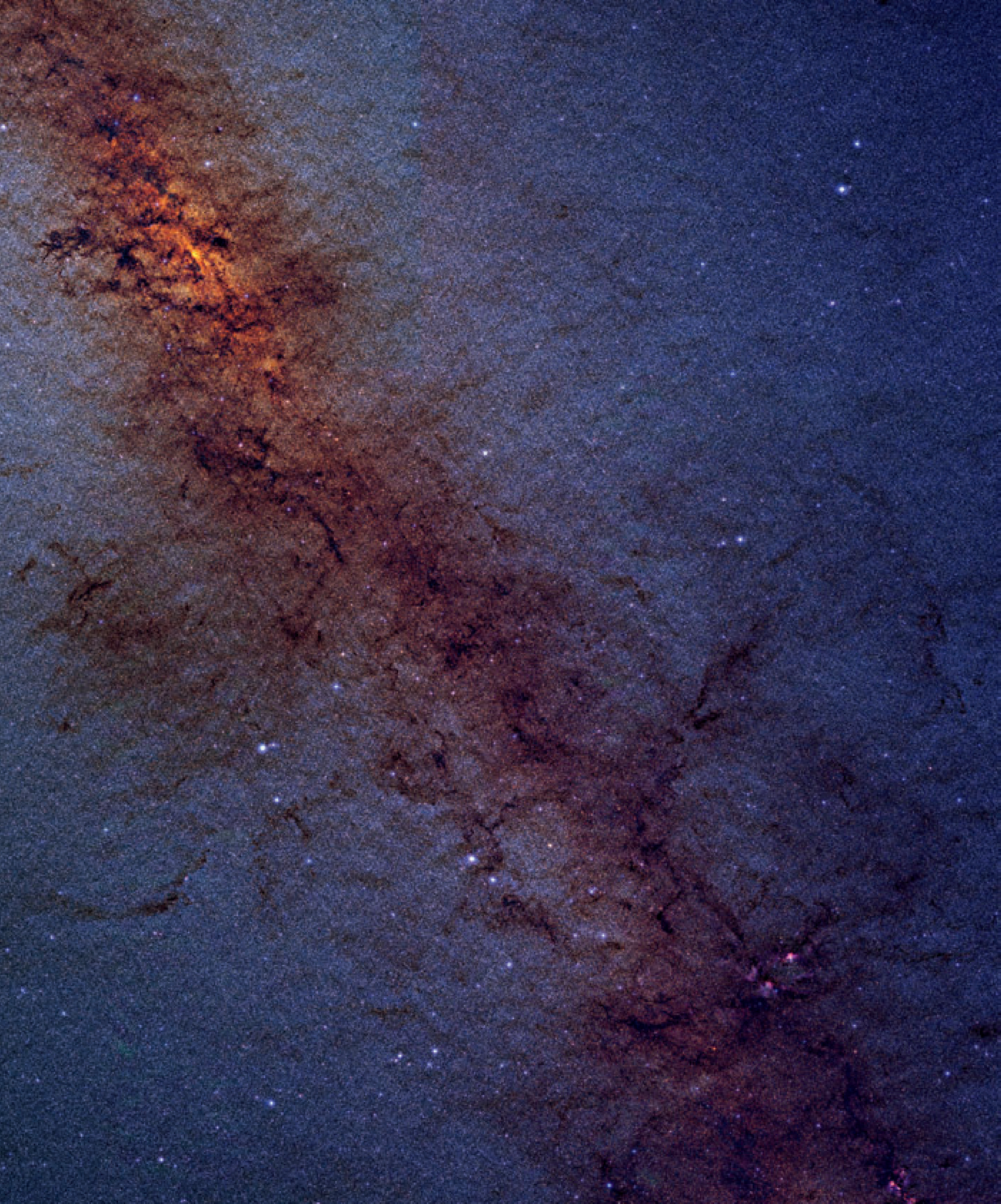


5 THE INFRARED UNIVERSE

FIGURE 32: THE MILKY WAY CENTRE

The centre of our Milky Way galaxy is located in the constellation of Sagittarius. When viewed in the visible part of the spectrum, most of the stars are hidden behind thick clouds of dust. This obscuring dust becomes increasingly transparent at infrared wavelengths. This Two Micron All-Sky Survey (2MASS) image, covering a field roughly 10 x 8 degrees (about the area of your fist held out at arm's length) reveals multitudes of otherwise hidden stars, penetrating all the way to the central star cluster of the galaxy. The central core, seen in the upper left portion of the image, is about 25 000 light-years away and harbours a supermassive black hole. The reddening of the stars here and along the Galactic Plane is due to scattering by the dust; a process similar to the one causing the red sunset. The densest fields of dust are still opaque in this near-infrared image.

The infrared band lies just beyond the deepest red we can see. This band of the electromagnetic spectrum is a window onto a cool, dust-filled Universe. By allowing us to peer through the obscuring dust, strewn between the stars like an interstellar fog, it reveals distant reaches of our Milky Way hidden outside the visible spectrum.

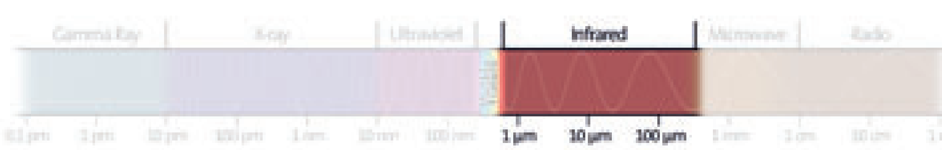
At longer infrared wavelengths the dust itself becomes luminous, showing us a different facet of the wispy tendrils of tiny grains that drift through the vastness of space between the stars. Shrouded by these dust clouds, young stars form and planets like our own are assembled.

“Infrared radiation reveals the hidden, the cold and the dusty”

Infrared radiation reveals the hidden, the cold and the dusty. While the term “infrared” is often synonymous with the idea of heat, in astronomy it is actually more valuable for studying objects that are cool by Earthly standards. It gives astronomers a very different view of the Universe that complements the familiar visible perspective.

The infrared **spectrum** starts just beyond the reddest light visible to our eyes and ranges out to **wavelengths** up to a hundred times longer than visible light. While the visible spectrum is confined to a narrow **band** between 380 and 740 **nanometres** (0.38 to 0.74 **micrometres**), the infrared spectrum extends out from the upper end of the visible to around 400 micrometres.

Infrared regimes



The infrared spectrum is generally divided into three **regimes**, the near-, mid- and far-infrared. These divisions are observational definitions and not precisely bounded, but do provide useful guidelines.

Near-infrared: 0.8–5.0 micrometres

The near-infrared regime begins just beyond the extreme limits of the reddest light visible to the human eye and extends out to wavelengths about ten times longer than the eye can see. The properties of near-infrared radiation are similar to those of light, and the same technologies will usually work in the near-infrared. The atmosphere is largely transparent in the near-infrared, although there are some absorption bands caused by various molecules (primarily water).

Mid-infrared: 5.0–40 micrometres

The mid-infrared regime spans wavelengths that are roughly 10 to 100 times longer than those visible to humans. Thermal emission from objects close to room temperature, including people, peaks in this band; industrial thermal-imaging cameras typically operate at around 10 microns. The Earth’s atmosphere has a few windows of reasonable transparency, but becomes essentially opaque beyond 14 microns.

Far-infrared: 40–400 micrometres

Far-infrared radiation wavelengths range from about 100 to 1000 times longer than visible light. This band primarily covers thermal emission from cold objects at temperatures that can be as low as 10 degrees above **absolute zero**. The Earth’s atmosphere is completely opaque at these wavelengths; far-infrared telescopes must be in space — or very close to it — and cryogenically cooled to below -263 °C to operate effectively.

History

Sir William Herschel could be considered the father of infrared astronomy. Following his discovery of the planet Uranus in 1787, his investigations led him to discover the existence of infrared radiation in 1800.

Wondering how much heat came with different colours in the Sun's spectrum, Herschel placed a series of blackened thermometers into a spectrum of sunlight refracted through a glass prism. He noted that the measured temperatures increased towards the red part of the spectrum, and when he placed a thermometer just beyond the red it showed the highest temperature of all.

FIGURE 33: THE RHO OPHIUCHI CLOUD

The impressive Rho Ophiuchi cloud is one of the heavenly meeting points for astronomers in search of young stars. Located 540 **light-years** away in the constellation of Ophiucus, near the celestial equator, this dusty region is the nest of more than one hundred newborn stars. This image was made with ESA's Infrared Space Observatory (ISO), from a 7.7-micrometre infrared exposure (shown as blue), and a 14.5-micrometre infrared exposure (shown as red).