The Rosette Nebula in Monoceros, a cloud of gas made to glow by radiation from newly-formed stars.

Opposite page, bottom: *Dust-laden clouds in the young Pleiades star cluster reflect starlight with a bluish glow. This nebula surrounds the star Merope.*

Opposite page, top: *A 'radio photograph' of the supernova remnant Cassiopaeia A, the remains of an exploded star. Such energetic sources may be responsible for some of the cosmic rays which fill the disc of our Galaxy.*

Ironically, it is the least abundant component of the interstellar medium which is the most obvious. Dust in space only accounts for 0·1 per cent of the mass of our Galaxy, and although it is spread thinly inside the disc, its cumulative effect is to scatter and absorb the light from distant stars to such an extent that our view of the Galaxy becomes somewhat parochial. The amount of this absorption is uneven; it averages 1–2 magnitudes per kpc at visual wavelengths, but it can become tens of times higher in the dark, dusty clouds.

Absorption by dust is sometimes called **interstellar reddening**, because blue stars are dimmed far more by the dust than red stars of the same brightness. If we now compare the dimming at a wider range of wavelengths, we find that the dust is practically transparent to infrared radiation longer than 10 μm, while the amount of absorption at ultraviolet wavelengths ($\sim$0·1 μm) is far greater than in the optical. The resulting **extinction curve**, showing the absorption by dust as a function of wavelength, yields a great deal of useful information about the nature of the dust. It tells us at once that we can avoid the problems of dust obscuration altogether if we probe the Galaxy at long wavelengths (with infrared and radio waves). Even the size of the dust grains can be inferred from the extinction curve. The large dimming of optical and ultraviolet light indicates that the particles responsible must have sizes comparable with these wavelengths, that is, around 0·1 μm. Some astronomers believe that the three 'bumps' on the extinction curve (at 0·2 μm, 3 μm and 10 μm) reveal the actual composition of the grains. These are wavelengths at which graphite, ice and silicate particles absorb radiation, and it is plausible – although by no means certain – that the dust grains are made up of these substances. The model which best fits the data is that of a silicate core coated in ice, the whole grain weighing 10^{-18} kg!

In addition to being spread out through space, dust grains are frequently found in large clumps around sites where stars are forming. It appears that grains may play a key role in star formation by protecting collapsing gas clouds from the disrupting effects of ultraviolet-bright stars nearby; and it is likely that the dust has a further role to play in the formation of planetary systems around young stars. Many very young stars are cocooned in shells of heated dust; and even some of the stars in the 6×10^7-year-old Pleiades cluster are seen to be wreathed in dust. These particles reflect starlight, shining in the sky as a glowing **reflection nebula**.

Although grains are found in association with the birth of stars, astronomers believe that they originate in the atmospheres of extremely old stars. It is possible that the condensation of gas in the outer atmospheres of cool red giants, such as μ Cephei and IRC + 10216, produces dust grains, ultimately blown away by a stellar wind into space. In this way, stars of varying compositions could create different types of grain.

Magnetic field and cosmic rays

Another facet of the interstellar dust is revealed in the light from distant stars. Their starlight is **polarized**, that is, the light vibrations tend to occur in one plane. The amount of POLARIZATION increases with the extinction due to dust, showing that some alignment of the dust grains is responsible. This is one of the many indications that a large-scale magnetic field, with a strength of about 3×10^{-10} TESLA (T), permeates the disc of our Galaxy (Fig. 6·7).

Radioastronomers can detect the field more directly, for it 'splits' the 21-cm hydrogen line into two closely-spaced lines (by the ZEEMAN EFFECT); and hot interstellar gas in the general magnetic field affects the polarization of radio waves from pulsars and extragalactic radio sources. The magnetic field also has an important effect on the very high speed particles called **cosmic rays**. These are electrically charged particles, moving through space with almost the velocity of light, and without the restraint of a magnetic field they would escape from the Galaxy in a few thousand years. Charged particles become 'tied' to magnetic fields, however, whirling along them in extended helixes, and consequently the disc magnetic field can bottle up the cosmic rays for millions of years.

Nine-tenths of cosmic ray particles are protons (hydrogen nuclei), and almost one-tenth helium nuclei, with a small admixture of the nuclei of the heavier elements; in addition there is one electron to every hundred protons. Energies of cosmic rays are