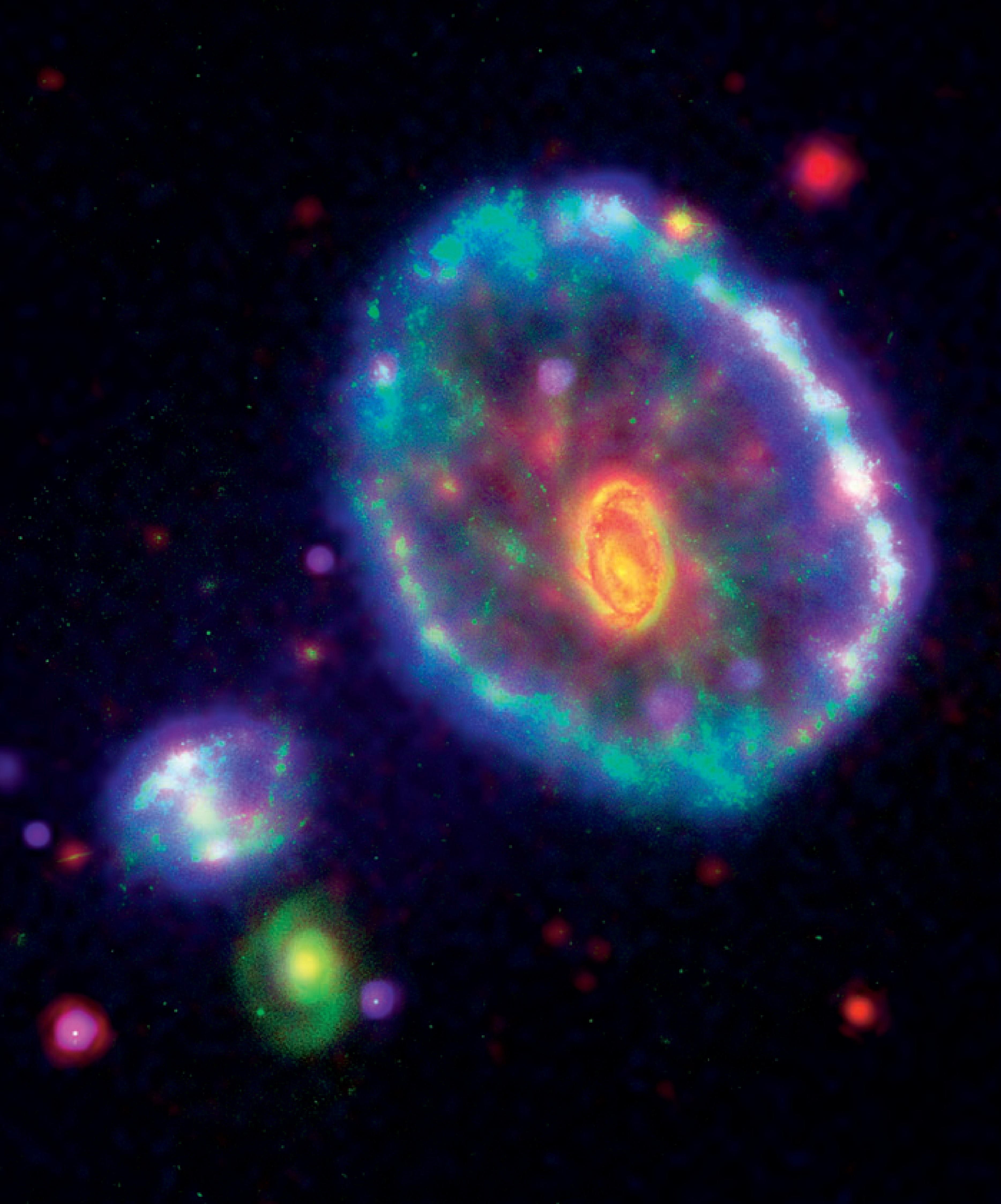

9 THE MULTI-WAVE-LENGTH UNIVERSE

FIGURE 73: A MULTI-WAVELENGTH VIEW OF THE CARTWHEEL GALAXY

This amazing image shows a truly panchromatic view of the Cartwheel galaxy. In purple we see the X-rays (Chandra X-ray Observatory); ultraviolet light (Galaxy Evolution Explorer) in blue; in green we show the visible light (Hubble Space Telescope) and red is infrared light (Spitzer Space Telescope). A few hundred million years ago, a smaller galaxy plunged through the heart of a large spiral galaxy, creating expanding ripples of star formation. In this image, the first ripple appears as an ultraviolet-bright blue outer ring where associations of stars tens of times as massive as the Sun are forming. The clumps of pink along the outer blue ring are regions where both X-rays and ultraviolet radiation are superimposed, likely to be collections of binary star systems containing a black hole. The yellow-orange inner ring and nucleus at the centre of the galaxy result from the enhanced combination of visible and infrared light here. This region of the galaxy represents the second ripple, or ring wave, created in the collision, but has much less star formation activity than the first (outer) ring. The faint wisps of red spread throughout the interior of the galaxy are from dust. Based on its position, velocity and apparent lack of gas, the green galaxy at the bottom left of the picture, seen principally in the visible-light glow of less massive stars, is thought to be source of the "splash".

Astronomy began as a visual science. For thousands of years, humans used little more than their eyes to observe and record the light from the stars. All this changed 400 years ago when Galileo first turned his telescope towards the heavens, dramatically expanding our ability to see and understand the Universe. Yet, for the next 350 years, the potential of this magnificent device was limited to that tiny sliver of the spectrum visible to human eyes. As we have seen in this book, a series of technological advances over the past 50 years or so has given us access to the hidden Universe: the cosmic domains of radio waves, infrared light, ultraviolet light, X-rays and gamma rays. Layer by layer, the cosmic onion has been peeled away to reveal a richness and complexity that was unimaginable from our long-held visible perspective. We show the fundamental change in worldview brought about by expanding our perception to include the full spectrum of light.

“By pulling all the individual wavelength bands together — radio through gamma rays — we can try to paint a much more holistic picture of the vastness of space”

This book is about our recently *expanded* multi-wavelength view of the Universe. This new perspective has made us realise that the Universe “out there” is much richer and more complex than our visual experience suggested. The profound change of viewpoint brought about by the development of quantum mechanics in the early 20th century launched a deep and mind-wrenching adventure into those aspects of the physical world that are not so open to our direct perception. Like nothing else at the time, quantum mechanics expanded our concept of physical reality and inspired philosophers and scientists alike. The discovery of radio waves from the cosmos in 1932 was the first of many steps in the revelation of the full **electromagnetic spectrum** emitted by objects beyond the Earth. Steps that slowly moved astronomy from a visual science to one governed by phenomena that stretch our imagination. Going hand in hand with the physical understanding enabled by the quantum revolution, our new view of the Universe would have been unimaginable to a scientist even a century ago.

This chapter presents the full view of the hidden Universe. By pulling all the individual **wavelength bands** together — radio through gamma rays — we can try to paint a much more holistic picture of the vastness of space and its contents. This is a field of research that is rapidly developing as new pieces of the jigsaw are shaped and put into place. It employs the full breadth of our scientific knowledge.

The active galaxy Centaurus A serves as an example of this holistic view, taking us on a journey through the entire electromagnetic spectrum following the same order as the chapters in this book. It is the nearest active galaxy (see Box: Black holes, quasars and Active Galactic Nuclei in Chapter 7) to Earth, at a distance of 10 million light-years, and is well-observed over a very wide range of wavelengths. We will examine how each slice of the spectrum illuminates different aspects of this galaxy, and how they all combine to provide a more complete overall view.

FIGURE 74: CENTAURUS A IN VISIBLE LIGHT

The active radio galaxy Centaurus A seen in visible light with ESO's 2.2-metre telescope (left) and the Hubble Space Telescope (right). An older population of stars is seen as the soft glow of yellowish-white light. A dramatic dark lane of dust girdles the galaxy. Clusters of newborn stars are seen in blue and silhouettes of dust filaments are interspersed with blazing orange-glowing gas.

Centaurus A in visible light

The Centaurus A galaxy, also known as NGC 5128, is one of the most studied objects in the southern sky. The British astronomer James Dunlop noticed the unique appearance of this galaxy as early as 1826, although he was unaware that its beautiful and spectacular appearance is due to an opaque dust lane that covers the central part of the galaxy (see Figure 74). This dust is likely to be the debris remaining from a cosmic merger that took place some 100 million years ago between a giant elliptical galaxy and a smaller, dust-rich spiral galaxy.

In visible light it is easy to see the soft, hazy elliptical glow of Centaurus A's old population of red giant and red dwarf stars. Brilliant blue clusters of young hot stars lie along the edge of the dark dust lane, and the silhouettes of the dust filaments are interspersed with blazing glowing gas (seen in yellow/red).