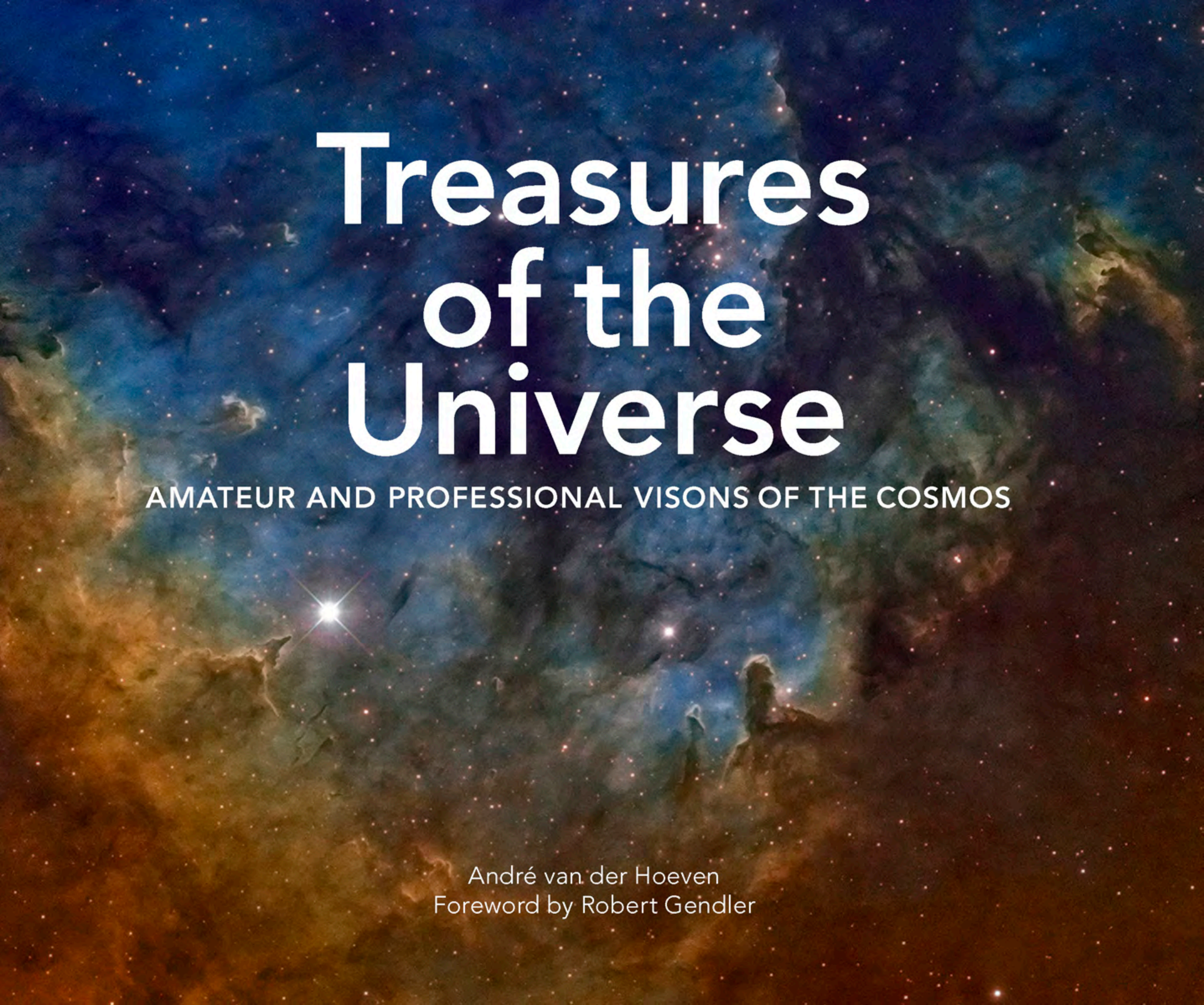

Treasures of the Universe

AMATEUR AND PROFESSIONAL VISONS OF THE COSMOS

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Foreword by Robert Gendler

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Observing

Modern amateur astrophotography setup using a cooled QSI CCD camera and computer guided mounting.

Most professional observations are presently performed from space and huge astronomical conglomerations, like Mauna Kea in Hawaii, Cerro Paranal in Chile and Rogue de los Muchachos on the island of La Palma.

Besides the professional side of astronomy there is also a huge number of active amateur astronomers all over the world. Using their equipment or even their naked eyes, they observe the night skies to see the stars in their full glory.

As light pollution increases, good observing sites become more difficult to find. Modern society asks for a non-stop economy where businesses and labor continue day and night. This gives rise to an increase of artificial lighting all over the world.

Light pollution is like a blanket covering the light from the Universe. The light that strays into the atmosphere is reflected in the higher layers by particles of dust and vapor. This increases the sky background, making it harder to see faint objects shining through this layer.

Using modern techniques and good filters, a lot of this light pollution can be removed from images made by CCD cameras and DSLRs but dark skies make observing much easier.

In this book, images from both professionals using state-of-the-art observatories on land and in space as well as amateur astronomers with more modest equipment are shown. The fast pace of development allows amateurs today to compete with the best images made only 20-30 years ago by professional astronomers. Professional observing campaigns and research now regularly benefit from data acquired by amateur astronomers because observing time on the large telescopes is limited. Organizations like the AAVSO (American Association for Variable Star Observers) and many other organizations coordinate these amateur efforts to form the link between the professional and amateur astronomy world.

Keep in mind that this is just the start of the journey. The coming decades will reveal significant developments and we can only dream of what the future will bring us.

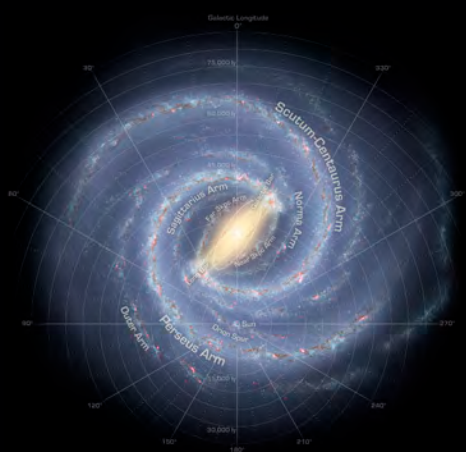
Professionals and amateurs join forces.

Amateur image of M31 showing the central bulge together with the surrounding spiral arms and dust bands. This image was taken with a 9 cm refractor from a relatively light-polluted location.

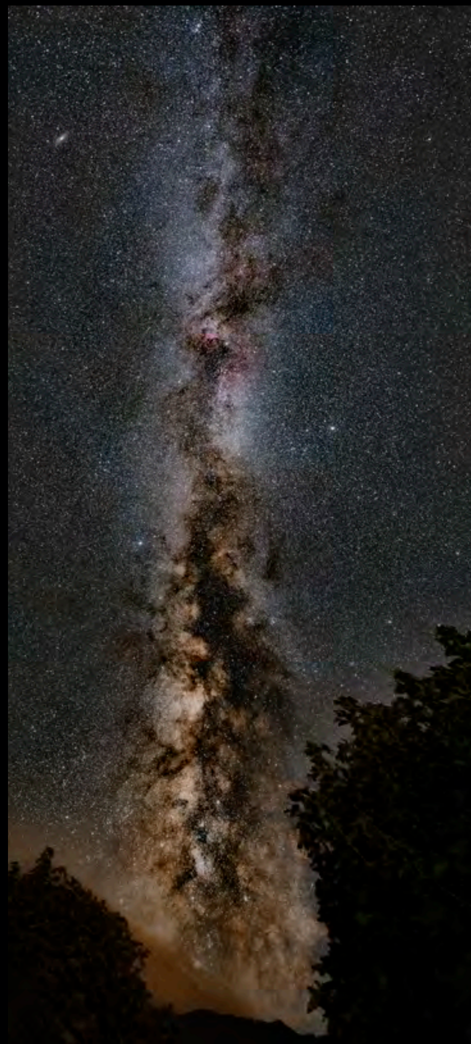
Clouds in the Sky: The Milky Way

Seeing all the beautiful galaxies surrounding us it could easily be forgotten that we are part of a galaxy ourselves also, which is the Milky Way. Our Sun is located in the suburbs of our galaxy at almost 2/3 from the center. This gives a front-seat position when looking at our galaxy.

In dark locations, where light pollution is not fading the light from the stars, the Milky Way is an impressive sight. We can look into the plane of the disc and see the dust and gas that hides the center of our galaxy from our view. In the Northern hemisphere we can mainly see outward towards the Perseus Arm, while in the southern hemisphere we are mainly looking toward the Milky Way center with its big dust clouds.



Structure of the Milky Way as determined using data from the Spitzer Space Telescope. Clearly the central bar with its two main arms can be seen.



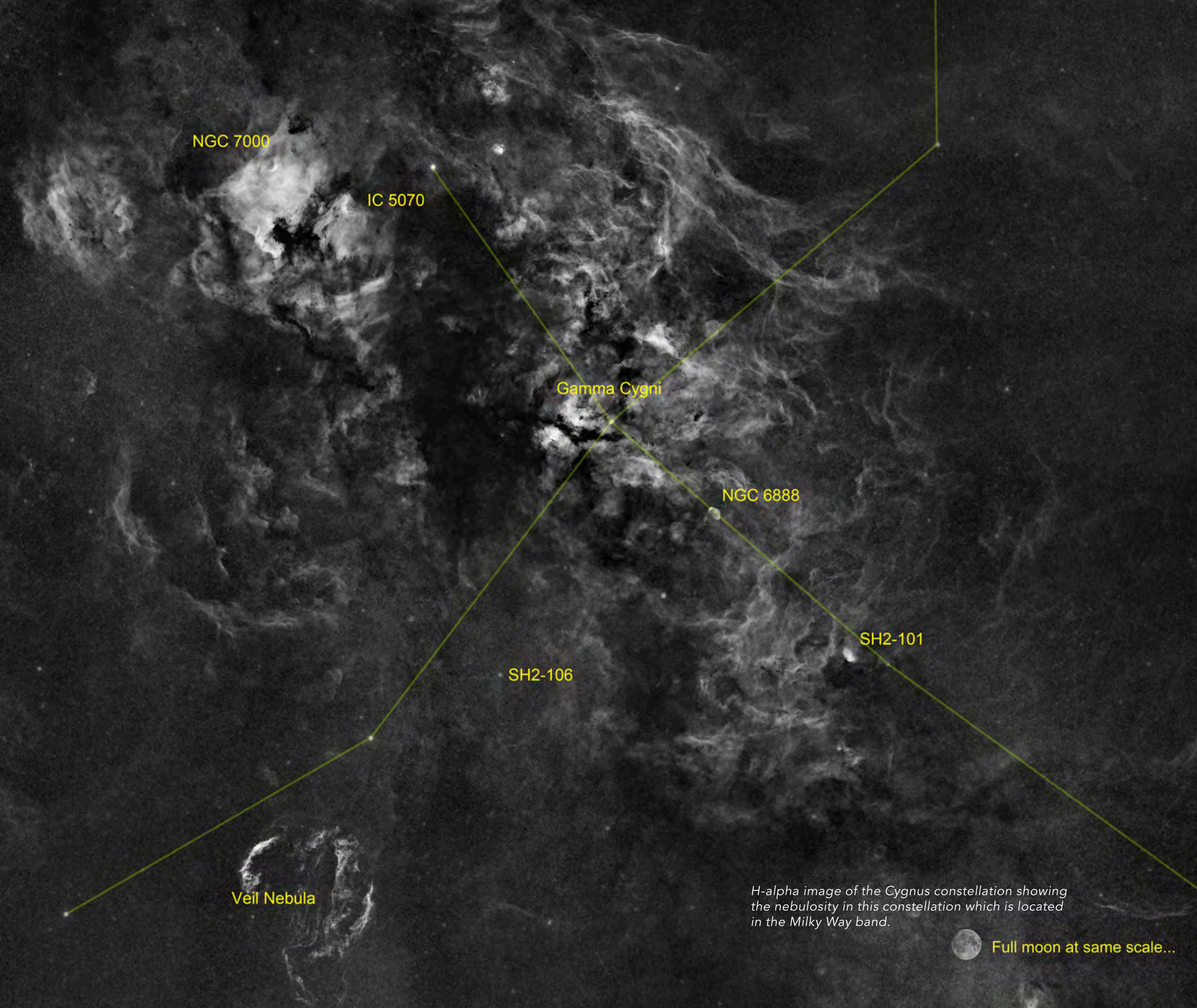
Milky Way as seen from a dark location in Austria. Here we have a view close to the center which is located just below the horizon in this view.

For decades, astronomers have been blind to what our galaxy really looks like. After all, we sit in the midst of it and can't step outside for a bird's-eye view.

Using images from the Spitzer Space Telescope the structure of the Milky Way has been thoroughly investigated, revealing that it has two major arms of stars connected to the near and far ends of the galaxy's central bar. These major arms, the Scutum-Centaurus and Perseus arms, have the greatest densities of both young, bright stars, and older, so-called red-giant stars. The two minor arms, Sagittarius and Norma, are filled with gas and pockets of young stars.

Though galaxy arms appear to be intact features, stars are actually constantly moving in and out of them as they orbit the center of the Milky Way, like London commuters in a busy traffic circle. Our own Sun might have once resided in a different arm. Since it was formed more than 4 billion years ago, it has traveled around the galaxy 16 times.

When observing the sky from a true dark location another special effect of our atmosphere can be seen. Due to the solar radiation molecules in the upper layers of the atmosphere get ionized during daytime. During nighttime, when the irradiation stops, the molecules release their energy in the form of light, which causes airglow. These are like bands of mostly green and red light that seem to move through the night skies and can be seen in the images on the next pages.



H-alpha image of the Cygnus constellation showing the nebulosity in this constellation which is located in the Milky Way band.

Sun

The Sun is our nearest star. An average star, as there are billions like it in our galaxy. Despite this, it is of utmost importance to life on Earth. The energy produced by the Sun is the fundamental source of energy on Earth and without the Sun our Earth would not exist at all.

About 4.5 billion years ago our Sun formed from a hydrogen cloud not unlike examples shown in this book with many other stars in an open star cluster. The cluster of its youth has fallen apart; the stars once nearby have long since diffused into our galaxy. Around the Sun a disk of dust and gas coalesced into the planets. Closer to the Sun the more dense materials resulted in the solid planets like Mercury, Venus, Earth and Mars. Further from the Sun the more gaseous materials resulted in the planets Jupiter, Saturn, Uranus and Neptune.

In the center of the disk the gases collapsed into a spherical shape that formed our Sun. Because of gravitational pull the gases collapsed more and more while the core temperature and pressure started rising. When temperatures reached a scorching 10 million degrees Kelvin nuclear fusion started to generate energy.

In the process of nuclear fusion hydrogen atoms are merging in several steps into helium atoms. Large amounts of mass are transferred into pure energy that is transferred to the surface of the Sun.
The transfer of the energy from the core to the surface takes several thousands of years. In the central part the transport is performed via radiation that changes from X-ray in the core to visible light more outward. At the surface of the Sun the temperatures have lowered to 6000 Kelvin and in the underlying layer convection of gases transfer the energy outward into space. This convection causes the surface of the Sun to bubble and change all the time.

Moving within the Sun is plasma which generates a very strong magnetic field. These magnetic fields form loops along which the gases move. When viewing the Sun in the spectral band of hydrogen these loops can be seen as solar flames and prominences along the solar limb (next page). When viewed from above, on the surface, these prominences show up as solar filaments that seem to crawl over the surface. Because of the magnetic fields sometimes the gases are slowed down and can't reach the surface easily. At these places the surface cools down to about 4000 Kelvin and sunspots form. These are darker spots because of their reduced radiation output. High points in the Sun's 11-year cycle coincide with high sunspot activity.

Solar prominence as seen by NASA's SDO satellite on August 31, 2012.

A solar outburst as seen by an Earthbound amateur solar telescope (Lunt 60mm) in the H-alpha band.

Comets

Comets are icy small bodies that originate in the Kuiper Belt and the Oort Cloud. The Kuiper Belt is located between the orbit of Neptune at 30 AU up to a distance of about 50 AU. This belt is comparable with the asteroid belt between Mars and Jupiter, except that its bodies mostly consist of volatile icy components. The Oort Cloud is a spherical cloud of predominantly icy planetesimals surrounding the Sun at up to 50 000 AU.

Through perturbations caused by the planets in the Solar System or even by passing stars the orbits of these objects can be changed, sending them falling towards the Sun.

When passing close to the Sun, comets heat up and begin to outgas, displaying a visible atmosphere or coma and sometimes also a tail. These phenomena are due to the effects of solar radiation and the solar wind upon the nucleus of the comet. Comet nuclei range from a few hundred meters to tens of kilometers across and are composed of loose collections of ice, dust, and small rocky particles. The coma and tail are much larger and, if sufficiently bright, may be seen from the Earth without the aid of a telescope. Comets have been observed and recorded since ancient times by many different cultures.

Comets are distinguished from asteroids by the presence of an extended, gravitationally unbound atmosphere surrounding their central nucleus. However, extinct comets that have passed close to the Sun many times have lost nearly all of their volatile ices and dust and may come to resemble small asteroids. Asteroids are thought to have a different origin from comets, having formed inside the orbit of Jupiter rather than in the outer Solar System.

In the past few decades several space missions have been giving a closer look into comets and their structure. In 1986 the first close flyby of comet Halley was performed by the Giotto mission. Since then several comets have been visited. The latest mission, Rosetta, even sent a lander to the surface of comet 67P/Churyumov-Gerasimenko that aimed to measure the surface composition of the comet. Unfortunately the lander bounced and very few data was gathered.

This mission will follow the comet for an extended period of over a year during its perihelion passage around the Sun. The data Rosetta returns will detail the processes taking place during this closest approach.

Image of comet C/2014 Q2 Lovejoy seen from Australia in December 2014. Left above of the comet is M79, a globular cluster in the constellation of Lepus. Just below the comet spiral galaxy NGC 1886 can be seen.

Comet 2011 L4 PanSTARRS over the world heritage windmills of Kinderdijk seen in March 2013.