Light Phenomena over the ESO Observatories III: Zodiacal Light

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The zodiacal light is often seen at the ESO observatories in the hours after sunset and before sunrise. The origin of the zodiacal light is described and recent research briefly summarised. Some fine images of the zodiacal light from Paranal and La Silla, including the full extent of the night sky are presented.

Figure 1. (Above) Column of zodiacal light (right) photographed from the platform at Paranal Observatory. The bright source within the zodiacal light cone is Venus.

Figure 2. (Below) The zodiacal light photographed soon after sunset from La Silla Observatory.

On a moonless night from Paranal Observatory in the Atacama Desert in Chile, it is possible to see several different large-scale sky phenomena in addition to the faint light from the Milky Way. These include atmospheric phenomena, such as airglow — natural radiation arising in the Earth's atmosphere (Christensen et al., 2016) — and occasional flashes called sprites that can appear over the Andes and are connected with electrical storms (Horálek et al., 2016). Another light phenomenon that can be seen on every moonless night at a very dark site is the zodiacal light (Figure 1). Most evident in the hours after dusk or before dawn, zodiacal light appears as a faint, diffuse column of light in the sky, just above the horizon and extending towards the zenith (Figure 2).

Even after the brightest part of the zodiacal light is below the horizon, faint traces of it are still present. During the night it takes the shape of an extremely faint wispy bridge that brightens again in the early morning, before sunrise. Figures 3 and 4 show sophisticated panorama images of the zodiacal light from sunset to sunrise, clearly demonstrating its full extent across the sky.

The nature of the zodiacal light

The origin of the zodiacal light is to be found in the inner Solar System. Infrared observations from the Infrared Astronomical Satellite (IRAS[1]; Low et al., 1984) and Cosmic Background Explorer (COBE[2]; Reach et al., 1995) revealed emission from small grains composed of dust and ice surrounding the Sun. Most of the observed particles have sizes in the range 1 to 100 μm. The Poynting–Robertson effect (Guess, 1962) forces particles inward through the absorption of solar radiation and isotropic emission, reducing their angular momentum, while the dominant force for micrometre-sized particles is the solar radiation pressure that accelerates them away from the Sun. The zodiacal dust hence needs to be constantly replenished. This replenishment is primarily served by crumbling icy comets, but also by colliding asteroids and possibly interstellar dust (Rowan-Robinson & May, 2013). The zodiacal light itself is sunlight that is forward-scattered from these particles in the direction of Earth.

Recent studies show that over 85 % of the cometary material in the zodiacal cloud comes from dust from comets in the Jupiter family (Nesvorný et al., 2010; Schulz et al., 2015). These are short-period comets, with orbital periods less than 20 years, that take their name from the fact that their current orbits are determined primarily by the gravitational influence of Jupiter. The Jupiter family of comets contains 67P/Churyumov–Gerasimenko, now extremely well known as a result of the *in situ* research carried out by ESA's *Rosetta* satellite in August 2014. The *Philae* probe landed on the nucleus of this comet in November 2014.

The dust grains that give rise to zodiacal light are distributed in a disc in the plane of the ecliptic (Nesvorný et al., 2003). When viewed from Earth, this disc appears as a band across the sky passing through the constellations of the zodiac, hence the name zodiacal light. As the scattering of sunlight is most effective at smaller angular distances from the Sun, the band of light along the ecliptic gets fainter and narrower further away from the Sun (Figure 3). Along the ecliptic, at the point in the sky opposite the Sun (the antisolar point), coherent backscattering from dust particles further out in the Solar System beyond the Earth's orbit leads to the oval patch of light known as the Gegenschein (Figures 3, 4 and 5). The name was given by the German explorer Alexander von Humboldt (1769–1859).

Observations of the zodiacal light

The zodiacal light was first investigated in the late 1600s, by the Italian astronomer Giovanni Cassini and the Swiss mathematician Nicolas Fatio de Duillier. Of course, back in the 17th century there was very little light pollution, so it was relatively easy to observe this phenomenon, even from cities. Observations of zodiacal light in more recent times have mostly focused on particular structures of the zodiacal cloud. Interesting zodiacal dust bands were discovered by IRAS in 1984 (Low et al., 1984; Dermott et al., 1984). They are produced by collisions of asteroids in the Main Belt between Mars and Jupiter within the last few million years (Nesvorný et al., 2003). Hints of these dust bands are noticeable on the full-night panoramic imaging of the zodiacal light taken by commercial cameras after post-processing, including colour

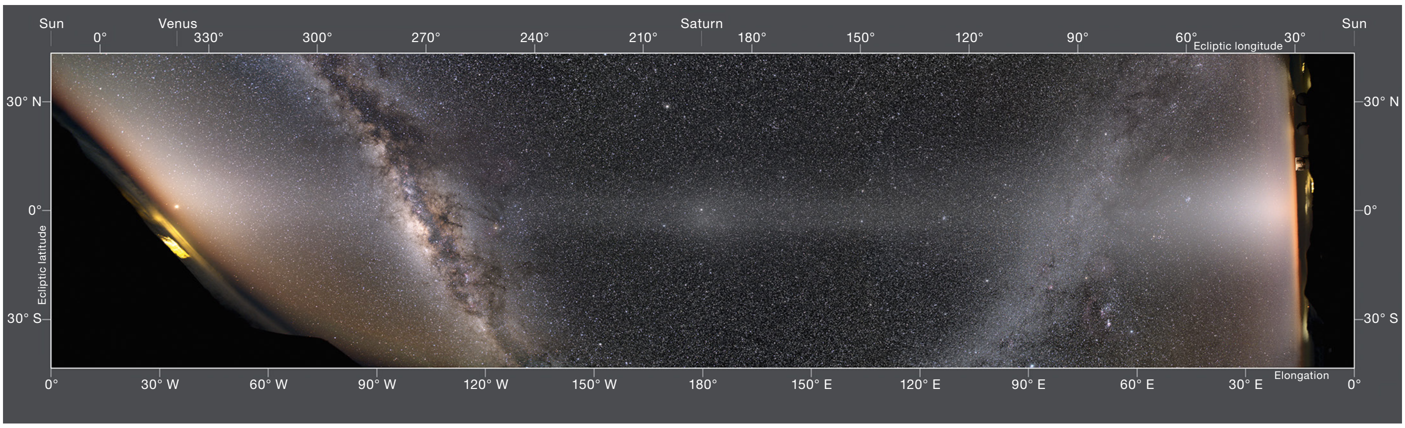

Figure 3. (Upper) All-night 360-degree panorama of the zodiacal light from Mauna Kea in April 2011, showing the structure of the zodiacal light almost in its entirety. On the left and right, the columns of light are visible after dusk (right) and before dawn (left) respectively, brighter closer to the Sun (which is under the left and right horizons). In the middle of the band, the Gegenschein appears at the antisolar point.

Figure 4. (Lower) 270-degree panorama of the zodiacal light, photographed from La Silla in April 2016, showing almost the full structure. On the right, the column of light is visible before dawn, brighter closer to the Sun (which is below the right horizon). To the left, the Gegenschein appears at the antisolar point. Unique hints of substructure are visible around the Gegenschein. Extensive image processing was performed by Petr Horálek and Miloslav Druckmüller to enhance the structures.

Figure 5. Image of the Gegenschein obtained in October 2007 above Paranal Observatory.

correction of the background (see Figures 3 and 4).

Subsequent observations with IRAS and more sensitive photometric observations from NASA's STEREO satellites[3] have revealed a circumsolar dust concentration in a ring along the orbit of Venus. This was expected and is caused by the influence of the planet's gravitational resonance on the particles (Dermott et al., 1994; Jones et al., 2013). A brightening of the zodiacal cloud by ~ 10 % near the apex of the Earth's orbital motion has also been found (Dermott et al., 1994).

Recent observations of nearby stars have demonstrated that the Solar System may not be the only one to exhibit zodiacal light. Data from the Very Large Telescope Interferometer have revealed that other planetary systems are also surrounded by interplanetary dust leading to zodiacal light, but much brighter than in the Solar System (for example, Lebreton et al., 2013; Marion et al., 2014; Ertel et al., 2015).

Acknowledgements

The contribution of David Nesvorný was supported by the Southwest Research Institute. We are grateful to Prof. Miloslav Druckmüller (Inst. of Mathematics, Brno University of Technology, Czech Republic) for significant support of the image processing of Figure 4, and to Bob Fosbury for illuminating discussions.

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Links

[1] IRAS: http://irsa.ipac.caltech.edu/Missions/iras.html
[2] COBE satellite: http://lambda.gsfc.nasa.gov/product/cobe/
[3] NASA STEREO satellites: http://stereo.gsfc.nasa.gov/mission/mission.shtml

The First NEON School in La Silla

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The NEON Observing Schools have long provided PhD students with practical experience in the preparation, execution and reduction of astronomical observations, primarily at northern observatories. The NEON School was held in Chile for the first time, with observations being conducted at La Silla. The school was attended by 20 students, all from South America, and observations were performed with two telescopes, including the New Technology Telescope. A brief description of the school is presented and the observing projects and their results are described.

After many years of discussions and preparations, the NEON Observing School could finally take place at La Silla