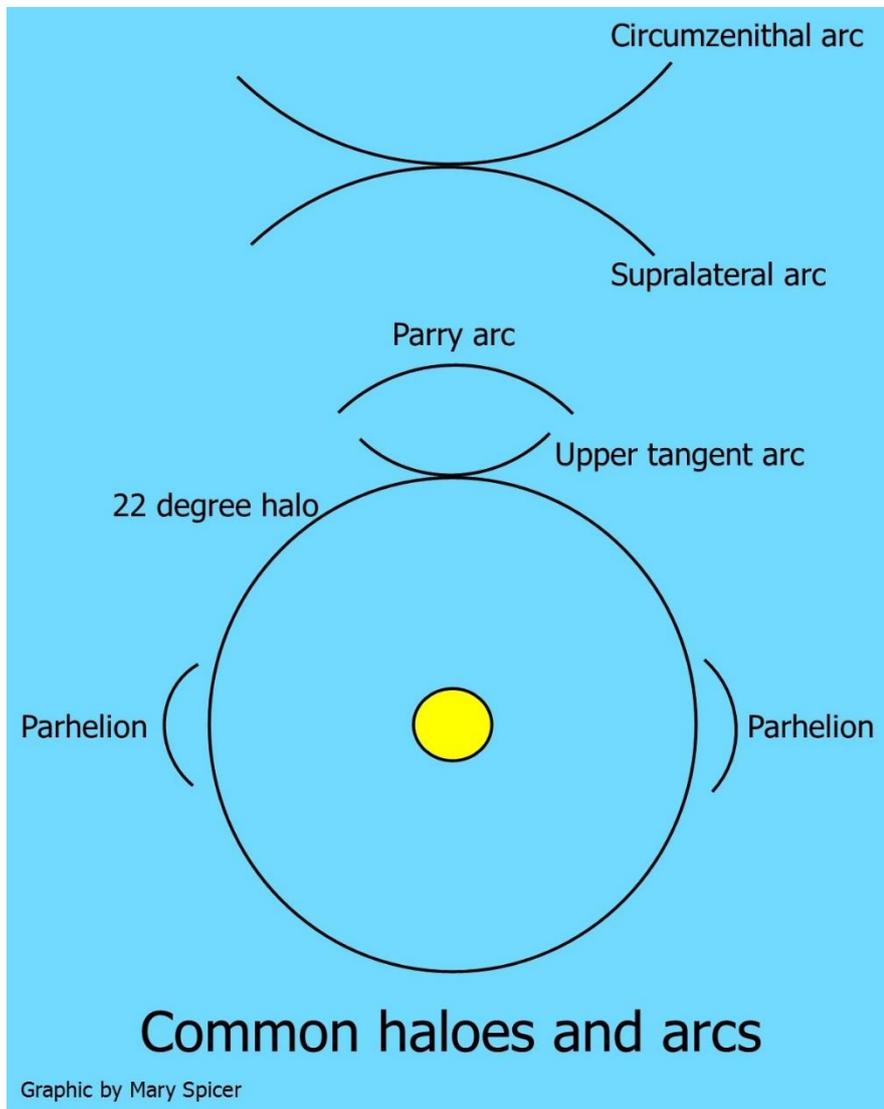


Sundogs - The Fact and Fiction!

A sundog, or to give it its correct name, a parhelion (plural parhelia) is a well-documented optical atmospheric phenomenon, manifesting as small, bright patches one or both sides of the Sun. They may look multi-coloured, like tiny rainbows, but the colours are not usually as well defined as those you see in a rainbow. The component colours often overlap with each other and are much more muted. Parhelia often co-occur with halos, with the parhelia sitting just on the outside of a 22 degree halo. At the same time there may be other halos or arcs present, the common ones being an upper tangent arc and circumzenithal arc, or less commonly a supralateral arc or parry arc. Where these phenomena occur in relation to each other is shown in the diagram below.



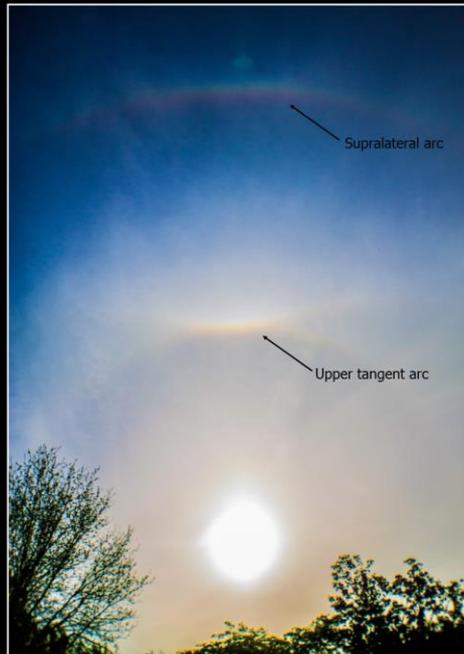
First I will talk about the facts, then move on to the fiction.

How do these optical phenomena occur? It's all thanks to the composition of cirrus clouds, more specifically cirrostratus clouds, which are some of the highest clouds in our atmosphere (excluding noctilucent clouds). Cirrus clouds are very cold clouds made up of plate-like, hexagonal shaped ice crystals. In a similar way to how light is split by water droplets when a rainbow forms, parhelia and halos are formed when the light from the Sun is refracted, or bent by these ice crystals. The crystals behave like millions of tiny prisms, causing the light to be refracted and reflected in various directions. When the ice crystals are oriented in a random fashion, it causes a 22 degree halo or other arcs to form. However, as the crystals sink through the atmosphere, they align vertically with each other and this causes all of the light to be refracted in a horizontal direction, therefore causing a parhelion to be visible on one or both sides of the Sun. Sometimes you can have a mixture of random and vertically aligned crystals at the same time and see a halo as well as parhelia. If you are really lucky, you may see one or more of the other arcs at the same time. I was lucky enough to witness such an event from Oxfordshire on 24th April 2014, and also on 24th November 2014, but more commonly you will see parhelia associated with a 22 degree halo.

22 Degree Solar Halo 12/12/14 2:20pm



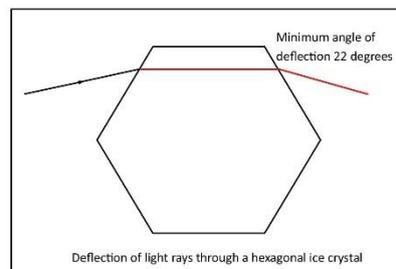
22 Degree Halo, upper tangent arc & supralateral arc 12/12/14 2:20pm



Circumzenithal Arc 24/11/14 12:15pm



The sky is divided up in a similar way to how the Earth is divided into latitude and longitude. If you imagine the sky as being a huge sphere, the entire thing is divided up into degrees, with the total being 360. A parhelic circle stretches out by 22 degrees in every direction from the Sun. To give you an idea of how big that is, if you place your hand at arm's length and stretch out your fingers, the distance from your thumb to your little finger will cover approximately 20 degrees of sky. Why is 22 degrees so special? It is to do with the angle that the light is deflected as it passes through those hexagonal ice crystals. Light rays enter the hexagon and is deflected twice; once as it enters and again as it exits. The result of this is that the light is bent by between 22 and 50 degrees, causing a halo to form around the Sun. Because the minimum angle of deviation is 22 degrees, no light is bent less than this, so the sky inside a halo can appear to be darker than that which surrounds it.



Graphic by Mary Spicer

The exact angle of deflection varies for different wavelengths of light, so consequently the inner edge of the halo will be reddish in colour whilst the outer is bluish. Similarly, the side of a parhelia which is nearest to the Sun is red, whilst the side furthest away is blue. This is clearly shown in the images below. Halos can occur at any time of the day, but parhelia are usually only visible when the Sun is low in the sky (below 60 degrees) either at sunrise or sunset. However, their position changes slightly depending on the altitude of the Sun; the higher the Sun, the further the light rays are skewed from the horizontal plane, so parhelia are visible further away from the Sun when it

is higher than when it is lower. The shape of upper tangent and parry arcs also vary considerably with the altitude of the Sun.



Although parhelia are only visible when the correct conditions are present, they are relatively common. Far less common though, are moondogs, or to give it its correct name, paraselene (plural paraselenae). Also caused by light being refracted by cirrus clouds, the Moon needs to be almost full in order for there to be enough light for a paraselene to form. Because the Moon is much less bright than the Sun, a paraselene is rarely bright enough for us to be able to pick out individual colours; it usually just looks like a bright white patch. Paraselenae are also associated with 22 degree haloes, which can be visible at any time of night, but as with parhelia, paraselenae are usually only visible when the Moon is below 60 degrees. Much smaller and more colourful halos may occur around the Sun and Moon and these are called coronas. But they are caused by water droplets, not by ice crystals.

Halos are not unique to the Sun and Moon. They can also occur around other light sources. In extremely cold conditions you may see a halo around a street light, caused by light being refracted by tiny ice crystals which are present in the air at ground level. These crystals are known as "diamond dust".



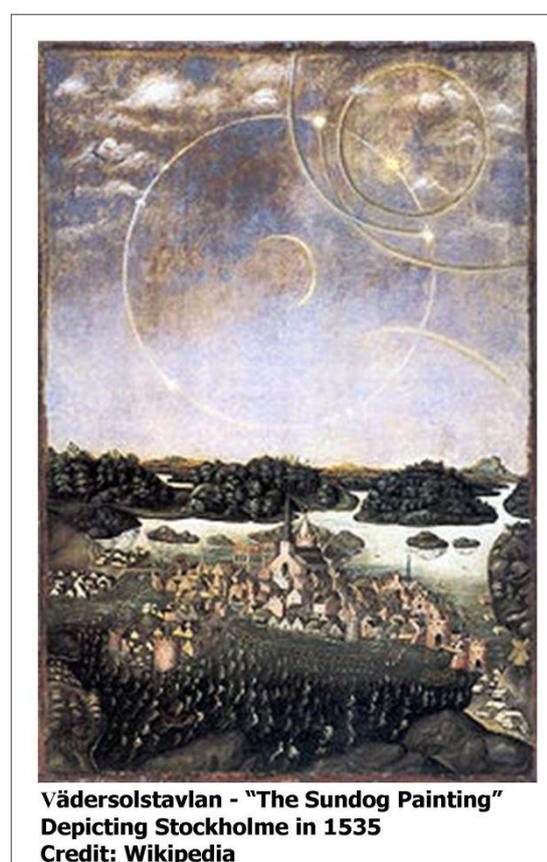
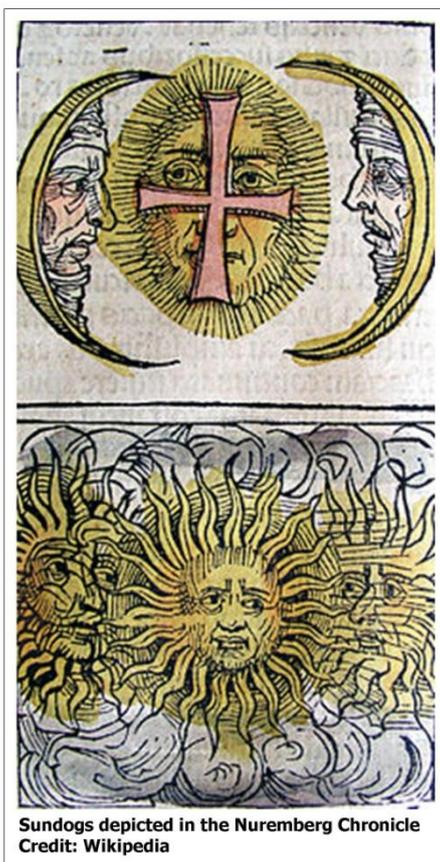
Now we have all the facts, it's time to move on to the fiction, with particular reference to parhelia, or sundogs. We understand these optical phenomenon very well now, and we can even speculate that they form in the atmosphere of other planets too. But this wasn't always the case. There are a lot of references in mythology and folklore which we now believe are referring to sundogs.

The word "parhelia" comes from the Greek language, meaning "beside the sun". But it is also known by several other names; sundog, mock sun or phantom sun. It is easy to understand how ancient civilizations would have interpreted these peculiar bright patches as "mock suns" but where did the name sundog originate? Its first recorded use was in 1631 by the British Naval Captain Luke Foxe. He used it in his journal whilst on a search for the North West Passage. However, this was clearly not a new term that he had coined himself. In the 1st century AD, the Greek playwright Seneca used the term "parhelion" to mean sundogs. The origin of these two parallel terms is thought to be from the Greek and Germanic languages which then entered into the English language. If the two bright patches of light rise alongside the Sun, following it as dogs would follow their master, then this is perhaps one possible origin of the term "sundog". However, a better explanation may come from Germanic mythology. Odin was the sky god, and he was said to have two dogs, one named Geri and one named Freki, so people seeing their god rising with two faithful companions may have been the source of the name sundog.

The appearance of atmospheric phenomenon like parhelia would have given ancient story tellers many opportunities to tell their tales, and many stories there are. Most of the ancient writings refer to sky gods and twin sons of the sky. In Greek mythology Zeus was god of the sky, and there is reference to “Dioskouri” which translates as “Sons of God”. In Greek mythology there are two sets of twin sons of the sky god. Stories from Babylon, China and India all feature twin sons of the sky. The Native American cultures of Zuni, Hopi and Apache feature sun twins. Elsewhere in America, sun twins appear in the writings of the Seneca of New York State and Maya of Central America. Women of South East Africa who gave birth to twin sons were said to have children of the sky. Finally, there are ancient carvings in Scandinavia which depict twin figures that are associated with the Sun.

Sometimes only one parhelion is visible, and this is thought to have given rise to other mythological tales. In the Greek myth of Phaethon, Phaethon was the son of Klymene, however, his father was absent. Upon questioning, Klymene told him that his father was Helios, the Sun, so the presence of the Sun with one parhelion was symbolic of Helios and his son Phaethon.

The first clear description of parhelia as an atmospheric phenomenon rather than the stuff of myth and legend comes from a passage in a book written in 1533. In “Brotherly Faithfulness: Epistles from a Time of Persecution”, Jakob Hutter wrote, “My beloved children, I want to tell you that on the day after the departure of our brothers Kuntz and Michel, on a Friday, we saw three suns in the sky for a good long time, about an hour, as well as two rainbows. These had their backs turned toward each other, almost touching in the middle, and their ends pointed away from each other. And this I, Jakob, saw with my own eyes, and many brothers and sisters saw it with me. After a while the two suns and rainbows disappeared, and only the one sun remained. Even though the other two suns were not as bright as the one, they were clearly visible. I feel this was no small miracle...” Two years later, in 1535, came the earliest pictorial record of parhelia in the form of a painting called “Vädersolstavlan”. This literally translates as “The Weather Sun Painting” but is more widely referred to as “The Sundog Painting”, shown below. It depicts the city of Stockholm on the morning of 20th April, 1535. In this painting, the sky is full of various optical phenomena, including those described earlier. The king was not impressed with the painting, viewing the mock suns as some kind of threat to his authority. Prior to the *Vädersolstavlan*, other artistic depictions of parhelia existed. One famous example also shown below is taken from the Nuremberg Chronicle, one of the first books to combine words with pictures. It follows human history, paraphrasing the bible. This picture is clearly representing parhelia, the top image depicting them as the holy trinity.



One of the most famous stories involving the appearance of parhelia is the one which occurred shortly before the battle of Mortimer's Cross in 1461. Edward of York's troops were initially terrified by this apparition, described as "three glorious suns, each a perfect sun"; they thought it was a portent. But Edward convinced them that it was in fact an auspicious sign; that it represented the holy trinity and that it foretold of their victory. It is also reported that he thought the three suns represented himself and his two brothers. This scene is re-enacted within Shakespeare's play Henry VI Part 3, where the would-be King Edward exclaims, "Dazzle mine eyes, or do I see three suns?" This event clearly had an impact on Edward, as he later incorporated the Sun into his personal badge.

Appearances of halos and parhelia have long been associated with weather predictions, often recorded as meaning that stormy weather is approaching. An old weather saying states "haloes around the moon or sun means that rain will surely come". This is because cirrostratus clouds spread out in front of approaching weather systems. We now know that this isn't always the case; it depends on the exact direction of the weather front in question. So the presence of halos does not always mean it is going to rain. Given our current level of knowledge, it is difficult to imagine a time when people truly believed the appearance of an optical atmospheric phenomenon could be interpreted as a sign of good or bad luck; that their fate was hinged upon a bright patch in the sky. But it is easy to see how awe inspiring the sight must have been for our ancient ancestors, and how it inspired so many stories. Even with our vast knowledge of these phenomenon today, I am still captivated by the sight myself, imagining all of those tiny prisms diffracting rays of sunlight, and I was totally blown away when I saw my first parselene. But I know it doesn't mean that I will be successful in battle, or that they are a portent for some terrifying event. The presence of one or two parhelia and/or a halo or arc, means only thing for certain; that there are cirrus clouds in the sky!

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