Unusual glories

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When our shadow falls on fog or clouds, a coloured system of rings of a few degrees in diameter appears centred at the shadow point of our eyes. If we are close enough to the fog bank we also may discern our own shadow, which is then crowned with an aureole similar to those on religious paintings from the Middle Ages. So the phenomenon, not without reason, is called 'glory'. In the past, the glory was seldom observed as very few people were in a position to watch clouds from above. The scarce pre-1960 photographs of a glory were usually taken from mountains, mostly showing a glory with its lower segment missing because of the shadow of the mountain (Figure 1). As that problem does not occur on an aircraft, the glory appears with full 360° coloured rings. Such a complete glory is a common companion of air travellers nowadays, often mistakenly described as 'a little rainbow following the aircraft'. If one's aircraft is sufficiently high above the clouds to make its shadow invisible, one can even observe the glory´s central point (Figure 2).

A glory is formed when light is backscattered by spherical droplets. If a light path exists through a spherical body (other than a simple back reflection) which enables backscattering, then a bright region appears around the shadow point surrounded by coloured interference rings. As the refractive index of water is too low to achieve such backscattering with normal light rays, a satisfactory explanation of the glory was not given until 1947 when the role of surface waves was recognized (Van de Hulst, 1947). As surface waves are effective only in small drops, a glory appears in cloud or fog, but never in rain.

Figure 1. Glory on a fogbank close to the observer, photographed by Claudia Hinz on the mountain Wendelstein (1835 m; 47° 42.2′ N, 12° 0.7′ E) in the Bavarian Alps on 14 April 2006, 1546 UTC.

Figure 2. The glory around the shadow point of a plane. The shadow itself is invisible because of the large distance to the cloud deck. The picture was taken by Armin von Werner on a flight from Tampere (Finland) to Frankfurt on 27 August 2005.

Deformed glories

The diameter of the glory is inversely proportional to the size of the droplets. In

Figure 3. Deformed glory, photographed by Philip Laven on a flight from Geneva to London on 12 July 2006.

Figure 4. Discontinuity in a shadow of a TV tower cast on an uneven cloud deck, photographed by Claudia Hinz from the mountain Wendelstein in the Bavarian Alps on 18 August 2007, 1619 UTC.

Figure 5. Glory on a cloud cap over the top of a neighbouring mountain. The gradients in droplet size cause the formation of coloured legs running away in seemingly random directions from the circular part of the glory. The sun's elevation is low and the mountain from which the picture was taken casts a triangular shadow. The picture was taken by Claudia Hinz from the mountain Wendelstein (1835 m) in the Bavarian Alps on 18 November 2007, 0726 UTC.

nearby fog, the glory is usually almost perfectly round because the droplets in which the glory appears tend to be uniform in size. But if the glory is formed in distant droplets, its shape may deviate considerably from the circular. This occurs when the droplet size varies significantly along the coloured rings. This may result in elliptical or even angular deformed glories (Figure 3). Strong and sometimes conflicting perspective effects may occur if there are irregularities in a cloud deck resulting in discontinuities in shadows of nearby objects (Figure 4).

In some cases, such as in orographic clouds over a mountain top, the spatial variations in droplet size can be large enough to become the determining factor in the shape of a glory. Such a situation was observed on 18 November 2007 from the summit of the 1835 m Wendelstein with the glory visible in a cloud cap over a neighbouring mountain. The gradients in droplet size created extensions of the glory in the directions of the smaller droplet sizes (Figure 5). The somewhat bizarre impression of this picture is completed by the perception that this seemingly flat glory structure stands out against the mountainous background.

Iridescence and polarization

In cases of even larger spatial variations in droplet size – for instance by more than a factor of two in adjacent clouds bands – the shape of the glory may become unrecognizable in the structure of the colours. Hence the glory turns into iridescent clouds, not by diffraction on the sun side of the sky but by glory-scattering in the region of the shadow point. To observe this glory-induced iridescence, again one has to be above the clouds. Figure 6 is taken from the top of the highest mountain in the Bavarian Forest.

A deformation of another kind occurs if one views the glory though a polarizer (e.g. in Polaroid® sunglasses). In that situation, there emerges a structure in its inner part which rotates as the filter is rotated. With this remarkable property the glory distinguishes itself from the diffraction corona, being its counterpart on the other side of the sky, which shows no polarization effects at all. The fact that the glory does exhibit polarization effects is related to subtleties in the mechanism of its formation, in particular the role of the surface waves in the water droplets (Van de Hulst, 1947; Laven, 2005). Unfortunately, these polarization effects are difficult to observe through aircraft windows because the window material disturbs the polarization. However, the effects can be beautifully seen from an air balloon or from a mountain (Figure 7).

Figure 6. Iridescent clouds near the shadow point, photographed by Stefan Rubach from the mountain Grosser Arber (1456 m; 49° 6.7′ N, 13° 8.1′ E) in the Bavarian Forest on 26 January 2007, 0852 UTC.

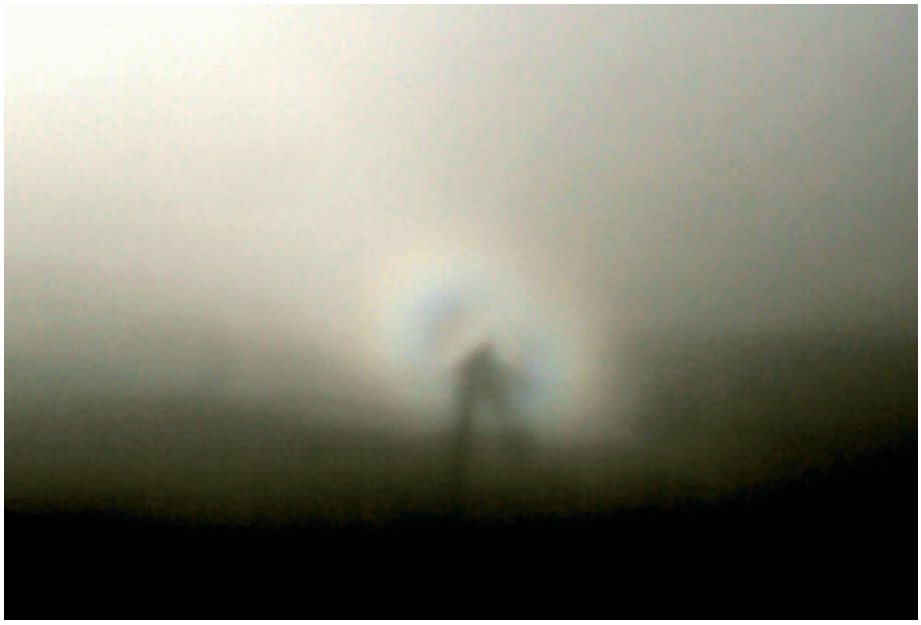

Figure 7. Deformation of a glory due to the use of a polarizer in front of the camera. The polarization axis of the filter is parallel with the line connecting the two dark spots in the glory. The fog bank in which the glory was formed was very close to the observer; note the ghostly deformation of her shadow. The picture was taken by Claudia Hinz on the mountain Wendelstein in the Bavarian Alps on 13 October 2006, 0918 UTC.

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Ice patterns formed on a car roof in Sidmouth, Devon on the morning of 30 January 2008. (© Jeff Norwood-Brown.)