

Moilanen arc observations from Davos

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Summary

This report describes halo displays including Moilanen arcs (MAs) which occurred in Davos from 2005 to 2017, caused by snow gun induced diamond dust. Four of them are discussed in more detail. The MAs are presented in relation to the degree of ripening of the diamond dust crystals, and with respect to the other halo types in the displays.

Introduction

Davos is a world-renowned winter sport resort. Because of the decreasing amount of natural snow over the past decades, numerous snow guns have been installed. In the winter season 2017/18, more than 150 of them are running.

Snow guns produce artificial snow made from clumps of small ice spheres without any discernible hexagonal crystal structures. However, a part of the water spray is converted into microscopically small ice spheres which drift off. These will serve as condensation seeds for larger crystals, often in column shape, but also plates do occur.

Remarkably, MAs are preferably generated during the first stage of crystal growth. Full-ripe crystals produce only dull MAs or none at all.

Geographical situation in Davos

Davos lies in the relatively flat valley of the Landwasser river, with three other valleys branching off under right angles towards the south east (Flüelatal, Dischmatal, and Sertigtal). Between Dischmatal and Sertigtal, the ski resort Jakobshorn is situated, being equipped with about 50 snow guns.

At the ends of Dischmatal and Sertigtal, located at the periphery of Davos city, cold air pockets form during nighttime and early morning, which act as aging reservoirs for the crystal growth and are thus of great importance for halo displays in Davos.

Two other sources of humidity, the river Landwasser and the outdoor pool of the swimming bath, do not influence crystal formation. The ground fog arising from them is dissolved due to a flow equilibrium before ice clouds prone to generating halos are formed.



[1] Overview of Davos. Camera symbols: Positions at which photographs were taken. © Google Inc.

Application of artificial snow

At the beginning of the winter season (in Davos during November), the higher areas above the forest limit at the Jakobshorn are massively subjected to artificial snow. The microscopic ice particles generated in this process serve as condensation seeds for the desublimation of air humidity. The growing crystals accumulate in the cold air pockets or form ice clouds of typically fuzzy outlines in mediocre height. The crystals are allowed to grow and ripe over hours, resulting in well-defined and colorful halos. On the other hand, this results in the absence of MAs:



[2] 7.11.2017 09:30 - Davos Islen (position 4)

- singly and doubly oriented columns

- no plates

- no MA generating crystals

Far stretched and sharply defined upper tangent arc, suncave and sunvex Parry arcs

Occasionally, contrail-like stripes are formed, which appear as remarkably long and thin bands starting at the snow guns (3 observations in 12 years):



[3] 16.12.2009 - Davos promenade (position 1)

View of Dischmatal and Jakobshorn with its left pre-summit Brämabüel

"Contrail" filling the valley, starting off a single snow gun at Brämabüel

The cross-country skiing trails at the bottom of the Jakobshorn are also treated with artificial snow, but only from few snow guns (<5). No specific halo formation could be inferred from them.

Starting from the end of November / beginning of December, 5 snow guns at the outskirts of Davos produce huge amounts of snow for the half pipe (marked by the blue snow flake symbols in the geography overview picture), usually from 8:00 – 9:00. Most often, these are the only running snow guns at that time, so that the resulting halo displays can be safely attributed to them. Under favorable wind conditions, the growing ice clouds drift slowly along the base of the Jakobshorn towards the cold air pocket at the end of the Dischmatal.

The first two halo displays discussed here are prototype examples for the process described above:

5.12.2017

Course of events

- Cloudless night
- 7:00 (long before sunrise), -8°C 89% relative humidity, no visible ground fog made of ice or arising from the river
- 8:30 (first sunshine in parts of Davos) small thin halo generating ice fog near Dorfseeli, and a rather small but compact amount of ice fog from the half pipe snow guns drifted at about 5 km/h towards north east in the direction of the Dischma cold air pocket.



[4] 05.12.2017 08:30 - Davos promenade (position 1)
Only a small amount of ice fog in total, but a piece of the supralateral or infralateral arc sticks out. A compact ice crystal cloud is moving in from the right.



[5] 05.12.2017 08:57 - Davos Talstrasse (position 2) - panorama stitched from four single frames
view into Dischmatal, at the right Brämabüel / Jakobshorn
The prolate shape of the supralateral arc and the pseudo kink at the parhelic circle (superposition with the infralateral arc) are clearly visible.

The quality of the ice crystals changed from minute to minute, with the halo contrast decreasing at first, but being restored again later on. Note the much less wide upper tangent arc in comparison to the Parry display in mature crystals shown above. The crystal cloud needed about 10 minutes for its migration from the half pipe snow guns to the position of the observer.



[6] [7] [8] [9] 05.12.2017 09:09 to 09:12 - Davos Talstrasse (position 2)

Again, only the half pipe snow guns were running in this case.



[10] [11] 02.12.2010 14:20 - Davos Bolgen (half pipe)

In the afternoon, the wind had turned and now blew the snow clouds into a south western direction

The following photograph shows that the MA is indeed the first halo species to become visible! The diamond dust might be about 5 minutes old at this time (drift from the snow guns to the observer [2]). A faint 22° halo is barely visible on the left side.



[12] 02.12.2010 09:14 - Davos Talstrasse (position 2)

Further to the north west, at the Davos Dorfseeli, the crystals are more mature, but still some way off from being perfectly shaped:



[13] 02.12.2010 09:20 - Davos Dorfseeli (position 3)
The yellow cones are christmas decoration, being illuminated in various colors from the inside at night.



[14] 02.12.2010 09:22 - Davos Dorfseeli (position 3)

Apart from the already very impressive MAs induced by the half pipe snow guns, there is also the possibility of the snow guns on the upper slopes producing MAs. The following display including an interesting detail occurred in very light diamond dust.



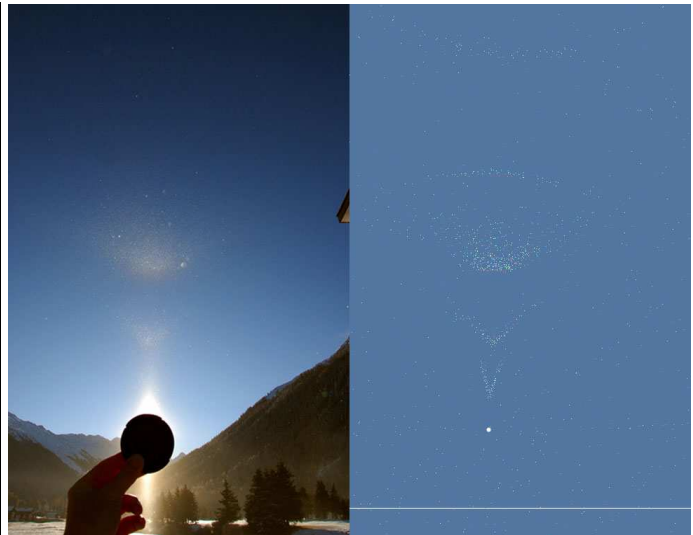
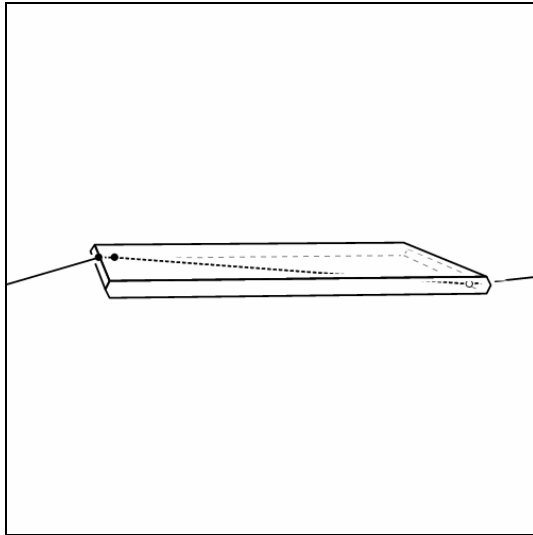
[15] [16] 07.11.2009 14:41 - Davos Talstrasse (position 2)

Already during the observation I noticed visually some faint glittering between the MA and the lens cap (above the bright aureole around the sun). Marko Riikonen identified this as a reflected Parry arc and sent me a proper simulation (image to the right).

In the same display also the lower tangent arc was present (photograph below).



[17] 07.11.2009 14:45 - Davos Talstrasse (position 2)

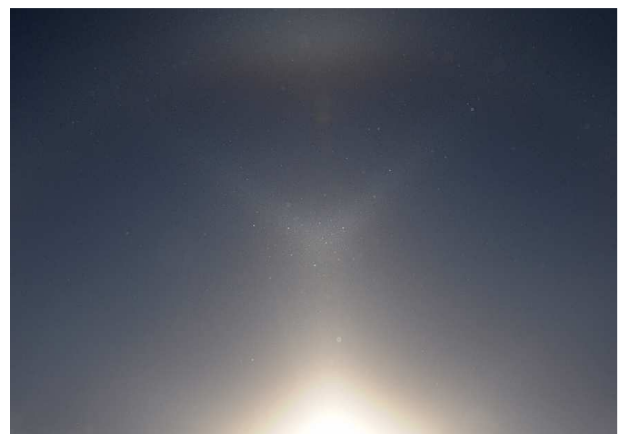


[18] [19] © Marko Riikonen

12.12.2012

Halo displays do occur as well at the Serigdal cold air pocket, induced by the snow guns in the Clavadel region (some photos show their snow trails). Regrettably, the displays dissolve within only a few minutes after the onset of solar irradiation onto the crystals, likely due to sublimation quickly rounding off their edges.

All pictures were taken in great hurry between 9:59 and 10:02, shortly afterwards everything was over.



[20] [21] [22] 12.12.2012 9:59 - Davos Islen (position 4)



[23] 12.12.2012 9:59 - Davos Islen (position 4)

The three dimensional impression during the actual observation is fascinating. The upper tangent arc is bulging out towards the observer, whereas the MA appaers like a slanted V-shaped slide facing him. One is almost inclined to fill in snow balls at the far upper end... which is of course impossible, as you cannot step aside from a halo.



[24] 12.12.2012 9:59 - Davos Islen (position 4)



[25] 12.12.2012 9:59 - Davos Islen (position 4)

Note the 46° circular halo in contrast to the elongated shape of the supralateral arc in the first display from 05.12.2017. Here, we also have a larger amount of plate crystals, as indicated by the parhelia and parhelic circle.

The photograph is not defocused, but halos in thin diamond dust give this impression. (Note from translator (A. Haussmann): This is likely due to diffraction by small-sized crystals. The correct focusing is proven by the sharp outline of the distant trees.)

20.12.2005



[26] 20.12.2005 10:25 - Davos Dischmatal (at the SLF - WSL Institute for Snow and Avalanche Research)
© Christian Rixen, SLF, with permission

Typical (weak) appearance of the MA in diamond dust of well-ripe, mixed crystals



[27] 20.12.2005 10:20 - Davos Talstrasse (position 2) © Claudio Silberroth, with permission (non-correctable white balance mismatch due to erroneous setting to "neon lamp")

13.12.2007



[28] 13.12.2007 - Davos, below the middle station of the Parsennbahn funicular.

28.11.2008



[29] 28.11.2008 - Davos Talstrasse (position 2)

17.12.2008



[30] 17.12.2008 - Davos Talstrasse (position 2)

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