The Quest for the Gegenschein

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The sun's counterglow — or gegenschein — is kind of a stargazers' legend. Every amateur astronomer has heard about it, only a few of them have actually seen it, and even fewer were lucky enough to capture an image of this dim and ghostlike apparition. As a fellow observer put it: "The gegenschein is certainly not a GOTO-object." Matter of fact, it isn't an object at all. But let's start from the beginning.

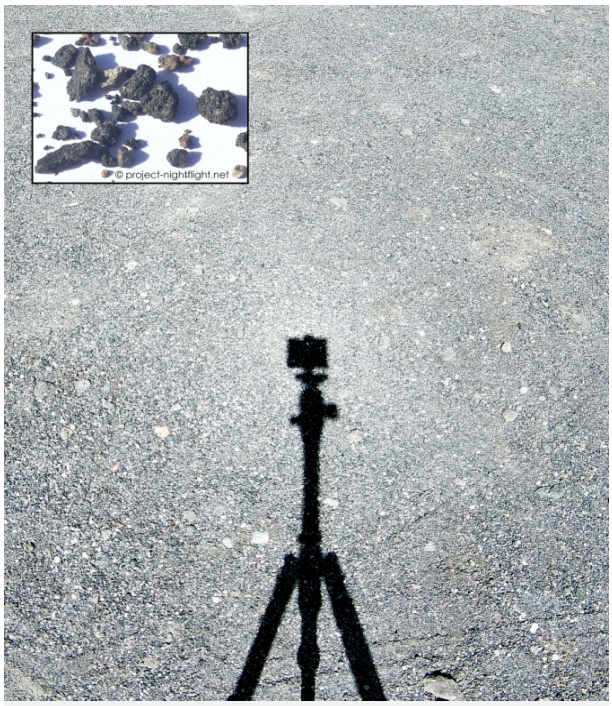
What exactly is the gegenschein?

It is widely known that the space between the planets isn't empty. The plane of the solar system is filled with an enormous disk of small dust particles with sizes ranging from less than 1/1000 mm up to 1 mm. It is less commonly known that this interplanetary dust cloud is a highly dynamic structure. In contrast to conventional wisdom, it is not an aeon-old leftover from the solar system's formation. This primordial dust is long gone. Today's interplanetary dust is — in an astronomical sense of speaking — very young, only millions of years old. Most of the particles originate from quite recent incidents, like asteroid collisions.

This is not the gegenschein. The picture shows the zodiacal light, which is closely related to the gegenschein. Here imaged from a rural site, the zodiacal light is a cone of light extending from the sun along the ecliptic, visible after dusk and before dawn. The gegenschein stems from the same dust cloud, but is much harder to detect or photograph.

Exposed to various forces, the particles do not remain in stationary orbits but inhabit the disk in ever changing motion. The smallest particles (less than 1/1000 mm) are swiftly blown out of the solar system by the solar wind. The larger particles don't survive very long either. They tend to collide with larger bodies or slowly spiral into the inner solar system where they fall into the sun. Nevertheless, the supply of interplanetary dust particles is constantly replenished by the above-mentioned asteroid collisions and the erosion of comets. So, the interplanetary dust cloud of the solar system is not a static formation but a dynamic structure consisting of quite young components. For an observer on Earth, this dynamic dust cloud is mainly visible in the form of the so-called zodiacal light. After dusk and before dawn it extends as a cone of light from the sun along the ecliptic path. Often called the "false dawn", the zodiacal light is quite bright and can be seen from any observing site that doesn't suffer from severe light pollution, especially when the ecliptic is high in the sky. For northern hemisphere observers, this is the case in the evening sky during

spring and in the morning sky during autumn. The morning and evening zodiacal light are the two areas of the interplanetary dust disk where sunlight gets forward scattered to earth, resulting in the bright silvery light cones. The interplanetary dust disk is also visible along the rest of the ecliptic path, where it is called the zodiacal band. Unlike the zodiacal light, however, these sections are very hard to detect since they have an extremely low surface brightness. But at the point directly opposite the sun the geometry again works in our favor and enhances the visibility of the interplanetary dust. This is the area of the gegenschein.



This is like the gegenschein. For this photo a small action cam was positioned on a tripod and looking down on volcanic gravel on La Palma island. The insert shows some of the gravels with a size of several millimeters and their rough surface structure. Around the camera's shadow the opposition effect results in an obvious brightening. The glow pictured here is similar to the glow of the gegenschein on the night sky.

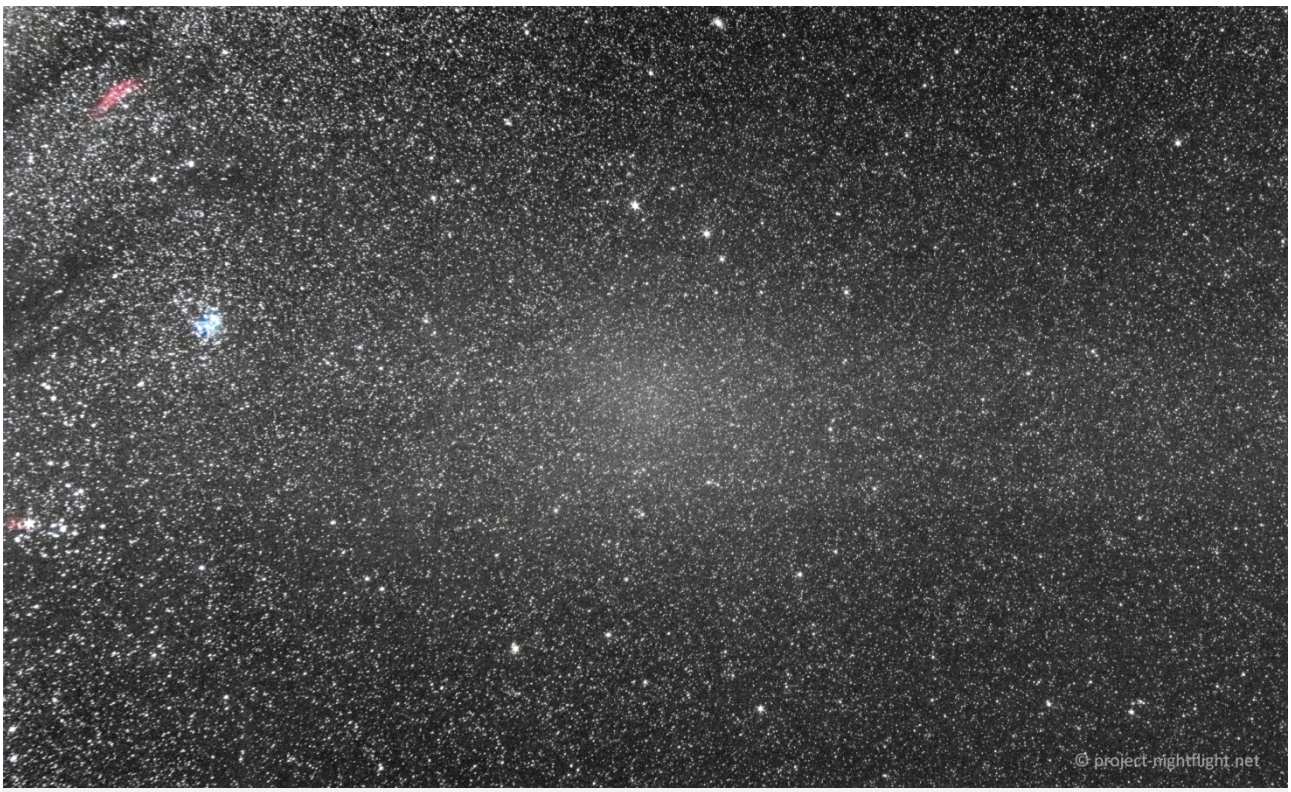
But why does the gegenschein glow brighter than the rest of the zodiacal band? Looking at the interplanetary dust disk from earth, the section at the antisolar point is illuminated from directly behind our heads. This results in an increase in brightness that is called the opposition effect. The opposition effect is a frequent phenomenon for solar system bodies. For example, the moon shows a significant peak in brightness around full moon, i.e. at its opposition. Another example are Saturn's rings in the days around opposition, when they brighten drastically. The main reason for this brightening during opposition is shadow hiding, meaning that all particles are fully illuminated. This opposition effect can even be experienced here on earth during daylight if you are outdoors and look at the ground in front of you. If the ground is sufficiently coarse, you will see a brightening around the shadow of your head. To document this phenomenon, we made a photo that shows the opposition effect on volcanic gravel. Interestingly, the brightening around the camera's shadow had an apparent diameter of 10 degrees, which is about the same size as the diameter of the gegenschein in the night sky. Next time you walk on a rough surface in sunlight, give it a try and look for this terrestrial version of the counterglow.

To sum it up, the gegenschein is not a real object. It is a play of light on the solar system's interplanetary dust disk. The section of the dust at the antisolar point is squarely illuminated, which results in a brightness enhancement due to shadow hiding. This so-called opposition effect can be encountered at many occasions, but with the gegenschein it makes its most ghostlike and outlandish appearance. This is probably the reason why it is such a prized trophy among amateur astronomers.

How we captured the gegenschein

From our observing and photography sessions at dark-sky sites, the gegenschein was a familiar companion. Out under the stars, sooner or later one of us would mention: "Mmh, the gegenschein is quite obvious tonight", followed by the typical reply: "Yep, bright and shiny!" This short dialogue would indicate that our eyes had reached full dark adaption and our night vision was at maximum capacity. We often talked about making an image of our good old dark-sky companion, the gegenschein. But for some reason it never came to it. Other projects were in the way, on other occasions the position in the sky was not right, or the atmosphere's transparency was just not good enough. But on the night from October 30 to 31, 2019, we finally did give it a go. On October 30 we were already several days on an imaging excursion on La Palma island. During daytime the annoying Calima weather pattern had finally stopped and skies were again as deep blue and transparent as they can be on this beautiful stars island. Accommodated in a solitary finca far away from inhabited areas and about 800 meters above sea level we had the perfect conditions for

photographing the gegenschein. Around midnight, when the counterglow culminates, our instruments registered a sky brightness of 21.4 magnitudes per square arcsecond in the zenith. This is so dark that Sirius noticeably brightened the landscape when it rose behind a mountain ridge later that night. The gegenschein itself was pretty obvious to the unaided eye. Below the constellation Aries, directly on the



This is the gegenschein, shot from La Palma island on October 31, 2019. On the left side of the image, the Hyades and Pleiades clusters and the red California Nebula are familiar markings. Above the gegenschein, the three bright stars of the constellation Aries can be seen. The faint extensions left and right of the gegenschein are part of the zodiacal band that marks the ecliptic.

ecliptic path, a distinct glow about 10 degrees across marked the antisolar point. The very faint zodiacal band crossing the whole sky was visible too, almost looking like an artificial marking of the ecliptic. Under these conditions, shooting the gegenschein was an easy task. For those interested in the technical details: we made 23 unfiltered exposures of 4 minutes with a 16mm lens @f/5.6 on a Baader-modified 1100D Canon DSLR. For sky tracking we used a purely mechanical device, the Mini Track LX2. This innovative device is a frequent companion on our imaging excursions. For those interested in more details, we provide a thorough review of the Mini Track LX2 for download on our website. The total weight of our imaging gear was less than 3 kilograms, including camera and tripod. The 23 individual exposures of the gegenschein were later calibrated, registered and stacked with DeepSkyStacker. Processing of the final image was done in Photoshop, where we applied substantial contrast enhancement.

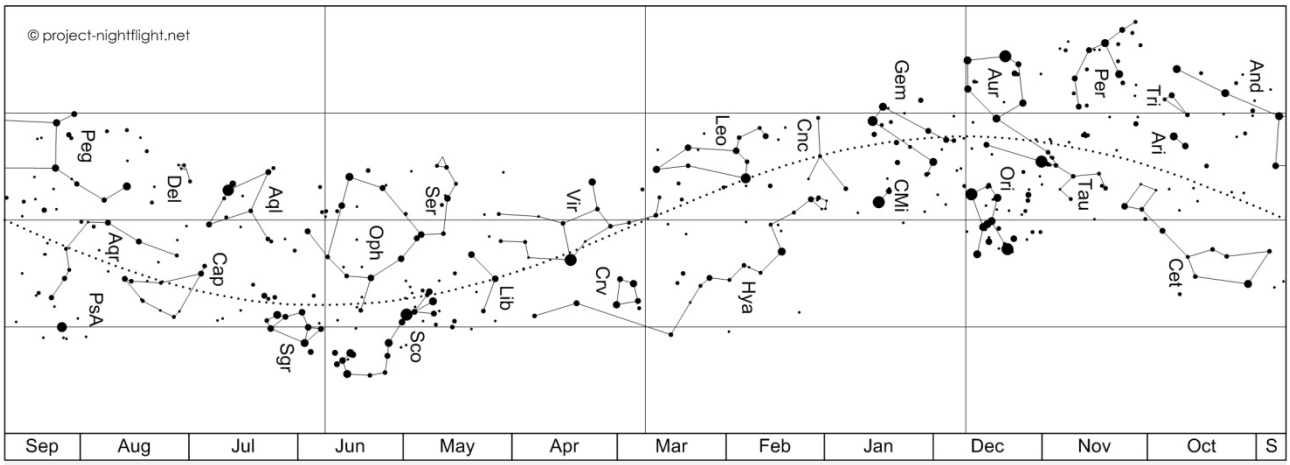
For shooting the gegenschein on La Palma island we used a highly portable setup. A Mini Track LX2 equipped with a ball head provided sky tracking. The tracker rested on a lightweight travel tripod with a MENGS mini wedge. The exposure series of the counterglow was timed with a remote release timer.

How you can see the gegenschein

If you never encountered the gegenschein yourself, don't expect it to be as prominent as in the photograph above. We applied heavy contrast enhancement to the image to make the counterglow, its shape, and its size better visible. To our human eyes, even under the best conditions the gegenschein is an elusive and dim glow. On several occasions we compared the visual brightness of the counterglow and sections of the Milky Way. We always found it to be about as bright as the dimmest parts of the Winter Milky Way. The stretch of the Milky Way that approximates the counterglow's brightness best is the section between the star Mirfak and the asterism called "the Kids" next to Capella. That is — very dim. Any bright object in its vicinity (e.g. Jupiter or Mars at opposition) makes it hard to observe. Aside from being slightly brighter in the middle and fading out uniformly in all directions the gegenschein shows no structure at all. It has a roundish form, circular or elliptical, measuring approximately 10 degrees across. That is about the size of a fist stretched out at arm's length. If you want to hunt down the elusive gegenschein yourself, the tips below might come handy.

Drawing of the gegenschein as seen on November 23, 2019, from a dark-sky observing site in Lower Austria. On this night the antisolar point was between the two star clusters of the Hyades and Pleiades. The drawing gives a realistic impression of what to expect when looking for the counterglow.

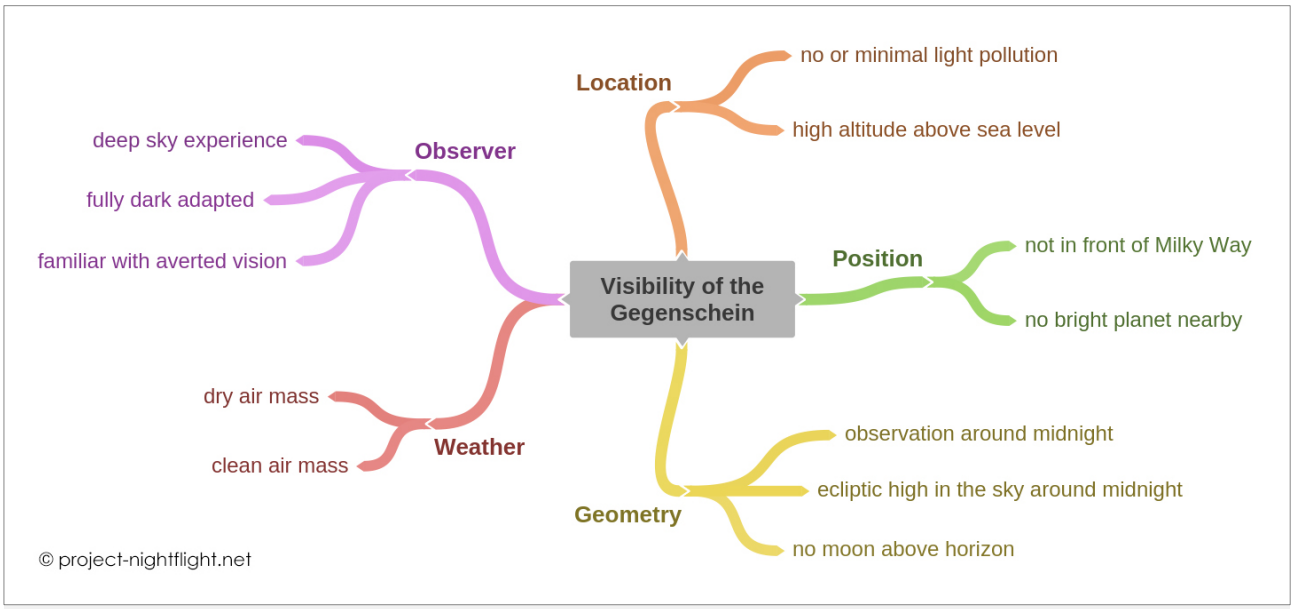
First of all, check the position: Before you begin searching for the gegenschein in the night sky you should check its current position. The map below helps you to determine where to look for it. It also shows you whether the counterglow is detectable at all, because its visibility highly depends on its position against the starry background. In June, July and December it is completely invisible, because it is in front of the Milky Way. Other obstacles can be the bright planets Mars and Jupiter. When one of them is near opposition, it is in the same region of the sky as the counterglow and may outshine it.



This map gives you an idea where to look for the gegenschein in front of the starry background. The scale at the bottom indicates the constellations that culminate at your local midnight on a given date. This also approximates where you can find the gegenschein on the dotted line of the ecliptic. For example, at the end of March it will glow in the constellation Virgo.

Some planetarium programs or stargazing apps might also be useful tools to determine the position of the gegenschein. If the software provides an option to display the center of the earth's shadow this will show you the current antisolar point.

Look for it at maximum height above the horizon: The gegenschein is always highest above the horizon around local midnight, so that is the best time of the night to give an observation a try. There should also be no moon above the horizon. But that's not all. Like the sun itself, the antisolar point too has different culmination heights during the course of the year. For observers on the northern hemisphere the antisolar point has its highest culmination at the winter solstice around December 21. Sadly, during December the gegenschein is in front of the Winter Milky Way and therefore invisible. So, the best months to see the gegenschein from northern latitudes are November and January. For southern hemisphere observers, the largest culmination height of the antisolar point happens at summer solstice around June 21. For southerners too, the Milky Way is in the way. Again, one should look before or after the solstice, in this case during May or August.



Only if all of the conditions listed in this diagram are true, you have a valid chance of actually detecting the gegenschein.

Try from the best observing location you have access to: The gegenschein cannot be seen from light-polluted sites. Even moderate light pollution diminishes the counterglow's contrast way too much. Based on our observations, the absolute minimum to detect the gegenschein is a sky brightness of 21.0 mag/arcsecond^2 in the zenith. But this applies only if you are already quite familiar with the gegenschein and know exactly what and where to look for. For first-time observers we recommend a site with a sky brightness of 21.2 mag/arcsecond^2 in the zenith or better. These conditions can only be found far away from cities or other inhabited areas. Observing sites in the mountains especially qualify because of the reduced air mass at higher altitudes above sea level.

Wait for favorable weather conditions: Even if you observe from a dark-sky location, the average clear sky might not be good enough for seeing the gegenschein. What you really want is a night sky with exceptionally high transparency. This will only be the case if the air mass above your observing site is as dry as possible. To get an idea of the current situation at your location, you can use a website that provides weather forecasts for astronomical observations (e.g. 7timer.info). Sites like this display data about humidity at all tropospheric layers. Another condition for high transparency would be that the air is clean, i.e. free of dust. At mid-latitudes, the necessary conditions of dry and clean air often can be found after the passage of a cold front or a trough.

Expand your observing skills: Given you have good eyesight in the dark and you already have some observing experience, there are several observing techniques you need to master for the gegenschein. First of all, you need to learn how to become truly dark adapted. This might put your patience to a test, since your eyes need at least three quarters of an hour to fully adjust to the dark. So, no smartphones or other

handheld devices during this time. You should only use very dim red lights if you don't want to ruin your night vision. A second technique you might need for seeing the gegenschein is averted vision. With averted vision, you do not look directly at an object but a little off to the side, while continuing to concentrate on the object. This way you are using peripheral vision which is more sensitive to low light levels than the center of the eye. Some observers report that this technique makes a big difference for them and it might help you too. In any case, hunting down the gegenschein will improve your observing skills a lot. Besides, it makes a highly interesting project and sooner or later you too will be able to put that prized stargazer's trophy on your shelf.

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