The green flash seen from the Italian west coast

"Starting from the observation of 600 sunsets, the authors describe an empirical method to foresee the green – ray . This method is based on stochastic observations extrapolated in Italian west coast). In this article the authors examines the phenomena connected with physical conditions and suggests some advice on photography".

The green flash is an atmospheric phenomenon which can be seen as a faint green light beam visible on the top of the Sun's disk at dawn or at sunset. Seldom the green can fade into blue.

Estimated from the Italian west coast, it can last a very second up to two-three. Its duration is due to the velocity of the sunset during the year; it also changes with the changing of the latitudes. For example: the light beam can last many minutes in the Poles.

Sir Kristian Birkeland observed long beams from Swalbard (Norge) and from Novalia Zemalja (C.S.I.) during his researches about aurora borealis in Autumn 1899 and in Spring 1900. During a voyage to Little America (lat. 78° north) the Admiral Byrd observed the duration of a ray up to 35 minutes, which went beyond any forecast.

The first observation described in scientific literature was "Sopra alcune apparenze del Sole presso l'orizzonte", by P.G. Maggi in 1852 (Atti delle Adunanze dell'I.R. Istituto Veneto Sci. Lett. Arti).

In Italy at the end of '50s the green flash was taken with high profile photos by "Specola Vaticana" Observatory for the first time. Nowadays the astronomer Andrew T. Young explains a good study on his Web site: http://mintaka.sdu.edu./GF.

The main causes which determine the sight of the phenomenon are:

Atmospheric refraction: it is the variation of the direction of propagation of the light rays which cross the atmosphere of the Earth. It happens when the phase front of the Sun light hits the surfaces of the different air thickness. The phenomenon changes according to the time and the place you are watching from.

The phenomenon proportionally goes with the rise of air thickness, therefore when the Sun approaches the horizon the deformation of its disk increases step by step.

Dispersion: the spectrum of the electromagnetic radiation (light-wave) is scattered by distinguished atmospheric refraction according to different wave-length (colour). The phenomenon follows the changing of the spreading speed of the radiation through the atmosphere of the Earth according to its wavelength and this is the reason why the violet rays are pushed down more than the red ones. The observer can look at the upper side of Our Star coloured in violet and the lower one shining red.

Scintillation: the sparkling makes the Sun apparently change its brilliance. This phenomenon is due to all turbulences and all fast fluctuations of the air-cells which belong to the column of the atmosphere between the observer and the Sun.

Indeed the turbulences are responsible for the irregularities in flashes, such as the one at the top of the Web page. The scintillation does not determines an angular amplification of the green flash, not even it reduces the chromatic bright of the Sun.

The atmospheric selective absorbition: the spectrum of the electromagnetic radiation loses its energy when the light wave hits atmospheric particles which change the energy into heat.

Some particles, such as oxygen, ozone, humidity and dust absorbe a little in the red, favouring a bit passage of the green and the blue. However the selective absorbition is a small effect because the wave-length region absorbed is too narrow to effect the colour of green flashes appreciably. There is a slightly effect from the Chappuis bands of ozone in the orange part of the spectrum, but it is small in determining he colour of green fleshes.

Scattering: the light wave radiation, exactly the short wave-length, can appear less bright according to scattering increasing due to more and more dense atmosphere strati. Therefore the shortest wave lengths, the violet and the blue colour, are reduced and that favours green colour.

Diffraction: diffraction plays no part at all in green flashes. It occurs only when some part of the optical system is comparable in size to the first Fresnel zone (for visible light this is about a millimetre at a distance of 2 meters). However when the phase front of the Sun light travels near the Earth’s surface the light waves are deviated so the Sun disk changes its shape.

Other reasons are the turbulences, due to the random atmospheric motions and the high jet-streams, and the strong temperature inversions and pressure ones next to the horizon line.
The primarily physiological mechanism is: the bleaching of the red-sensitive cones in retina, that makes the low Sun appear greener than it normally would. This is dealt with in detail in a paper publisher by Andrew T. Young (see his Web pages).
There could be also a further condition which makes it be watched, that's not a physical reason, but it is a cognitive mechanism: the phenomenon doesn't happen, so the observer's eyes do not see it, but subjectively the mind recreates it and deceives itself, thinking to watch it only because it wants to see it.

An outlook on statistical figure

We have carried out a series of visual and instrumental observations on the phenomenon, trying to be able to foresee it with a very low miscalculation in order to understand which could be the true value of exposure before the snapshot. We have based our observations on a sample of 600 sunsets which we have been randomly chosen during clear skies ones. We have observed 500 sunsets from the sea-coast next to Rome from January 1997 to October 2000 using a 20 X 60 binocular and a 4–inch f/6 Newtonian (used at 24X and at 48X). From October 2002 to October 2004 we have sampled 30 sunsets in Rome, 10 in Sorrento (Naples), 40 ones from the "Royal Palace" in Caserta and 20 in Pisa; we have used a binocular Zeiss 7X50 and a 5-inches Maksutov. We have carefully observed local weather conditions, atmospheric colours, deformation of the Sun disk and its colours.
While watching far from the sea (in Roma and in Caserta), we have seen the green flash only two times and many times only the green rim, viceversa while watching from the sea-cost, the green ray was very frequent. According to the statistical estimates, we can affirm that a thin green rim precedes all flashes.
Every year we can see 45-50 rays on average; they are concentrated in the following months: May, June, September, October (with a ratio of about 70% of the annual intensity).
The chance to see the phenomenon daily is 12.3%-13,7% (up to 25.8% all through the above mentioned mentioned months, and less than 5.5% during the others).

We have to consider we can see the 80% of these flashes only using the telescope. So the daily chance to observe the green flash without instruments decreases to 2,6%.

However, as I said, it is important not to underestimate the incidence of the cognitive process.

We can roughly estimate the incidence on a representative sample to be about 20%.

You could deduce that, even if, we can watch on average 45-50 green rays from the Italian central coast yearly only 36 - 40 are a real phenomenon, so "the probability to watch the phenomenon daily" (2,6%) becomes "the probability that it happens daily" (2%). You are able to understand the cognitive trick only if you observe in a team. If you are watching alone you are not aware because, may be, you are tricked by your mind and by its cognitive mechanism.

To foresee the visibility

Many people believe in "serendipity", but I think if they are able to observe the following conditions carefully, they will reduce the randomness. An half hour before the sunset we can forecast the ray with a chance of 66%. You are able to do this if the following meteorological phenomena are present:

a) there must be a north and cold wind, which cames from inland;

b) the wave motions, far from the coast, can determine an angular amplification of the ray, but a very strong wave or only one too close to the coast can delete it;

c) the "veli" make it unlikely but not impossible;

d) there must be high pressure above the horizon and the sky must be clear for at least 10 degrees above the Sun disk. We have watched green flashes two times even if few cirrostrati were 3-4 degrees above the Sun;

e) the presence of a new offspring anticyclone, but if it has been present for more than 3 days, the observation is unlikely;

f) the sky close to the horizon must be white-blue.

Looking through the following phenomena about 5minutes before the sunset, the likelihood of successful forecast increases up to 90%;

g) if the Sun disk is heavy misshaped and flickering, but also bright and white, the phenomenon is more evident and it is visible with naked eyes.

We can watch the flash shading into violet-blue;

h) if we observe a pedestal under the Sun, it means that the conditions of visibility are optimum;

i) if the Sun disk is heavy crushed, but it is red, only the green rim is visible using the telescope.

All these conditions change when the Sun sets behind the Archipelago Toscana's islands (second half of June, July), because during these periods the sunset takes place on the earthy horizon, therefore the influence of the sea runs out, all through these cases the phenomenon happens at the higher altitude above the sea level so the atmospheric refraction and the air density decrease. Furthermore the thermic and baric incidences are less strong. This is due to higher diffraction above the outline of the islands, where the speed of the ray is faster and the green is much brighter.

Among all the green flashes recorded during the sample survey carried out the period, only four had not been conformed with the hypothesis of the forecast, thus they are negligible.

Photo

The first necessary condition to shoot is an optimal clearness of the air. We have always used the following formula to understand the right value of exposure:

[(f/) X (f/)] / [Iso X B] = T (seconds).

The main problem has been to determine "B". We suggest that the best value is between "360" and "700". But, photographing the ray from a place far from the sea, trials and errors prove that "B" decreases to values between "100" and "400"; the more the photographer is far from the sea-cost, the less value he will use.

Example: using a 50 ISO film, and using a telescope f/12 as a telephoto lens, we get:

(12 X 12) / [50 X 700] =0,004";

it means that the right exposure is 1/250. If "B" was 360, the value would be 1/125. As a general rule all intermediate exposures would be right, nevertheless the photographer should be able to foresee the real ray's brightness, using his experiences, to choose the best value he can.

I advice 50 iso slide films, Fuji Velvia and Kodak Ektachrome 64 seems to be the best.
The best focal lens lengths for 35 mm camera must be longer than the 1000 mm ones, but we don't advice the achromatic lens because the achromatic aberration could blurr the green.
In order to observe the Green Lantern, we consider the central sea-cost of Italy a privileged place, compared with the other inland countries in Europe, where the phenomenon seems to show itself at a far less frequency. Also this is in accordance to the experiences published by Prof. Paolo Candy (in Le meraviglie del cielo).
Whatever it is your experience rate, we advice everyone to try to watch it, especially if you are where the sunset takes place on the sea. We advice to visit the wonderful Wes site www.polarimage.fi.
If you see the ray it will remain in your mind as a shining pearl.
Good luck!
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Web Ring: http://astrocultura.uai.it/avvenimenti/raggioverde.htm