

Green Flash During a Partial Eclipse

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With 2 Figures

Zusammenfassung: Die Möglichkeit, während einer partiellen Sonnenfinsternis einen grünen Strahl zu beobachten, ist ohne Benutzung optischer Hilfsmittel kleiner als bei einem normalen Sonnenuntergang, aber gleich groß bei Benutzung eines Teleskops (oder eines Feldstechers).

Samenvatting: De kans om tijdens een gedeeltelijke zonsverduistering met het blote oog de groene flits waar te nemen is kleiner dan tijdens een gewone zonsopgang. Neemt men waar met een teleskoop (of met een verrekijker) dan zijn de kansen gelijk.

Summary: The probability of observing a green flash with the naked eye during a partial eclipse is lower than during a normal sunset; if the observations are made with a telescope (or with a pair of binoculars) then the probabilities are equally high.

Introduction

On July 20, 1981, a partial eclipse of the setting sun was observed in the Netherlands (Fig. 1). Many people went to the Dutch coast to see the green flash, since some journals and newspapers had suggested that there was a good chance to observe it. In fact, the chance of the occurrence of a green flash during a partial eclipse, observed with binoculars or with a telescope is the same as the chance to see it on any other occasion. An observation of the green flash with the naked eye during a partial eclipse is even less probable than on other days. The reason for this will be discussed here. At first we describe the four types of green flash that can be observed during "normal" sunsets. We then continue to discuss the forms that the phenomenon will take during a partial eclipse. We conclude with some remarks on the chance of seeing a green flash under these circumstances with a telescope or binoculars and with the naked eye. The phenomena described in this note apply equally well to the rising sun which is partially obscured by the moon.

Green flash

The green flash is the phenomenon of the upper rim of the disc of the setting sun taking a green or bluish-green colour. The physical principles that underlie the phenomenon are refraction, dispersion, scattering and selective absorption of the sunlight in the atmosphere (Floor 1982b). The simplest form is the green rim (Fig. 2a). The width of this rim is under normal atmospheric conditions at the moment of sunrise or sunset about 10 seconds of arc.

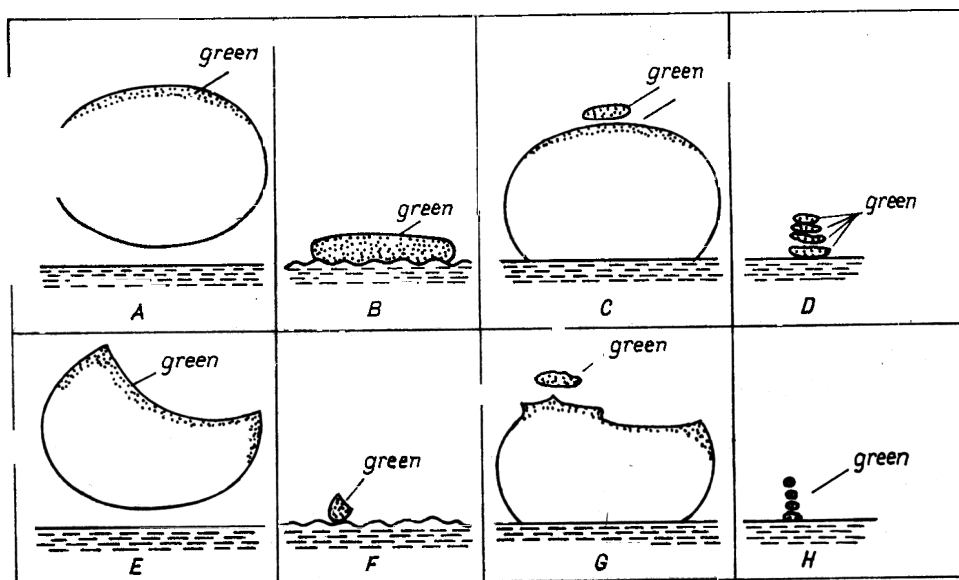


Fig. 2. Forms of the green flash under normal conditions (A–D) and during a partial eclipse (E–H)
 A and E: green rim,
 B and F: green last segment,
 C and G: green isolated segment,
 D and H: green ray.

Therefore, the phenomenon usually can only be observed with the help of binoculars or a telescope. The only exception is if the disc of the sun has sunk behind the horizon except its upper rim; then it is theoretically possible to observe the green rim with the naked eye, since it is the only light source in a darkening sky.

In the practise of observing sunsets, however, it becomes clear that the green colour at the top of the sun's disc can be seen especially when the atmosphere forms multiple images of the green upper rim of the disc of the low sun. Then the green area near the top of the sun's disc is bigger, and the green light brighter than under normal conditions. Multiple images can be formed by the atmosphere in two different ways: by inferior mirages and by gravity waves. (Superior mirages only form multiple images of objects which are below the inversion layer that causes the mirages). Inferior mirages, for instance, can occur above the warm water of the sea, over which the sunset is observed. Then the reflection of the green rim in the warm air which is in contact with the warm water is added to the "normal" image of the green rim (Floor, 1981); in this way the "green last segment" is formed (Fig. 2b).

Gravity waves can occur at the boundary between a cold layer of air near the surface and a warm layer of air above (inversion). Then the disc of the sun takes a rippled image as if it were reflected in rippling water (Floor, 1982a). The green flash in this case takes the form of a green isolated segment (Fig. 2c). The green last segment can only be seen when the green rim is the only part of the sun's disc that is above the horizon (or, in fact, above the so called vanishing line; cf Floor 1981, 1983); it can be seen with the naked eye. For the green isolated segment to occur it is not necessary that the sun has partially set or even has touched the horizon; an observation of the green isolated segment with the naked eye, however, requires the green rim to be the only part of the sun above the horizon, since the brightness of the remainder of the sun's disc will blind the observer. Several isolated segments above each other that happen to occur at the very moment of sunset except the green rim, have been called the green ray (Fig. 2d). An observer who observes this phenomenon with the naked eye perceives it as a green ray that emerges from the sun's disc at the moment of sunset (O'Connell 1958).

Green flash during eclipse

We shall now study the forms of the green flash that may be expected during a partial eclipse of the low sun, when the narrow parts of the crescent are directed upwards as was the case on July 20, 1982. The green colour then may be expected along the boundary between the discs of the sun and the moon and from the points of the crescent a little downwards along the rim of the sun's disc (Fig. 2e). (This was what the author in fact observed with a telescope on July 20, 1982; the rim however was rather narrow because of the rather high solar elevation at the moment that the sun had not yet disappeared behind the clouds and because of the high amount of scattering that occurred.) When inferior mirage conditions prevail the latest part of the crescent-shaped disc of the sun that can be seen above the vanishing line merges with its reflection in the warm air; then the last segment occurs, shaped as shown in Fig. 2f. Multiple images formed by gravity waves will appear in the ways as shown in Fig. 2g and 2h. Inspection of the various forms of the green flash during a partial eclipse shows that the green area that appears above the horizon just before the sun has set is smaller during a partial eclipse, (and therefore the green light dimmer) than on other occasions.

It was said before that usually, if the green flash was observed with the naked eye, the atmosphere formed multiple images of the green rim. Obviously, the magnification of the green area in the sky, and its increasing brightness under these circumstances, are important factors. It is clear that a magnification of the green rim of the sun's disc is much more effective than a magnification of a green end of a crescent (cf Fig. 2b, 2c and 2d with 2f, 2g and 2h). We therefore conclude that a partial eclipse does not favour the occurrence of a green flash for an observer, looking with the naked eye.

The formation of multiple images by the atmosphere – that is so important for the possibility to observe a green flash with the naked eye – is not required when observing with binoculars or a telescope. Then the only important condition for the observation of the phenomenon is that the air is clear, so that the green light is not so much attenuated that it can not be seen. Just as the clearness of the air is, of course, independent of solar eclipses, so is the chance of observing a green flash with binoculars or a telescope. Therefore, the chance of observing a green flash during a partial eclipse is the same as on any other day.

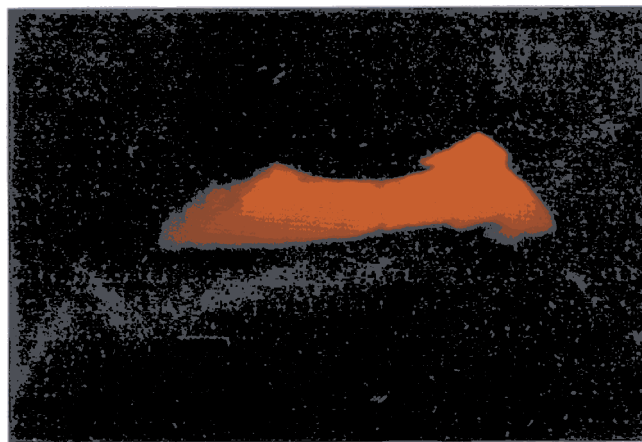
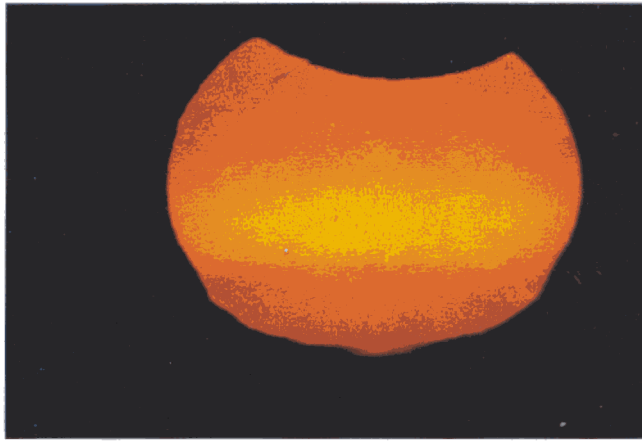
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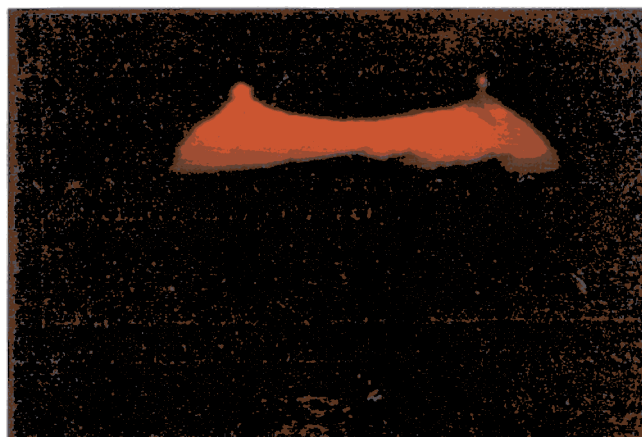
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zu Floor: Green flash during a partial eclipse

Fig. 1. Distorted image of the low sun with isolated segments near the lower rim of the sun (a) and near the ends of the crescent (b and c). The photographs were taken during the partial eclipse of July 20, 1982 at Egmond aan Zee, The Netherlands.