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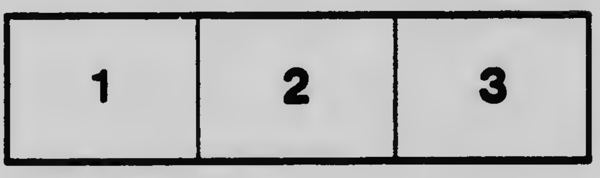

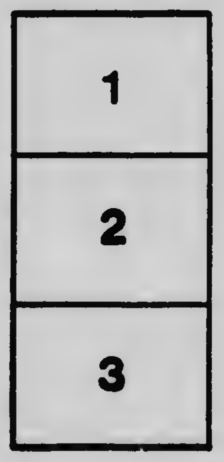

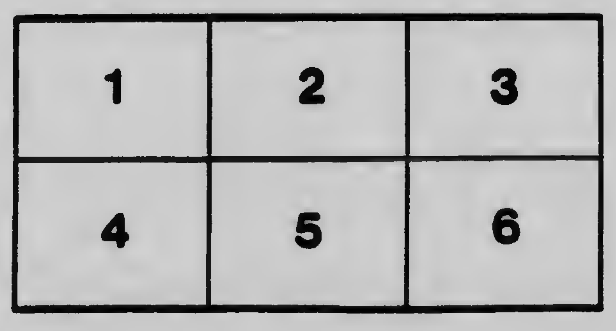

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DISTORTED SOLAR HALOS.

BY

A. F. HUNTER, M.A.

TORONTO:
1918

DISTORTED SOLAR HALOS.*

By A. F. Hunter.

THERE is a class of halos which I have not seen described in scientific publications, although if any account of them exists I may easily have overlooked it, so vast is the field of literature on the subject.

On March 25th, 1899, at 10.30 a.m., I saw a solar halo at Barrie, Ont., consisting of a primary circle around the sun, but the sun was not at its centre, i.e., it was excentric (Fig. 1). On measuring the parts with a long-armed compass, I found that the instrument confirmed what my unaided eye had detected. The inner edge of the top part of the circle was 21½ degrees from the sun's upper edge, and the inner edge of the lowest part of the circle was 23 degrees from the sun's lower edge,—a difference of about three times the sun's width.

This eccentricity is not difficult to understand, and as the observer of a phenomenon has the first right to speculate on its causes, I will offer an explanation of it. With a common glass

* A portion of a paper on Halos, read at the meeting of the Society in Toronto, November 6th, 1917.

prism one may see how the position of the image of an object changes (a distant street lamp at night, for example, which gives rays of light that are nearly parallel to each other, and therefore resemble the sun's rays in that particular) as the inclination of the prism to the object changes. When the prism is held at right angles to the line of sight, the image of the object is in the same horizontal plane as the object itself. But inclining the top of the prism toward the object, the image of it rises above the horizontal plane; and on the other hand, inclining the bottom of the prism

FIG. I
Excentric Solar halo observed at Barrie, Ont.

toward the object makes the image fall. If, therefore, the sun's rays shine through very small prisms of snow that have their upper ends inclined toward the sun, the sun images, and consequently the entire halo, will be somewhat elevated relatively to the sun. But if the small prisms have their top ends inclined away from the sun, the opposite result will follow, viz., the halo will be somewhat lowered relatively to the sun, as in the example from nature, now under consideration. Hence, I concluded that the snow prisms producing this excentric halo had their longer axes situated in a horizontal plane. It is only within a limited range that this rule can be true for the ordinary prism. And when the sun had an intermediate altitude in the sky, as it had at 10.30 a.m. on the abovementioned date, it was within the range in which the phenomenon could occur.

This conclusion agrees very well with what we are already familiar in nature. From seeing the horizontal wisps that are often projected from the tops of thunder clouds or from cirrus clouds, we know that there are lines of strong forces in the higher air driving snow particles in horizontal directions. Indeed, the name "cirrus" itself is the Latin word for a curl, especially a curl of hair, and expresses the wispy character of such clouds driven horizontally. Accordingly, the only explanation that will suffice is that the snow particles were arranged horizontally by lines of electro-magnetic forces.

Two days later, March 27th, 1899, also at 10.30 a.m., I observed a solar circle 23½ degrees from the sun's upper edge, and 22½ degrees from its lower edge. This was almost the reverse of the halo first seen. In this later example, the snow crystals must have had their longer axes ranged in the vertical plane, i.e., inclined toward the sun.

ELLIPTIC OR CIRCUMSCRIBED HALOS.

On May 31st, 1904, at a point some 15 miles northwest of Barrie, I observed a halo of the sun consisting of an ordinary first circle surrounded by an ellipse, which had likewise the sun for its centre (Fig. 2). The sheet of haze producing this halo was thin at first, but it covered the entire sky and seemed to be at a very high altitude. As time went on, the haze continued to thicken, and seemed to come into lower strata of the air. But no definite *forms* of clouds were to be seen at any time, not even after the haze had become too thick for the halo to be seen. The atmospheric disturbance appeared to be of a wide-reaching nature. I was in the open air during the whole time the halo was visible, and

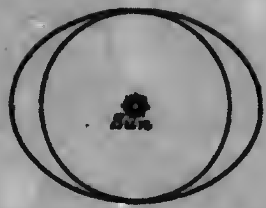

FIG. 2

Elliptic halo observed in Simcoe Co., Ont., May 31st, 1904.

had a good opportunity of watching its progress. At that time I sent the following paragraph with a diagram to the Journal of this Society (1904), then published as an annual.

ELLIPTICAL SOLAR HALO,

Observed in Simcoe Co., Ont., May 31, 1904.

(TRANS. ROY. ASTRON. SOC. CAN., 1904, P. 62.)

At 9.45 a.m. I first observed parts of both curves—the circle and the ellipse—at the right-hand side. By 10 o'clock the ellipse had become intensely bright all around the sun, and the circle was less bright, the intensity being greatest at the top and the bottom where the two curves overlapped. By 11.20 a.m., the halo was clouded over, and only the circle showed very faintly through the cloud film. No trace of mock suns or other similar formations at the sides could be seen at any time. As the mock sun formations at the right and left are much the commonest form of solar halo, I think this unusual elliptical form is worthy of note. It may be added that the cyclone (of which this phenomenon was the forerunner) was of very general or widespreading form, as rain began to fall at 9 p.m. and continued with some interruptions for two days.

It will be necessary to point out that the circle had some color, i.e., was a halo of refraction, but the ellipse was colorless, i.e., it was a halo of reflexion. It could not be possible to confuse the two curves on this occasion, so distinct were both of them.

Mr C. W. Nash, the provincial naturalist, related to me that he saw an elliptic halo, along with the ordinary first circle, in a halo of the sun, on Lake Manitoba, in December, 1884, but his observation was never published. This was the only specific example of the ellipse in his experience. The halo began with the ellipse in the morning and kept changing, the circle finally being left. The half-breed who was with him as driver, said that a big storm would follow, and that they should keep near the shore. Sure enough, it was followed later in the day by a terrible blizzard.

The only other account I have met in Canadian records, of a halo bearing any resemblance to the one I reported in 1904, was a solar halo recorded by Mr. A. Clifford Thomson, P.L.S., in the *Canadian Journal* for September, 1862, with a diagram which I reproduce here (Fig. 3). He describes the halo as *"Seven mock*

FIG. 3

Halo observed on the Muskoka River, Ont., Nov. 10, 1861, by A. Clifford Thomson, P.L.S.

suns." The Toronto Observatory record reported a lunar halo for the same date, Nov. 10, 1861, at 8 p.m., but otherwise no unusual features were noted at Toronto.

From the *Canadian Journal*, September, 1862, p. 462:—

NOTICE OF MOCK SUNS, AS SEEN NEAR THE MUSKOKA RIVER, IN NOVEMBER, 1861.

BY A. CLIFFORD THOMSON, P.L.S.

"While camped near the mouth of the Muskoka River, Canada West, on the 10th of November, 1861, I observed at about 9.40 a.m. the somewhat remarkable phenomenon of seven mock-suns, as shown in the accompanying sketch. In this drawing the line H.H. represents the horizon, and the point Z the zenith. Unfortunately, I had not any instrument with me at the time, to enable me to note the position of the halos; but two of these were quite eccentric, both with regard to the sun and the zenith. The sun was too bright to be regarded with the naked eye, though the atmosphere was slightly hazy. The wind was light, and from the N.W.

"I venture to send this brief notice to the *Canadian Journal*, as I believe the phenomenon to which it refers is rarely witnessed in so southern a latitude. It was observed on this occasion at Orillia, and other places more or less distant from the point at which the above sketch was taken on the Muskoka River. The latitude of this point is 45° 10′ N."

When we compare together the two diagrams (Fig. 2 and Fig. 3), it will appear that, of the so-called intersecting circles in Fig. 3, the inner segments might be taken to form a circle, and the outer segments, an ellipse. At the time Mr. Thomson recorded this observation fifty-six years ago, it was usual to interpret this portion of a halo as two intersecting circles. And it would appear to be still an interpretation, if we may judge from the article by Dr. Besson on halos in the Washington *Monthly Weather Review* for July, 1914. As an example of a halo containing elements similar to those seen by Mr. Thomson, we reproduce just one example, viz., one seen by Vice-Admiral Kalmar at Pola, on March 26, 1896, and described by Dr. Besson with a diagram to which is affixed an interpretation as above mentioned (Fig. 4). Pola is the headquarters of the Austrian fleet on the Adriatic, and often figured during the past summer as a point attacked by Italian airmen. Its latitude is about 44½ deg. N.

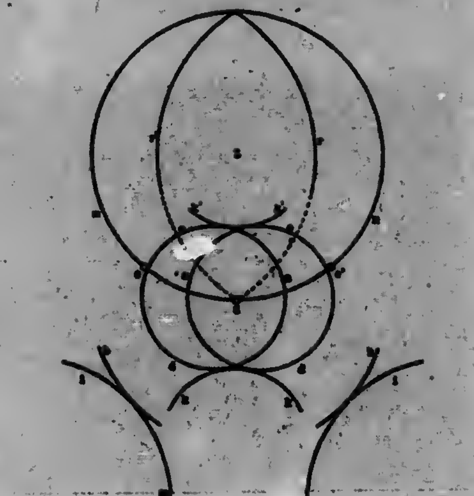

FIG. 4

Halo observed by Rear Admiral A. von Kalmar, at Pola, on March 26, 1896, embracing: Halo of 22° (a), circumscribed halo of 22° (c–d), ordinary parhelia (e, e′), extraordinary tangent arcs of the halo of 22° (k, k′), infralateral tangent arcs (i, i′) accompanying fragments of the 46°-halo (b, b), the parhelic circle (m), the oblique arcs of the anthelion (r, r′). S, the sun; Z, the zenith.

It is possible that we may have two circles intersecting each other, as I have just shown in Fig. 1 an example of one excentric circle, whose eccentricity, however, is in the vertical direction. But I have no doubt of the interpretation of the elliptic forms as halos of reflexion, and it will be a duty in future obesrvations to note carefully whether a curve has color.

In this connection I should also describe a solar halo which I saw at 1 p.m., June 9, 1917, consisting of a circle with very little color, in the position of the primary circle, that is, at approximately 22 degrees from the sun, and a whitish curve visible finally as a quadrant of an ellipse (Fig. 5). The latter, at the time when it became possible for me to measure it, and when it was only a quadrant, had a distance of 30 degrees from the sun at the nearest part, but at the earlier time I had seen it almost entirely around

FIG. 5

Halo with quadrant of ellipse.

the sun, though just then I was unable to take its measurements. This ellipse was unusual in having the fluorescence on the inside, not on the outside as the primary circle has, the outside here being dark, and it was this circumstance that first called my attention to it as not being the first or primary circle itself. All signs of the ellipse disappeared by 2.15 p.m., and the circle with color remained for a short time afterward. Cirrus haze was abundant, and then clouds.

Prof. Cherriman mentioned a halo seen at the Toronto Observatory on March 9, 1841, having a radius of 30 degrees, which agrees as to its angle with the observation I made on June 9, 1917. (See "On the Atmospheric Phenomena of Light," *Canadian Journal* (First series), Vol. 1, p. 27.)

But Dr. Besson mentions several halos of abnormal radius (in his article in the U. S. Weather Review for July, 1914) regarding which he makes this remark: "the ordinary halo (22 degrees) is almost always simultaneously visible."

Again, as the observer of a phenomenon, I will venture to use my right to speculate as to its causes, and to offer an explanation, as, in the words of a notable French writer, "it requires a theory to satisfy the mind."

EXPLANATION OF THE ELLIPSE.

By means of this simple diagram (Fig. 6) we can arrive at an understanding of this elliptic form of halo. If we suppose that

FIG. 6

A circular halo viewed edgewise.

an observer at B is looking at a great white horizontal circle passing through the sun's disk, for example, made by a film of haze, extending, say, at a height of ten miles, he would see it as a great circle with the zenith as its centre and the sun in its rim. But an observer at A, say ten miles distant from B, and with the luminary at, say, an altitude of 45 degrees, would see it as an ellipse with the sun as its centre, because a horizontal circle formed by reflexions becomes by projection a flattened circle, *i.e.*, an ellipse.

In the previous example we saw a case of a distorted halo of refraction. Here in the elliptic form we have what we may regard as a distorted halo of reflexion, in which a horizontal circle, seen obliquely or partly edgewise, is flattened into an ellipse. It is never directly overhead like the parhelic circle with its centre overhead, and it probably occurs at a very great height above the ground, 10 miles or upward. For parallel light forming a halo of reflexion, there would be only a certain range of visibility within which it could be seen. This range would necessarily be small and hence the elusive and rare appearance of the elliptic halo.

This concludes what I have to say in regard to distorted halos, both of refraction and of reflexion, in which we see nature at her best, like "sports" in biology.