

for Mount Weather, Va., at the same season of the year, as published in the REVIEW for December, 1914, above referred to. The diffuse sky illumination, however, is markedly less.

It is of interest to note that the results of this investigation show about the same percentage of diminution in daylight illumination under the city smoke cloud as was given by a comparison between the decomposition of oxalic acid at Pittsburgh, Pa., and at Sedgwick, Pa., the latter a suburb of Pittsburgh.<sup>2</sup>

551.594

ON HORIZONTAL HALOS.

By Y. TSUJII.

[Reprinted from Journal of the Royal Meteorological Society of Japan, May, 1917, 36: 53.]

Horizontal halos are produced by the refraction of the sun's rays at the surface of frost crystals of tabular form deposited on the surface of snow or ground, or [at the surface] of freshly fallen snow crystals. The author of this article describes 50 cases of ground halos observed at Ueda in Nagano prefecture, central Japan. In a general consideration of these optical phenomena he has deduced the equation for them in the following way:

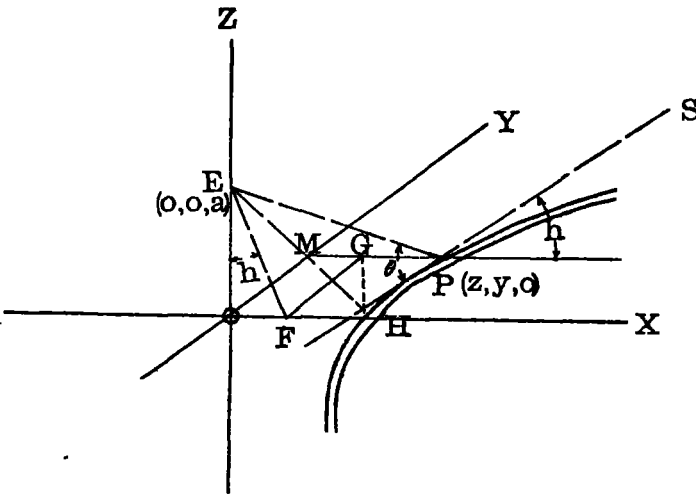


FIG. 1.—Construction illustrating Tsujii's demonstration on ground halos.

In figure 1 let  $\theta$  be the angle of deviation of the solar rays through an ice prism. Taking the vertical through the observer as Z-axis and X and Y axes in the plane of the halo, we get as the equation of the halo

$$(a^2 + x^2 + y^2)^{\frac{1}{2}} \cos \theta = (x - a \tan h) \cos h,$$

where  $a$  is the height of the observer's eye, and  $h$  the sun's altitude.

Transforming the origin of the coordinates to the center of symmetry the equation becomes,

$$\frac{\xi^2}{\cos^2 \theta \sin^2 \theta} - \frac{\eta^2}{a^2 \frac{\sin^2 \theta}{\cos^2 h - \cos^2 \theta}} = 1.$$

The angle of deviation of the rays deduced from the observation of the horizontal halos is considerably greater than  $22^\circ$  for the inner halo, and than  $46^\circ$  for the exterior halo. This shows that the explanation of the halos afforded by the geometrical method was unsatisfactory and must be founded on the principles of physical optics.—T. Okada.

<sup>2</sup> See MONTHLY WEATHER REVIEW, January, 1914, 42:32.

SOLAR HALO AT VICKSBURG, MISS., APRIL 24, 1917.<sup>1</sup>

551.594 (762)

By WILLIAM E. BARRON, Meteorologist.

[Weather Bureau Office, Vicksburg, Miss.]

Unusual halo phenomena were observed at Vicksburg, Miss., on April 24, 1917. Attention was first directed to the phenomena at 11:15 a. m., 90th meridian time, and they continued visible until 12:15 p. m. In the first place there was an ordinary halo usually mentioned as of  $22^\circ$  radius. The circle was well defined and the colors were brilliant. But the most striking phenomenon was a circumhorizontal arc, such as is described in the MONTHLY WEATHER REVIEW, July, 1914, page 440. The colors of this arc were most brilliant, showing all of the spectral colors over a belt estimated at  $3^\circ$  in width, the red being nearest the sun, and the violet nearest the horizon. At times the band was broken owing to the shifting character of the clouds. Throughout the period there were six to seven tenths of cirrus clouds, those nearer the sun appearing to be of the more matted cirro-stratus type. During most of the appearance the arc was  $40^\circ$  to  $50^\circ$  in length, and at 11:35 a. m. extended from az.  $523^\circ$  to az.  $43^\circ$ . At about 11:40 a. m. a second complete circle was discovered, white in color and well defined, with its circumference passing through the sun, and its center north of the sun, probably in the circumference of the first circle.

It was some time before instruments could be gotten out with which to measure the angles and by that time the horizontal arc was becoming shorter, and there was some difficulty in using a transit on account of the lenses. The elevation of the red edge of the arc was found to be  $25^\circ$ . The elevation of the inside edge of the colored circle was found to be  $50^\circ 30'$ . These angles were measured at 11:55 a. m. and 12 noon, respectively. The angular elevation of the sun was not obtained at the time, but was obtained at the same time on the next day by computation from the shadows.

Elevation of sun at 11:55 a. m., 25th.....	70	39
Upper edge of arc at 11:55 a. m., 24th.....	25	00
Angular distance of arc.....	45	39
Elevation of sun at 12 noon, 25th.....	70	46
Inner edge of circle, at 12 noon, 24th.....	50	30
Radius of circle.....	20	16

No measurements of the white circle were made on account of its height.

Parhelia with prismatic colors were observed, one above and one to the north of the sun at 6:17 p. m. The angular distance was not measured, but was thought to be about  $22^\circ$ . At the same time there was a vertical light pillar, about the apparent width of the sun, and extending upward from it  $8^\circ$  or  $10^\circ$ .

HALO PHENOMENA APRIL 8, 1917, AT YORK, N. Y.<sup>1</sup>

Mr. Milroy N. Stewart, of York, N. Y. (lat. N.  $42^\circ 52' 30''$ , long.,  $77^\circ 53'$ ) contributes the following notes of halo phenomena observed April 8, 1917:

At 10:55 a. m. I noticed the very bright upper and lower arcs of a  $22^\circ$  halo. This caused me to look for the circumscribed halo formed by the tangent arcs, and almost immediately the arc on the western side appeared and in a very few minutes the eastern limb was apparent. At

<sup>1</sup> Published with approval of Division of Aerological Investigations.