The average hourly velocity is highest near the hours of maximum temperatures, i. e., from 10 a. m. to 3 a. m. and lowest near the hours of minimum temperatures, 5 to 7 a. m. Calms are common in the early morinng.

As a rule, the maximum wind velocities occur during rain or thunder squalls. These storms are almost invariably too short to cause dangerously rough seas, although at times they do blow down trees and damage plantations set to bananas or other fruit. The Isthmus, fortunately, is at least 200 miles west of the path of the West Indian hurricanes. Occasional dry-season "northers" give general winds from the north, averaging up to 30 miles an hour. The greatest velocity recorded since American occupation was in a local storm at Ancon, Canal Zone, when the wind went up to 59 miles an hour.

The Isthmus has little fog, but occasionally one sees a dense fog bank hanging over a low-lying valley in the night or early morning in the interior, particularly in the wet season. Practically all fogs are dissipated by 8:30 a. m.

Daytime cloudiness is less in the dry season. March has the least cloudiness; June and November the most. Due to prevailing wind direction, there is more cloudiness in the interior and on the Pacific coast. These winds reach the Isthmus from the Carribean with water vapor in large measure uncondensed, and therefore are not visible as clouds. As they cross the Isthmus, this vapor is partly condensed and becomes visible as a cloud.

Cloudiness is generally greater in the daytime than at night. This is especially noticeable during the dry season, when heavy cumulus clouds form during the day and as regularly disappear with the approach of night.

Humidity is the feature of Isthmian climate that makes many days decidedly "sticky." In the dry season it is not so bad. The change of season from dry to wet is particularly oppressive, owing to low wind movement and high humidity. It is necessary to maintain "dry" closets—a small closed room containing a lighted lamp—to prevent molding of clothing and shoes. Bedding must be aired and renovated frequently.

CONCERNING HALOS OF ABNORMAL RADII.[1]

LOUIS BESSON.

[Paris, France, May 3, 1923.]

The theory of halos of abnormal radii recently explained by Dr. W. J. Humphreys[2] is not as new as he thinks. Three years ago,[3] I showed how one can explain all these halos by means of a single ice crystal with oblique faces, except that I assigned to these faces an inclination of 25° 14′ to the principal axis, instead of 24° 51′ given by Doctor Humphreys.

I hope I may be permitted to return to this debatable question of meteorological optics in which X-rays are called into testimony in a manner equally curious and unexpected.

In my work of 1920, I gave a list of 26 observations of one or more halos of radius different from 22°, 46°, and 90° which had come to my attention. From the examination of these observations, I concluded that "of these extraordinary halos, the less rare and better determined are the halo of van Buijsen (8° 30′), that of Rankin (17° 30′), that of Burney (19°), and that of Scheiner (28°). There exist one or two others—that of Dutheil (24°) and an ill-defined halo of 32° or 35°, that of Feuilleé."

Authors have been in accord, since Bravais, in explaining these phenomena by means of oblique faces of crystals of atmospheric ice, assuming the different possible known inclinations. Following an inverse process, I have sought to deduce from the radii of the observed halos the inclination of the faces.

"The halos which furnished the most reliable basis for this research were," I said, "that of van Buijsen, of Rankin, and of Burney. These are the most frequent and there is an evident relation between them since they appear together; they ought, reasonably, to be the products of the same ice crystal."

For the study of this question, it is convenient to calculate, for a certain number of values of the inclination between 0° and 90°, the radii of all the halos which the complete form can produce and to make a graph showing how the radii vary with respect to the inclination, and which are the halos that correspond to given inclinations.

On the graph, one sees immediately that there are only two inclinations which can possibly furnish at one time the three halos of 8° 30′, 17° 30′, and 19°. One of these is in the neighborhood of 25° and the other is near 28°. I have remarked that these two inclinations give not only these three halos but also those of Feuilleé and Dutheil—that is to say, five of the six known extraordinary halos.

The inclination in the vicinity of 25° is in better accord with the observations of halos and it is also in harmony with the value 54° 44′ which Bravais has given of a crystallographic observation of Clarke, which is

$$3 \tan 25° 14.4' = \tan 54° 44.1',$$

and this has led me finally to maintain as particularly probable, the value 25° 14.4′.

I reproduce below an extract of a table from my note of 1920, introducing, for the reader's convenience, the notation employed by Doctor Humphreys to designate the faces of the crystal.

TABLE 1.—*Dihedral angles in an hexagonal prism with oblique faces inclined 25° 14.4′ to the principal axis and the radii of halos produced by them.*

Faces of incidence and emergence.	Dihedral angle.		Radius of halo.		Name of halo.
	°	′	°	′	
p_1, p_4	50	28.8	17	26	Rankin.
p_1, p_3	76	51.8	32	10	Feuilleé.
c, p'_1	64	45.6	24	21	Dutheil.
m_1, p_4	25	14.4	8	2	van Buijsen.
m_1, p_3	63	6.6	23	27	Dutheil.
p_1, p'_6	53	46.8	18	53	Burney.

Halos of van Buijsen, Rankin, and Burney.—In order to know as closely as possible the real values of the radii of these halos, we return to those observations made most recently and retain only those in which at least two of the three were seen together. This is to eliminate the cases of halos of nearly the same radii which could be produced in another way. These observations to the number of seven are as follows:

[1] Translated by C. LeRoy Meisinger.
[2] Mo. WEATHER REV., October, 1922, 50: 535–536.
[3] *Comptes Rendus de l'Academie des Sciences*, pp. 334 and 607, 1920.

TABLE 2.—*Observations of halos of abnormal radii.*

Observer and date.	Halo of—		
	van Buijsen.	Rankin.	Burney.
	°	°	°
Hissink, 1899	7.5	17.5	19.5
Hissink, 1899	9.0	....	19.0
Hissink, 1905	....	18.0	19.5
Besson and Dutheil, 1911	9.0	[1] 18.5	....
Andrus and Riley, 1915	8.5	17.5	18.5
Brush, 1919	7.0	17.0	19.0
Grundmann, 1922	9.0	17.0	19.0
Mean	8.3	17.4	19.0
Theoretical value with inclination 25° 14.4′	8.0	17.4	18.9
Theoretical value with inclination 24° 51′	7.9	17.1	19.0

[1] This halo could be classed almost as well as the halo of Burney.

The values of the radii deduced from an inclination of 24° 51′ clearly show a larger departure from the observed value. Further, for the halos of van Buijsen and Rankin, the radius varies very rapidly with inclination, the sign of the departure being precisely that which results from too small a value of the inclination. The experimental results upon which the value of 24° 51′ is based not being more than approximate, I do not see a decisive reason for rejecting the value of 25° 14.4′.

Halo of Dutheil.—A halo of 24° was very clearly seen by Dutheil in 1911 of which the radius was measured.[4] One can explain this by refraction either between the base *c* of the crystal and an oblique face at the other end, or between a prismatic and an oblique face. If these crystals are prisms terminated at both ends by non-truncated pyramids, only the second mode of production is possible; but if these crystals are simple or double pyramids, without prismatic section, it is, on the contrary, only the first mode that is possible.

Halo of Scheiner.—It does not appear possible to admit with Doctor Humphreys that the halo of Scheiner and the halo of Feuilleé constitute one and the same phenomenon. There are six observations of the halo of Scheiner; three very old ones—those by Scheiner (25° to 28°), Greshow (26°), and Whiston (29°), which I cite from Bravais; and three recent ones—those by Besson (28°), Andrus and Riley (28° to 29°), and Noyer[5] (28°). These observations assign a value of the radius in the neighborhood of 28°.[6]

[4] Annales de l'Observatoire de Montsouris. 12: 236.

When one passes in review the halos which can be produced by crystals whose oblique faces are inclined either by 19° 28′ (inclination which X-rays seem to designate as corresponding to the prismatic form of ice) or by an angle of which the tangent is in simple relation with tan 19° 28.2′, one perceives that a very large number of these halos have a radius little different from 28°.

Calling x the inclination and placing

$$K=\frac{\tan x}{\tan 19° 28.2'},$$

we find that for values of K smaller than unity that there are no halos of the required size produced; but, if K is given the values 1, 2, 3, or 4, one finds not less than seven. These are enumerated in the following table:

TABLE 3.—*Different methods of possible formation of the halo of Scheiner.*

	K	x		Faces of incidence and emergence.	Radius of halo.	
		°	′		°	′
No. 1	1	19	28.2	p_1, p_3	27	45
No. 2	1	19	28.2	c, p'	27	45
No. 3	2	35	15.9	p_1, p_4	27	45
No. 4	3	46	41.2	m_1, p_3	27	23
No. 5	3	46	41.2	p_1, p'_6	29	18
No. 6	4	54	44.1	p_1, p'_4	27	45
No. 7	4	54	44.1	m_1, p_3	29	32

The halo of Scheiner which I have observed was reduced at its highest point. For that reason it can not be attributed very satisfactorily to mode of formation No. 2, but clearly does not prove that this halo is not produced in that manner. In whatever manner, the most probable value of its radius appears to be 27° 45′.

[5] Annales des Services techniques d'Hygiène de la Ville de Paris. 2: 269, 1920.
[6] I do not believe the error can exceed 1°.

COMMENTS ON HALOS OF UNUSUAL RADII.

By W. J. HUMPHREYS.

[Weather Bureau, Washington, D. C., June 1, 1923.]

Unfortunately Besson's article on the extraordinary halos[1] had not come to my attention when I wrote the paper he refers to above. Nevertheless, the two papers are entirely different in their lines of approach, and essentially supplementary each to the other—certainly in no sense antagonistic.

Besson's method of computing the inclination of the pyramidal faces of the snow crystal to the principal axis from the radii of the unusual halos is logical, but as these radii are known to only a rough approximation any value computed from them must also be correspondingly unreliable. I tried at first the same method and found 25° to be about right, but did not adopt it because, if the generally accepted goniometric measurements of the pyramidal ice crystal are correct, this value is crystallographically impossible.

But Dobrowolski had shown that none of these goniometric values was at all reliable, and so Besson's method of computing the angle from the radii of the halos again seemed both allowable and desirable. Then came the X-ray determinations of the axial ratio, 1.62, of the ice crystal, a ratio that permits the angle in question to be 24° 51′, which value therefore was adopted.

The computed radii of the unusual halos, that such snow crystals would give, for a point source of yellow light (refractive index, 1.31) and the correspondingly measured radii are listed in the accompanying table:

Computed.		Measured.	
°	′	°	′
7	54	8	12
17	06	17	±
18	58	19	±
23	24	23	20
24	34	......	
31	49	32	00
39	28	......	

The measurements are very unsatisfactory, because, so far as I know, two of these halos have never been instrumentally measured at all, and the others but once each, and because it is not certain to what refractive index (color, or portion of the halo) each measurement corresponds.

[1] *Comptes Rendus*, 170: 334, 1920.