A Halo Orders Its Colours Opposite to a Rainbow, Because Light Passes Through a Prism, Not Back Inside a Sphere

— the **22** degree halo has violet **0.911483** degrees outside and the primary rainbow has red **1.677527** degrees outside: violet deviates more in both, yet the orders are reversed — the separator is whether the angle is measured from the sun or from the point opposite the sun — [Paper 767]

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— From thinking to syncing. —

Abstract

Rings of coloured light in the sky include halos around the sun and rainbows seen with the sun behind. Both spread colours, but in opposite orders.What sets the order is counted by minimum deviation and by the point from which the angle is measured.No new theorem or law is claimed. First, the halo angle is set by the angle between prism faces ——21.839300 degrees for yellow through faces at 60 degrees, 45.733421 through faces at 90 (Section 2). **Second, a halo has violet outside——red 21.612019, violet 22.523502 degrees, a width of 0.911483** (Section 2). **Third, a rainbow has red outside——with Paper 325's indices, red 42.252933, violet 40.575405 degrees, a width of 1.677527** (Section 3). **Fourth, and this is the core. Violet deviates more in both, yet the orders are reversed—— because a halo's angle is measured from the sun and a rainbow's from the point opposite** (Section 3). **Fifth, the formula's minimum matches a grid search——a search over incidence angles in steps of 0.0001 degrees differs by 2.102×10^{-11} degrees** (Section 2). **Sixth, the separator is whether the angle is measured from the sun or from the point opposite the sun——"rings of light in the sky have red outside" has no truth value until one says whether light passes through or turns back** (Section 4). **Keywords**: halo, rainbow, minimum deviation, hexagonal ice prism, order of colours, reference point of the angle.

Scope of this paper (scope note): **No new theorem or law is claimed——the prism minimum-deviation formula, that face pairs at 60 and 90 degrees in hexagonal ice make the 22 and 46 degree halos, that halos are red inside, and the minimum deviation and colour order of rainbows are all known (Tape 1994, Greenler 1980).Indices are representative——ice indices of 1.307 for red, 1.310 for yellow and 1.319 for violet are for comparison and move with wavelength and temperature.Only minimum deviation——crystal orientation distributions, brightness and polarisation are not treated; only the minimum deviation that places the ring is considered.Other phenomena are not treated——parhelia, circumzenithal arcs and coronae are not treated.Rainbow values are earlier values——the primary rainbow radii, obtained with Paper 325's indices, equal Paper 325's values and are set here for comparison.Relation to earlier papers**: **Paper 325 showed that the size of the drop is not in the angle of the rainbow——there minimum deviation set the rainbow's angle and drop size did not enter. Here crystal size does not enter the halo angle either, but because light passes through without reflecting, the angle is measured from the sun, and the colour order is the reverse of the rainbow's.**What is added is **deriving minimum deviations for face pairs at 60 and 90 degrees in three colours**, **checking the closed form by a grid of incidence angles**, **setting the halo's violet-outside width 0.911483 degrees beside the rainbow's red-outside width 1.677527 degrees**, and **placing the separator on the point from which the angle is measured**.

1. Notation and the Question

Setting: **for light of index n passing through a prism of apex angle A, the minimum deviation D is given below. For the primary rainbow, with one reflection inside a spherical drop, the incidence angle i of minimum deviation and the angular radius ρ measured from the point opposite the sun are also given.**

$$D = 2\arcsin\!\left(n\sin\frac{A}{2}\right) - A, \qquad \cos^2 i = \frac{n^2-1}{3}, \qquad \rho = 4r - 2i, \quad \sin i = n\sin r$$

A halo's angular radius is D measured from the sun; a rainbow's is $\rho = 180^\circ - D_{\text{bow}}$ measured from the point opposite the sun.

Question: **why are the colour orders of halo and rainbow reversed?**

2. A Halo Has Violet Outside

Computation 2.1: **with ice indices for three colours, minimum deviations through face pairs at 60 and 90 degrees were derived.**

colour (index)	faces at 60 degrees	faces at 90 degrees
red (1.307)	21.612019 degrees	45.092627 degrees
yellow (1.310)	21.839300 degrees	45.733421 degrees
violet (1.319)	22.523502 degrees	47.711060 degrees

Observation 2.2

the halo angle is set by the angle between prism faces.For yellow, faces at 60 degrees give 21.839300 degrees and faces at 90 give 45.733421, and crystal size does not enter the formula——searching incidence angles in steps of 0.0001 degrees also gave a minimum of 21.839300, differing from the formula by 2.102×10^{-11} degrees.

Observation 2.3

a halo has violet outside.The 22 degree halo has red at 21.612019 and violet at 22.523502 degrees, a width of 0.911483——violet, with the larger index, bends more and appears farther from the sun.

3. A Rainbow Has Red Outside

Computation 3.1: **with Paper 325's water indices, the primary rainbow's angular radii were derived.**

colour (index)	primary radius (from the point opposite the sun)
red (1.3318)	42.252933 degrees
violet (1.3435)	40.575405 degrees

Observation 3.2

a rainbow has red outside.Red at 42.252933 and violet at 40.575405 degrees, a width of 1.677527; these are the same as Paper 325's values——in a rainbow too violet bends more, and by that much it comes closer to the point opposite the sun.

Observation 3.3

this is the core: violet deviates more in both, yet the orders are reversed.Halo light passes through the prism, so the angle is measured from the sun and the more-bent violet lies outside. Rainbow light turns back inside the drop, so the angle is measured from the point opposite the sun and the more-bent violet lies inside——what separates the colours is the same difference of index; what reverses the order is the reference point.

4. The Separator

Observation 4.1

the separator is whether the angle is measured from the sun or from the point opposite the sun.Measured from the sun, the halo's violet lies 0.911483 degrees outside; from the opposite point, the rainbow's red lies 1.677527 degrees outside——"rings of light in the sky have red outside" has no truth value until one says whether light passes through or turns back.

Observation 4.2

beside Paper 325.Paper 325 showed that drop size does not enter the rainbow angle, which is set by minimum deviation——crystal size does not enter the halo angle either. The difference is that the light passes through without reflecting, which swaps the reference point and reverses the colour order.

Observation 4.3

what is not said.Parhelia, circumzenithal arcs, brightness, polarisation and crystal orientation are not treated, and ice indices are representative——what is shown is that the same difference of index becomes opposite orders depending on the reference point.

5. Roll Call and Closing

1. **21.839300 degrees through 60 degree faces** (Computation 2.1): **the 22 degree halo.**
2. **45.733421 degrees through 90 degree faces** (Computation 2.1): **the 46 degree halo.**
3. **red 21.612019 degrees** (Computation 2.1): **inside the halo.**

4. **violet 22.523502 degrees** (Computation 2.1): **outside the halo.**
5. **halo width 0.911483 degrees** (Observation 2.3): **violet outside.**
6. **rainbow red 42.252933 degrees** (Computation 3.1): **Paper 325's value.**
7. **rainbow violet 40.575405 degrees** (Computation 3.1): **inside the bow.**
8. **rainbow width 1.677527 degrees** (Observation 3.2): **red outside.**
9. **orders reversed** (Observation 3.3): **the core.**
10. **from the sun or from the opposite point** (Observation 4.1): **the separator; Paper 325.**

Closing: **A halo orders its colours opposite to a rainbow, because light passes through a prism rather than turning back inside a sphere.Through two faces at 60 degrees of a hexagonal ice prism, minimum deviation with representative indices is 21.612019 degrees for red and 22.523502 for violet, so the 22 degree halo has violet 0.911483 degrees outside; through faces at 90 degrees it is 45.733421 degrees for yellow——crystal size does not enter the angle; the angle between faces sets it.With Paper 325's water indices, the primary rainbow's radius is 42.252933 degrees for red and 40.575405 for violet, red 1.677527 degrees outside——violet bends more in both, but the halo's angle is measured from the sun and the rainbow's from the point opposite, so the orders reverse.The separator is whether the angle is measured from the sun or from the point opposite the sun——"rings of light in the sky have red outside" has no truth value until one says whether light passes through or turns back.Placed among the earlier papers——Paper 325 showed drop size absent from the rainbow angle; this counts, in halos sharing that property, how the reference point reverses the colour order.To be honest——parhelia, brightness and polarisation are not treated, and ice indices are representative.**

References

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