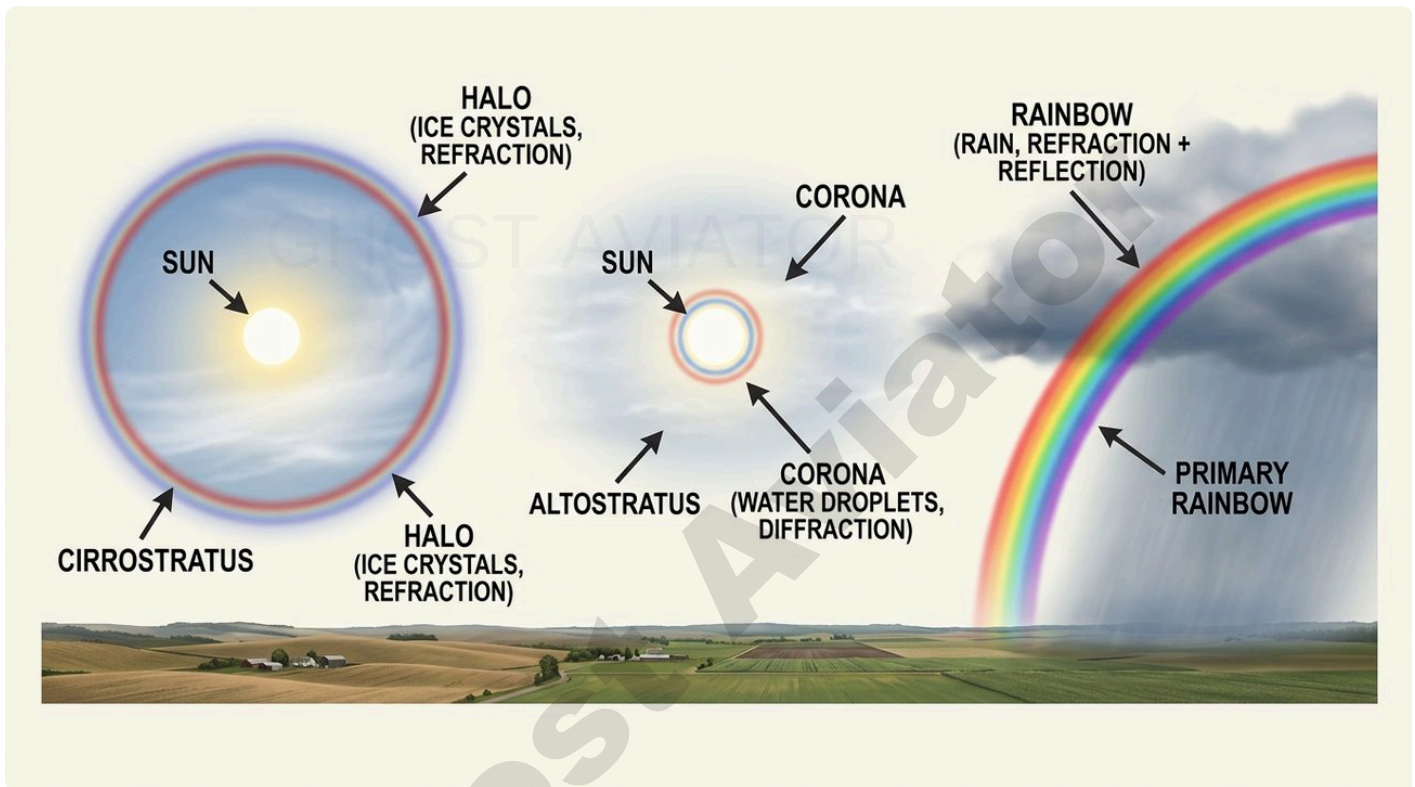


Table of Contents

1. Introduction
2. Rainbow
3. Halo
4. Corona
5. Mirage
6. Bishop's Ring
7. Twilight Colours
8. Irisation
9. Glory
10. Crepuscular Rays
11. Aurora
12. Atmospheric Electricity and Lightning
13. Saint Elmo's Fire
14. Practice Q&A
15. Master Reference Tables

1. Introduction

Optical phenomena occur frequently in the atmosphere. They provide useful information about cloud constitution, cloud type, atmospheric turbulence, lapse rate, ice accretion etc. — all important for aviation safety.



Halo, corona and rainbow compared

flowchart LR

```
A[Optical Phenomena] --> B[Refraction-based\nRainbow, Halo, Mirage]
A --> C[Diffraction-based\nCorona, Bishop's Ring, Irisation]
A --> D[Reflection-based\nGlory]
A --> E[Emission-based\nAurora, St Elmo's Fire]
A --> F[Scattering-based\nTwilight Colours]
```

2. Rainbow

Rainbow: A group of concentric arcs with colours ranging from violet to red, produced on a background of water drops (raindrops, droplets of drizzle or fog) in the atmosphere by light from the sun or moon. Sometimes two rainbows are observed — Primary and Secondary.

Primary Rainbow

A circle or arc of circles of coloured light in the sky while it is raining. The circle subtends an angle of **42°** at the eyes. Seen opposite to the sun or moon. Its centre is on the line joining the luminary and the observer. The rainbow may form a complete ring when seen from a hill, high tower or from an aircraft. Due to **double refraction** on entering the rain drop (once on entering, second time on leaving) with **one total internal reflection**. Colours: **VIBGYOR** (red outside, violet inside).

Secondary Rainbow

Concentric with the primary. Radius about **52°**. Much less bright than primary with breadth almost double. **Red is on the inside (radius of arc 50°) and violet on the outside (radius of arc 54°)** — colours reversed compared to primary.

Feature	Primary Rainbow	Secondary Rainbow
Radius	42°	52°
Red colour position	Outside	Inside (50°)
Violet position	Inside	Outside (54°)
Brightness	Bright	Much less bright
Internal reflections	One	Two
Breadth	Normal	Almost double

Mnemonic: VIBGYOR (Violet Indigo Blue Green Yellow Orange Red) — Primary: Red Outside Violet Inside (ROVIn). Secondary: reversed (VIOIR = Violet Outside, Red Inside).

3. Halo

Halo: A circle of light around the sun or moon. Produced by **refraction** of light through **ice crystals** present in Cirrostratus (CS) clouds.

Small Halo (Most Frequent)

Mostly white luminous ring of **22° radius** around the sun or moon at its centre. When well developed, the halo round the sun shows a pure clear halo — the **red on the inside** but other colours usually difficult to

recognise. Presence of a halo signifies predominance of ice crystals in the cloud → **negligible chances of ice accretion.**

Large Halo

A circular halo with a radius of **46°**. The portion of the sky inside the ring is conspicuously darker than the rest of the luminous ring. Sometimes a large halo is observed — called the **Large Halo**. This is less bright.

Feature	Small Halo	Large Halo
Radius	22°	46°
Colour	Mostly white, red inside	Less bright
Sky inside ring	Normal	Conspicuously darker
Cloud type	Cirrostratus (CS)	CS
Ice accretion risk	Negligible (ice crystals)	Negligible

Aviation Significance of Halo: Halo = ice crystal cloud (CS) = **negligible icing risk**. Fly through CS clouds with halo = safer than flying in clouds with Corona (water droplets).

Exam Tip: HALO = 22° (Small) or 46° (Large). CS cloud. ICE crystals. A halo alone does not establish icing safety. Red on INSIDE.

Remember: Halo from CS; Corona from AS/AC.

4. Corona

Corona: Luminous one or more (seldom more than three) coloured rings of relatively small radius, not more than **5°**, centred on the sun or moon. In each ring, **red appears on the outside and violet or blue on the inside**. Colours usually dull. Formed due to **diffraction** of light passing through **very small water drops** in mist, fog or through a thin cloud (especially Altostratus clouds). Diffraction = slight bending of light wave as it moves along the boundary of an object like a water drop.

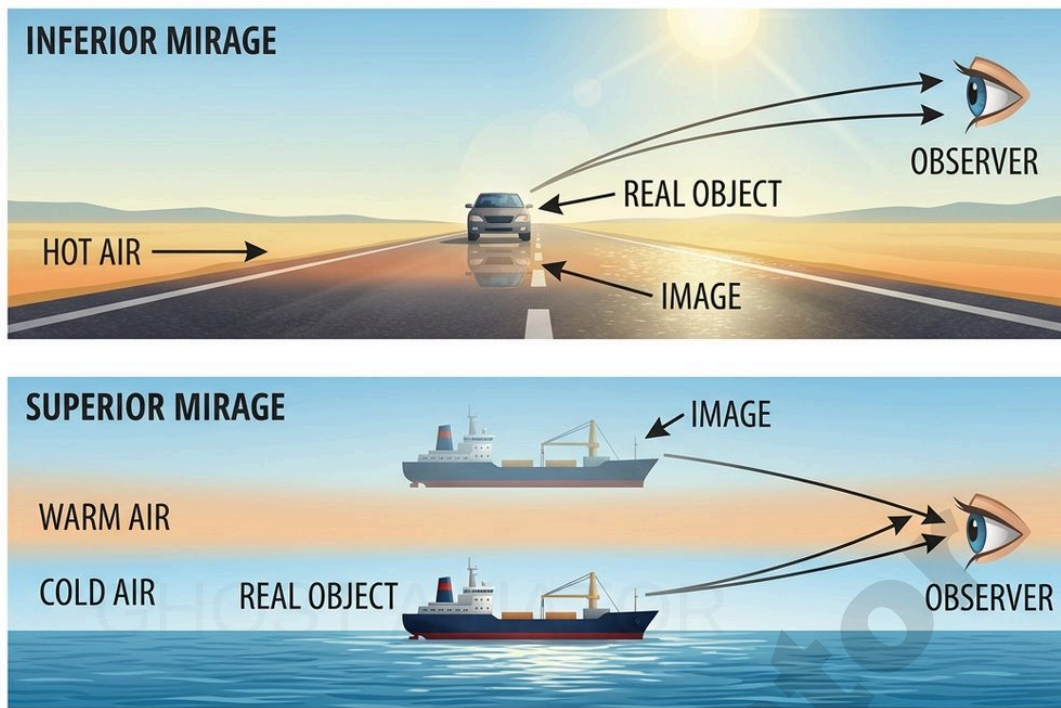
Aviation Warning: Corona indicates **moderate icing** — the cloud is above freezing level. Water droplets (supercooled) = icing risk. If cloud is above freezing level = icing risk.

Feature	Corona	Halo
Radius	<5° (small)	22° or 46° (large)
Cause	Diffraction (water drops)	Refraction (ice crystals)
Cloud type	AS, thin AC, mist, fog	CS
Icing risk	Moderate (water droplets)	Negligible (ice crystals)
Red position	Outside	Inside

Mnemonic: Corona = Close rings (<5°) = supercooled water = CAUTION (icing). Halo = Huge rings (22°/46°) = ice = A halo alone does not establish icing safety.

5. Mirage

Mirage: Light rays are refracted (bent) as they travel from one medium to another of different density. In the atmosphere, density reduces with altitude. Light reflected from a distant object travels in a curved path, keeping lower density on the convex side of the curve. Rising sun or moon thus appears slightly higher than they actually are.



Inferior and superior mirage

Mirages are due to curving of light rays passing through layers of air in which refractive index changes considerably with height due to density differences. Observed when temperature of earth's surface differs markedly from that of air above.

Type	Name	Condition	Appearance
Inferior (Lower) Mirage	Lower Mirage	Lapse rate is steep (strongly heated surface, hot road/desert). Air density decreases rapidly upward.	Object appears lower than actual. Pool of water on road. "Water" on hot desert.
Superior (Upper) Mirage	Upper Mirage	Inversion (temperature increases with height). Cold sea surface, cold snow field.	Object appears higher than actual. Levitating ships.

Mnemonic: Inferior Mirage → It looks like Inferior pool (fake water on hot road) → Lapse rate steep. **Superior Mirage** → Sky reflection, object raised up → Supercooled surface (inversion present).

6. Bishop's Ring

Bishop's Ring: A whitish faint ring, centred on the sun or moon, with a slightly bluish tinge on the inside and reddish brown on the outside. Due to **diffraction** of light by **fine dust particles** in the high atmosphere. The dust may also be of volcanic origin. Radius of the ring is about **22°**.

Bishop's Ring vs Halo: Same radius (22°) but different cause and appearance. Halo = CS (ice crystals, refraction, bright). Bishop's Ring = fine dust (diffraction, faint, reddish-brown outside).

7. Twilight Colours

Various colours in the sky are produced at sunset and at sunrise by **refraction, scattering or selective absorption** of light rays from the sun.

8. Irisation

Sometimes due to **diffraction** of sun light, colours or bands nearly parallel to the margin of the cloud appear, in which pink colour predominates. Occurs in AC lenticularis and other clouds with uniform-sized droplets.

9. Glory

Glory: One or more coloured rings, seen by an observer around *his own shadow* on a cloud consisting of numerous small water droplets, on fog, or very rarely on dew. The coloured rings are due to **reflection** — arrangement same as corona. **Airborne observers often see a glory around the shadow of the aircraft** in which they are flying.

10. Crepuscular Rays

Dark bluish streaks which radiate from the sun. They are the **shadows of clouds** at or below the horizon.

11. Aurora

Aurora: (Latin: aurora = dawn). A phenomenon in which visible light is emitted by the high atmosphere, at heights varying from **typically about 100–250 km**. Aurora are ghostly displays of light in the form of streamers, rays, arches, hands, curtains, draperies, sheets or patches. They appear to shimmer or flit across the sky. Aurora are most common in higher latitudes, centering around magnetic poles. They are greenish white or pronounced red or violet.

Feature	Aurora Borealis	Aurora Australis
Name meaning	Northern Lights	Southern Lights
Hemisphere	N hemisphere (generally over NW Greenland)	S hemisphere
Called	Aurora Borealis	Aurora Australis

Cause: Aurora results from bombardment of gases in the rarefied upper atmosphere by electric particles from magnetic storms. These cause excitation of gases with consequent emission of radiation. **They impair radio communication.**

Aurora may be compared with the coloured commercial sign displays in which high voltage electric discharge is passed through tubes containing particular gas under low pressure, from which the colour light characteristic of the gas is then emitted.

12. Atmospheric Electricity and Lightning

In fine weather, the earth is negatively charged and the electric potential is directed towards the earth and has a mean value of **100 volts/m**. During a thunderstorm, the direction of current is locally reversed. Atmosphere carries a positive charge towards rain, and air to ground lightning flashes convey predominantly negative charge to ground.

Types of Lightning

Type	Description
Ground Discharge (Thunderbolt)	Lightning between cloud and ground. Usually branches downward from distinct main channel (streak or ribbon lightning). Generally between 10–20 m diameter . A luminous ball observed soon after a ground discharge and disappears with a violent explosion = ball lightning . Moves slowly in air/on ground.
Cloud Discharge (Sheet Lightning)	Lightning takes place within the cloud.
Air Discharge	Lightning from cloud to the air — does NOT strike the ground.

13. Saint Elmo's Fire

Saint Elmo's Fire: Sometimes when flying in CU/CB clouds, an aircraft may experience **bluish or greenish luminous discharge** due to strong electrical field in the cloud. The continuous luminous glow is also accompanied by **cracking sound**. Intensity of the glow is **weak to moderate**.

Aviation Warning: Saint Elmo's Fire = strong electrical activity in cloud = in or near CB/CU → precursor to lightning → AVOID the cloud. If experienced, immediately divert.

14. Practice Q&A

Q1. Aurora Australis occur in the (a) S hemisphere (b) N hemisphere (c) Equator

✓ Answer: (a) S hemisphere

Aurora Australis = Southern Lights = Southern hemisphere. Aurora Borealis = Northern Lights = N hemisphere.

🎯 Australis = Australia = South. Borealis = Boreal (northern forest) = North.

Q2. Aurora Australis are called Lights (a) Northern (b) Southern (c) Temperate

✓ Answer: (b) Southern

Aurora Australis = Southern Lights. Aurora Borealis = Northern Lights.

🎯 Straight definition question — memorise the pairing.

Q3. Aurora Borealis occur in the (a) S hemisphere (b) N hemisphere (c) Equator

✓ Answer: (b) N hemisphere

Aurora Borealis = Northern Lights, generally over NW Greenland in the N hemisphere.

🎯 Borealis → Boreal → Northern. Common exam pairing.

Q4. Aurora Borealis are called Lights (a) Northern (b) Southern (c) Temperate

✓ Answer: (a) Northern

🎯 Fixed pairing: Borealis = Northern; Australis = Southern.

Q5. Corona occur in clouds (a) AS (b) NS (c) Both AS and CS (d) Any one of all these

✅ Answer: (a) AS (Altostratus — and thin clouds/mist/fog)

Corona forms in AS, thin AC, mist or fog — wherever small uniform water drops exist. Not in NS (too thick) or CS (ice crystals produce Halo, not Corona).

🎯 Corona = AS. Halo = CS. This is a common exam distinction.

Q6. Bishop's ring is due to the diffraction of light by fine particles of (a) water (b) dust (c) ice

✅ Answer: (b) dust

Bishop's Ring = diffraction of light by fine dust particles (possibly volcanic) in high atmosphere. Not water drops (that's Corona) or ice crystals (that's Halo).

🎯 Bishop's Ring = DUST diffraction. Radius = 22° . Reddish-brown outside.

Q7. The radius of the Bishop's Ring is about (a) 32° (b) 22° (c) 42°

✅ Answer: (b) 22°

Bishop's Ring radius is about 22° — same as Small Halo radius but different cause and appearance.

🎯 Both Bishop's Ring and Small Halo share 22° radius — distinguish by cause: dust vs ice crystals.

Q8. Superior Mirage occurs in (a) Lapse (b) Isothermal (c) Inversion

✅ Answer: (c) Inversion

Superior (Upper) Mirage occurs when there is temperature inversion. Cold sea surface → inversion → light bends upward → object appears higher (superior) than actual.

Lapse rate steep = inferior mirage. Inversion = superior mirage.

🎯 Superior = Inversion (temperature inverted = superior mirage). Inferior = steep lapse (hot surface).

Q9. Inferior Mirage occurs when there is (a) Lapse (b) Isothermal (c) Inversion

✓ Answer: (a) Lapse

Inferior (Lower) Mirage occurs when lapse rate is steep — strongly heated surface, hot road or desert. Surface air is very warm, density rapidly decreasing with height.

🌀 Inferior Mirage → I = Image appears below = Intensive heating = Insolation-driven lapse.

Q10. Corona are formed due to of light (a) Refraction (b) Diffraction (c) Scattering

✓ Answer: (b) Diffraction

Corona = diffraction of light by very small water droplets. Halo = refraction by ice crystals. Rainbow = refraction + internal reflection.

🌀 Corona = Diffraction (water drops). Halo = Refraction (ice). Rainbow = Refraction + Reflection.

Q11. Corona are formed due to light passing through (a) Mist only (b) Fog only (c) small water or ice particles only (d) Any one of all these

✓ Answer: (d) Any one of all these

A corona forms when light is diffracted by very small, uniform water droplets, whether they are in mist, in fog or in thin cloud such as altostratus.

💡 Corona = diffraction by small water drops. Halo = refraction by ice crystals.

Q12. Halo is produced by (a) Refraction (b) Diffraction (c) Scattering

✓ Answer: (a) Refraction

Halo = refraction of light through ice crystals in CS cloud. This is a fundamental distinction in DGCA exams.

🌀 H for Halo → H for Higher clouds (CS) → H for refraction (Halo = refraction).

Q13. Halo is produced when light passes through (a) water particles (b) ice crystals (c) both

✓ Answer: (b) ice crystals

Halo = light refracted by ice crystals in Cirrostratus. Exclusively ice crystals.

🎯 Halo = ice crystals in CS. A halo shows that ice crystals are present; it does not establish that the cloud is safe to enter.

Q14. Halo occur in the cloud (a) AS (b) NS (c) CS

✓ Answer: (c) CS

Halo occurs due to ice crystals in Cirrostratus (CS) — a high cloud. Not AS (medium, water drops → Corona) or NS (low, thick).

🎯 Halo = CS. Corona = AS. Permanent exam distinction.

Q15. Halo is a luminous ring of radius (a) 22° (b) 32° (c) 42°

✓ Answer: (a) 22°

Small Halo = 22° radius. Large Halo = 46° radius. Primary rainbow = 42°. Secondary rainbow = 52°.

🎯 All the angles: Halo=22°/46°, Rainbow=42°/52°, Bishop's Ring=22°, Corona=<5°.

Q16. Halo round the sun shows a pure clear on the inside (a) Red (b) Yellow (c) Violet

✓ Answer: (a) Red

The red edge of the halo lies closest to the Sun or Moon. Colours grade towards blue on the outer side.

Halo: red inside, blue towards the outer side.

Q17. Halo signifies predominance in the cloud of (a) Supercooled water drops (b) Ice crystals

(c) Both

✓ Answer: (b) Ice crystals

A halo indicates ice crystals. The optical display alone does not establish the cloud's liquid-water content or aircraft icing risk.

Supercooled water drops → Corona, not Halo.

🌀 Halo: ice crystals. Do not use an optical display as permission to enter a cloud.

Q18. The cloud which cause Halo has chances of ice accretion (a) negligible (b) maximum (c) medium

✓ Answer: (a) negligible

Halo = CS cloud = ice crystals = negligible icing. Ice crystals do not accrete on airframes the way supercooled water droplets do.

🌀 Ice crystals bounce off airframe; supercooled WATER freezes on contact = icing. Halo cloud = safe.

Q19. Sometimes a halo with a radius of is observed, called Large Halo (a) 32° (b) 42° (c) 22°

✓ Answer: (b) 42°

The small halo has a radius of about 22°; the large halo is the bigger ring at roughly 46°. Of the options offered, 42° is the nearest to that larger ring.

💡 Small halo 22°. Large halo about 46°. Rainbow about 42°.

Q20. Halo occurs from cloud (a) Low (b) Medium (c) High

✓ Answer: (c) High

Halo occurs from Cirrostratus (CS) — a HIGH cloud. High clouds are composed of ice crystals that

refract light to form halo.

 High cloud (CS) = Halo. Medium cloud (AS) = Corona.

GHOST AVIATOR

Ghost Aviator

GHOST AVIATOR

15. Master Reference Tables

All Angular Values

Phenomenon	Angle/Radius
Primary Rainbow	42°
Secondary Rainbow	52° (arc 50° for red, 54° for violet)
Small Halo	22°
Large Halo	46°
Corona	<5°
Bishop's Ring	~22°

Optical Phenomena Master Comparison Table

Phenomenon	Cause	Mechanism	Cloud/Medium	Icing Risk	Key Distinction
Rainbow	Water drops (rain/drizzle)	Double refraction + 1 total internal reflection	Rain, drizzle, fog	N/A	VIBGYOR; red outside primary
Halo (22°)	Ice crystals	Refraction	High ice-crystal cloud	Cannot be established from a halo alone	Red on inner side; about 22°
Large Halo (46°)	Ice crystals	Refraction	Ice-crystal cloud	Cannot be established from a halo alone	About 46°
Corona	Small water drops	Diffraction	AS, mist, fog, thin AC	Moderate	<5° radius; icing warning
Bishop's Ring	Fine dust particles	Diffraction	High atmosphere (volcanic)	None	Reddish-brown outside; 22°
Mirage (Inferior)	Steep lapse rate	Refraction (curved ray)	Hot surface	N/A	Image below real; fake water
Mirage (Superior)	Inversion	Refraction	Cold surface	N/A	Image above real
Glory	Water drops	Reflection (backscatter)	Fog, cloud	N/A	Around observer's own shadow
Aurora	Solar particles	Emission	Typically about 100–250 km altitude	N/A	Impairs radio; Borealis=N; Australis=S
St Elmo's Fire	Electrical discharge	Luminous discharge	CB/CU clouds	High (in CB)	Blue/green glow + cracking sound

Join live classes for guided practice and doubt clearing.

Quick Revision Summary — Chapter 10:

- Rainbow: water drops; primary 42° (red outside); secondary 52° (colours reversed, red inside)
- Halo: ice crystals in CS; 22° (small) or 46° (large); refraction; not an icing-safety indicator
- Corona: water drops in AS/mist; $<5^\circ$; diffraction; MODERATE ICING RISK
- Bishop's Ring: fine dust; 22° ; diffraction; reddish-brown outside
- Mirage: inferior = hot surface (steep lapse); superior = cold surface (inversion)
- Glory: observer's shadow on cloud/fog; reflection by water drops
- Crepuscular Rays: shadows of clouds at/below horizon
- Aurora: Typically about 100–250 km altitude; magnetic storms; impairs radio; Borealis=N; Australis=S
- St Elmo's Fire: in CB/CU; blue-green glow + cracking; electrical field; AVOID
- KEY EXAM: Halo indicates ice crystals; neither halo nor corona alone establishes aircraft icing severity.