Interference Figures

Uniaxial Minerals

Interference Figures

Uses:

- Means by which uniaxial and biaxial minerals can be _____________ from each other, and
- For determining the ___________ of a mineral, specifically for uniaxial minerals whether:
  - $n_\omega > n_\varepsilon$ **Optically Negative**, or
  - $n_\omega < n_\varepsilon$ **Optically Positive**

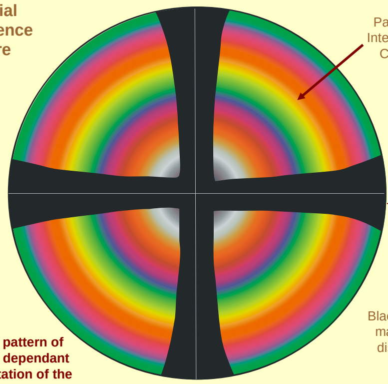
Interference Figures

To obtain and observe an interference figure:

1. With high power, focus on a mineral grain free of cracks and inclusions
2. Flip in the auxiliary condensor and refocus, open aperture diaphragm to its maximum
3. Cross the polars
4. Insert the Bertrand lens, look down the microscope tube

- Will not see the grain, but the interference figure, which appears on the top surface of the objective lense

Uniaxial Interference Figure



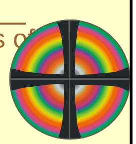
Nature and pattern of the figure is dependant on the orientation of the grain and its corresponding indicatrix

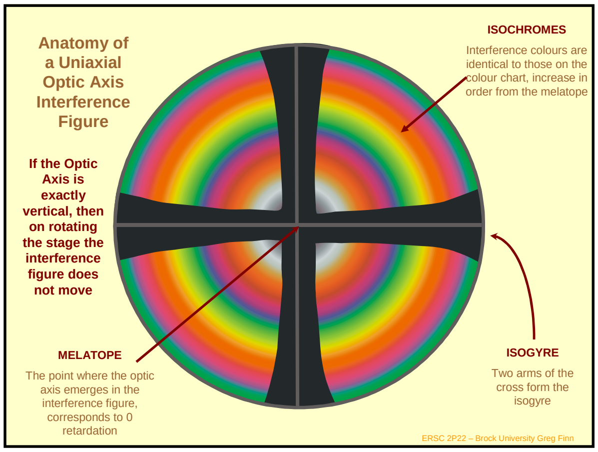
Uniaxial Interference Figure

- For Uniaxial minerals three types of interference figures are produced:
  1. Centred Optic Axis Figure (OA vertical)
  2. Off Centred OA Figure (OA) inclined)
  3. Flash Figure (OA horizontal)
- Each figure reflects the orientation of the indicatrix within the mineral grain

Optic Axis Figure

- If the optic axis is ________, the mineral grain will exhibit 0 birefringence and remain black, or nearly black, on rotating the stage
- Resulting figure produced is a ______ ______________________________
- Consists of a centred black ______ superimposed on _______ bands of __________________





Formation of Isochromes

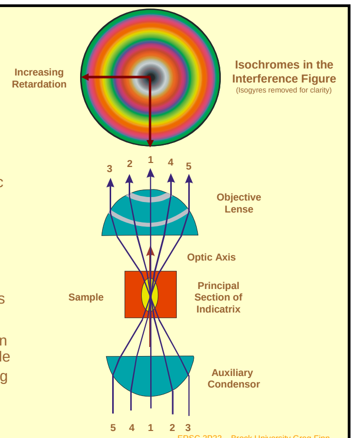
Optic Axis is vertical and the optic properties vary symmetrically about the OA

Ray 1 travels along the Optic Axis and experiences 0 retardation

All other light rays traveling through the mineral experiences a variable degree of retardation, reflecting the path it follows

Number of Isochromes depends on the retardation and thickness of the sample

Simplified, ignored the splitting of light into its two component rays



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Formation of Isogyres

- Isogyres form when the _________ directions in the interference figure are _______ to the _______ directions of the upper and lower _______
- Results in areas of __________ in the interference figure, as no component of light can be resolved into the vibration direction of the upper polar

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Formation of Isogyres

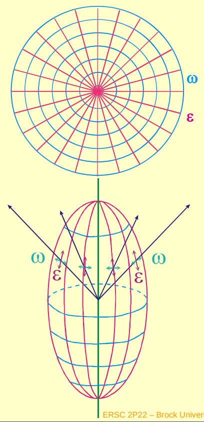
Vibration Directions on the Indicatrix Surface

Vibration directions for each ray of light passing through the mineral can be determined (we did this earlier)

If we do this for an infinite number of rays then:

All **Ordinary Rays** vibrate parallel to lines analogous to lines of latitude

All **Extraordinary Rays** vibrate parallel to lines analogous to lines of longitude

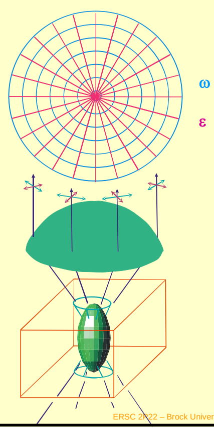


Formation of Isogyres

Vibration Directions in the Interference Figure

The mineral, with its indicatrix oriented such that the Optic Axis is vertical, with a convergent cone of light

Light rays, each of which is split into ε and ω rays, pass through the objective lense and the vibration directions for each ray can be projected onto the upper surface of the objective lense

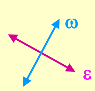


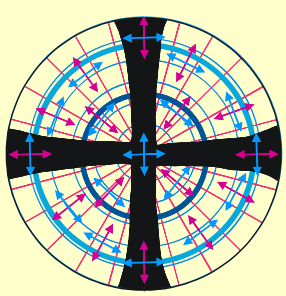
Formation of Isogyres

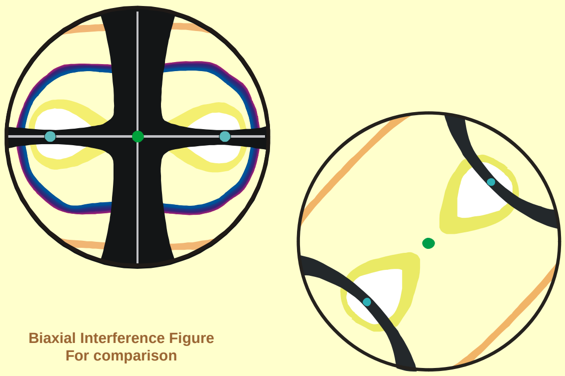
Vibration Directions in the Interference Figure

Extraordinary Ray

Ordinary Ray







Biaxial Interference Figure
For comparison

Determining the Optic Sign

- Once the interference figure has been:
  1. Obtained
  2. Identified as to whether it is uniaxial vs. biaxial, and
  3. The orientation of the optic axis in the figure is determined **then**
  4. The optic sign can be determined using the accessory plate(s)
- Why determine the optic sign?

Determining the Optic Sign

- The Optic Sign tells whether the **Ordinary Ray** is the ____ or ____ ray exiting the mineral
- **Optically Positive**
  - ω = fast ray
  - ε = slow ray
- **Optically Negative**
  - ω = slow ray
  - ε = fast ray

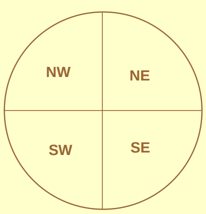
Determining the Optic Sign

To determine the optic sign:

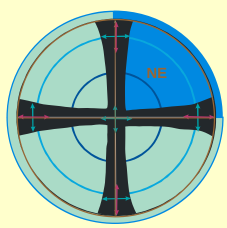
1. Obtain an optic axis interference figure, (Look for a grain that exhibits the lowest interference colour for the mineral)
2. Note the interference colour of the mineral
3. Insert the accessory plate (become familiar with the gypsum plate)
4. Observe the change in interference colours
   - In two quadrants the colours increase
     - Colours move up the colour chart
   - In two quadrants the colours decrease
     - Colours move down the colour chart
5. Look in the NE quadrant of the interference figure

CLARIFICATION!!!!!

Quadrants of the Field of View



Quadrants of the Interference Figure

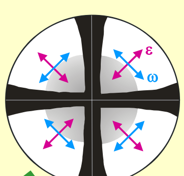


Uniaxial Optic Axis Figure – Optic Sign Determination

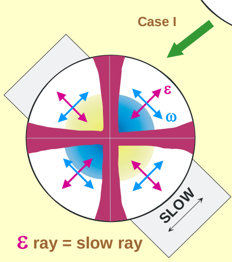
Few to no isochromes

Using the Gypsum Plate

Optically Positive



Case I

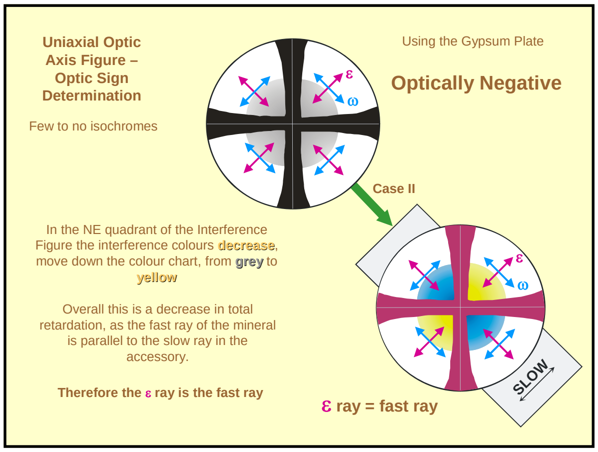


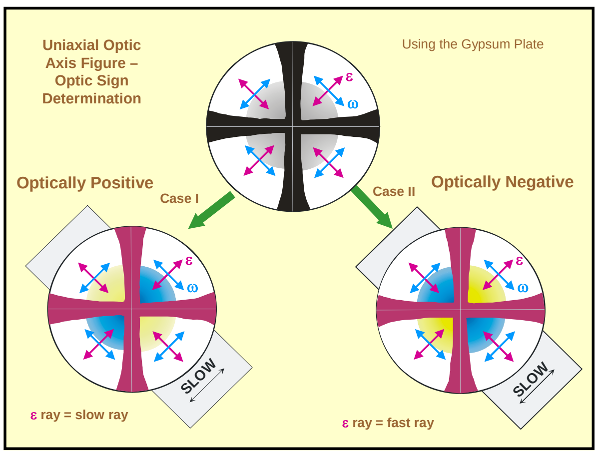
ε ray = slow ray

In the NE quadrant of the Interference Figure the interference colours **increase**, move up the colour chart, from **grey** to **blue**

Overall this is an increase in total retardation, as the slow ray of the mineral is parallel to the slow ray in the accessory.

Therefore the ε ray is the slow ray





Optic Sign Determination

- If the interference figure exhibits few to no _________, the gypsum plate is used to determine the sign,
- Insert the plate and note the change in colour in the NE quadrant, of the figure, from grey to:
  - **Blue** (positive) or
  - **Yellow** (negative)

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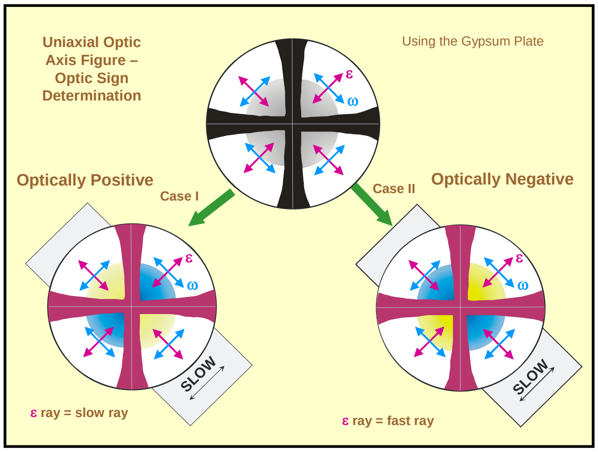
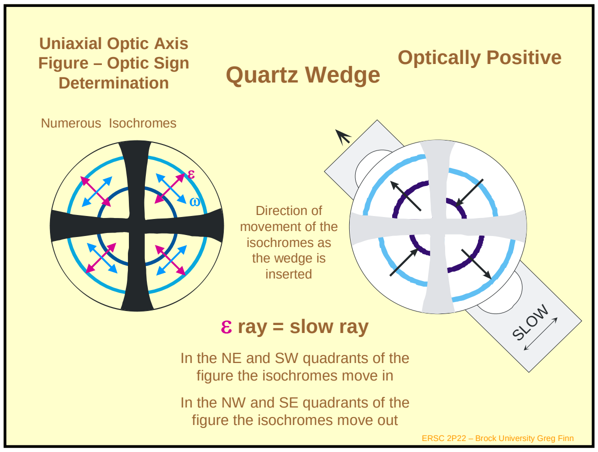


Quartz Wedge

- If the interference figure exhibits __________ isochromes then the quartz wedge is used to determine the optic sign
- Inserting the quartz wedge results in the __________ of the isochromes about the isogyre
- The direction of movement assists in determining the optic sign

Quartz Wedge

- In quadrants where the fast ray of the mineral is parallel to the slow ray of the wedge, the isochromes move ___, as ____ order colours form at the melatope and displace ______ order colours
  - ε = fast ray
- In quadrants where the slow ray of the mineral is parallel to the slow ray of the wedge, the isochromes move _______, as ______ order colours replace ______ order colours
  - ε = slow ray


Uniaxial Optic Axis Figure – Optic Sign Determination
Quartz Wedge
Optically Positive
Numerous Isochromes
ε
ω
Direction of movement of the isochromes as the wedge is inserted
SLOW
ε ray = slow ray
In the NE and SW quadrants of the figure the isochromes move in
In the NW and SE quadrants of the figure the isochromes move out
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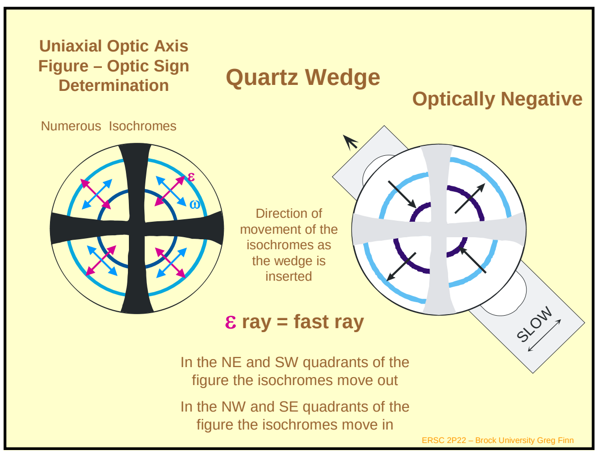
Uniaxial Optic Axis Figure – Optic Sign Determination
Quartz Wedge
Optically Negative
Numerous Isochromes
ε
ω
Direction of movement of the isochromes as the wedge is inserted
SLOW
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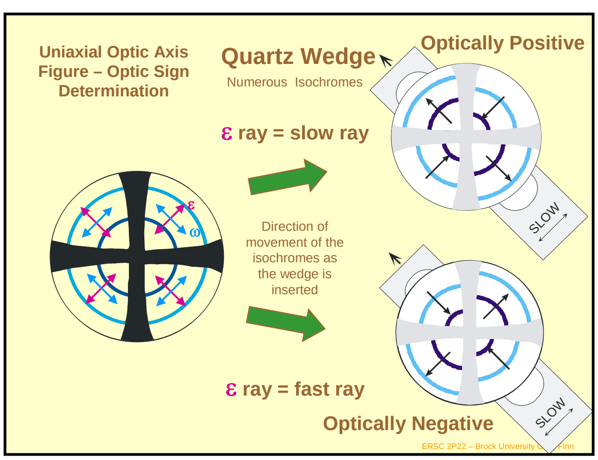
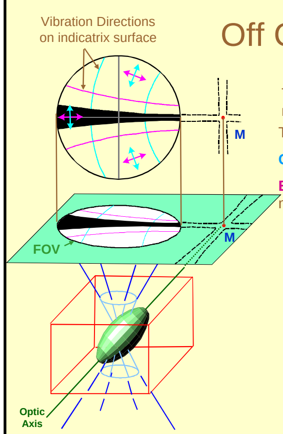

Uniaxial Optic Axis Figure – Optic Sign Determination
Quartz Wedge
Optically Positive
Numerous Isochromes
ε ray = slow ray
ε
ω
Direction of movement of the isochromes as the wedge is inserted
SLOW
ε ray = fast ray
Optically Negative
SLOW

Off Centred Optic Axis

- Produced when the optic axis is ____ _______, and results in the interference figure no longer ________ in the field of view (FOV)
- Isogyres still form a cross, which will lie outside the FOV with the melatope at the centre



Off Centred Optic Axis

(at extinction)

The isogyre fattens as the distance from the melatope increases

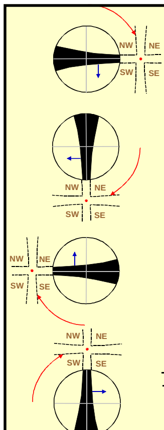
The vibration direction of the:

Ordinary ray is tangential to the isochromes,

Extraordinary ray is radial, from the melatope

Melatope (point where the Optic Axis emerges, the centre of the cross) lies outside the FOV. Will only see a single isogyre in the FOV

Mineral, with its indicatrix oriented such that the Optic Axis is inclined to vertical, with a convergent cone of light

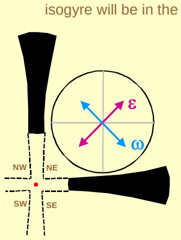


Off Centred Optic Axis

(on rotation)

Only one isogyre will be visible in the FOV at any time. As the stage is rotated the isogyre will sweep across the FOV, in the direction indicated, to be replaced by another arm of the cross

Identify the **NE quadrant** of the figure, no part of the isogyre will be in the FOV



Can now determine the optic sign in the same way as with a centred Optic Axis Figure:

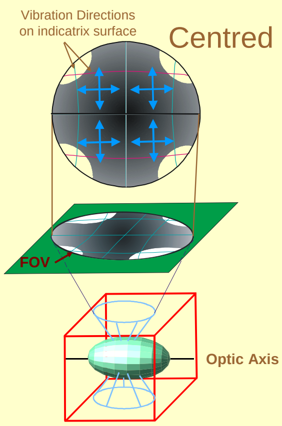
Is the ε ray the fast or slow ray?

Uniaxial Flash Figure

- Mineral grain is oriented with the optic axis ________
- Grain will exhibit its ___________ interference colour
- Interference figure is a broad, fuzzy cross

Centred Uniaxial Flash Figure

(at extinction)



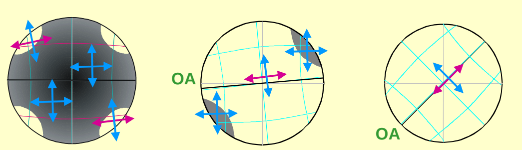
The resulting isogyre is a broad, fuzzy cross which nearly fills the FOV, because the vibration directions in all but the outermost parts of the FOV are parallel to the vibrations directions of the polars

Mineral, with its indicatrix oriented such that the Optic Axis is horizontal, in this case EW in the FOV

In this orientation the mineral will exhibit its maximum interference colour

Centred Uniaxial Flash Figure

(on rotation)



0° at Extinction

A broad fuzzy cross that fills the FOV

With a minor clockwise rotation (<5°), the isogyre splits and rapidly leaves the FOV, moving out into the quadrants of the FOV into which the Optic Axis (OA) is being rotated

With a rotation of 45°, the isogyres lie well outside the FOV and the OA is oriented either NE-SW or NW-SE, depending on the direction of rotation

Uniaxial Figures - Summary

- **Optic Axis Figure**
  - Section perpendicular to the c-axis (Optic Axis)
  - Lowest interference colour
  - Appears isotropic or nearly isotropic under crossed polars
- **Off-Centred Optic Axis Figure**
  - c-axis (Optic Axis) inclined to vertical
  - Only see one isogyre arm at a time, will sweep through the field of view
  - Intermediate birefringence therefore intermediate interference colour
- **Flash Figure**
  - c-axis (Optic Axis) is horizontal, parallel to the stage
  - Maximum interference colour

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