OTHER ANNOUNCEMENTS

Quiz on Monday covering:

- -symmetry operations
- -notations of axes, vectors, and face notation
- -Miller indices

2nd Draft of References due Monday

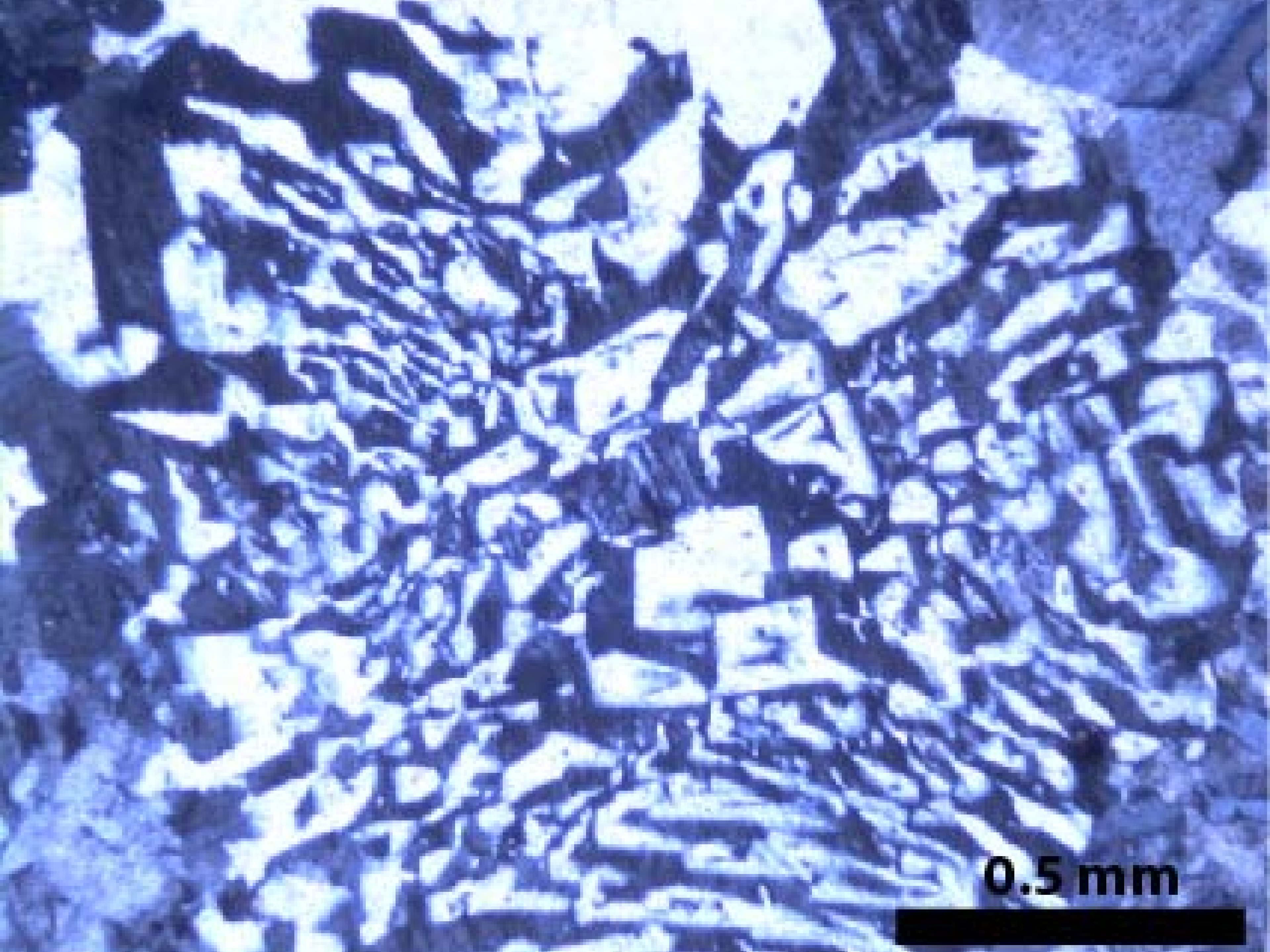
Field Trip Saturday 10/4 and Sunday 10/5

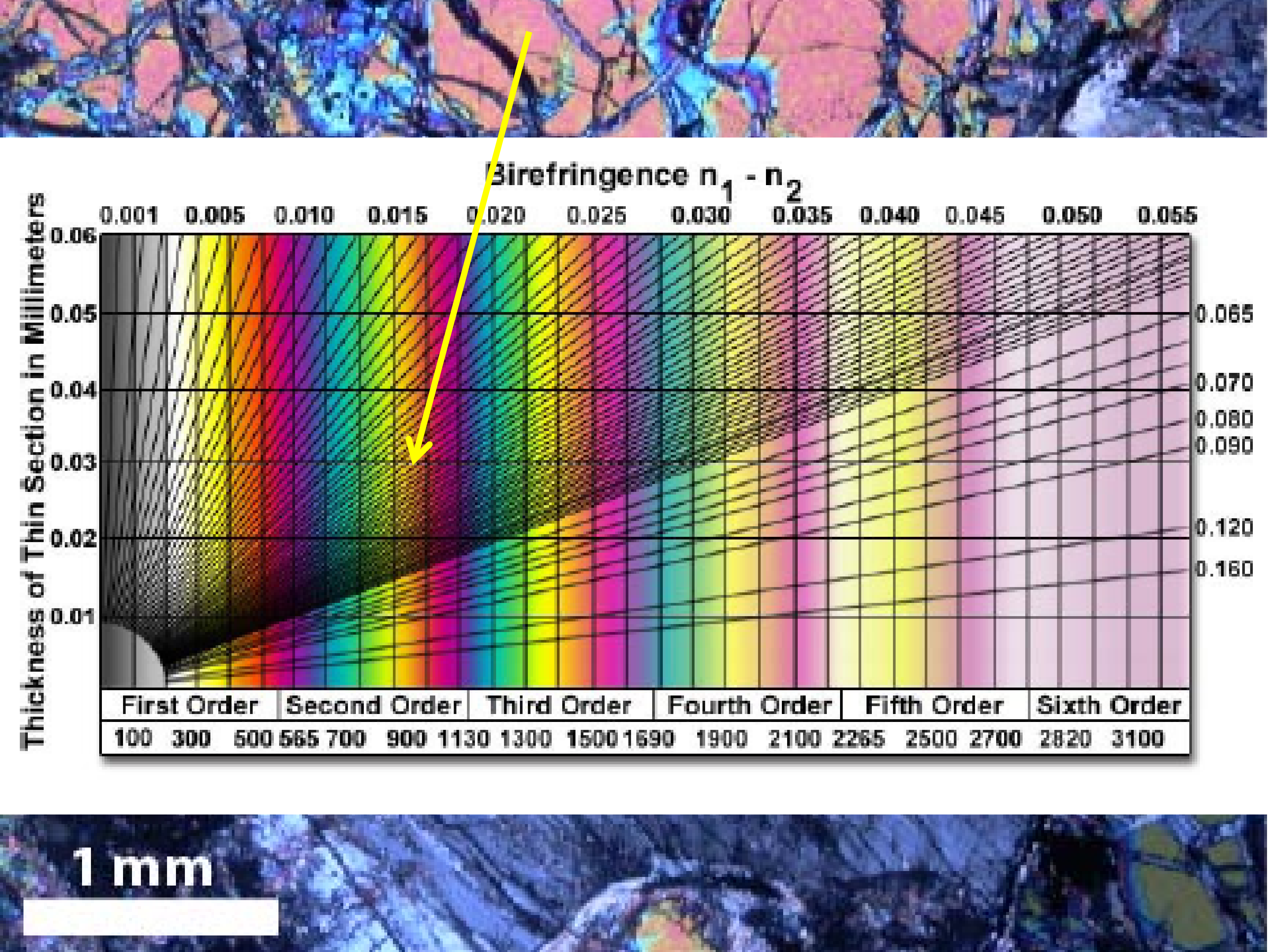
- -Cost will be $20.00 per person (snacks and lodging)
- *-participants must pay for their own dinner 10/4*

Transmitted light microscopy

The characteristics of light as it is transferred through a mineral can be used to describe and quantify certain mineral properties.

FOR EXAMPLE…


0.5 mm


Birefringence $n_1 - n_2$
0.001 0.005 0.010 0.015 0.020 0.025 0.030 0.035 0.040 0.045 0.050 0.055
Thickness of Thin Section in Millimeters
0.06 0.05 0.04 0.03 0.02 0.01
0.065 0.070 0.080 0.090 0.120 0.160
First Order Second Order Third Order Fourth Order Fifth Order Sixth Order
100 300 500 565 700 900 1130 1300 1500 1690 1900 2100 2265 2500 2700 2820 3100
1 mm

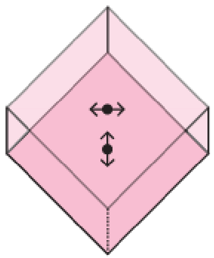
REVIEW

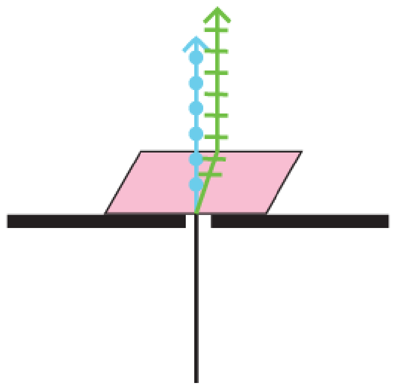
- Refractive indices: when light passes between two different materials (i.e. air and your mineral of interest) of differing refractive index (related directly to density), the velocity of that light ray will change
- Becke line test: method to observe the difference in the refractive indices of two adjacent minerals, the line moves into the lower RI material when the stage is lowered
- Relief: essentially the relative height of a mineral

- Light entering isotropic minerals is unchanged

- Light entering anisotropic minerals is split in two

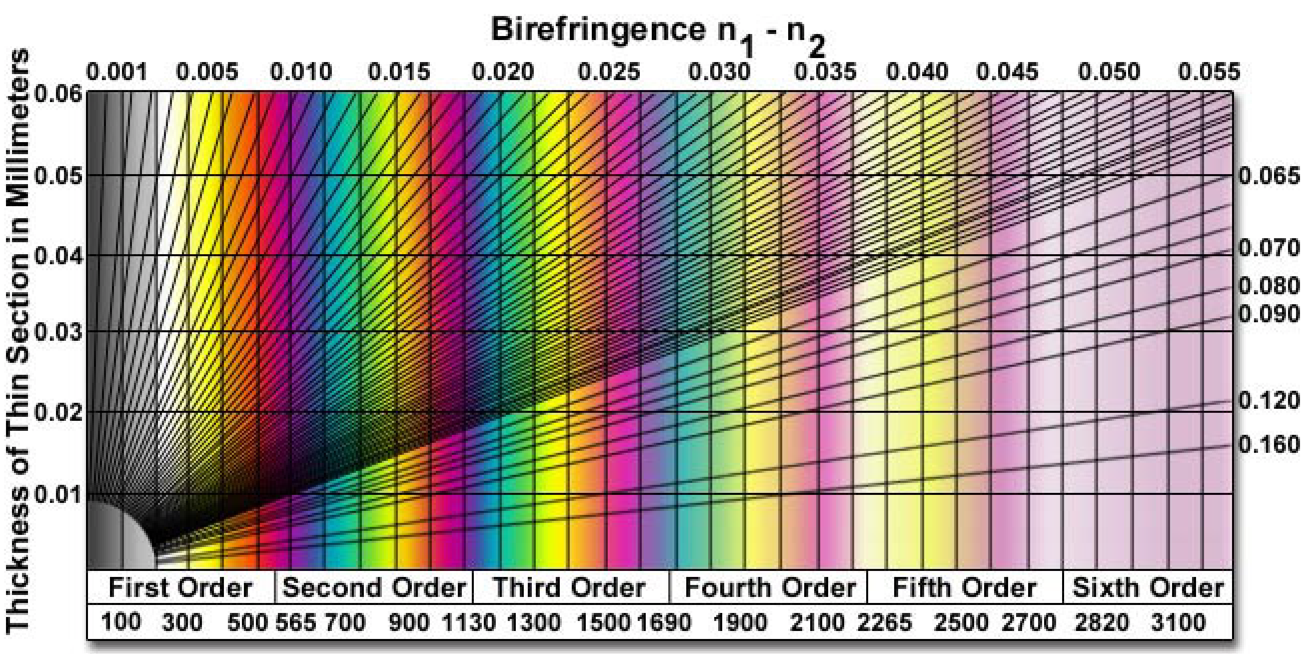
- Birefringence: the difference between the largest and smallest RI value of a mineral when view in crossed-polarized light





The difference between the largest and smallest possible refractive indice values is called the ***birefringence***.

The ***birefringence*** color is what is recorded when an anisotropic mineral is viewed in crossed-polarised light.



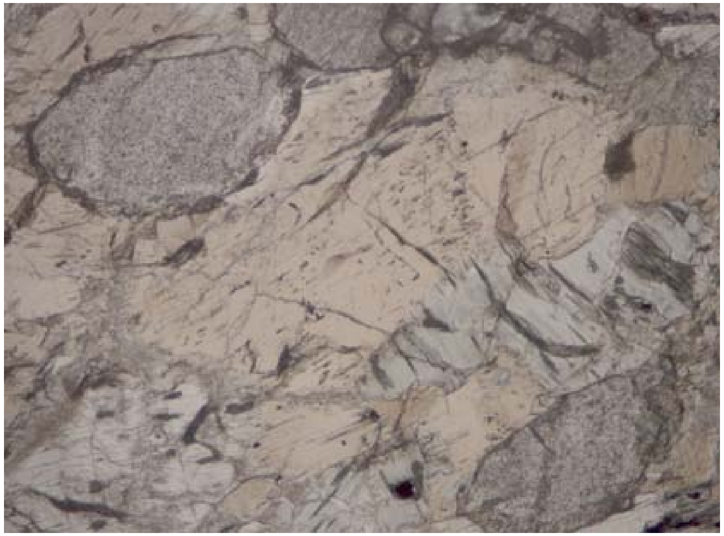
The interference order is a measure of retardation (path difference).

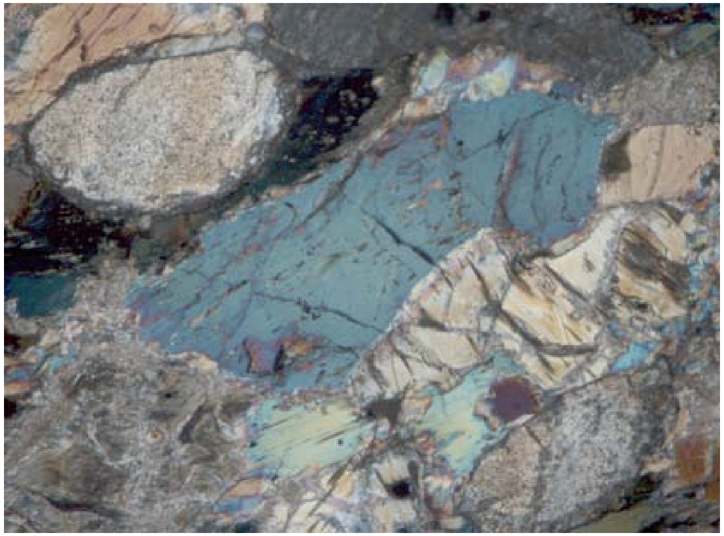
Retardation

If we look down a microscope with no thin section present, what is the color of the light?

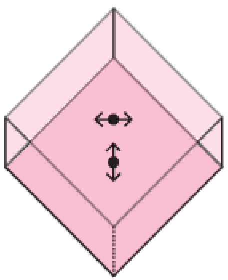
What happens when the polarisers are crossed?

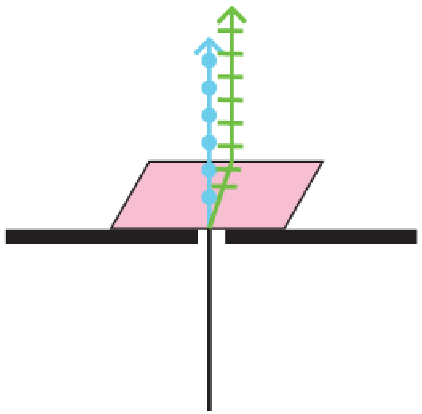
What happens if we place a thin section of anisotropic minerals in the light's path?





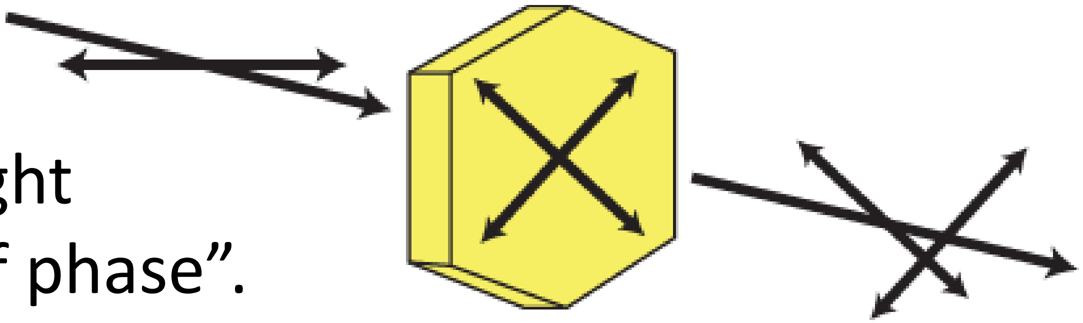
When **monochromatic** polarised light enters an anisotropic mineral it splits into perpendicular components creating two light beams that are independent.



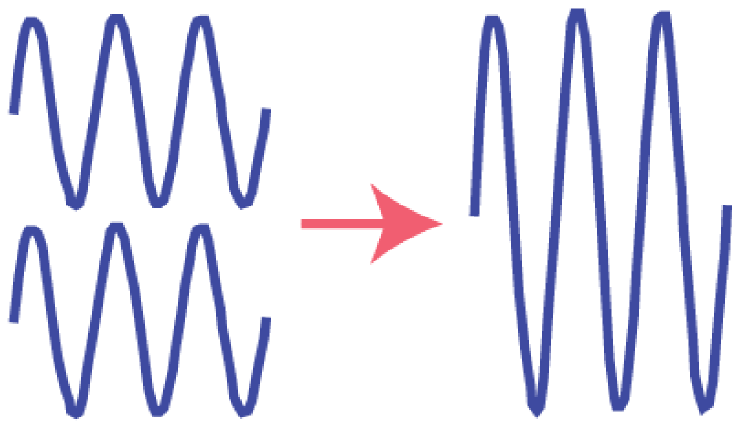


The RI of a mineral varies as a function of the crystallographic axis (orientation of C) such that the two beams are created simultaneously but exit at different times.

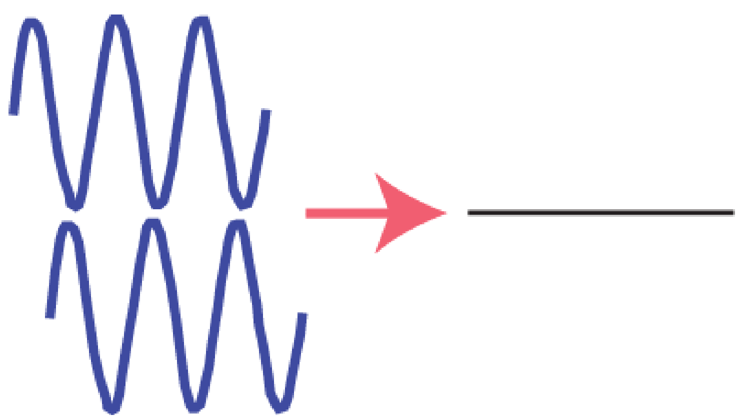
Therefore, the exiting light consists of two light beams that are "out of phase".



Constructive vs. Destructive Interference (I)



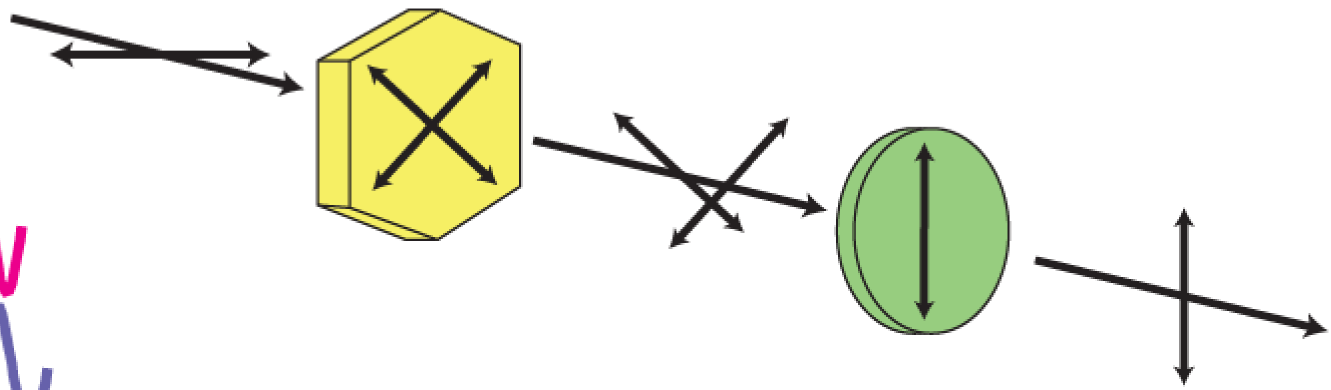
Constructive waves are
in-sequence =
Double the amplitude =
Brighter light!

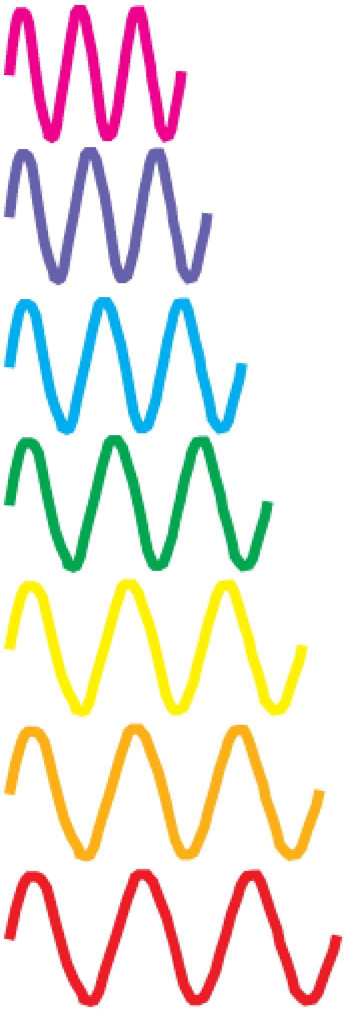


Destructive waves = No light.

The intermediate situation results in light, but of intermediate intensity (brightness).

What happens when the incident light is white?

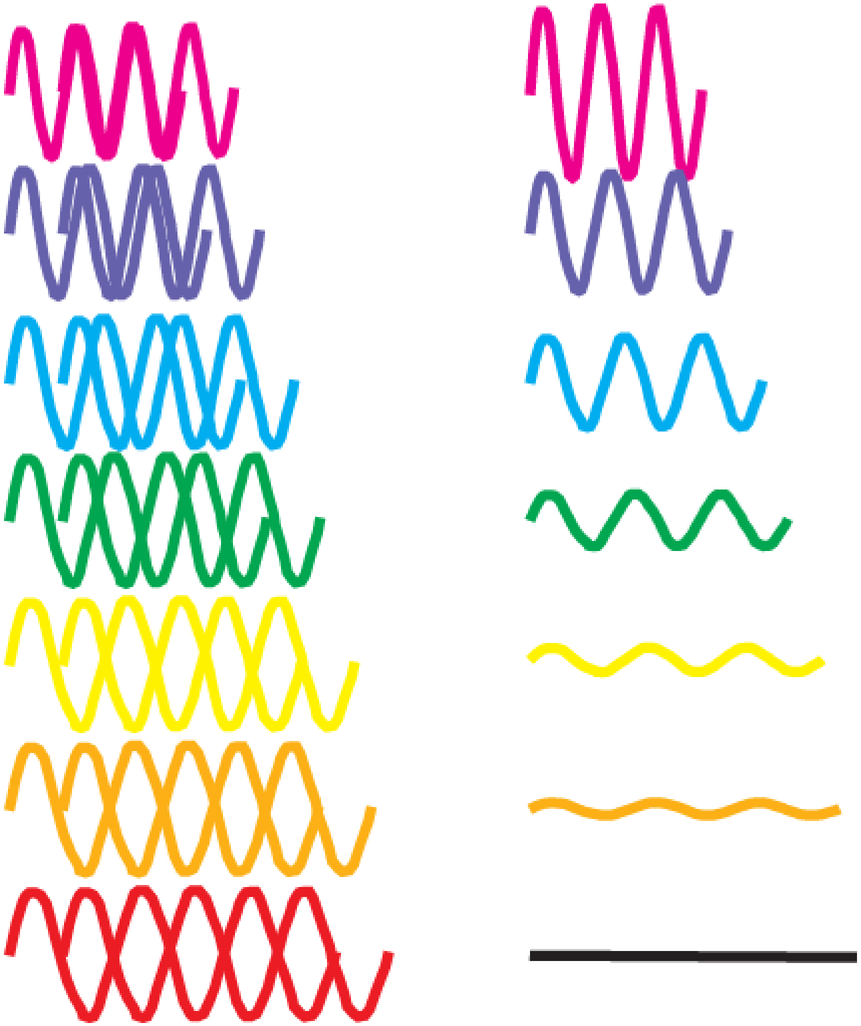




Depending on the RI and thickness of the crystal the some light waves exiting the crystal will interfere destructively, while others interfere constructively.

When a color wavelength is removed from white light - we see colored light.

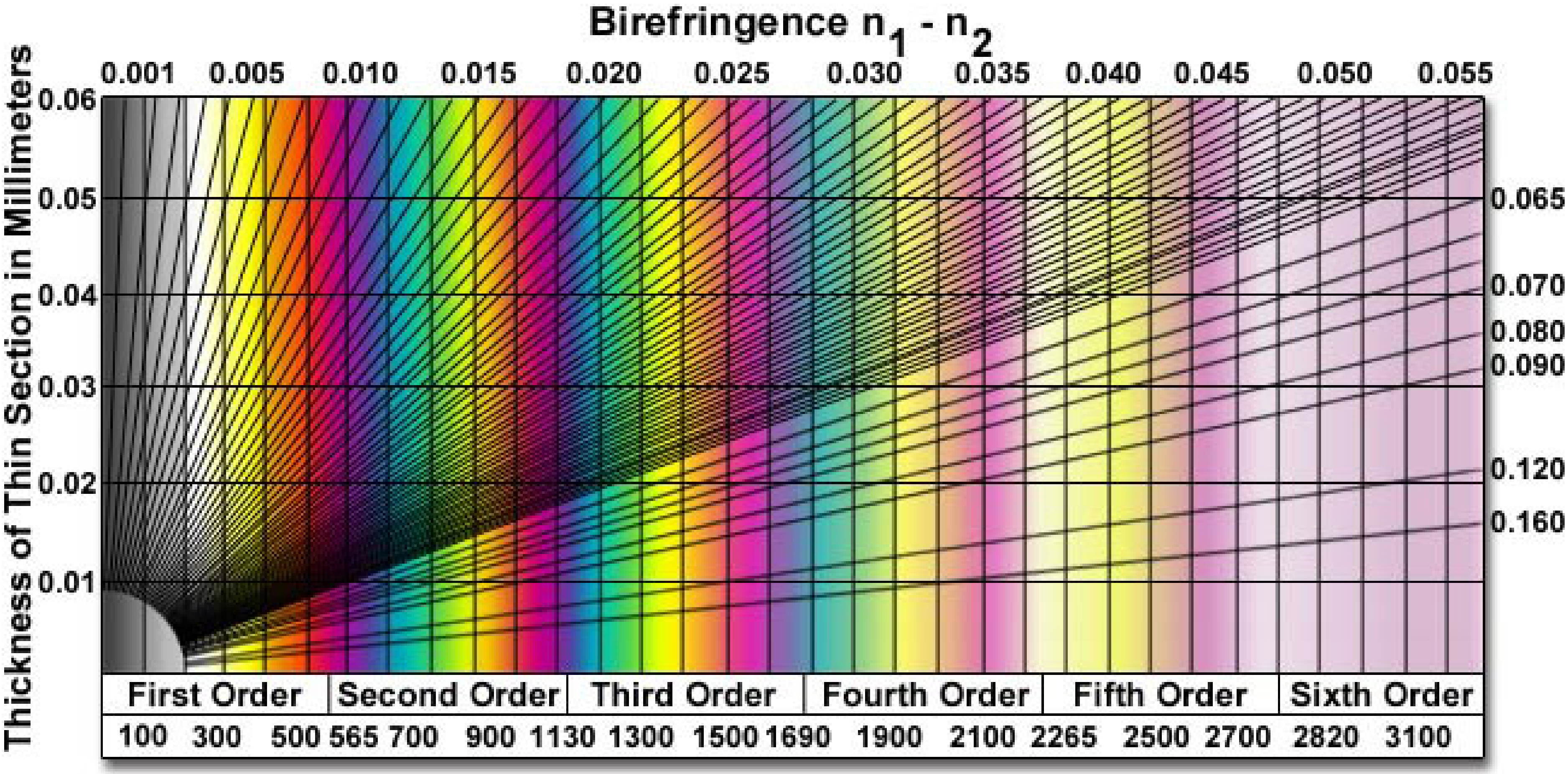
In a case where the longer wavelengths are retarded (i.e. ~½ l), the resultant color is dominated by blue/violet.



Retardation holds back particular wavelengths. In this case, the red light has been held back ~½ l.

The difference in the number of l is the ***path difference*** or ***retardation***.

Birefringence color or the color order of interference is related to the amount of light retardation or the path length.



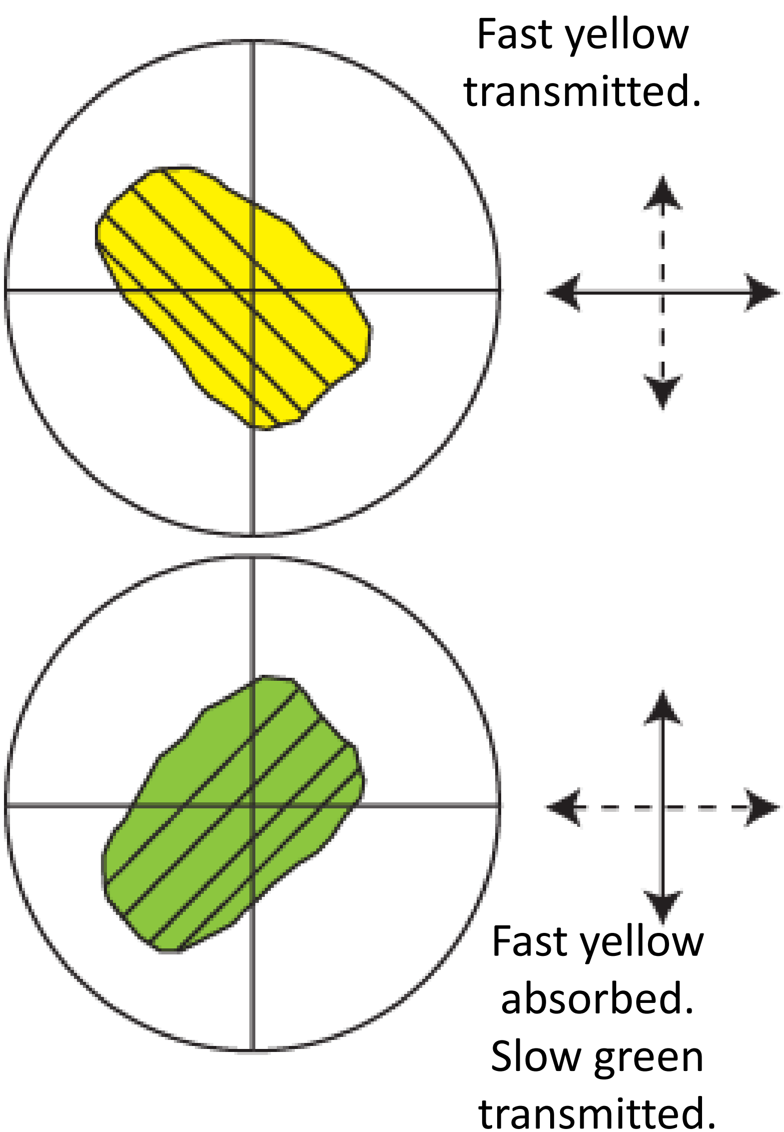
Other Consequences of Double Refraction

Colour and Pleochroism

In plane polarised light (ppl), double refraction induces characteristic colors – the reason is similar, but slightly different, from general mineral color (in hand sample)

Tourmaline Acorn. Crystal thickens from top-to-bottom. Therefore, the retardation of doubly refracted light increases from bottom up.

Pleochroism



Plane polarised light is vibrating in one plane (E-W).

When a mineral double diffracts the light into a fast and a slow travelling wave (perpendicular to one another) the orientation of the mineral controls the absorption of the light.

One vibration direction is completely absorbed in one orientation, and the other when the mineral is rotated 90°.

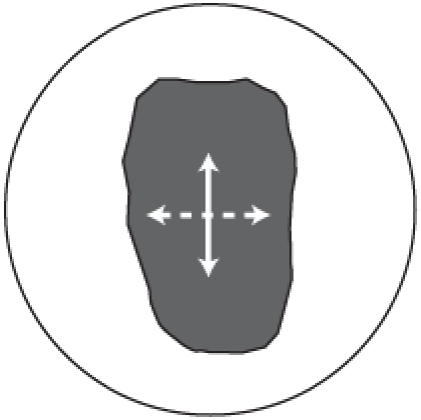
Length Fast and Length Slow

Sign of elongation

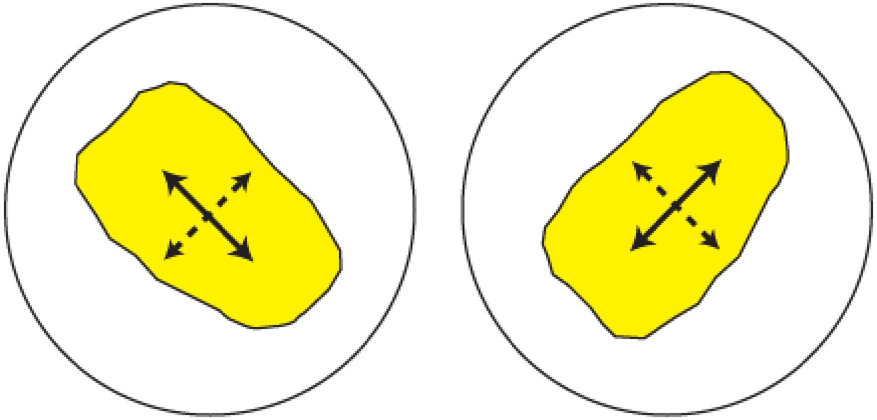
The two light waves generated by anisotropic minerals have different velocities, which are controlled by the refractive index.

These two vibration vectors may be referred to as the fast and the slow directions.

The vibration direction (fast and slow) can be determined using an "accessory plate"



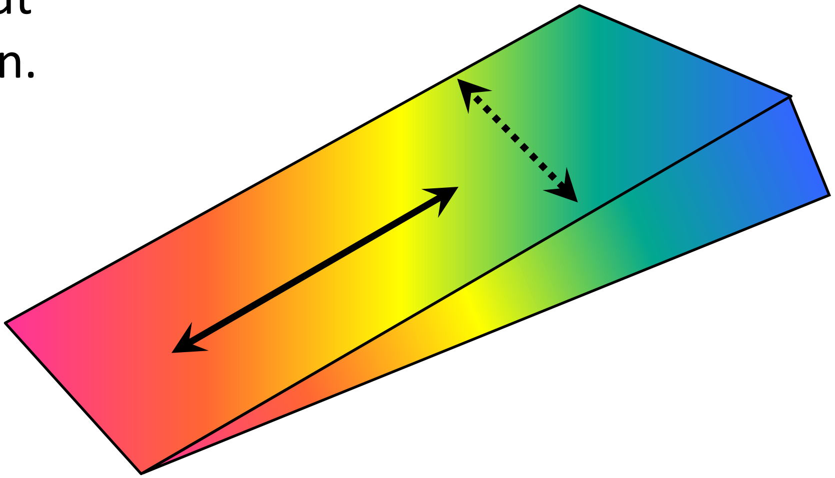
A Mineral with straight extinction in crossed polarized light (xpl) has its maximum birefringence at 45°



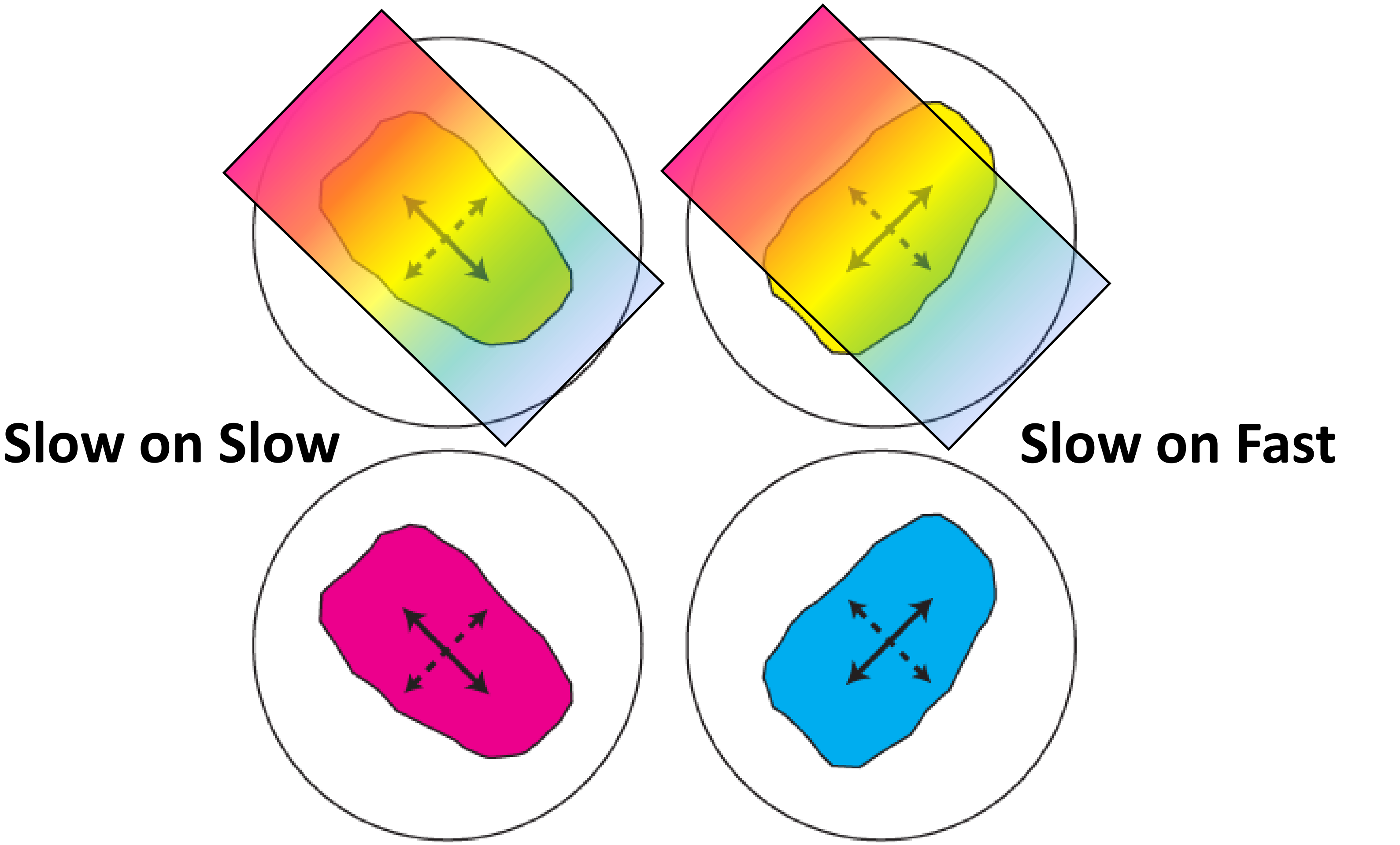
By using an accessory plate (commonly gypsum or quartz) it is possible to artificially augment or hinder the retardation.

The accessory plate is a wedge specially cut such that its vibration directions are known.

Typically, they are cut to be length fast.



When the accessory plate augments the retardation (i.e. increases the path difference) the order of birefringence colour increases.



When it reduces the path difference, the birefringence colour decreases.

FOR MONDAY

Quiz covering**:** symmetry operations, axes, & Miller indices

2nd Draft of References *due in class*

Have read through chapter 6 (Systematic Mineralogy)

Lab(s) next week on advanced projection and introduction to the polarizing microscope