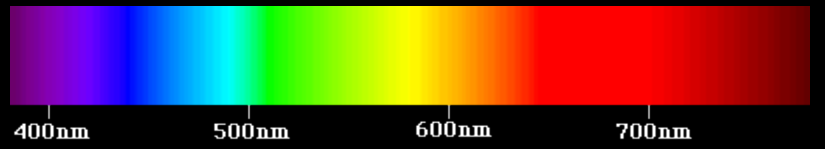
ASTEROID COMPOSITION

Surface composition detection using digital images

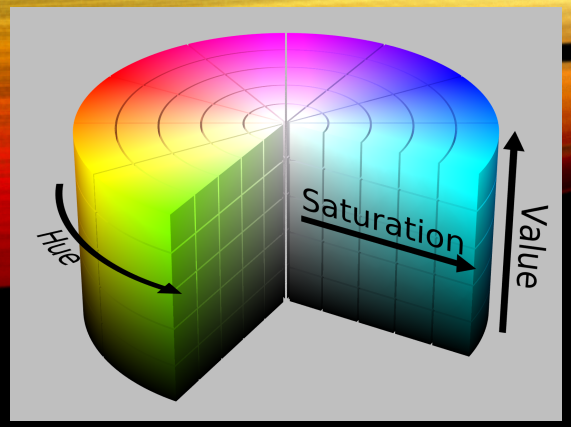
VISIBLE WAVELENGTHS

- Human visible light wavelengths range from 380 nm to 760 nm
- https://en.wikipedia.org/wiki/Electromagnetic_spectrum#Visible_radiation_.28light.29
- http://www.midnightkite.com/color.html



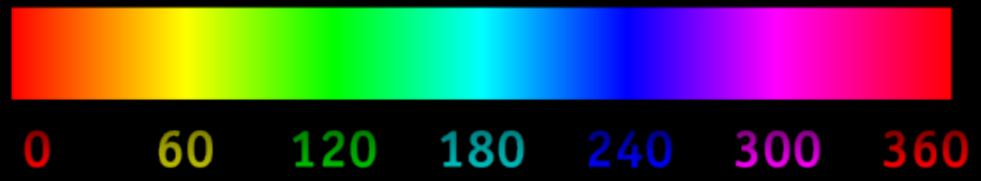
METEORITE COMPOSITION

- **Iron meteorites**
  - **Iron:** 91 percent
  - **Nickel:** 8.5 percent
  - **Cobalt:** 0.6 percent
- **Stony meteorites**
  - **Oxygen:** 36 percent
  - **Iron:** 26 percent
  - **Silicon:** 18 percent
  - **Magnesium:** 14 percent
  - **Aluminum:** 1.5 percent
  - **Nickel:** 1.4 percent
  - **Calcium:** 1.3 percent
- http://www.space.com/51-asteroids-formation-discovery-and-exploration.html



PROBLEM: RECOVER WAVELENGTHS FROM RGB SPACE

- This is technically impossible since an infinitely many combinations of wavelengths can produce the same perceived color to the human vision system.
- RGB is an approximation of real color by adding three primary colors from the red, green, and blue wavelengths.
- We can approximate wavelengths from RGB by converting to hue, saturation, and value (HSV) format.
  - The hue value which ranges from 0 to 360 degrees can be used to estimate wavelength.



OPENCV HUE TO WAVELENGTH CONVERSION APPROXIMATION

- OpenCV stores hue values for 8-bit images in the range of 0 to 179 as opposed to 0 to 359 to fit the entire range into the 8-bit field.
- http://docs.opencv.org/3.1.0/de/d25/imgproc_color_conversions.html
- So we can normalize the range from 0 to 359 by multiplying values by two and perform the approximation conversion given by the following equation:
  - $l = 620 - \frac{170}{270} * 270 * h$
  - Where: l is wavelength in nm and h is the hue value from 0 to 359.
  - http://stackoverflow.com/questions/11850105/hue-to-wavelength-mapping

PROBLEM: LIGHT SIGNALS ARE NOISY

- Measurements taken by cameras are inherently noisy.
  - For most images we don't know how well the camera was calibrated

- We don't know the albedo (ratio of surface reflectance) for the asteroid.
  - High albedo surfaces will have lots of specular reflection meaning that they will tend to look dark if the reflected light is not at the same angle as the camera lens
  - We don't know the albedo of the surface because we don't know what the surface composition is but we're trying to use light emissions to estimate surface composition.

PROBLEM: SURFACE LIGHT CAN BE AFFECTED BY OTHER PHYSICAL FACTORS

- Asteroid surfaces have craters which appear darker
  - Cratered surfaces also have slightly different surface composition because the impact that produced the crater adds heat and pressure to the surface which changes the chemical composition.
  - Objects impacting the asteroid surface also deposits foreign materials on the surface.