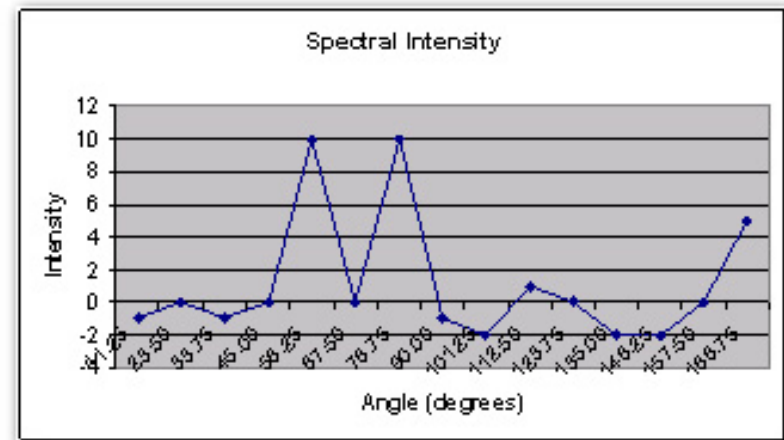


# Generating Experimental Polarization Data for Purposes of Developing an Automated Martian Geology Sensor

Kwame Porter-Robinson

Dr. Michael DeAntonio



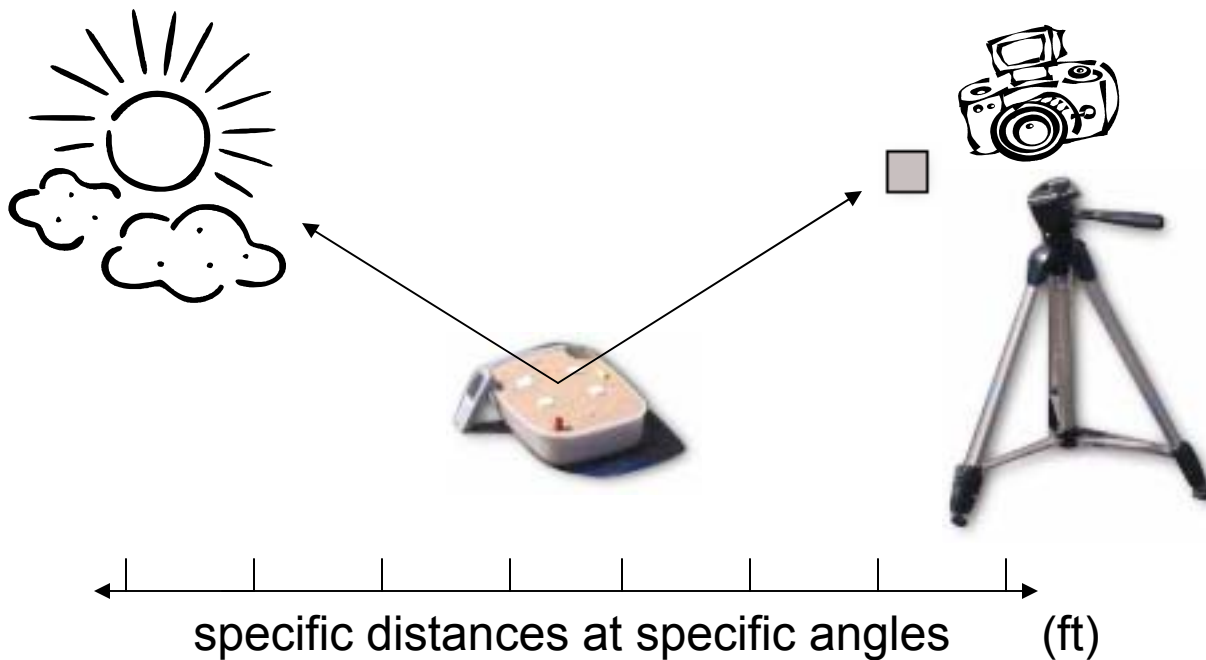
# Introduction

- The objective was to collect experimental data for purposes of developing an automated Martian Geological sensor.
- Automated discrimination of soil composition would allow interpretation of geological data almost as swiftly as the raw data is returned.
- Through experimentation I generated data which indicated that identifying similar sand composition types that differ only by indices of refraction is possible.

# Instrument Setup

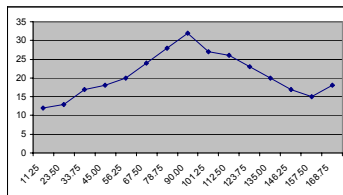
## Requirements:

- Multiple viewing angles
  - Restrict all unwanted translational and rotational movement
  - Able to take photographs at specific distances and angles
- Sun served as randomized light source.
  - Polarized sheet of plastic as polarizing filter.
  - Sun position given by U. Oregon's Sun Chart program.

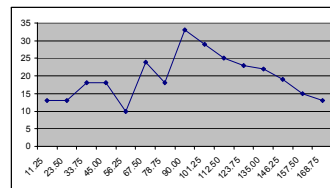


# Theory

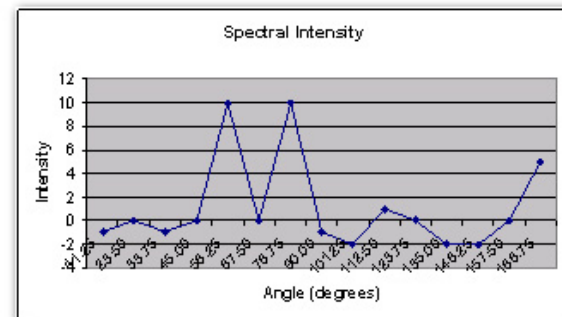
- Natural light is unpolarized.
- All materials have an index of refraction.
- A material's index of refraction can be determined by a two step process:
  - 1) Observe the angle where the maximum degree of polarization occurs
  - 2) Take the arctangent of that angle, which gives the index of refraction when observation occurs through air.
- Maximum polarization is given by the subtraction of two polarimeter orientations, horizontal and vertical, over a range of angles.
- However, what is the angle that the maximum degree of polarization occurs when 3-d angles are involved?

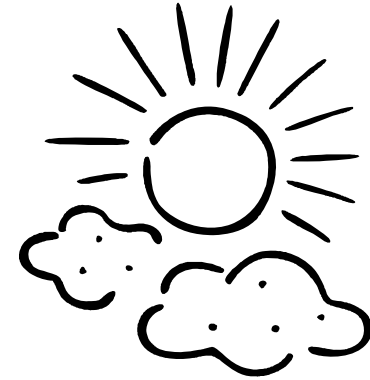
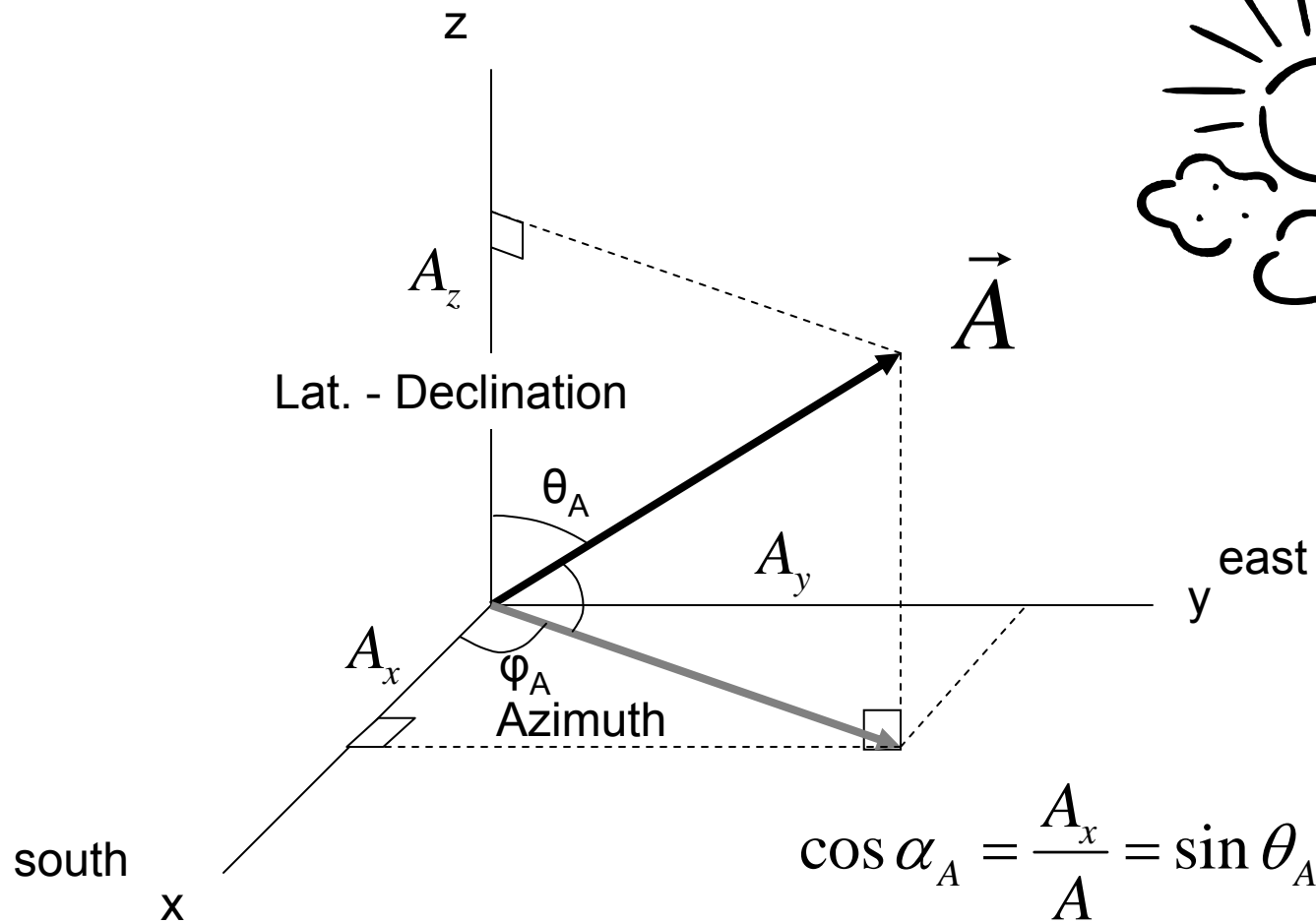


—



=





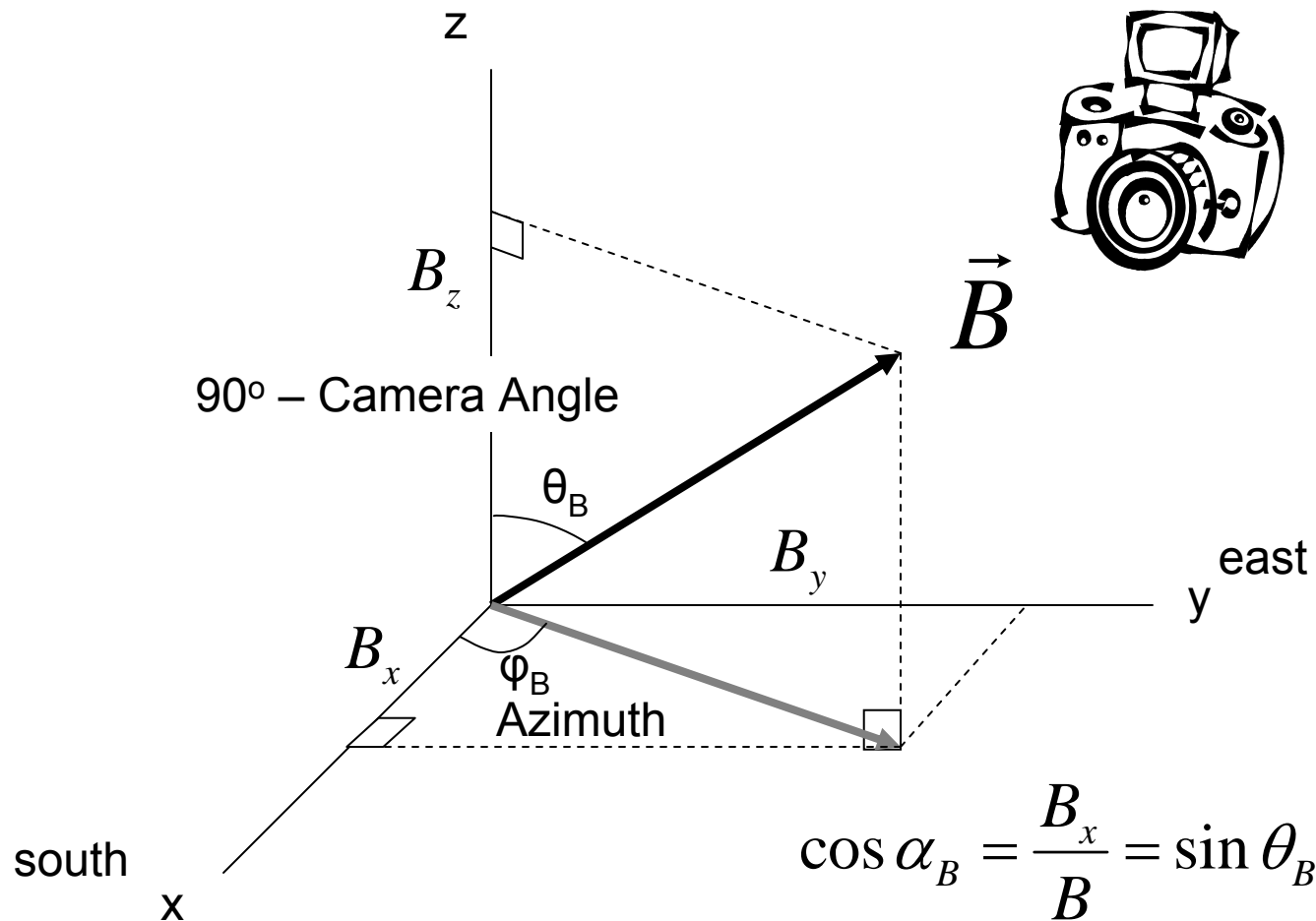
$\theta_A =$  Lat. - Declination

$\varphi_A =$  Azimuth

$$\cos \alpha_A = \frac{A_x}{A} = \sin \theta_A \cos \varphi_A$$

$$\cos \beta_A = \frac{A_y}{A} = \sin \theta_A \sin \varphi_A$$

$$\cos \gamma_A = \frac{A_z}{A} = \cos \theta_A$$



90° – Camera Angle

$\theta_B$

$B_y$

east

y

$B_x$

$\varphi_B$

Azimuth

south

x

$$\cos \alpha_B = \frac{B_x}{B} = \sin \theta_B \cos \varphi_B$$

$$\cos \beta_B = \frac{B_y}{B} = \sin \theta_B \sin \varphi_B$$

$$\cos \gamma_B = \frac{B_z}{B} = \cos \theta_B$$

$$\theta_B = 90^\circ - \text{Declination}$$

$$\varphi_B = \text{Azimuth} = 147^\circ = 180^\circ - 33^\circ$$

Cosine of angle between camera and sun

$$\cos \psi = \cos \alpha_A \cos \alpha_B + \cos \beta_A \cos \beta_B + \cos \gamma_A \cos \gamma_B$$

angle of incidence = angle of reflection

Angle of incidence between sun and normal to the surface of the grain of sand or asphalt is

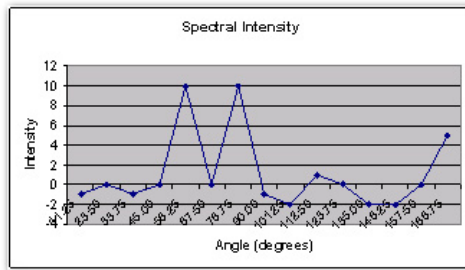
$$\frac{\psi}{2} = \frac{\cos^{-1} (\cos \alpha_A \cos \alpha_B + \cos \beta_A \cos \beta_B + \cos \gamma_A \cos \gamma_B)}{2}$$

For sand, Brewster's Angle is...

$$\frac{\psi}{2} = 56.85317 \text{ degrees} \quad n = \tan \left( \frac{\psi}{2} \right) = 1.53126$$

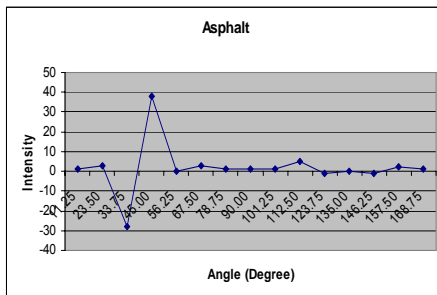
# Results

Sand, Index of Refraction:  $n = 1.53126$



Brewster's Angle (sand) = 56.85317 degrees

Asphalt, Index of Refraction:  $n = 1.34845$



Brewster's Angle (asphalt) = 53.43965 degrees

# Conclusion

- The index of refractions I calculate support several conclusions:
- The experimental method was reasonably accurate: My sand result of 1.531 compares well with the standard 1.54 value as given by Dr. DeAntonio.
- The hypothesis has been validated:

“The data shows that for materials having different indices of refraction, even if they have the same color and composition, can be uniquely identified by a polarimeter.”
- Therefore, I have demonstrated that a polarimeter may be attached to a viewing source and used to observe the Martian surface at horizontal and vertical polarizations in order to classify the terrain into a series of soil compositions at various locations.