Comparative polarization study of light scattering by aerosol particles and particulate surfaces

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Collaborators

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Objectives

Polarization of the scattered sunlight is an important source of information on physical and chemical properties of scatterers.

Analysis of the light-scattering response from an unknown target

require

Comparison with well-characterized reference samples

Laboratory measurements are essential for validation of the retrievals
Objectives

• Comprehensive comparative investigation of polarization of the scattered light by particles suspended in the air and the same particles deposited on surface.

• Establishment of the interrelation between light-scattering responses from particles suspended in the air and deposited on a surface.

Examples of volcanic sand particles on the left and particulate surface on the right.
Applications

By measuring and comparing polarization of atmospheric aerosols and particulate surfaces, can we find the place of origin of the dust clouds?

Can we use polarization to estimate the density of thin clouds?

Dust across the Atlantic
http://earthobservatory.nasa.gov/IOTD/view.php?id=81864&src=eoa-iotd

Comet Hartley 2
M. F. A’Hearn et al., Science, 2011
Observation geometry

\[ \alpha = 180 \text{ deg} - \Theta \]

\[ \begin{pmatrix} I_{sc} \\ Q_{sc} \\ U_{sc} \\ V_{sc} \end{pmatrix} \propto \begin{pmatrix} F_{11} & F_{12} & F_{13} & F_{14} \\ F_{21} & F_{22} & F_{23} & F_{24} \\ F_{31} & F_{32} & F_{33} & F_{34} \\ F_{41} & F_{42} & F_{43} & F_{44} \end{pmatrix} \begin{pmatrix} I_{in} \\ Q_{in} \\ U_{in} \\ V_{in} \end{pmatrix} \]

Phase function: \[ \frac{F_{21}}{F_{11}} \]


Depends on:
- shape
- size
- refractive index
- orientation
- wavelength

Stokes vector
Scattering Matrix
Stokes Vector
FGI experimental setup
particulate surface measurements
IAA experimental setup
aerosole measurements
Measured samples

- Structural particle’s analogues

- Mississippi road dust
- Volcanic sand
- Construction Clay

Graphs showing keV vs cps/eV for Mississippi road dust and Construction Clay.
Polarization properties of aerosols and particulate surfaces.
Polarization properties of aerosols obtained with experiment and modeling. Refractive index estimation

Volcanic Sand at $\lambda=0.52 \, \mu m$

**Graphs:**
- $F_{11}/F_{II}(90^\circ)$
  - **Experiment**
  - **Modeling**
  - $m=1.6+0.02i$
  - $\rho=2.2$

- $F_{12}/F_{II}$
  - **Experiment**
  - **Modeling**
  - $m=1.7+0.05i$
  - $\rho=1.5$
Polarization properties of aerosols and particulate surfaces.
Conclusions

• Set of samples have been measured with two experimental setups.
• The comparative polarization analysis of light scattering by aerosol particles and particulate surfaces has been performed.
• We estimate refractive index of volcanic sand sample to be $\text{Re}(m)=1.6-1.7$ $\text{Im}(m)=0.02-0.05$.

Future plans:

• Measuring polarization of light scattering by aerosol particles at 483, 568, 647 nm.
• Comparative analysis of circular polarization of light scattered by particulate surfaces.
• Establishment of the interrelation between light-scattering responses from particles suspended in the air and deposited on a surface.
Thank you!

Polarisation as a tool to study the Solar System and beyond
Action MP1104
Umov law

Polarization $P$ is inversely correlated with albedo $\alpha$

$$P \propto \frac{1}{\alpha}$$

Umov effect has linear trend in log scale

The Umov effect measured for 22 sites on the Moon at wavelength 650 nm (circles), and in different mixtures of the volcanic sand and salt (NaCl) at wavelength 633 nm and 750 nm (triangles).
Application of Umov law

Can we estimate the density of thin dust cloud?

- By measuring max degree of linear polarization we can estimate the reflectance in single scattering dust particles.
- Using this information we can discover number density of particles in optically thin clouds.

Density ∝ \frac{Flux}{Reflectance}
Observation geometry

\[ P = \frac{I_\perp - I_\parallel}{I_\perp + I_\parallel} \]

- \( P > 0 \) if \( I_\perp > I_\parallel \)
- \( P < 0 \) if \( I_\perp < I_\parallel \)