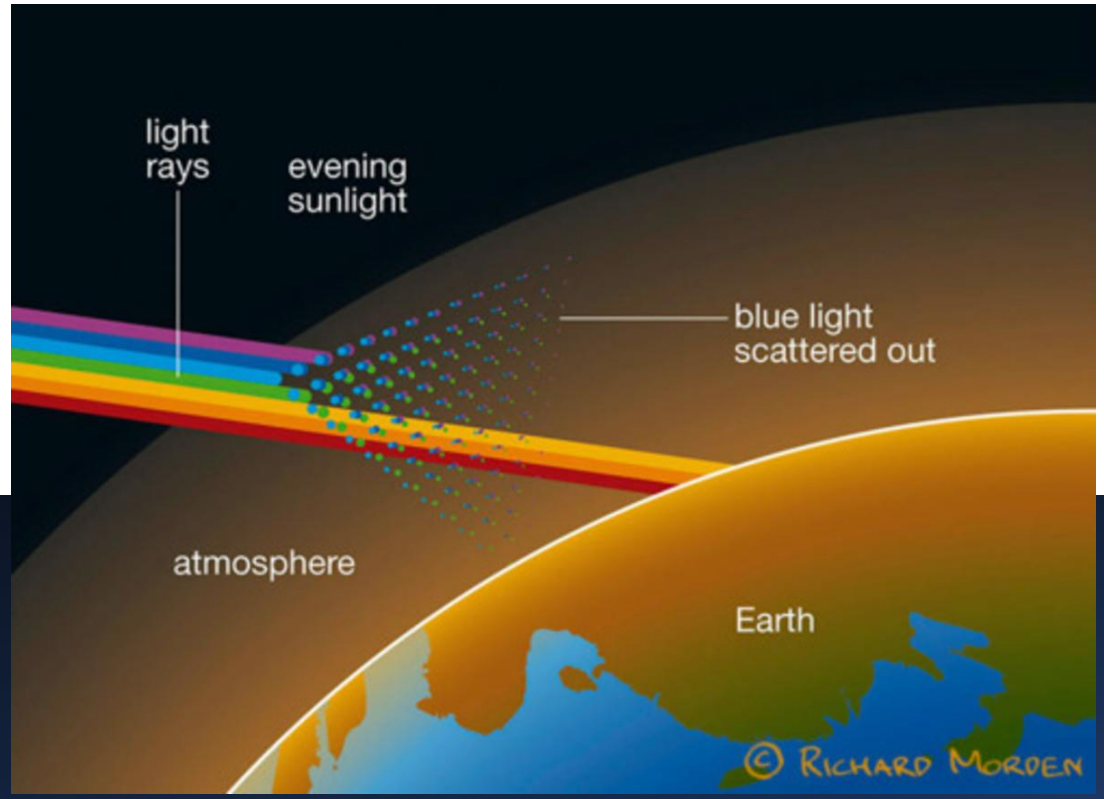
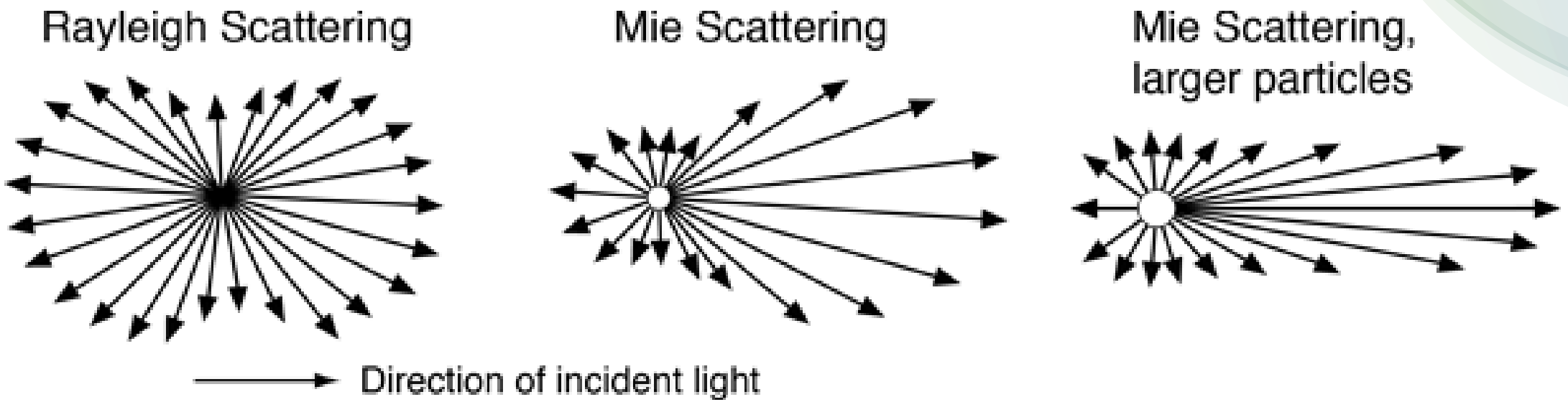
Expt.-1: Small Angle Light Scattering



- **Scattering:** The redirection of light that takes place when an electromagnetic (EM) wave encounters an obstacle or non-homogeneity.
- Scattering is the reason behind blue sky, white clouds and red sun at sunrise and sunset.

Types of Scattering



Rayleigh Scattering:

- Particle size of the scatterer is much smaller than the incident light wavelength ($2\pi r/\lambda << 1$).
- Independent of particle size.
- Uniform in all direction.

Mie Scattering:

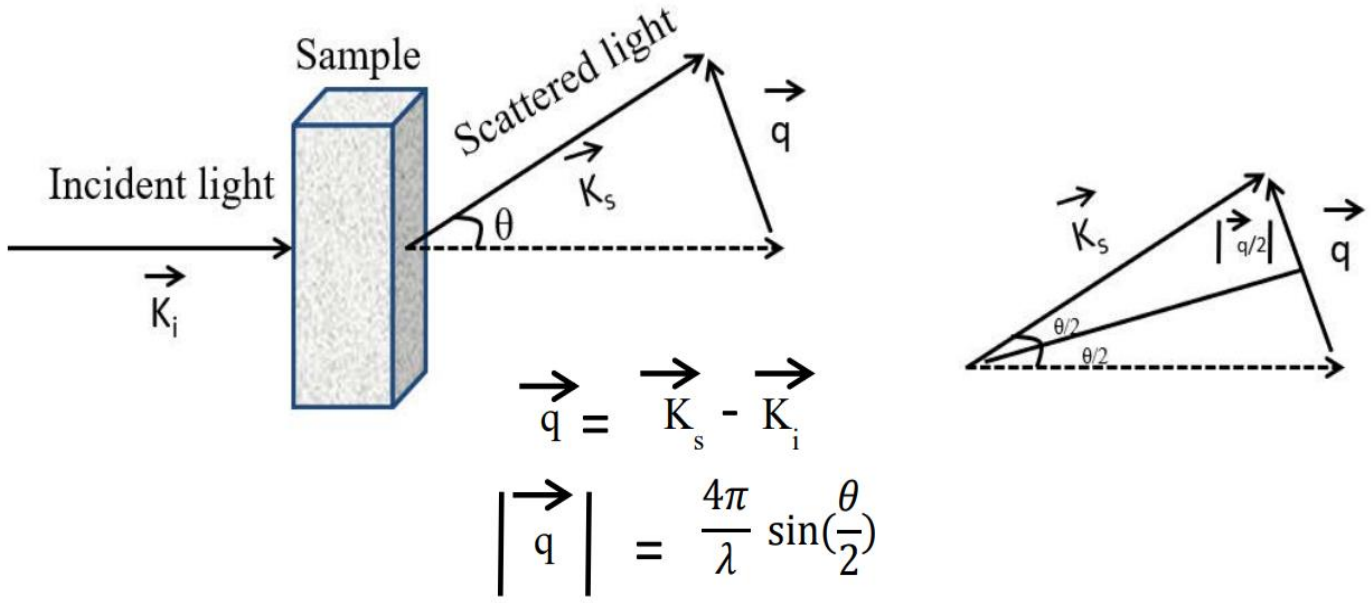
- Particle size is equivalent or greater than the incident light wavelength ($2\pi r/\lambda \geq 1$).
- Dependent on particle size.
- Dominant in forward direction.

Motivation and Aim

- **Motivation:**
  - The Particle size plays important role in chemical and drug industry.
  - The rate of chemical reactions, dissolution rate, effectiveness of drug delivery are some parameters which is affected by particle size.
  - We can determine the particle size by microscopic techniques (like Scanning Electron Microscopy and Atomic Force Microscopy).
  - The Light Scattering provides us the cost-effective tool to determine the particle size.

- **Aim:** To determine the particle size in a colloidal solution (polystyrene beads) using scattering of light.

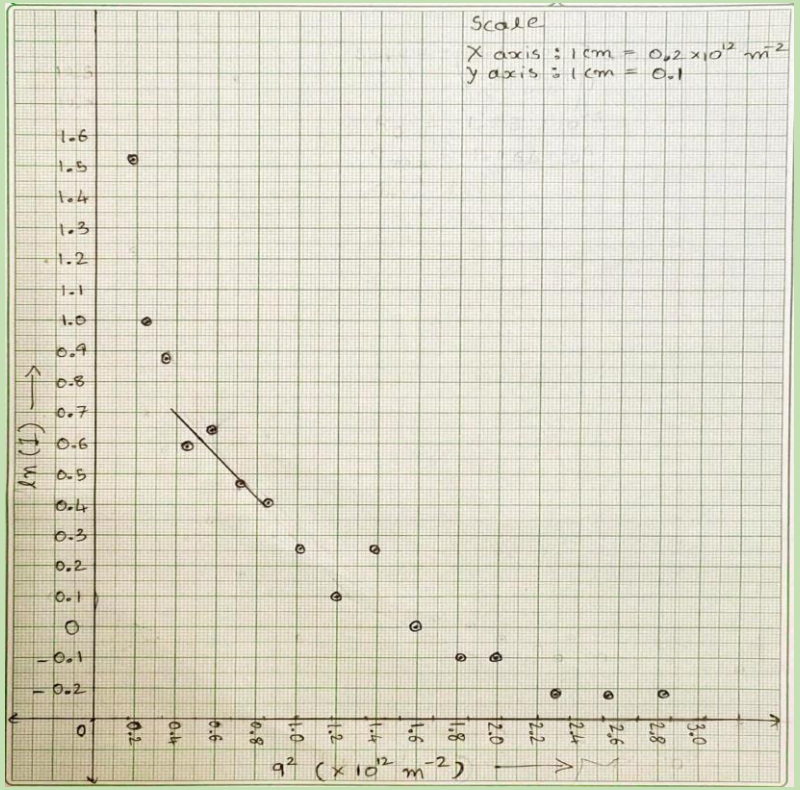
Concept



- Small Angle Scattering: Limiting Case of Mie Scattering
- Guinier's approximation: Limiting case of Mie Scattering and a way to find particle size.
- Guinier's approximation: At low q,

$$I(q) = I(0)exp\left(-\frac{1}{3}q^2R_g^2\right)$$

Guinier plot: ln(I) vs. q^2



- Guinier region: The region chosen for the linear fit.
- The slop of the graph gives $\frac{1}{3}R_g^2$.
- $R = \sqrt{\frac{5}{3}}R_g$
- For spherical particle, $q_{max} \times R_g < 1.3$

Experimental Setup

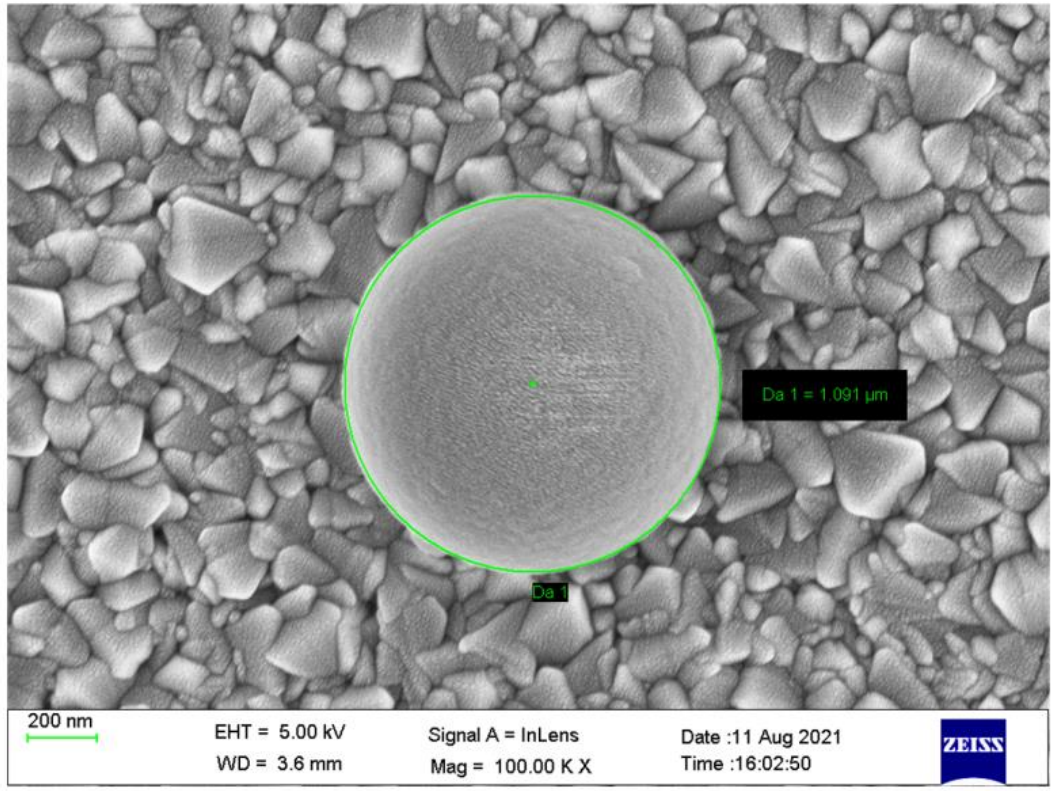
Objectives and Conclusion

Objectives:

- Measure the photocurrent as a function of angle.
- Plot the graph and find out the required parameters from it.
- Calculate the particle size.
- Check the validity of slope

Conclusion:

- The particle size can be detected using simple and cost-effective scattering technique.
- The particle of size of polystyrene beads has been measured and compared with the size obtained from SEM image.



SEM image of Polystyrene Beads

Further Reading

- http://plaza.ufl.edu/dwhahn/Rayleigh%20and%20Mie%20Light%20Scattering.pdf
- http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/blusky.html#c2
- https://sites.google.com/a/umn.edu/mxp/student-projects/spring-2018/s18_mie-scattering
- https://bioxtas-raw.readthedocs.io/en/latest/saxs/saxs_guinier.html
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