

# Optics Letters

## Efficient single-scattering look-up table for lidar and polarimeter water cloud studies

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Combined lidar and polarimeter retrievals of aerosol, cloud, and ocean microphysical properties involve single-scattering cloud calculations that are time consuming. We create a look-up table to speed up these calculations for water droplets in the atmosphere. In our new Lorenz-Mie look-up table we tabulate the light scattering by an ensemble of homogeneous isotropic spheres at wavelengths starting from 0.35  $\mu\text{m}$ . The look-up table covers liquid water cloud particles with radii in the range of 0.001–500  $\mu\text{m}$  while gaining an increase of up to  $10^4$  in computational speed. The covered complex refractive indices range from 1.25 to 1.36 for the real part and from 0 to 0.001 for the imaginary part. We show that we can precisely compute inherent optical properties for the particle size distributions ranging up to 100  $\mu\text{m}$  for the effective radius and up to 0.6 for the effective variance. We test wavelengths from 0.35 to 2.3  $\mu\text{m}$  and find that the elements of the normalized scattering matrix as well as the asymmetry parameter, the absorption, backscatter, extinction, and scattering coefficients are precise to within 1% for 96.7%–100% of cases depending on the inherent optical property. We also provide an example of using the look-up table with *in situ* measurements to determine agreement with remote sensing. The table together with C++, Fortran, MATLAB, and Python codes to interpolate the complex refractive index and apply different particle size distributions are freely available online.

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Liquid water clouds are an important radiative constituent of the Earth-atmosphere system, but microphysical processes related to clouds remain highly uncertain and poorly represented in climate models [1]. Remote sensing observations are crucial to

improving our knowledge on cloud processes, but traditional methods are often biased especially in cases of broken or small clouds [2]. Furthermore, ignoring the temperature dependence of the refractive index may lead to biases in cloud remote sensing products [3]. The polarimetric cloudbow observations from NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will enable retrievals of cloud-top effective radius, variance, and droplet number concentration [4–6]. In addition, lidar observations contain information on cloud optical and microphysical properties [7]. NASA's future Atmosphere Observing System (AOS) mission will likely include an imaging polarimeter and high spectral resolution lidar that will make collocated measurements further advancing cloud remote sensing capabilities. In this Letter we present a new cloud look-up table (LUT) that enables fast and precise retrievals of the microphysical properties of liquid water clouds from existing and next-generation remote sensing instruments. The LUT can also be used to compute the optical properties of clouds from airborne *in situ* droplet size distribution data. Our LUT supports a wide range of size distributions of spherical liquid water cloud droplets and derives the corresponding optical properties across the ultraviolet, visible, near-infrared, and shortwave infrared spectra.

The purpose of our LUT is to provide a fast and precise way to compute the liquid cloud inherent optical properties (IOPs) for a single-scattering case. These cases are characterized by a low value of depolarization measured by lidar and can be seen near the cloud edges [8]. The list of IOPs covered by the cloud LUT is the same as for our aerosol LUT and includes the normalized scattering matrix, the asymmetry parameter, the absorption, backscatter, extinction, and scattering coefficients [9]. Both LUTs use the same principles of work and similar unit test framework to assess the precision of estimations. Both LUTs can be used with the advanced single-instrument and combined microphysical retrievals as a part of radiative transfer model for an arbitrary lidar, spectrometer, or polarimeter wavelength. Our

# Studies In Optics

**R Sandford**



## **Studies In Optics:**

## **Studies In Optics** Book Review: Unveiling the Power of Words

In a global driven by information and connectivity, the power of words has be more evident than ever. They have the capacity to inspire, provoke, and ignite change. Such is the essence of the book **Studies In Optics**, a literary masterpiece that delves deep in to the significance of words and their effect on our lives. Published by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we shall explore the book is key themes, examine its writing style, and analyze its overall effect on readers.

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### **Table of Contents Studies In Optics**

1. Understanding the eBook Studies In Optics
  - The Rise of Digital Reading Studies In Optics
  - Advantages of eBooks Over Traditional Books
2. Identifying Studies In Optics
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Studies In Optics
  - User-Friendly Interface
4. Exploring eBook Recommendations from Studies In Optics
  - Personalized Recommendations
  - Studies In Optics User Reviews and Ratings
  - Studies In Optics and Bestseller Lists
5. Accessing Studies In Optics Free and Paid eBooks

- Studies In Optics Public Domain eBooks
  - Studies In Optics eBook Subscription Services
  - Studies In Optics Budget-Friendly Options
6. Navigating Studies In Optics eBook Formats
    - ePub, PDF, MOBI, and More
    - Studies In Optics Compatibility with Devices
    - Studies In Optics Enhanced eBook Features
  7. Enhancing Your Reading Experience
    - Adjustable Fonts and Text Sizes of Studies In Optics
    - Highlighting and Note-Taking Studies In Optics
    - Interactive Elements Studies In Optics
  8. Staying Engaged with Studies In Optics
    - Joining Online Reading Communities
    - Participating in Virtual Book Clubs
    - Following Authors and Publishers Studies In Optics
  9. Balancing eBooks and Physical Books Studies In Optics
    - Benefits of a Digital Library
    - Creating a Diverse Reading Collection Studies In Optics
  10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
  11. Cultivating a Reading Routine Studies In Optics
    - Setting Reading Goals Studies In Optics
    - Carving Out Dedicated Reading Time
  12. Sourcing Reliable Information of Studies In Optics
    - Fact-Checking eBook Content of Studies In Optics
    - Distinguishing Credible Sources
  13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development

- Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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