Chapter 1 : Interpretation of Extinction in Gaussian-Beam Scattering - CORE

When a Gaussian beam of half-width w0 is incident upon a spherical particle of radius a with w 0 y a, 1, the extinction efficiency attains unexpectedly high or low values, contrary to intuitive expectations.

Mie scattering is an important tool for diagnosing microparticles or aerosol particles in technical or natural environments. Mie theory is restricted to spherical, homogeneous, isotropic and non-magnetic particles in a non-absorbing medium. However, as microparticles are hardly ever spherical or hom However, as microparticles are hardly ever spherical or homogeneous, there is much interest in more advanced scattering theories. During recent decades, scattering methods for non-spherical and non-homogeneous particles have been developed and even some computer codes are readily available. Extension of Mie theory covers coated spheres, stratified spheres and clustered spheres. For homogeneous non-spherical particles such as spheroids, ellipsoids and finite cylinders, surface discretization methods have been developed. Scattering by inhomogeneous particles may be computed by volume discretization methods. Different methods to compute the beam shape coefficients have been developed. The coefficients of a Gaussian beam can also be computed by a finite series for on-axis particle positions [33]. The localized approximation of the beam shape coefficients leads to the fastest algor Yet another face of Lorenz-Mie scattering: Mono disperse distributions of spheres produce Lissajous like patterns by Alfons G. The complete scattering matrix S of spheres was measured in a FlowCytometer. The experimental equipment allows simultaneous detection of two scattering matrix elements for every sphere in the distribution. Samples of spheres with very narrow size distributions were analyzed with a FlowCytometer and produced unexpected two parameter scatterplots. Instead of compact distributions we observed Lissajous-like loops. Simulation of the scatterplots, using Lorenz-Mie theory, shows that these loops are not due to experimental errors, but due to true Lorenz-Mie scattering. We show that the loops originate from the sensitivity of the scattered field on the radius of the spheres. This work demonstrates that the interpretation of rare events and hidden features in FlowCytometry needs reconsideration. Adams, Al Carlozzi , "

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Chapter 2 : Forward scattering of a Gaussian beam by a nonabsorbing sphere.

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 Abstract Based on the generalized Lorenz Mie theory GLMT , the scattering cross section of mineral aerosol within the Gaussian beam is investigated, and an appropriate modeling of the scattering cross sections for the real mineral aerosols including the feldspar, quartz, and red clay is proposed. In this modeling, the spheroid shape is applied to represent the real nonspherical mineral aerosol, and these nonspherical particles are randomly distributed within the Gaussian beam region. Meanwhile, the Monte Carlo statistical estimate method is used to determine the distributed positions of these random nonspherical particles. Moreover, a method for the nonspherical particles is proposed to represent the scattering cross section of the real mineral aerosols. In addition, the T matrix method is also used to calculate the scattering cross sections of the spheroid particles in order to compare the scattering properties between the plane wave and the Gaussian wave. Simulation results indicate that fairly reasonable results of the scattering cross sections for the mineral aerosols can be obtained with this proposed method, and it can provide a reliable and efficient approach to reproduce the scattering cross sections of the real randomly distributed mineral aerosols illuminated by the Gaussian beam. Introduction The problem of light scattering by particles has been an important topic of research interest in the wide areas of applications [1 â€” 5]. Since the light scattering has been established, some researches have studied the electromagnetic light scattering of particles for the plane wave case [1]. And some common theories and methods have been utilized to analyze this problem. When the plane light wave is incident into the particle, the classical Mie theory, the discrete dipole approximation DDA , the T matrix method, and the finite difference time domain FDTD method can be used for sphere and nonsphere particles [6 â€” 9]. Nevertheless, none of those methods can be applied to analyze and calculate the scattering of particles for the nonplane waves such as the Gaussian beam incidence or a top-hat beam. In recent years, with the development of laser technique and the expansion of its application areas, the laser has been used for the measuring of particle sizing and other particle prosperities. It is well known that the generalized Lorenz Mie theory GLMT proposed by Gouesbet is a generalization of the Lorenz Mie theory for an arbitrary incident-shaped beam such as the Gaussian beam laser in the fundamental mode TEM00 and the light sheet [10 â€” 12]. In this paper, the scattering cross sections for the practical nonspherical mineral aerosols are investigated, and modeling of the scattering cross sections for the feldspar, quartz, and red clay is conducted. Actually, the nonspherical calculations and measurements show significant differences from the sphere particles [13 â€” 16]. Here, we choose the spheroid to represent the nonspherical mineral aerosol in order to study the scattering cross sections of nonspherical particles within the Gaussian beam incidence. The field components are then found to be where are the transverse magnetic TM and transverse electric TE BSP, respectively; ; are called electric field and magnetic introduction field, respectively; is the spherical coordinate system; is the wave number; is the angular frequency of the electromagnetic wave; and and are the permeability and the permittivity of the medium, respectively. The scattering cross section and extinction cross section of particle are evaluated by where are the generalized functions of GLMT, and are the scattering coefficient of Mie theory, and and are the magnetic and electric energy. According to the GLMT, the particle is randomly located in the Gaussian beam, and the scattering properties are also determined by the location information in the beam. In Figure 1 , the beam propagates alone the z axis from negative z to positive z, and the electric field component is essentially vibrating in the x axis. The coordinate origin o is the beam waist center, and its waist radius is. Geometry of coordinate of the incident Gaussian beam. For a measured particle system, the particles can be distributed anywhere within the Gaussian beam [18]. Here, we define the particles in the semicircular region, that is,. Table 1 shows the scattering cross section of the sphere particle with different location in the Gaussian beam. The particle radius r is 0. The six positions in the Cartesian coordinate are 0, 0, 0 , 0, 1, 0 , 0, 2, It is very obvious that the scattering cross section of sphere particle is also different when the position of particle is different. In Table 2 , the scattering cross section and absorbing cross section of the sphere particle are calculated in the Gaussian beam. The relative complex reflective index of particle m is 1. We can see that the absorbing cross section of sphere particle is still different with the different position in the Gaussian beam. Scattering and absorbing cross section of sphere particle with the different location. In order to investigate the general average scattering cross sections of nonspherical mineral particles, three aerosols, that is, the feldspar, quartz, and red clay, are studied, and the spheroid model is used to represent the real nonspherical mineral particle. Since the scattering prosperities of particles within the Gaussian beam are related with the position information, the Monte Carlo statistical estimate method is used to determine the distributed positions of these random nonspherical particles [19 , 20]. After making the average of the position information, we can obtain the general location for the random particles, and then the average scattering cross section of particles is also calculated with the GLMT framework. Figure 2 gives the scattering cross sections of spheroid quartz particles with different sizes. For a spheroid, there are two parameters representing its shape, that is, the aspect ratio and the radius of rotation axis. Here, we use the equal-surface area sphere to represent the spheroid particle, and the equal-surface diameter can be calculated by the spheroid particle. In Figure 2 , is equal to 1 and 10, respectively, and the T matrix method is also used to obtain the scattering cross sections of spheroid particles for the plane wave as a comparison [21]. The relative complex reflective index of quartz particle m is 1. We can see that serious differences are occurred between the Gaussian beam and the plane wave, and the differences are decreasing with larger. That is because the Gaussian beam gradually becomes the plane wave when is infinite. The parameter in the horizontal axis is the diameter of rotation axis, and the T matrix method is also used to obtain the scattering cross sections of spheroid particles for the plane wave as a comparison. Figure 4 gives the scattering and absorbing cross sections of feldspar particles. For the feldspar particles, the imaginary part of the complex reflective index is not zero, and then the absorbing cross sections of feldspar particles can be calculated. With the increasing equal-surface diameter or the diameter of rotation axis, the differences between the Gaussian beam and plane wave are enlarged. Figure 6 gives the scattering and absorbing cross sections of red clay particles. For the red clay particles, the real part of the complex reflective index is larger than that of the feldspar particles and the quartz particles. Figures 8 and 9 show the scattering and absorbing cross sections of spheroid particles with 1. In Figure 9 , the incident wavelength is 1. According to this simulation, there are still differences between the Gaussian beam and plane wave, and the differences are smaller with larger incident wavelength. Conclusions In this paper, the scattering cross sections of nonspherical mineral particles are investigated with in the Gaussian beam based on the GLMT. In the framework of GLMT, the general location information is statistic by the Monte Carlo statistical estimate method, and the scattering cross sections of spheroid particles including the feldspar, quartz, and red clay are calculated. Actually, the spheroid shape can represent the nonspherical feldspar, quartz, and red clay particles with good accuracy. In order to research the scattering of spheroid particle with more efficiency, a sphere of the same surface area as the spheroid is used to calculate the scattering cross sections of spheroid particles within the Gaussian beam, and then the scattering cross sections of spheroid particles are also calculated within the plane wave incidence. The results show that the scattering cross sections and absorbing cross sections of spheroid are different from the plane wave, and the differences are more obvious with the increasing diameters. Meanwhile, the incident wavelength and the complex reflective index of mineral particles also have effects on the scattering cross sections of nonspherical mineral particles. Conflicts of Interest The authors declare that they have no conflicts of interest.

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Chapter 4 : "Interpretation of Extinction in Gaussian-Beam Scattering" by James A. Lock

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Chapter 6 : Forward scattering of a Gaussian beam by a nonabsorbing sphere. - Abstract - Europe PMC

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Chapter 7 : Modeling of Scattering Cross Section for Mineral Aerosol with a Gaussian Beam

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