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Preface. Laser-light and Interactions with Particles (LIP), 2020.

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Previous JQSRT special issues devoted to the "Laser-light and Interactions with Particles (LIP)" conferences were accompanied by prefaces written for issues published in a single volume, followed by peer-reviewer papers based on the topics discussed, but not necessarily presented, during the conferences, see [1] in [2], [3] in [4], and [5] in [6]. Papers associated to the LIP-conference in 2018 however, have been published as a virtual topical issue, the word "virtual" meaning that the papers have been published once they have been accepted, rather than collected in a single issue of JQSRT. In other words, the authors of accepted manuscripts have seen their papers officially published without having to wait for the rest of the manuscripts to get accepted. The corresponding preface/afterword was published in 2019 [7]. The 2020 conference was scheduled to be held in Warsaw, Poland, but has been postponed to 2022 due to the Covid pandemic. It has been decided, nevertheless, to publish another virtual issue of JQSRT to limit the effects of the impact of the pandemic and stick to a tradition as much as possible.

LIP conferences were in the filiation of a series of conferences which started under the name of "Optical Particle Sizing, OPS, theory and practice" in Rouen,

France, 1987, essentially devoted to optical measurements, using laser sources, of sizes of particles embedded in flows. Later on, the development of the field required some extensions toward the measurement and/or the characterization of other particle properties, such as shapes, temperatures, refractive indices or chemical compositions, so that the OPS conference was extended to an OPC (Optical Particle Characterization) conference.

After Rouen conference in 1987, OPS and afterward OPC conferences were held in Phoenix, USA, 1990 (organized by D. Hirleman), Yokohama, Japan, 1993 (M. Maeda), Nürnberg, Germany, 1995 (F. Durst), Minneapolis, USA, 1998 (A. Naqwi), Brighton, England, 2001 (A. Jones), Kyoto, Japan, 2004 (M. Itoh), and Graz, Austria, 2007 (O. Glätter). The delay between two successive conferences has usually been three years, but for one case, namely Nürnberg, 1995, adjusted to make the conference coinciding with Partec 1995.

Further developments such as involving morphology-dependent resonances, mechanical effects of lights, the use of different kinds of structured beam shapes including laser pulses, the development of new experimental techniques for optical particle characterization, and of theoretical approaches to deal with the scattering of arbitrary shaped beams by arbitrary shaped particles, required a new extension of the conference scope. Hence, it has been decided to reformat the conference and to start a new series, actually an OPC follow-up, the 9th of the series, in Rouen, 2012, under the title "Laser-light and Interactions with Particles", to be abbreviated as LIP2012, and chaired by G. Gouesbet and G. Gréhan who actually started the series 25 years ago. LIP2012 has been followed by LIP2014, in Marseille, France, under the chair of F.R.A. Onofri and B. Stout and by LIP2016, in Xi'An, China, under the chair of Yiping Han and Lixin Guo. In 2018, the 12th "Laser-light and Interactions with Particles" conference (LIP2018) took place at the Texas A&M University, College Station, USA, under the chairs of P. Yang, G. Kattawar and E. Fry, from 4th to 9th March 2018 jointly with the "Electromagnetic and Light Scattering by nonspherical particles" conference ELSXVII, see [8]. The present preface for the 2020 "no-shown" conference compiles and reviews 23 peer-reviewed papers, providing a significant sample of the issues usually discussed during LIP-conferences. Authors and readers are kindly asked to forgive the authors of the present preface for unavoidable biases resulting from their particular limited expertise. Papers are essentially ordered from more fundamental topics to more applied topics, following the organization of recent reviews, e.g. the contents of [9].

We begin with a paper devoted to the study of photonic wheels carried out in the framework of generalized Lorenz-Mie theory, i.e. GLMT in short, by Orlov and Berskys [10]. We recall that the GLMT *stricto sensu* deals with the interaction between an arbitrary shaped beam and a homogeneous sphere characterized by its diameter and its complex refractive index [11], [12] and references therein dating back to [13]. The expression GLMT is used as well, in a generic way, for theories which describe the interaction between arbitrary shaped beams and regular particles which allow one to solve Maxwell's equations by using the method of separation of variables. In [10], the author deals with a GLMT for illuminating electromagnetic fields which carry both longitudinal and

transverse angular momentum, called photonic wheels, applied to the interaction with gold and silicon spheres. They also employ a multiple scattering method to simulate a chiral cluster of nanoparticles – specifically a chiral assembly of three particles – in the focal plane of a photonic wheel. It is worthwhile to mention that the authors correctly state that the GLMT is a genuine T-matrix method, avoiding the misleading identification between T-matrix and EBCM (Extended Boundary Condition Method). We also have to recall that, in GLMT approaches, the illuminating beam is encoded in a set of coefficients, named beam shape coefficients (BSCs in short), usually denoted $g^m_{n,TM}$ and $g^m_{n,TE}$, in which TM stands for "Transverse Magnetic" and TE for "Transverse Electric", with n ranging from 1 to ∞, and m from $(-n)$ to $(+n)$. Equivalently, the authors deal with BSCs denoted A_{mn} and B_{mn} which are evaluated by using a quadrature method under the form of one-dimensional integrals.

Next paper by Zhang *et al.* [14] deals as well with GLMT *stricto sensu* , i.e. scatterers are (in particular) spherical, but the illumination is achieved by using non-paraxial Bessel pincer light-sheet depending on two parameters, namely the order l of the Bessel beam and a scaling parameter α_0, and having auto-focusing and self-bending properties. The electric field of the beam is expanded using an angular spectrum of decomposition (ASD, see subsection 2.6 of [15]) and the BSCs are expressed in terms of one-dimensional integrals. Numerical results, obtained by using a Python program, concern the distribution of field intensities (internal, near-surface field intensities, intensities of the incident light, of the scattered light, and of the total – incident plus scattered – light) and the efficiency factors (for extinction and scattering and, by substraction for absorption), paying attention to the influence of the beam parameters and of the size parameter of the scatterer.

Next paper by Shi *et al.* [16] deals as well with the GLMT but the illuminating beams are high-order vector Bessel Gaussian beams (which are nondiffracting beams) and the scatterers are formed by a spherical marine aerosol, sensitive to the humidity of the surrounding medium, characterized by its diameter and complex refractive index, therefore satisfying the conditions of applicability of the GLMT *stricto sensu.* Linear (x and y), circular (left and right), azimuthal and radial polarizations are considered. It must be recalled that high-order Bessel beams are not physical because they carry an infinite amount of energy and that Bessel Gaussian beams (or Bessel-Gauss beams) are Bessel beams apodized by a Gaussian envelope, therefore satisfying the constraint of finite energy. BSCs are evaluated by using an ASD in terms of one-dimensional integrals. The effects of various parameters (of the incident beam, and of the aerosol) on the normalized differential scattering cross-sections (DSCS) are investigated. From the results obtained, it is concluded that it is not feasible to retrieve the relative humidity of aerosol environment by using the differences of normalized DSCS for various polarization states, although DSCS may be highly influenced by the parameters of the incident beam and of the illuminated aerosol.

The paper by Chafiq and Belafhal [17] deals as well with nondiffracting beams made physical by using a two-dimensional Gaussian envelope, named

pseudo-nondiffracting beams (pNDBs) because, in contrast with the case of the unphysical Bessel beams, they are actually diffracting. The aim of the paper is to calculate the Fourier transform of pNDBs in the focal plane of a converging thin lens, dealing with the electric fields of the beams expressed using cylindrical coordinates (the Fourier transform is actually expressed as the electric field in the focal plane of the thin lens). The propagation in free space, after the focal plane, of the beams so generated is studied using the Huygens-Fresnel diffraction integral, and illustrated numerically. Various kinds of pNDBs, known as Cosine-Gauss beams, Bessel-Gauss beams, Mathieu-Gauss beams, Parabolic-Gauss beams and Lommel-Gauss beams, are investigated under paraxial approximations. It is observed that the nondiffracting property of the original beams is conserved in the first stage of propagation, and afterward dramatically affected at the end of propagation because of the presence of the Gaussian envelope which represents a diffraction beam (i.e. characterized by a beam waist radius).

The evaluation of BSCs is a major ingredient of the use of any GLMT and a strong effort has been devoted to the development of various techniques to the purpose of such evaluations, e.g. subsection 2.5 in a recent review [15]. The most popular method may have been the use of localized approximations (with several variants), see review in [18], and complements in [19], [20], [21]. A justification of the use of localized approximations for "arbitrary shaped beam" illumination has been demonstrated in 1999 [22]. However, it has been demonstrated as well that this justification does not hold for two classes of beams (i) "axionic" beams whose description contains a propagation term of the form $\exp(ikz\cos\alpha)$, in which α is the axicon angle, in contrast with the more "usual" form $\exp(ikz)$, such as Bessel beams, e.g. [23], [24] and references therein and (ii) helical beams possessing a topological charge, such as Laguerre-Gauss beams, e.g. [25], [26], [27]. As a result, another technique known as the finite series technique, invented in 1988 [28], [29] and given up the same year due to the success of localized approximations techniques, was born again in 2019 in the case of Laguerre-Gauss beams freely propagating [30], or focused by a lens [31]. The paper by Votto *et al.* summarized in the present preface [32] implements the finite series technique for Laguerre-Gauss beams focused by a lens, complements another paper [33] devoted to the case of Laguerre-Gauss beams freely propagating, and constitutes some kind of conclusion in the series told in the present paragraph.

The previous papers of the special issue have been dealing with scatterers being spheres or assemblies of spheres, more generally with the treatment of Maxwell's equations in spherical coordinates. With a paper by Chen *et al.* [34], the special issue is pursued with the use of cylindrical coordinates for a study devoted to the electromagnetic beam propagation through a gyrotropic anisotropic circular cylinder. The theoretical approach relies on the expansion of the scattered and internal electromagnetic fields in terms of appropriate cylindrical wave functions and the use of boundary conditions, with a theoretical structure akin to the one of a GLMT for cylinders. However, as stated by the authors, they used a projection method which, "compared to the GLMT for cylinders", relies on the knowledge of "an explicit description of the incident EM beam, either

in terms of coordinates or expansions over CVWFs" (Cylindrical Vector Wave Functions), meaning that the evaluation of BSCs (cylindrical BSCs) is not necessarily required. If the incident fields are expanded over CVWFs, the projection method takes the form of a GLMT for cylinders. Otherwise, the projection method is a semi-analytical solution in which integrals related to the incident fields have to be evaluated numerically. Various kinds of illuminating beams are considered, namely Gaussian beam in the mode TEM_{00}, Hermite-Gaussian beam and zeroth-order Bessel beam, and the wave/particle interaction is described in terms of normalized field intensity distributions. In particular, in the case of an incident Gaussian beam, the fields are described by using a third-order Davis beam (which does not exactly satisfy Maxwell's equations), e.g. [35], [36], [37], agreeing well however with the description in terms of a localized beam (which does exactly satisfy Maxwell's equations). Propagation inside the gyrotropic anisotropic circular cylinder leads to a distortion of the beam and to a splitting effect due to the birefringence property of a gyrotropic medium.

The next paper by Hricha *et al.* [38] deals as well with propagation properties in "exotic" media, here in strongly nonlocal nonlinear media (SNNM). The propagating beam is a vortex cosine-hyperbolic-Gaussian (vChGB) beam which is a beam carrying angular momentum, with a spiraling wavefront implying a dark hollow profile associated to a topological charge. The authors took advantage of the fact that the characteristic length of the response function in a SNNM is very large compared to the beam width and the wave equation, which is a nonlocal nonlinear Schrödinger equation, can be simplified to a linear model which is afterward reduced to the paraxial Helmholtz equation. The propagation formula of the vChGB, the beam width and the curvature radius of the wavefront are obtained in closed-form. These beam characteristics evolve periodically during propagation with a period which depends on the initial beam power. Depending on this power, the beam can steadily propagate in SNNM or adopt a soliton-like behavior.

Sekulic *et al.* [39] deals as well with nonlinear effects, numerically studying second-harmonic generation from clusters of arbitrarily distributed homogeneous centrosymmetric and isotropic spherical nanoparticles. They used a T-matrix method in which the electromagnetic fields at the fundamental and second-harmonic frequencies are expanded in series of vector spherical wave functions (VSWFs) and the single sphere T-matrix entries are computed by imposing field boundary conditions at the surface of the particles. The illuminating beam is a monochromatic electromagnetic plane wave (so that the BSCs are "trivial") and the nonlinear polarization density responsible for the second-harmonic generation is governed by a third-rank nonlinear susceptibility tensor. The T-matrix method used, which allows one to relate the incident and scattered electromagnetic fields, is specifically the Extended Boundary Condition Method, EBCM in short (recall however that EBCM is not the only T-matrix method available, e.g. [40], [41]). Numerical examples to compute the scattered field and the scattering and absorption cross-sections, both at the fundamental frequency and at the second harmonic frequency, are provided for several generic examples (with nanospheres made of gold, or silicon), and the numerical results

obtained are validated by comparing with those of a commercial software based on the finite-element method.

With Zhang *et al.* [42], we consider the scattering of evanescent waves which are generated by total reflection as an electromagnetic wave propagates from an optically denser medium to an optically thinner one. The optically thin medium is then the support of an evanescent wave which is scattered by a particle located in this medium. The scattering is described by using an exact semi-analytical method in which the scattered and internal fields are expanded in terms of VSWFs, using a projection technique already mentioned above in the paper by Chen *et al.* [34], requiring the evaluation of surface integrals. A specific difficulty in the problem at stake is that the field scattered by the particle will be reflected by the interface between the dense and the thin media, requiring to take account for the scattered-reflected fields. The theoretical approach is applied to discuss the far field scattering of various kinds of scatterers, expressed by using the differential scattering cross-section (DSCS), namely a polystyrene sphere, or a polystyrene prolate spheroid, and a polystyrene circular cylinder of finite length, deposited at the interface, as the sum of two contributions, one from the scattered field and the other from the scattered-reflected field. It is found that, contrary to the evanescent wave that decays fast, the presence of a particle can transfer a portion of the electromagnetic energy to the radiation zone, so that the particle actually functions as an antenna. It is also found that the spherical particle radiates more energy than the circular cylinder, and the circular cylinder more energy than the prolate spheroid.

Beside analytical (e.g. GLMTs) and semi-analytical methods (e.g. EBCM, projection method), light scattering may be handled as well by using numerical methods, for instance finite-difference time-domain (FDTD) method and finite-element method (FEM) which are alternative methods to solve Maxwell's equations. In FDTD, Maxwell's equations are discretized with the computational domain being meshed by a cubic grid, and the method can been implemented by using a commercial software package. Both FDTD method and FEM have been used by Geints [43] to carry out a numerical study of photothermal effect in core-shell microcapsules. More specifically, the author presented a systematic study of optical absorption and laser-induced heating of dielectric microcapsules with water filling and light absorbing polymer shell, such particles simulating transport cargo microcontainers which are the basis of modern drug delivering systems which can significantly increase therapeutic effects while minimizing side effects. The numerical calculations of optical field spatial distribution inside and near the microcapsules are carried out, and the temporal dynamics of temperature profiles of core-shell microparticles of various morphological types (spheres, ellipsoids, boxes, cubes, cylinders) and microcapsule clusters in different configurations is addressed, for a near-IR radiation at $\lambda = 800$ nm (which is the fundamental harmonic of a titanium-sapphire laser) radiation. Depending on the situations investigated, the illumination was the one of a linearly polarized plane wave or of a pulsed optical radiation.

Core-shell microstructures, more specifically core-shell magneto-plasmonic nanostructures incorporating Ni, Ag, Fe and Au chemical elements, with in

mind the same applications to drug delivery than in the aforementioned paper, are studied by Bhatia *et al.* [44]**.** They however use another numerical method which is the discrete dipole approximation (DDA), in which the particle is represented by an assembly of discrete coupled (interacting) electric-dipoles located on a cubic lattice spanning the particle volume. Spherical and prolate geometries are investigated in order to characterize the behavior of localized surface plasmon resonance (LSPR). It is found that this behavior strongly depends on the geometry of the nanoparticle, aspect ratio (when relevant), core sizes and shell thickness. Furthermore, there is a high tunability of LSPR peak position as well as larger enhancement in the absorption efficiency when the spherical nanoparticle is stretched to prolate core-shell configuration. The publicly available code DDSCAT written in FORTRAN 90 is used for DDA calculations, and calculations are carried out in the range from 300 to 1100 nm.

DDA is used as well in a work by Argentin *et al.* [45]**,** relying – as in the paper above – on a publicly available code DDSCAT, to investigate and understand empirically observed deviations between accurate calculations of forward scattering and absorption cross-sections (using DDA) with those predicted by the Rayleigh-Debye-Gans (RDG) theory. This is carried out by investigating the internal electric field within bi-spherical nanoparticles under various configurations, illuminated by an incoming linearly polarized plane wave, allowing one to emphasize that the internal fields may exhibit significantly different amplitudes from one monomer to the other, in contrast with the usual RDG-assumption that internal fields in monomers are uniform. The analysis is carried out by using the phasor concept relating contributions to the far-field scattered wave from local internal field at a volume element in a particle, leading possibly to semi-graphical representations, allowing one to understand how particle morphologies influence the scattering behavior, using an in-house Python code post-processing the data retrieved from preliminary DDSCAT runs. The technique used aims to the visualization of slices through the particles in order to reveal which parts of them cause under- or over-estimation of the effective scattering with respect to the idealistic RDG-scattering.

Among the various applications of light scattering theories, the study and use of mechanical effects of light offers a large panorama of opportunities made famous by Arthur Ashkin (2018 Nobel prize of physics). Since his large body of works, in particular concerning the invention of optical tweezers – see [46] for a volume of reprints –, a huge number of papers has been devoted to mechanical effects of light, in particular for optical levitation, trapping and manipulation of particles. A review with 284 references has recently been devoted to the applications of GLMTs to mechanical effects of light [47]. However, up to recently, there has not been any systematic study of optical forces using GLMT in the Rayleigh regime, a particular appealing situation because the choice of working in the limit of point-like particles makes the formalism simplified to easily handled expressions, allowing one to interpret the physical mechanisms at hand.

A first article in this framework has been devoted to the study of longitudinal optical forces exerted by off-axis Bessel beams in the Rayleigh regime of GLMT [48]. The present special issue has been the opportunity to present a similar

study, but devoted to transverse optical forces rather than to longitudinal optical forces [49]. An important question has then been raised to know whether the Rayleigh limit of GLMT does identify or not with the dipole theory of forces (more specifically with the Rayleigh limit of the dipole theory of forces). Relying on numerical studies [50], [51] and on formal studies [52], [53], the answer has been found to be positive. However, the dipole theory of forces expresses forces in terms of the total electric field **E**. Conversely, the Rayleigh limit of GLMT demonstrates that all the partial waves of the electric field, from $n = 3$ to ∞ actually have a null contribution, in such a way that only partial waves of order 1 and 2 do contribute to optical forces. These forces (catalogued as gradient, scattering and non-standard forces) can then be expressed in terms of a few BSCs $g^m_{n,TM}$ and $g^m_{n,TE}$ with $n = 1$ and 2. Therefore, the Rayleigh limit of GLMT, although equivalent to the Rayleigh limit of the dipole theory of forces, nevertheless expresses a "reduction" of the dipole theory of forces to a few relevant contributions. This approach has been applied to on-axis Bessel beams [54] and, more generally, to on-axis non dark axisymmetric beams of the first kind [55].

With a paper by Yang *et al.* [56], we go on with optical forces exerted on Rayleigh particles, with gradient and scattering forces considered in the framework of the classical Rayleigh limit of the dipole theory of forces. The illuminating beam is a focused rotational elliptical Laguerre-Gaussian correlated Schell-model beam. Such a beam is a Laguerre-Gauss Schell model beam (which exhibits a spatial coherence which is only partial) extended by introducing elliptical symmetry into the degree of coherence. It is used to trap small dielectric particles of different refractive indices (specifically glass spheres and bubbles of diameter 50 nm, in water) and it is found that, for a judicious choice of the beam parameters, the particles with higher relative refractive index can be trapped along an elliptical ring centered at the focus, while, at the same time, the particles with lower refractive index are trapped at the focal point. Relying on the comparison between gradient, scattering, Brownian and gravity forces acting on the particles, an analysis of the trapping stability is carried out.

The next paper by Ambrosio [57] deals with the examination of other kinds of forces, which can have an amplitude orders of magnitude greater than gradient and scattering optical forces, namely photophoresis forces exerted on low-loss particles of the order of a few micrometers under plane wave or uniform illumination. Such thermal forces, which can be attractive or repulsive, arise from the uneven heating of the particle surface under illumination over a hemisphere. Different regimes may be considered (i) a free molecular regime when the Knudsen number Kn>>1, i.e. when the particle is much smaller than the mean free path of the gas molecules, so that photophoretic forces can be investigated using kinetic theory of gases, (ii) a slip-flow regime for Kn<1, and (iii) a continuous regime when Kn<<1. The applied force then depends on the asymmetry factor which involves an integration of the normalized absorbed light intensity over the volume of the particle. The author then considered particles with arbitrary index of refraction and analytically investigated photophoretic forces in terms of the asymmetry factor, for both slip flow and free molecular regimes. He

made use of the Mie theory for lossy and homogeneous spheres with arbitrary size parameters, and obtained the photophoretic forces as analytic closed-form solutions in the case of low-loss spherical particles under plane wave illumination. Examples of the behavior of the asymmetric factor for micro-spheres with distinct materials are provided and discussed, for all optical regimes, i.e. for Rayleigh, Mie and geometrical regimes. The author states that he is planning to extend this work to the case of non-uniform illumination by using GLMT instead of the classical Mie theory.

An application of optical tweezers used by Donato *et al.* [58] was devoted to photonic force microscopy (PFM) where an optically trapped probe in liquid is scanned over a sample (possibly a three-dimensional environment) to collect both morphology and forces sensing detection through its thermal fluctuations, i.e. by recording an interference pattern which fluctuates due to the fluctuations of the position of the particle induced by Brownian motion. In the present case, to avoid the requirement of using a transparent sample chamber, the authors relied on a backscattering configuration in which the sample is illuminated by light and the back pattern is detected by a quadrant photodiode (QVD) whose voltage signals are converted in 3D particle displacement in the trap. Noisy modulations, due to the interference of backscattered and back-reflected light (from nearby chamber surfaces), detrimental for the experimental procedure, are limited or even completely removed by the use of cylindrical vector beams (CVBs) when compared to the use of Gaussian beams, depending on whether radially or azimuthal CVBs are used. The apparatus allows one to measure trap spring constants and particle fluctuations. Calculations of light scattered by the trapped particle in forward and backward directions, as well as the optical forces for particles of any shape and composition, are obtained by T-matrix methods (e.g. EBCM) which, as mentioned by the authors, reduce to GLMT for spherical particles. The incident focused illuminating fields are expanded using an ASD and each plane wave can in turn be expanded into multipoles having their own BSCs (this is indeed one of the ways to use ASD to deal with scattering, see subsection 2.6 of [15]).

Optical trapping has indeed become a famous field of research with many applications. It is however worth recalling that another active field of research concerns trapping by acoustical waves, a field which presents many analogies with the one of electromagnetic trapping, if only because the theoretical description of the set-up may require the use of "acoustical BSCs". Such analogies are exhibited in a review by Thomas *et al.* [59] who very comprehensively discussed acoustical and optical radiation pressures and the development of single beam acoustical tweezers, with a strong emphasis on the mutual enrichment which arose from a long common history between electromagnetic and acoustical scattering.

However, this should not lead us to forget a more classical method in which particles are trapped in a quadrupole ion trap in high vacuum. Such a trapping technique has been used by Coppock *et al.* [60] for preparing highly charged Au nanospheres, and heat them beyond the melting point. The charge and mass of the nanospheres can then be determined from the effect of discrete discharging

on their charge to mass ratio. Also, nanosphere temperatures can be estimated by mass loss from Au thermal evaporation. It is furthermore possible to observe that contaminants in the vacuum can have a profound effect on the thermal and optical properties of the nanospheres near their melting point. Oxygen can be used to prevent such contaminations, likely due to carbon, to avoid to spoil the accuracy of measurements.

For another study involving a non-optical trapping/levitating system, we may consider trapping in a 3D electrodynamic trap, allowing one to levitate a charged particle with a combination of AC and DC electric fields, which has been used by Kolwas *et al.* [61] to study the evolution of mass, surface layer composition and light scattering of evaporating single microdroplets of sodium dodecyl sulphate/diethylene glycol mixture illuminated by laser beams. Such droplets exhibit a surfactant surface monolayer which is compressed during evaporation due to the shrinking of surface area, leading to a possible transition from a simple monolayer, named Langmuir monolayer, to a behavior in which the saturated monolayer must fold/buckle or even break above a critical concentration, therefore generating a transition from a 2D monolayer to a 3D structure. Surface area evolution are obtained from measurements of the droplet mass with electrostatic weighting, while morphology/structure dependent resonances (known as MDRs or WGMs) manifested in the intensity of scattered light allows one to examine the evolution of the microdroplet surface smoothness. Mie theory is used to calibrate radii of droplets at the beginning of evolution with the aid of Mie Scattering Look-up Table Method (MSLTM).

Light extinction spectroscopy (LES) is another optical characterization technique to measure the particle size distributions (PSDs) and concentrations of spherical to complex shaped aggregates or irregular nano- to microparticles, e.g. [62], [63], [64], [65], [66]. It is used by Erenen *et al.* [67] to measure PSDs, more specifically concentration and volumetric PSDs of colloids and nanofluids, with a particular attention paid to the issues of sensitivity to complex refractive index uncertainties and to noise. The LES technique analyzes the variations in the transmittance of a collimated poly-chromatic light beam passing through a medium containing an ensemble of particles. For a given wavelength of the poly-chromatic illuminating beam, and under some restrictions such as the absence of dependent scattering – produced by near-field optical interactions between particles – or of multiple scattering effects, the light extinction for homogeneous, isotropic, non-magnetic spheres, is analytically modeled by the Mie theory in an expression incorporating a normalized PSD function in number, from which it is possible to retrieve a PSD in weight if the particle density is known. This requires a careful inversion procedure which has been selected as being the Tikhonov regularization procedure also known as penalized least square method. Experiments are carried out using polystyrene latex beads commonly employed for the calibration of light extinction based instruments to generate mono-modal or bi-modal colloidal suspensions in water. These beads are illuminated by a highly stabilized UV light source and with the transmitted light being recorded by a spectrometer highly sensitive in the UV range and offering a high signal-to-noise ration, before being fed to a laptop for data inver-

sion (these LES experiments are complemented by Dynamic Light Scattering experiments).

Next, although Gaussian beams are the most familiar kinds of beams used in measurements, we have above met papers showing that alternative kinds of beams can be very beneficial for measurements. The paper by Zhao *et al.* [68] used complex Gaussian-correlated beam to overcome the Rayleigh diffraction limit (i.e. realizing a sub-diffraction resolution) and achieve micro-displacement measurements. It is a fact that overcoming the Rayleigh diffraction limit is a somewhat counter-intuitive but exciting field in which the modulation of the properties of illumination sources may be efficiently introduced, in particular the use of partially coherent beam, e.g. Laguerre-Gaussian correlated Schell-model beams, such as already encountered in the present preface when dealing with [69]. The present paper deals with an improved choice of partially coherent beams named complex Gaussian-correlated beams, which allowed an optimum resolution distance equal to 0.05 times the Rayleigh diffraction limit when applied to the separation of images of four pinholes in the detection plane. Displacement measurements (requiring calibration) are carried out by using two symmetrical pinholes in the object plane, consistently with the fact that a displacement measurement can be considered as a measurement of two end-points.

Partially coherent beams as discussed above can furthermore be useful for studying laser propagation in turbulent atmospheres as discussed by Liu *et al.* [70] who deal with the propagation of twisted Laguerre-Gaussian Schell model. Analytical expressions for the cross-spectral density function propagating in free space and in turbulence are derived based on the extended Huygens-Fresnel integral, and the evolution of the spectral density as well of the orbital angular momentum (OAM) are discussed. A choice of parameters allows one to enhance the OAM and, simultaneously, to improve the resistance of the beam to its propagation in a turbulent medium. A purpose of such a work is in particular to increase the capacity of free-space communications.

The propagation of beams in a turbulent atmosphere is also studied, using the Rytov Approximation Theory, by Li *et al.* [71], but using a more conventional Laguerre-Gauss (vortex) beam. More specifically, the authors studied the echo speckle characteristics of the light scattering from rough targets in turbulence and compared these speckle characteristics with those produced by Gaussian beams. It was found that, in the weak turbulence regions, the target characteristics are the main influencing factors of the speckle fields while, in the strong turbulence regions, the main influencing factors are the turbulence effects. Furthermore, the effects of these influencing factors are observed to be less than those of the Gaussian beams. It is concluded that such studies can potentially provide theoretical and technical guidances for applications to laser target detection and recognition, related to speckle measurements processes in space.

Concerning specifically weak turbulence regions, Gökçe *et al.* [72] noticed that turbulence-induced wavefront deformations cause the irradiance of an optical signal to fluctuate resulting in a serious degradation of the bit-error rate

(BER) performance of optical wireless communication systems. They therefore investigated an adaptive optics aiming to compensate for the wavefront aberrations in order to reduce the flucutations in the received intensity (known as scintillations), knowing that the use of adaptive optics may improve the BER by a few orders of magnitude. They used a still more conventional laser than in the previous paper, namely a Gaussian beam, and studied its propagation in a communication channel which is a weak oceanic turbulence, considering both scintillations and the beam spreading effects causing an additional power loss in the receiver. The adaptive optics technique employed for their study in ocdeanic optical wireless communication (OOWC) takes the form of a sum of spatial filters. It is found, in particular, that the effective beneficial effect on BER of the adaptive optics used increases when the turbulence level decreases, and that it becomes more efficient with an enlarged receiver aperture diameter.

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We are now looking forward to the next edition, namely the 13th "Laser-light and Interactions with Particles, Optical Particle Characterization follow-up (LIP2022)", to be organized by the authors of the present preface, in Warsaw, Poland, on August 21-26th, see at www.lip-conferences. Since Science also required technical and financial resources, our final acknowledgments go to the institutions who are sponsoring LIP-conferences, and most notably to the French National Research Agency [grant number ANR-13-BS090008-02 (AMO-COPS)].

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