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3 **Editorial**  
4 **Laser-light and interactions with particles (LIP), 2022**

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21 **Keywords:**

22 Lorenz-Mie theory and shaped beams, Bessel functions, optical forces, plasmon-polariton  
23 excitation and photonic molecules, optical wireless communication, optical particle  
24 characterization methods

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27 This “Laser-light and interactions with particles (LIP), 2022”, or “LIP2022”, topical issue brings  
28 together papers selected after the organization, but not exclusively, of the eponymous conference  
29 which took place from August 21<sup>st</sup> to 26<sup>th</sup>, 2023, in Warsaw, under the chairmanship of Professors D.  
30 Jakubczyk and M. Kolwas [1]. The biennial LIP conference series is a direct descendant of the former  
31 "Optical Particle Sizing (OPS), theory and practice" conference, launched and chaired by G. Gouesbet  
32 and G. Gréhan in Rouen in 1987. OPS was renamed as "Optical Particle Characterization Conference  
33 (OPC)" after 1990. The OPS and OPC conferences were mainly devoted to optical measurements,  
34 using laser sources, of the size of individual particles and, subsequently, to the characterization of their  
35 composition or temperature. In 2012, to take account of the most recent developments in the field, it  
36 was decided to rename the conference series to “LIP” and broaden its topics to laser beams  
37 description, including acoustical and quantum beams; mechanical effects of light for particle  
38 manipulation, optical tweezer, force measurement; near-field, far-field and time-resolved scattering  
39 computations and laboratory experiments; plasmonic and other resonances; scattering properties of  
40 complex shaped particles and aggregates: morphology; multiple scattering in random, dense or  
41 turbulent. Since the beginning applications are also welcomed in the following domains: two- and  
42 multiphase flow characterization; aerosol and atmospheric sciences: nucleation, transport,  
43 characterization; plasma and soft matter physics: colloids, suspensions, aggregation; biomedical  
44 optical engineering: cell manipulation and properties, microrheology; remote sensing and free space  
45 communication and optical particle characterization [2-5].

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47 The present topical issue contains 16 papers that are briefly introduced in what follows. They are  
48 organized in seven categories or topics: computation of complex functions related to light scattering  
49 problems, description of particular structured beams in free space, scattering of nanoemitters and  
50 photonic molecules, optical forces, shaped beams and their propagation in the atmosphere, evaluation  
51 of asymptotic light scattering models and optical particle characterization methods.

52  
53 We start with two papers by Ambrosio et al. [6, 7], dealing with the computation of complex  
54 functions related to light scattering problems. Since the beginning of electromagnetic theory, the

55 numerical calculation of solutions has been a key issue. The case of the Lorenz-Mie theory (LMT),  
56 whose formalism was established more than a century old [8, 9], is well known. The applicability of  
57 this theory, which gives the general expressions for the scattering of a plane wave by spherical,  
58 homogeneous and isotropic scatterers, became only real from the end of the 1970s, beginning of the  
59 1980s. This, thanks to the spreading of personal computers, but also its partial rewriting, in terms of  
60 the ratio of complex functions and their derivatives as well the development of stable numerical  
61 algorithms using specific upward and downward recurrences [10-12]. This is precisely what it is  
62 proposed by Ambrosio et al [6], for specific expressions involving products between (Ricatti-)Bessel  
63 functions, and their derivatives, that are of interest to compute photophoresis effects on lossy  
64 concentric spherical particles. This approach is extended by the same authors, in a second article [7],  
65 for expressions of complex functions appearing in the calculation of the photophoretic asymmetry  
66 factors of infinite cylinders. The latter, illuminated by plane waves or light-sheets, being, either  
67 isolated or positioned near conducting corners or planar boundaries.

68  
69 The next two papers [13, 14] deal with the description of structured beams in the frame of the  
70 Generalized Lorenz-Mie theory (GLMT) [15]. Generally speaking, GLMT gives general expressions  
71 for the scattering of shaped beams by spherical homogeneous or concentric particles, spheroids...,  
72 with a separation variable method and the introduction of beam shape coefficients (BSCs) [15]. In the  
73 first paper, Ambrosio [13] introduces an analytical approach to overcome numerical limitations in the  
74 description of frozen waves, i.e. a specific class of non-diffracting and stationary localized wave field  
75 whose intensity envelope remains static [16]. The two major improvements concern the determination  
76 of the Fourier coefficients of compositions of generalized Legendre functions and the exact solution to  
77 integrals involving Bessel functions for an on-axis configuration. The second paper deals with the  
78 description of Ince-Gaussian beams (IGBs, named for Edward L. Ince's polynomials) [17] in the  
79 frame of the GLMT[15]. IGBs beams are exact solutions of the paraxial wave equation, like Hermite-  
80 Gaussian, Laguerre-Gaussian or hypergeometric-Gaussian beams for instance. The Hermite-Gaussian  
81 and Laguerre-Gaussian modes are a special case of the IG modes that are natural solutions to the  
82 paraxial wave equation (PWE) in elliptic cylindrical coordinates. In the present work, Votto et al.  
83 succeed to derive with the finite series method the BSCs of IGBs beams from the BSCs Laguerre-  
84 Gaussian beams, opening perspectives for a better description of frozen waves in light scattering  
85 problems notably.

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87 The beam shape also matters when dealing with long distance optical wireless communication and  
88 LIDAR remote sensing, due to the diffraction of the beam, the presence of aerosol and raindrops [18],  
89 as well as the turbulence of the atmosphere [19]. Dong et al. [18] consider the energy attenuation  
90 characteristics of high-order Bessel vortex beams [20] under rainfall atmospheric conditions. An  
91 optical vortex is a structured light wave which has an isolated point singularity. A polarization vortex  
92 (vector beam) has spatially variant polarizations with a polarization singularity, whereas a phase  
93 vortex has a spiral phase front with a phase singularity or screw dislocation [21]. The fact is that  
94 optical vortices has recently gained increasing interest in optical particle manipulation, laser  
95 machining, optical microscopy and optical communications. In the present paper, the authors show,  
96 through numerical simulation using GLMT framework, that the beam extinction caused by raindrop is  
97 significantly reduced when using Bessel vortex beam instead of classical Gaussian beams. The authors  
98 also show that increasing the topological charge and axial cone angle of Bessel vortex laser beam  
99 increases their penetrating ability in rainfall environment, like the use of near-infrared beams rather  
100 than visible or mid-infrared ones. Then, Gökçe et al [19] investigate the propagation of multimode  
101 beams whose wavefront is distorted by the turbulence of the atmosphere itself, limiting the quality and  
102 range of optical communications [22]. The model developed [19] accounts particularly for the  
103 structure constants of atmosphere, the number of modes of the laser beam, the bi-static distance, the  
104 focal length and radius of the coupling lenses at the optical fiber outputs. Numerical simulations reveal  
105 that increasing the number of modes enhances notably the coupling efficiency performance when  
106 compared with Gaussian beams. The same hold for the source size, so has to the size and the focal  
107 length of the coupling lenses, and the wavelength in a certain extent.

109 The next two papers deal with the scattering of nanoemitters [23] and photonic molecules [24]. The  
110 work by G. Burlak G. and Medina-Ángel [23] is part of the studies devoted to the linear and nonlinear  
111 plasmonic properties of nanohybrids and nanocomposites made of metallic nanoparticles and  
112 nanoemitters emitters (e.g. [25, 26]). The model developed herein reveals that the inclusion in these  
113 structures of dispersed single-walled carbon nanotubes considerably changes the properties of the  
114 plasmon-polariton fields in such a hybrid system. This makes possible to control the properties of local  
115 optical fields that allows creating of miniature low threshold coherent sources with tunable  
116 polarization. Numerical simulations show also that the strength of coupling of nanoemitter with  
117 plasmon-polaritons is maximal when the field interconnections appear in the entire carbon nanotubes  
118 array. We then move to a work by Y. E. Geints that is focused on the optical properties of miniature  
119 resonant microcavities whose efficiency is sufficient to provide whispering-gallery modes. These  
120 “photonic molecules (PM)” [27], composed of “atoms” (e.g., cylinders or spheres) are studied when  
121 excited simultaneously via two light channels (tapered fibers). The current numerical study, restricted  
122 to mirror-symmetric PM, reports that for a seven-atom silicon microcylinder cyclic-PM a tenfold  
123 intensity amplification/suppression of several supermodes from the Stokes and anti-Stokes bands of  
124 PM spectrum can be reached [26].

125  
126 In many situations laser diagnostics can be considered as non-intrusive. This is no longer the case  
127 when the laser beams ionize or heat up matter or, as the following two papers [28] [29] show, induce  
128 mechanical forces through radiation pressure. Gouesbet et al. [28] study forces exerted on  
129 quadrupoles, in terms of BSCs and Mie coefficients, within the framework of GLMT. These forces are  
130 categorized in mixing forces and recoil forces, gradient and non-gradient forces. The authors also  
131 propose to introduce a third category, in which the so-called scattering forces are actually decomposed  
132 in scattering forces and non-standard forces [28]. The second paper on optical forces is from the same  
133 authors, it is the last paper of a series aiming to the partition of optical forces exerted on arbitrary sized  
134 particles in the framework of GLMT [29].

135  
136 Although there are various electromagnetic approaches for calculating the scattering properties of  
137 fractal aggregates [30-32], they are still limited in terms of maximum dimension of the aggregates or  
138 the size and absorptivity of the monomers. The computational efforts they require with respect to  
139 analytical models like the Rayleigh-Debye-Gans approximation for fractal aggregates (RDG-FA)[33-  
140 36] is also a critical aspect for inverse methods requiring the creation of large database. RDG-FA, that  
141 is intrinsically based on Rayleigh theory of the scattering by a dipole, also neglects electromagnetic  
142 coupling within the aggregate. But it provides simple formula for the interpretation of the behavior of  
143 the optical structure factor (OSF) with key parameters such as the number of monomers, the fractal  
144 dimension or the radius of gyration [35, 37], that are at the basis of numerous reasoning in various  
145 research fields. In the present paper [38], Argentin et al employ the discrete dipole approximation and  
146 phasor approach [39] to study the role of the coupling on the OSF for the specific case of soot  
147 particles. The later have an intermediate fractal dimension (1.6 to 1.8) and high monomer absorptivity  
148 (carbonaceous material) that partially violate the basic assumptions of this theory. However, via a  
149 numerical study, the authors succeed to propose correction functions allowing to slightly extend the  
150 range of validity of RDG-FA for soot particles. These functions are thought to be useful for related  
151 laser diagnostics. The Geometrical Optics (GO) is another asymptotic approach whose hypothesis  
152 regarding the scatterer size is totally opposite. It basically assumes that the scattered is much larger  
153 than the wavelength and that other optical properties (like the Fresnel coefficients for instance) change  
154 slowly regarding the wavelength scale. The fact is that, during the last decades, the interest in GO and  
155 physical optics approximations (e.g. [40-47]), and their hybridization (e.g. [47, 48]), has considerably  
156 raised. This is certainly due to the fact that electromagnetic models stalled in the race towards particles  
157 with large size parameters (i.e. a few hundred). In the work by Zhang et al [49], the authors evaluate  
158 the characteristic size of a particle that is the most relevant to the accuracy of the GOA in the case of  
159 faceted dielectric particle generated from platonic solids. This model, introduced more than one  
160 decade ago, is not based on a conventional ray tracing method with differential geometry  
161 considerations, e.g. [44, 50-52]. As a hybrid model, it uses conventional GO to calculate the particle  
162 near-field and physical optics to calculate the corresponding far-field. It comes out from numerical  
163 comparisons with a rigorous invariant imbedding T-matrix method [53], that accuracy of this hybrid

164 model is determined by the individual facet size and the maximum dimension of the particle. The  
165 curvature of the particle surface, that acts as a divergent factor [50, 54] in the calculation of the  
166 intensity of the scattered rays or the focusing of the indent rays, is not considered in this work.

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168 This topical issue ends with three papers on optical particle characterization methods. The first paper,  
169 by Shopa et al [55], deals with experiments on the analysis of the migration of nanoparticle towards  
170 the surface of a slowly evaporating colloidal droplet trapped in an electrodynamic trap. For this  
171 purpose, the authors track the change in the laser induced fluorescence of the doped nanoparticles as  
172 well as in the fine resonance structures of the scattering patterns and whispering gallery modes of the  
173 droplet. Moreover, despite some successes, the authors stress on a possible direct interaction of the  
174 pumping beam with the nanoparticles self-organization. The second paper, by Brunel et al [56],  
175 proposes a model accounting for spherical aberrations introduced by the imaging lens of  
176 interferometric particle imaging (IPI) systems. Note that IPI systems were initially designed to  
177 characterize the size and velocity of flowing droplet or bubble [57-59]. The correction model  
178 introduced here decomposes the aberrating phase term introduced by the imaging system over a basis  
179 of Gaussian functions. The predictions and corrections achieved with this model are in excellent  
180 agreement with experimental data for on-axis or off-axis rough particles, or for neighbored rough  
181 particles whose interferometric images overlap, producing complex speckle-like images. These  
182 developments are powerful not only for the correction of IPI images, but also all 3D reconstructions  
183 based on multi-view setups and back projections from different 2D images. In the last paper, by Peng  
184 et al [60], the authors investigate the robustness of the analysis of Global rainbow signals [61, 62] for  
185 signal-to-noise-ratios in the range 60 down to 5dB. The inversion method used is a conventional  
186 parametric analysis assuming the particle distribution shape (normal, log-normal, and bimodal  
187 normal)[63] but it is coupled with a more innovative empirical mode decomposition (EMD) for  
188 denoising. The numerical study, as well as preliminary experimental results, shows that the EMD  
189 method helps a lot in the ideal case of an additive white noise.

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191 To conclude this editorial, as guest editors and on behalf of the committees of LIP conferences, we  
192 want to thank the JQSRT editorial board, for the quality of their work and their unwavering support.  
193 We also thank all authors of selected papers presented herein and the anonymous reviewers who have  
194 helped us, collectively, to improve the readability and impact of all selected papers. We also take this  
195 opportunity to announce that the 14th edition of LIP conference will be organized by the School of  
196 Physics of Xidian University, in Xi'an, China, on September 19<sup>th</sup>—22<sup>nd</sup>, 2024, see at [http://lip-](http://lip-conference.org/)  
197 [conference.org/](http://lip-conference.org/), under the supervision of the conference conveners, L. Guo, Y. Han, F. Onofri and  
198 G. Gouesbet.

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201  
202 **Fabrice Onofri** is senior researcher (directeur de recherche) at the French National Center for  
203 Scientific Research (CNRS). He is mainly working on the optical and electromagnetic characterization  
204 of particle and particle systems. Over the years, his research has found applications in various fields  
205 ranging from aerosols and multiphase flows to soft matter and plasma physics, in the frame of national  
206 and international academic as well as industrial granted projects.

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**Gérard Gouesbet** is a Professor Emeritus of the National Institute of Applied Sciences of Rouen. He has worked in particular on the modeling of turbulent and multiphase flows, on the nonlinear dynamics of systems, on combustion and plasmas, on optical particle characterization and light scattering. He is the driving force behind the development of generalized Lorenz-Mie theories, and the winner of the 2020 van de Hulst award. He published nearly 400 papers in peer-reviewed journals and book chapters. He is also involved in philosophical studies, e.g. his book in philosophy of sciences entitled "Hidden world in quantum physics, Dover publications" and his recently achieved tetralogy on the philosophy of violence (written in French)



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**Maciej Kolwas** is professor in the Institute of Physics of the Polish Academy of Science. His scientific activity started in field of quantum optics studying two photon phenomena - Hanle effect, photon bunching, nonlinear phenomena inside laser resonators. Then his interest concentrated on study of thermodynamics of micro and nano droplets of pure liquids and colloidal suspensions with the laser light scattering. He held several administrative positions at the Institute of Physics- head of group, head of division, rector of International Post Graduate Studies. He was active member of physical societies acting on the end as President of Polish Physical Society and President European Physical Society.

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**Daniel Jakubczyk** is an associate professor and head of the Group of Optical Characterisation of Micro- and Nanoobjects at the Institute of Physics, Polish Academy of Sciences. His research activities are essentially experimental. They have included the formation of light-induced sodium nanodroplets, near-field scanning optical microscopy, thermodynamics of evaporation of micro- and nanodroplets, surface thermodynamics of evaporating microdroplets of suspensions/nanofluids,

238 application of machine learning to optical recognition of nanofluids. He received his Ph.D. and  
239 habilitation degree at the Institute of Physics PAS.

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