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EDITORIAL

Special issue on singular optics

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Singular optics is a relatively mature field shaped as a distinct discipline almost two decades ago [1, 2]. This special issue continues the series [3, 4] evolving from the conferences with the same name, traditionally organized in the Ukraine since 1997. The 5th International Conference in Singular Optics took place 16–21 September 2012 in Sevastopol, Crimea, Ukraine, co-chaired by Professors Michael Berry (Bristol, UK), Marat Soskin (Kiev, Ukraine) and Alexander Volyar (Simferopol, Ukraine). The collection of papers here extends well beyond the conference scope and takes a snapshot of current trends in singular optics and its novel directions.

The fascination with phase singularities [5], optical vortices [6], and twisted light [7] remains perhaps the strongest driving force in the progress of singular optics [8]. In this issue the experimental observation of vortex collisions in Airy beams is reported [9] and the inversion of a vortex in an astigmatic beam is studied in detail [10]. Optics provides many opportunities to visualize fundamental wave phenomena, and here [11] the vortex beams were used to visualize relativistic time dilation and Hall effects.

The generic role of singularities as the local organizing centres for the global field landscape arises now as a unifying concept in many disparate fields. The emerging trend of 'structured light' in diverse applications [12, 13] can also be traced back to the pioneering studies of the fine structure of light [14]. It appears that the importance of phase singularities will soon be discovered in many well-researched fields not associated directly with singular optics. One example is the Mie theory of scattering of light on a spherical particle. If a particle is absorbing, the power flow in the near field may contain remarkably complex topological structures. The review paper here [15] describes the rich structure of the near-field Poynting vector field and its relation to the Fano resonances in far-field scattering. A natural question arises of whether these new findings will have an impact in a more traditional application of singular light, for example optical tweezers [12, 16]. The interplay of electric and magnetic particle moments with the spin and orbital optical angular momenta discussed in [17] is certainly an interesting possibility to expand the toolbox of optical tweezing.

The maturity of a research field reveals itself in challenging the established limits in 'extreme' studies. In this issue, the experimental generation of optical vortices with extremely high topological charge of the order of 10^3 is reported [18], suggesting the possibility to observe and study experimentally superoscillations [19] and perhaps a vortex gas. The dynamics of twisted light in extreme conditions is another topic, including turbulent atmosphere [20–22] and nonlinear filamentation of extremely powerful ultra-violet optical vortices in air [23].

Studies of the nonlinear dynamics of vortices and vortex solitons [24] have a long history since the early 1990s [25] and evolve in a somewhat parallel course to linear singular optics. Here the experimental generation of stable vortex solitons in semiconductor lasers is reported [26] and the dramatic effect of nonlinearity and symmetry of the medium, in particular the periodic modulation of the refractive index, on the stability and dynamics of vortices is explored theoretically [27, 28]. Discrete symmetry has a profound effect on the vortex

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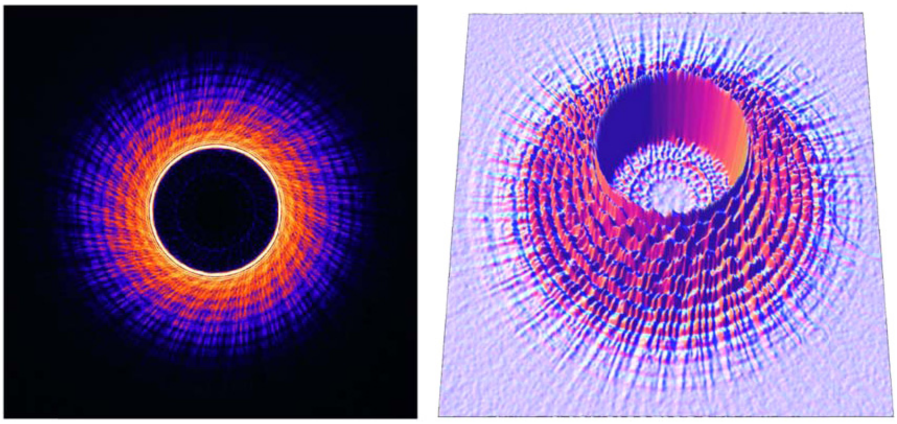

Figure 1. Intensity of a vortex beam with charge 100 generated with high efficiency spiral phase mirror manufactured on the aluminum disc with an ultra-precision single-point diamond turning lathe. The radial ripples are similar to the oscillating Bessel-like tails while azimuthal ripples replicate 25 saw-tooth mirror steps. Images courtesy of the authors of [18].

structure of the field [29] and the dynamics of angular spin and orbital momenta, as shown here in a circular array of coupled waveguides [30]. If such waveguides are nonlinear, the 'discrete' optical vortices [31] offer novel possibilities for all-optical switching. Another example of vortices in a structured matter is the two-dimensional interfaces supporting localized surface waves, such as surface plasmon polaritons [32, 33] and their nonlinear counterparts [34].

An active area of research is crystal singular optics, studying the dynamics of singular light in anisotropic media [35], including generation of vortex arrays by twisted liquid crystals [36]. Such dynamics involves polarization conversion and transformations, including complex topological reactions of polarization singularities [37, 38]. Similar to the interaction and complex geometrical structure of vortex lines in scalar fields, the spatial 'dynamics' of polarization singularities attracts much attention [39, 40]. Significant effort is directed towards robust methods to generate and control polarization textures of light [41–44] which will hopefully lead to interesting applications [45, 46].

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