Grant report

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My doctoral research is devoted to studying the interferometry and its various applications in scientific and technological areas. This optical phenomenon allows to extend the limits of the existing imaging techniques and to detect ultrafast signal fluctuations that cannot be measured using conventional methods. There are two main topics in my research: one of them is developing an interferometric imaging method that is able to retrieve sharp object images with high resolution even if it is screened by a strongly scattering layer and no details of the object can be seen with a bare eye. This method can significantly improve the microscopy of biological and medical samples, as well as endoscopy/3D scanning. The project was finalized in 2020 and resulted in two published articles [1, 2].

The second topic is related to creating structured optical beams with varying subluminal (slower than speed of light) and superluminal (faster than speed of light) group velocity values. We have demonstrated several examples of multifrequency Bessel beams with negative and arbitrary positive group velocities and proposed a relatively simple interferometric method to measure the achieved extreme group velocity values. Such beams can find useful applications in data transfer and optical tweezers. This research project has resulted in two recent outcomes: an article describing theoretical models of pulsed and continious-wave multicomponent Bessel beams together with the methods for controlling their group velocity [3], and the experimental verification of one of the theoretical models of the accelerating Bessel beam in free space [4].

The doctoral dissertation containing an overview of the two research topics has been thoroughly planned and the plan has been agreed with the supervisor. The manuscript is currently being written, and the estimated defense date is set to November 2022.

To sum up, I would like to acknowledge The Association of Electrical Engineers in Finland for supporting and encouraging my doctoral studies by awarding me a grant. The provided scholarship helped me to make significant progress in my research, publish two scientific articles in high impact open access journals, and concentrate on the final task - writing the dissertation.

References

[1] E. Ilina, M. Nyman, I. Švagždytė, N. Chekurov, M. Kaivola, T. Setälä, and A. Shevchenko, "Aberration-insensitive microscopy using optical field-correlation imaging," *APL Photonics*, vol. 4, no. 6, p. 066102, 2019.

[2] E. Ilina, M. Nyman, T. Mondal, M. Kaivola, T. Setälä, and A. Shevchenko, "Interferometric imaging of reflective micro-objects in the presence of strong aberrations," *Optics Express*, vol. 28, pp. 1817–1826, 2020.

[3] P. Hildén, E. Ilina, M. Kaivola, and A. Shevchenko, "Multifrequency bessel beams with adjustable group velocity and longitudinal acceleration in free space," *New Journal of Physics*, vol. 24, p. 033042, March 2022.

[4] E. Ilina, P. Hildén, M. Kaivola, and A. Shevchenko, "Continuous wave bessel beams with a strong longitudinal acceleration in free space," *Optics Letters*, vol. 47, pp. 4060–4063, August 2022.