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**REPORT ON THE HABILITATION THESIS
BY RNDr. MIROSLAV JEŽEK, Ph.D.**

The scientific works underlying the habilitation thesis of RNDr. Miroslav Ježek, concern the subject of precise and complex measurements of light beams. Light is commonly used as a carrier of information when it comes to communication, sensing, as well as imaging. The most elementary method to detect light is to perform an intensity measurement, e.g. imaging in the most elementary form consists in the determination of spatial intensity distributions. However, light beams can carry out a wealth of information in different degrees of freedom such as phase, polarization, frequency. Furthermore, at the most elementary level intensity measurement becomes detection of individual photocount events which correspond to absorption of elementary portions of light – photons – from the incident beam. This opens up a pathway to perform very sophisticated coincidence (intensity correlations at the macroscopic level) measurements which are particularly relevant for quantum information processing. At the same time, increasing precision of light measurements requires more detailed understanding of the measuring apparatus, including its imperfections, etc. Furthermore, much more computing power has become available in recent years that facilitates more advanced methods to extract information of interest from complex and noisy measurements.

Miroslav Ježek has made a number of important contributions to this area of research, documented by eight scientific articles published in renowned international academic journals over the years 2019-2026. The last paper, included in the documentation as the preprint arXiv:2502.18637, has in the meantime appeared in *Nature Communications* **17**, 8705 (2026). What I find particularly impressive in the submitted collection of works, is the combination of very refined and thoroughly understood experimental techniques with advanced methods for postprocessing of the collected data to obtain relevant information, also in scenarios when the system is too complex for complete tomographic characterization. This ambition is best illustrated by the paper D. Koutný *et al.*, *Science Advances* **9**, eadd7131 (2023), which is a result of collaboration with researchers from Stockholm University, Princeton University, Würzburg University, and Oldenburg University. The presented strategy to estimate quantum entanglement avoids the need to perform full quantum state tomography for which the number of estimated parameters scales exponentially with the dimension of the system. Instead, resorting to neural networks allows one to quantify the degree of entanglement based on an incomplete set of measurements. This approach has been tested using photons generated in the spontaneous down-conversion process as well as in semiconductor quantum dots.

The general nature of the tools developed by Miroslav Ježek is illustrated by the last the most recent paper in the collection, published in Nature Communications, where the problem of super-resolution imaging is addressed using a device-agnostic deep-learning framework. The canonical approach is based on constrained deconvolution, which requires knowledge of the instrument (point spread) function as well as *a prori* assumptions regarding the non-negativity of the reconstructed spatial intensity distribution. These requirements are relaxed through training of a neural network using a diverse numercally generated dataset covering a range of imaging conditions. As in other works by Dr. Ježek, the developed technique has been practically tested in an experimental setup for optical microscopy.

In conclusion, the works by Dr Ježek fulfill the requirements for a habilitation thesis in the field of physical and optical sciences and I recommend the thesis for further advancement of the habilitation procedure. I am also confident that results obtained by Dr Ježek will stimulate further research in the field of optical sciences and quantum information. On the fundamental side, which is closest to my own scientific interests, the presented works raise a number of interesting questions. One of them is the benchmarking of the performance of the presented protocols. While there exist standard measures, such as multiparameter Fisher information, it may be worthwhile to reexamine assumptions used in their derivation and verify whether improvements can be achieved by going beyond these. If so, is there room for generalizations of these measures? When it comes to incomplete measurements, are there universal methods to identify the optimum operating point for trade-offs between e.g. the number of measurements and their precision when the total number of samples is limited? Finally, are there issues related to reliability and confidence of results obtained using machine learning methods? Overall, I am delighted to congratulate Dr Ježek on the submitted body of work and I look forward to more inspiring results coming from his research activities.