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REVIEW

for a competition for occupation of the academic position "Associated Professor" in professional field 4.1. "Physical sciences", scientific specialty "Physics of wave processes", according to the announcement in SG no. 79 of 04.10.2022

Reviewer Assoc. Prof. Dr. Violeta Dimitrova Madjarova, IOMT-BAS
Member of scientific jury, appointed by Order of Director of IOMT-BAS № РД-15-717, dated Dec 1st, 2022 and № РД-15-728 dated Dec 7th, 2022

Applicant: **Dr. Branimir Ludmilov Ivanov**, Assistant Professor, Institute of Optical Materials and Technologies "Acad. J. Malinovski" (IOMT) – BAS

In the announced competition of IOMT-BAS for occupation of the academic position "Associated Professor" in professional field 4.1. "Physical sciences", scientific specialty "Physics of wave processes" the sole application was submitted by Dr. Branimir Ludmilov Ivanov, Assistant Professor, IOMT – BAS.

1. BRIEF BIOGRAPHICAL DATA OF THE APPLICANT

The autobiography of Dr. Ivanov shows his distinguished interest in the field of physics since young age. He has completed his high-school education in 1993 and graduated Technical School of Fine Mechanics and Optics "M.L. Lomonosov" in the field of Laser Techniques. In 2000 Dr. Ivanov graduated Sofia University "St. Kliment Ohridski", Faculty of Physics with master degree "Engineering Physics" in two majors – „Quantum electronics and laser technique" and „Medical Physics". Upon graduation he started work as physicist at Central Laboratory of Optical Storage and Processing of Information – Bulgarian Academy of Sciences (CLOSPI-BAS), and from 2001 till 2003 he was enrolled as a full-time PhD student in the same laboratory. After finishing PhD studies he was employed at CLOSPI-BAS as physicist researcher, research associate III degree, and from 2010 till 2013 as an assistant at IOMT-BAS. In 2013 he defended his doctoral thesis in scientific specialty "Physics of wave processes". The title of his thesis was „Multi-color holographic recording and holographic optical elements" and received a PhD degree. The same year he was employed as an assistant professor at IOMT-BAS, the same position he occupies at the moment. During 2005 – 2009 Dr. Ivanov had 3 one-month specializations abroad in the field of holography.

2. GENERAL DESCRIPTION OF PRESENTED MATERIALS

The documents, submitted by Assistant Professor Dr. Branimir Ludmilov Ivanov comply with the minimum requirements of art. 2b, item 2 and item 3 of the Act on Development of the Academic Staff in the Republic of Bulgaria (ADASRD), minimum requirements of Bulgarian Academy of Sciences and IOMT-BAS (Annex 1 of the Regulations of IOMT-BAS for rules and procedures for acquiring of scientific degree and holding an academic position at IOMT-BAS). In the competition for the academic position "Associated Professor" Assistant Professor Dr. Branimir Ludmilov Ivanov submitted 24 scientific papers, referred in Web of Science and Scopus – 9 in indicator C.4 (corresponding to habilitation work) and 15 in indicator D.7. From the 24 scientific papers 5 publications are in renown journals Applied Optics, Optics Letter, Optics Communications и Optics and Lasers in Engineering with Q1 rank, 2 publications are in journals with Q2 rank, 4 publications are in journals with Q4 rank, 13 publications are in proceedings with impact rank. In spite that the major part of his publications are in proceedings with impact rank, they are SPIE proceedings – one of the most distinguished platforms for publishing novelties in photonics and optical metrology. In the competition for the academic position "Associated Professor" he has submitted 32 independent citations referred in Web of Science и Scopus.

To sum up, the points in groups of indicators for holding an academic position „Associate Professor" are as follows:

Group A – 50 (minimum 50 points)
Group C – 104 (minimum 100 points)
Group D – 239 (minimum 220 points)
група E – 64 (minimum 60 points)

The presented documents and materials, and the points in groups of indicators clearly indicated that the candidate surpasses the minimum requirements for the academic position „Associate Professor". No publication or citation that the candidate submitted for this competition has been used previously in his PhD work.

3. GENERAL CHARACTERISTICS OF APPLICANT'S SCIENTIFIC RESEARCH ACTIVITY

His whole active research he published as a co-author of 37 scientific papers, referred at Web of Science and Scopus. In Scopus, as of 31.01.2023, there are 37 independent citations, and the h-index is 3. In the period after obtaining his PhD Dr. Ivanov has participated in more than 20 national and international conferences in the field of physics. Moreover, Dr. Ivanov was an active member of the research teams in 10 scientific research projects, financed both from Bulgarian and foreign organizations. Scientific research activity of Assistant Professor Dr. Branimir Ludmilov Ivanov is in the field of physics of wave processes. Main focus of his research is the development of methods and optical set-ups in coherent optical metrology. The physical phenomena on which these methods are based are interference, diffraction, polarization and dispersion of light. The developed methods in coherent optical metrology are contemporaneous due to their very high resolution, topographic and tomographic visualization and recoding and study of dynamic processes and events. Generally, the areas of the research works presented by Dr. Ivanov can be categorized into the following groups:

- Interferometric methods for determining the spectral characteristics of optical sources with noise correction.
- Holographic and interferometric methods for visualization and controlling samples.
- Numerical methods for the analysis of data from dynamic speckle measurements.
- Profilometric methods for remote determination of the shape and three dimensional visualization of objects.
- Monitoring and control of drying processes through dynamic speckle analysis.

4. MAJOR SCIENTIFIC AND APPLIED SCIENTIFIC CONTRIBUTIONS

4.1. The major scientific contributions in the papers corresponding to habilitation work (Group C) are as follow:

I. Interferometric methods for determining the spectral characteristics of optical sources with noise correction [A1-A3].

1. Three-channel correlation Fourier spectrometer with simultaneous recording of interferograms for the reference and working light source, and for the light from the investigated sample was developed. The noise sources in the spectrometer were analyzed using Monte Carlo simulations. A system for feedback to improve the accuracy is proposed [A1].

2. Accuracy of recovering a single absorption peak in a Fourier specter measurement in the presence of fluctuating component to the carrier frequency in the source and measurement channel of the interferometer is assessed. The results for test source (laser diode) using the prototype of a three-channel Fourier spectrometer based on a white-light Michelson interferometer were acquired [A1-A2].

3. An improved method based on a classical Michelson interferometer with a movable mirror was developed that allowed precise measurement of the optical characteristics of various light sources by means of a Fourier spectrometer. A procedure has been developed to process the recorded interferograms and its effectiveness was proven by Monte Carlo simulation of noisy interferograms. Various semiconductor sources were tested and the quality of the obtained spectra was confirmed using an optical spectrum analyzer. The time for recording the data and recovering the spectrum was within a few seconds which made possible system's applications in spectroscopy, optical communications, computer technology, etc. [A3].

II. Holographic and interferometric methods for visualizing and controlling samples [A4-A9].

1. The generation of 3D digital inputs of two types holographic printers has been analyzed. The first printer is a holographic printer for stereograms and the second holographic printer is wavefront printer to create real volume holograms from digital input. The first printer is illustrated both by simulation and by recording of an analog holographic stereogram. For the second holographic printer an accelerated method for calculating input data and print quality is demonstrated by printed color holograms [A4].

2. Phase-shifting holographic polariscopic system with a coherent light source was developed to determine mechanical stresses in photo-elastic coating. It was proven through simulation and experimentally the ability to accurately measure isochromatic and isoclinic phase maps, which give the locations of points with a constant principal stress difference and, accordingly, a constant principal stress direction [A5].

3. It is demonstrated experimentally the ability of the dynamic speckle technique to detect a change in the rate of processes following a change in humidity and a chemical effect on plant leaves in two test experiments. The analysis of time-varying speckle patterns is introduced as a non-destructive sensing technique to determine this effect. The characterization of the samples is performed in parallel over their entire surface with high spatial and temporal resolution [A6].

4. The potential of dynamic speckle analysis as an effective means of nondestructive, *in-situ* monitoring the cooling and aging process of bread and the ability of this approach to distinguish between different types of bread was confirmed. A temporal structure function was used to estimate activity from speckle images recorded sequentially over several days [A7, A8].

5. Based on dynamic speckle methods a diffusely reflective object was studied and an approach to improve the visualization of areas of slower or faster changes on the surface was proposed. The approach is based on an exponentially decreasing temporal correlation function of the intensity fluctuations. The approach is validated by a paint drying experiment, where using the temporal correlation function at a given point the activity was estimated quantitatively [A9].

4.2. The major scientific contributions in the publications outside the habilitation thesis (Group D) are as follows:

I. Numerical methods for the analysis of data from dynamic speckle measurements [B1-B8].

1. The workability to compress data in dynamic speckle analysis by coarser quantization of the raw speckle images was proposed and proven. Quantization level reduction before statistical processing was proposed in order to reduce computational complexity. The effectiveness of such speckle image compression was investigated by analyzing output data obtained for a synthetic digital object under ideal conditions of uniform illumination and uniform reflectance and for a test object when ideal conditions were not met. Both normalized and non normalized algorithms were applied and quantization up to 32 levels was found to cause no distortion in the resulting activity map. The coarse intensity quantization in dynamic speckle analysis was verified. For low-contrast images, the intensity distribution is symmetric and uniform quantization works well. For high-contrast images, the intensity distribution is highly asymmetric and uniform quantization is not appropriate. Nonuniform quantization by logarithmic transformation of captured images has been introduced, resulting in activity map quality comparable to that of low-contrast images. These results have been confirmed experimentally [B1,B2].

2. Point-wise processing of the dynamic speckle patterns was proposed, thus high spatial resolution achieved. The evaluation is performed by calculating the time correlation and structure functions. The variance estimate is used for normalization. Introducing a time lag in the evaluation of the correlation results in a more contrast two-dimensional map for the spatial characterization of the activity. In addition, the point-wise normalization of the evaluation provides a reliable result for the most common case of non-uniform intensity distribution within the illumination beam and varying reflectance on the surface of the specimen. These conclusions are proven by simulation and experiment for the normalized time correlation and structure functions [B3, B4].

3. A dynamic speckle analysis method for non-destructive detection of physical or biological activity by binarization of speckle images was proposed. It was proven, by simulation and experiment that the polar correlation function calculated from binary data effectively shows the regions of different activity under both uniform and non-uniform intensity distributions in the illuminating laser beam without normalization [B5, B6, B7].

4. A method is proposed to improve the quality of determining the two-dimensional speed distribution (activity map) of processes occurring in diffusely reflecting objects from changing speckle pictures, on their surface by filtering this distribution. The signal-dependent nature of the fluctuations was proven by analyzing the statistics of fluctuations in the activity maps constructed for three temporal structure function. Bilateral Gaussian kernel filters were applied to the activity maps. Improved the contrast and resolution of the activity map by filtering and greatly facilitated the two-dimensional quantification of short-term activity changes [B8].

5. Phase spatial light modulator (SLM) was used as an optical simulator of speckle patterns with controllable spatially varying time evolution in order to test algorithms in dynamic speckle metrology of physical or biological activity. The feasibility of SLM testing of algorithms in dynamic speckle analysis was confirmed [B9, B10].

6. The normalized scores in dynamic intensity-based speckle analysis when processing speckle images of non-uniform illumination of the specimen was explored. Modifications of algorithms that use the instantaneous sum of two intensity values or a single intensity for normalization have been proposed. The performance of these algorithms was verified to simulated low- and high-contrast speckle data for processing binary and compressed images. Dotted algorithms, in which normalization is performed at each time point using one or two intensity values, have been shown to be more efficient than algorithms applying time-averaged estimates of the mean and variance of speckle intensities [B11].

II. Profilometric methods for remote shape determination and visualization of three dimensional objects [B12-B13].

1. The design of a sinusoidal phase grating for sinusoidal fringe projection profilometry was studied. Distortions in the projected fringes due to phase quantization when the phase grating is generated by an 8-bit phase modulator were analyzed. It was shown by free-space propagation simulation that the intensity fluctuations of the projected fringes cover an interval of 4–5 levels if a modulator with a 2π phase range is used. It was shown that there can be distortion due to the phase encoding of the complex amplitude of the grating, modeled as gamma distortion with time-invariant behavior at small values of the modulation parameter. Experiments were performed with an 8-bit spatial light modulator with $\pi/2$ phase range, which confirmed the ability of this optical element to project sinusoidal fringes with high spectral purity [B12].

2. The reduction of speckle noise in fringes projected by a sinusoidal phase grating via a spatial light modulator and low-coherence point light source was experimentally proven [B13].

III. Monitoring and control of drying processes through dynamic speckle analysis [B14-B15].

The dynamic speckle technique for monitoring the drying process of azopolymer solutions was implemented. Changes over time in azopolymer solution's drops of different sizes were demonstrated by constructing two-dimensional maps of a given statistical estimate. Time scales of the drying process were determined by tracking the time change of the correlation radius of the intensity fluctuations within the speckle fields of surface of the object [B14, B15].

5. CONCLUSION

In conclusion, after thorough study of documents and materials submitted by Assistant Professor Dr. Branimir Ludmilov Livanov for the purpose of this competition, reading of the publications and personal scientific contributions, required indicators for research achievements, as well as the entire research activity of the candidate, I can tell with high degree of certainty that the quality and the volume of his the research work are on excellent level and fully meet the minimum requirements of ADASRD, BAS and those of IOMT-BAS for the academic position „Associate Professor". I have no doubts of plagiarism in the presented materials.

On the basis of all the above, I give my positive assessment and confidently recommend to the honorable Scientific Jury to support the application of Dr. Branimir Ludmilov Livanov and to propose to the Scientific Council of IOMT - BAS to award Dr. Branimir Ludmilov Ivanov the academic position "Associated Professor" in professional field 4.1. Physical sciences.

Sofia, 31.01.2023

Written by:

/Assoc. Prof. Dr. Violeta Madjarova/