JOINT ELECTRICAL & COMPUTER ENGINEERING AND PHYSICS COLLOQUIUM

"Speckle Statistics, Coherence, and Polarization of a Collisional Soft X-Ray Laser"

by

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Abstract: Plasma-based, transient-inversion X-ray lasers work nearly exclusively in the mirrorless arrangement using amplified spontaneous emission (ASE) as the energy extraction mechanism. Due to a very high gain coefficient the present-day X-ray lasers work even more readily in the ASE regime. One of the distinguishing effects of ASE-based lasers is presence of speckle - deep and random modulation of the intensity distribution in the output beam, giving a kind of granular structure.

We are presenting analysis, whether the observed in the output intensity inhomogeneity is really a classic speckle structure and undergoes well established statistical rules of the speckle-related phenomena [1]. Using results of this analysis the features of the transverse coherence of the X-ray laser output will be discussed and a simple model of the speckle structure origin in the X-ray laser output beam will be proposed. This will be related to the developed in 90's theory of the modal structure.

Considering a single-mode dynamics of the photon flux build-up from noise to saturation in terms of the Maxwell-Bloch equations it was found that the stimulated emission process is responsible for a strong increase in well-defined polarization state. The saturation process reduces this state due to mixing the quantum states involved in the transitions [2]. This effect is limited to a single shot and the polarization state changes randomly from shot-to-shot. This result caused our interest in the experimental confirmation of the increase in the well-defined polarization state of the output radiation. In the joint experiment at JAEA a double-target arrangement was used to generate coherent X-ray radiation at 13.9 nm and those was subsequently analyzed by a membrane/multilayer beam-splitter allowing quantitative distinguishing between the "amount" of *s*- and *p*-polarized

components in the output radiation. The results of this experiment and some theoretical analysis will be included. Surprisingly, overwhelming dominance of the *p*-polarization in the output radiation was stated in the conducted measurements. This is in contradiction to all previous measurements.

1. J. W. Goodman, "Statistical Properties of Laser Speckle Pattern" in "*Laser Speckle and Related Phenomena*", J. C. Dainty ed.,Springer Verlag Berlin, 2nd edition (1984)
2. C. M. Kim, J. Lee, K. A. Janulewicz, Phys. Rev. Lett. 104, 053901 (2010)
3. T. Kawachi et al., Phys. Rev. Lett. 75, 3826 (1995)

Biography: Prof. Janulewicz received his M.Sc. and PhD both in Quantum Electronics from the Warsaw University of Technology, Poland. During 1976-1988 he was a Senior Research Fellow (group leader at the Institute of Plasma Physics and Laser Microfusion in Warsaw, Poland, and during 1988 – 1990 he was a Research Fellow with the Dept. of Electronics, Warsaw University of Technology, Poland. From 1994-1996 he was a Research Fellow at the Dept. of Physics, University of York, UK; in the group of Prof. G.J. Pert . In 1997 he moved to the Max Born Institute in Berlin, Germany, where he remained as Project Leader until 2008. Since then he is an Associate Professor at the Advanced Photonics Research Institute of the Gwangju Institute of Science and Technology in Korea. Prof. Janulewicz major areas of research are laser physics, specifically X-ray laser physics; interaction of strong optical fields with matter, plasma dynamics and kinetics, especially as a source of coherent short-wavelength radiation and accelerated particles, numerical modelling of interaction processes; application of short-wavelength radiation

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