Brillouin-induced polarization pulling in single-mode optical fibers, with applications to sensing

Tel-Aviv University, ISRAEL

Moshe Tur
Email: tur@tauex.tau.ac.il

Behind one of the most successful fiber-optic distributed sensing techniques stands the Brillouin effect. In both Brillouin Optical Time Domain Analysis (BOTDA) and Brillouin Optica Time Domain Reflectometry (BOTDR) classical sensing is based on the value of frequency where the Brillouin Gain Spectrum attains its peak value. This value, the Brillouin Frequency Shift (BFS), being sensitive to both strain and temperature, is what makes Brillouin fiber optic sensing so important and useful. Clearly, any physical effect that influences the BFS, other than the measurand of interest, inherently degrades the measurement accuracy. Here comes the effect of Polarization Pulling (PP), which refers to the phenomenon where the state of polarization (SOP) of the probe(s) or pump waves becomes biased or aligned due to the interaction with the stimulated Brillouin scattering (SBS) process, particularly in fibers with random birefringence. Indeed, a few years ago, it was discovered that in Brillouin scenarios where a pump wave propagates against counterpropagating probe wave(s), their interaction involves not only gain (or loss) but also strong pulling of the probe(s) SOP towards an SOP related to that of the pump. This phenomenon has been harnessed, for example, to improve the resolution of optical and RF spectrum analyzers. This lecture will address recent studies of *pulse*-based classical BOTDA setups which mitigate pump depletion and polarization fading by sequentially launching two orthogonal pairs of parallel gain and loss probes against a single pump. It is experimentally observed and numerically simulated that PP introduces noise into the Brillouin Gain Spectrum, potentially degrading the measurement signal to noise ratio. Also discussed is a BOTDA setup where the gain and loss probes are orthogonal, rather than parallel. While preliminary experiments are supported by a detailed numerical model, its validity remains contingent on additional experimental verification. Possible implications and applications will be mentioned.

Moshe Tur received the B.Sc. degree in Mathematics and Physics from the Hebrew University, Jerusalem, Israel (1969), the M.Sc. degree in Applied Physics from the Weizmann Institute of Science, Rehovot, Israel (1973), and his Ph.D. from Tel-Aviv University, Tel-Aviv, Israel (1981). After spending two years at Stanford University (Information Systems Laboratory and Ginzton Laboratory), researching innovative fiber-optic technologies, he joined (1983) the Faculty of Engineering at Tel-Aviv University, becoming a full Professor in 1991. There, he has established an advanced fiber-optic sensing and communication laboratory. He authored or co-authored more than 900 journal and conference technical papers with emphasis on fiber-optic sensing (mainly in Structural Health Monitoring, using static and dynamic fiber Bragg gratings, as well as the Brillouin and Rayleigh effects), advanced fiber-optic communication systems, polarization pulling, polarization mode dispersion, phase noise and microwave photonics.

Prof. Tur is currently an active Professor Emeritus at Tel-Aviv University.

Prof. Tur has been involved in many international collaborations with leading universities and industries worldwide and participated in quite a few European Projects and activities.

Dr. Tur is a Fellow of Optica (the Optical Society of America) and a Life Fellow of IEEE. In September 2018, he was presented with a Life-Time Achievement Award by the International Optical Fibre Sensor Community for his outstanding contributions.