2[nd] URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Absolute Wavelength Photonic Time Stretch Spectroscopy

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In applications such as data communication, medicine, sensing and scientific research, communication signals and phenomena of interest occur on time scales too rapid and at throughputs too high to be sampled and digitized in real time. The future of telecommunications, switching networks, biomedical imaging, and remote sensing with ever-increasing the required speed of capturing, processing and computing is demanding for high speed and high-throughput signal processing units. Photonic-based real-time instruments are the promising candidates for this severe problem, they are capable of operating on signals at Terahertz speeds. To give some examples, the record throughput of recently developed instruments such as MHz-frame-rate brightfield cameras, ultra-high-frame-rate fluorescent cameras for biological imaging, and wideband photonic-assisted analog to digital conversion has enabled the discovery of optical rogue waves, the detection of cancer cells in blood with sensitivity of one cell in a million and demonstration of ADCs with 1 Tera bits per second sampling rate.

Time stretch dispersive Fourier transform (TS-DFT) is a spectroscopy technique that uses optical dispersion to decompose the light wavelengths and analyze the optical spectrum in real-time. TS-DFT employs a large group-velocity dispersion (GVD) to transform the spectrum of a broadband optical pulse into a time stretched temporal waveform. TS-DFT can perform Fourier transformation on optical signals in single-shot at ultrahigh high frame rates for real-time analysis of fast dynamic processes.

One of the critical drawbacks of the conventional TS-DFT method for time stretch spectroscopy is that it does not provide absolute wavelength information, i.e. it only provides the signal spectrum information with relative wavelength information. In many applications of interest, the signal spectrum with absolute wavelength information is necessary. To give an example, in gas absorption spectroscopy, absolute wavelength information is essential for detection of the position of each absorption line. Another example application is laser transients in nonlinear optics or during the mode locking phenomenon. In this type of applications, reliable pulse synchronization process is not possible using relative wavelength information. This is because dramatic pulse to pulse changes do not allow for proper synchronization in these applications. In this work, I present the latest developments and techniques in the techniques for absolute wavelength photonic time stretch spectroscopy. I also present some relevant results for absolute wavelength photonic time stretch spectroscopy.