The INCIPIT project aimed at the development of new experimental methods and systems for the characterization of ultrashort optical pulses. As requested for the development of new techniques and apparatus for such pulse characterization, the project targeted the study of nonlinear effects and interactions in integrated waveguides (and guiding structures at large) within optical platforms, which forms the basis of ultrafast pulse characterization techniques and related architecture designs. All aspects of the project aimed at expanding Dr Wetzel knowledge and scientific output to ensure his international visibility and successful career development as an independent researcher.

Over the three-year period of the INCIPIT project, Dr Wetzel characterized already available photonic waveguide samples and worked on the design of improved nonlinear waveguides allowing for direct pulse splitting and nonlinear frequency mixing on an integrated optical chip. This approach led to the implementation of a versatile photonic chip prototype, enabling the generation of up to 256 optical pulses replica with duration in the hundreds of femtoseconds regime and delay as low as 1 picosecond. This system allows for controlled optical pulse splitting with tuneable relative delay, power and phase difference, and foreseen as a key component in the development of advanced optical pulse characterization techniques and novel light source systems (e.g. mode-locked lasers, tuneable supercontinuum source).

Figure 1 : Photograph of the integrated photonic chip used in the developed prototype.

During this project, Dr Wetzel also studied various associated aspects of nonlinear optical pulse propagation dynamics and characterization techniques, as well as applications in related domains of Photonics such as quantum optics. These studies are at the core of the INCIPIT project, directly driven by the need of a better understanding of the underlying physical processes at the basis of ultrafast and nonlinear integrated optics. Among others, Dr Wetzel studied the propagation dynamics of light in integrated waveguide resonators which led to the realization of “on-chip” optical frequency combs [3,4,7], bi-chromatic optical parametric oscillator [1] and the generation and manipulation of versatile quantum state of light [10, 11, 14, 15] as well as the implementation of a mode-locked laser with a record-low spectral bandwidth (e.g. as required for numerous molecule excitation techniques and sensing applications) [9]. Similarly, studies of peculiar nonlinear processes relying on advanced optical pulse characterization techniques have been carried out, including the first experimental demonstration of controllable Riemann wave evolution in a physical system [5], the experimental observation of frequency combs spectral self-imaging using a Talbot effect [2], or even the first real-time measurement of so-called “optical rogue waves” here obtained using an integrated time-lens approach [8]. Additional study of nonlinear spatio-temporal optical effects directly in line with the project were also realized, such as the demonstration of Cherenkov radiation and Airy bullets control and reshaping [6,12,16].

Overall, the INCIPT project has already led to 16 publications among the most prestigious journals (including Nature, Science, Nature Photonics, Nature Communications, Physical Review Letters, etc.) as well as over 60 conference contributions. The obtained results are key achievements in the study of complex and fundamental nonlinear dynamics which are of interest for the broader scientific community. In addition, the methods and systems established throughout the INCIPIT project are foreseen as important assets for further developing disruptive light sources and advanced optical characterization techniques with direct applications in e.g. biomedical imaging, sensing, metrology, quantum computing, etc. The potential commercial exploitation of the developed foreground is under consideration, while the intellectual property related to the proposed systems, techniques and architectures have been protected.

More information can be found in the project website: http://incipit.scienceontheweb.net/

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