Tunable Femtosecond Pulses *Via* Dispersive Wave Generation in Optical Systems

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The efficient generation of tunable femtosecond pulses is critical for advancing ultrafast optics and its applications in spectroscopy, microscopy, and nonlinear light-matter interactions. Conventionally, tunable femtosecond pulses are achieved using optical parametric amplifiers or filtered supercontinuum sources. However, these methods often suffer from drawbacks such as system complexity, bulky setups, and low overall efficiency. Soliton dynamics, paired with resonant dispersive wave (RDW) generation, offer an elegant alternative technique to produce tunable femtosecond pulses in a compact and efficient manner.

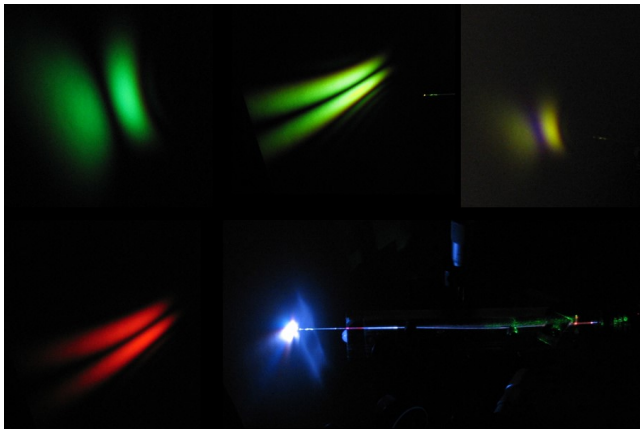

Figure 1: Tunable fs RDW generated after a piece of PCF pumped by a mode-locked Ti:Sapphire laser

This talk explores two innovative RDW-based approaches to generate tunable femtosecond pulses: (1) intracavity manipulation in a mode-locked Ti:Sapphire oscillator and (2) phase-matched nonlinear interactions in photonic crystal fibers (PCFs). The first method demonstrates that higher-order dispersion within a mode-locked Ti:sapphire laser can produce RDWs at tunable wavelengths. By precisely adjusting intracavity group-delay dispersion, a dual-soliton regime was achieved, with spectral separation adjustable over 1,200–2,200 cm^{-1}, providing a compact and efficient solution for multi-wavelength femtosecond light sources. The second approach utilizes PCFs, which offer unparalleled control over group velocity dispersion. Pumping with a simple Ti:sapphire oscillator, RDWs are generated, achieving octave-spanning pulses and a visible-to-infrared transition. This compact system is highly efficient, with RDWs comprising over 10% of the output power. Autocorrelation measurements validate the femtosecond duration of the output pulses, and simulations elucidate the role of guiding geometry and nonlinear interactions in spectral tuning.

By combining engineered dispersion with soliton physics, RDW offers a scalable, efficient pathway for creating tunable ultrafast light sources. Future work will explore extending these methods to mid-infrared wavelengths and chip-integrated systems for portable ultrafast applications.

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References

[1] J Peng and A V Sokolov, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies OSA Technical Digest (CD) (Optica Publishing Group, 2008), paper CthE6 (2007)

[2] J Peng and A V Sokolov, Joint Fall Meeting of the Texas Sections of the APS and AAPT, p. F3 (2007)

[3] J Peng, F Zhu and A V Sokolov, Opt. Lett. **33**, 1620 (2008)

[4] F Benabid, F Biancalana, P S Light, F Couny, A Luiten, P J Roberts, J Peng and A V Sokolov, Opt. Lett. **33**, 2680 (2008)

[5] J Peng, Tunable femtosecond pulse generation and applications in Raman micro-spectroscopy. Texas A&M University (2009)

[6] J Peng, Ai V Sokolov, F Benabid, F Biancalana, P S Light, F Couny and P J Roberts, Phys. Rev. A **81**, 031803(R) (2010)

[7] J Peng, F Zhu, F Benabid and A V Sokolov, Opt. Lett. **36**, 891 (2011)

[8] T Cao, M Liu, C Xu, J Yan, C Shen, S Liu, H Peng, J Peng and A V Sokolov, Sci. Rep. **8**, 181 (2018)