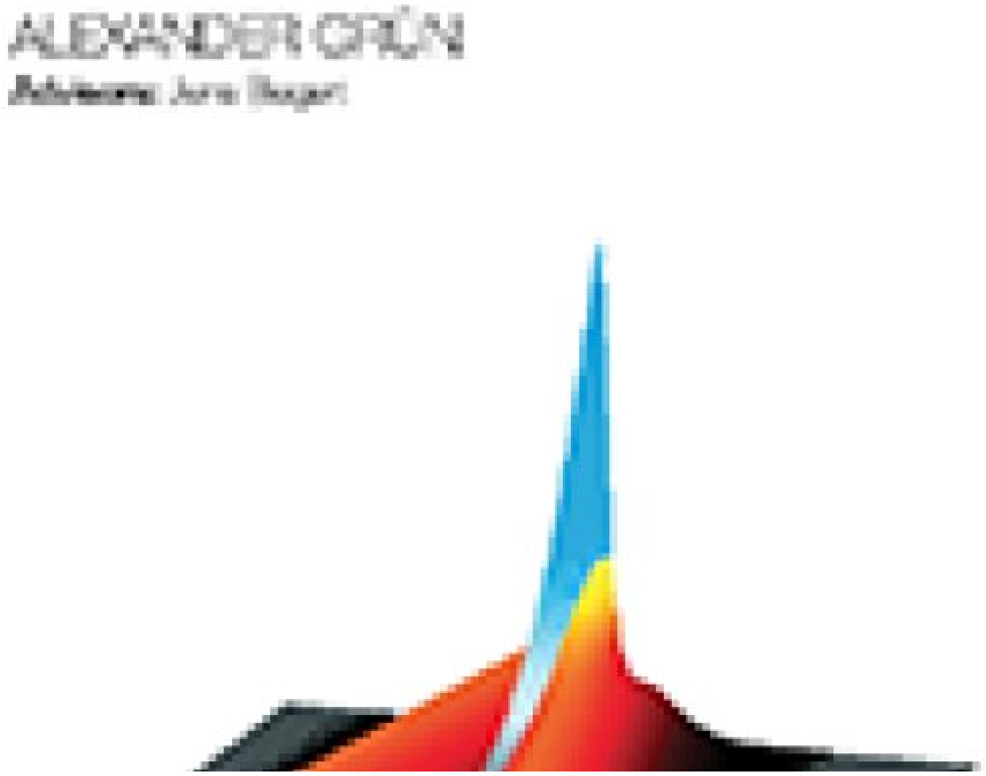

PhD Thesis Defense ALEXANDER GRUN 'Nonlinear Pulse Compression'

ALEXANDER GRUN

November 14, 2014

Friday November 14, 11:00. ICFO Auditorium

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Attoscience and ultrafast optics

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In this thesis I investigate two methods for generating ultrashort laser pulses in spectral regions which are ordinarily difficult to achieve by the existing techniques. These pulses are especially attractive in the study of ultrafast (few femtosecond) atomic and molecular dynamics.

The first involves Optical Parametric Amplification (OPA) mediated by four-wave-mixing in gas and supports the generation of ultrashort pulses in the Near-InfraRed (NIR) to the Mid-InfraRed (MIR) spectral region. By combining pulses at a centre wavelength of 800 nm and their second harmonic in an argon-filled hollow-core fibre, we demonstrate near-infrared pulses, peaked at 1.4 m, with 5 J energy and 45 fs duration at the fibre output. T
e four-wave-mixing process involved in the OPA is expected to lead carrier-envelope pha
e stable pulses which is of great importance for applications in extreme nonlinear optics. The
e NIR to MIR pulses can be used directly for nonlinear light-matter interactions making use
f its long-wavelength characteristics.

The second method allows the compression of intense femtosecond pulses in the ultraviolet (UV) region by sum-frequency mixing two bandwidth limited NIR pulses in a noncollinear phasematching geometry under particular conditions of group-velocity mismatch. Specifically, the crystal has to be chosen such that the group velocities of the NIR pump pulses, v1 and v2 , and of the sum-frequency generated pulse, vSF, meet the following condition, v1 < vSF < v2. In case of strong energy exchange and an appropriate pre-delay between the pump waves, the leading edge of the faster pump pulse and the trailing edge of the slower one are depleted. This way the temporal overlap region of the pump pulses remains narrow resulting in the shortening of the upconverted pulse. The noncollinear beam geometry allows to control the relative group velocities while maintaining the phasematching condition. To ensure parallel wavefronts inside the crystal and that the sum-frequency generated pulses emerge untilted, pre-compensation of the NIR pulse-front tilts is essential. I show that these pulse-front tilts can be achieved using a very compact setup based on transmission gratings and a more complex setup based on prisms combined with telescopes. UV pulses as short as 32 fs (25 fs) have been generated by noncollinear nonlinear pulse compression in a type II phasematching BBO crystal, starting with NIR pulses of 74 fs (46 fs) duration. This is of interest, because there is no crystal that can be used for nonlinear pulse compression at wavelengths near 800 nm in a collinear geometry. Compared to state-of-the-art compression techniques based on self-phase modulation, pulse compression by sum-frequency generation is free of aperture limitation, and thus scalable in energy. Such femtosecond pulses in the visible and in the ultraviolet are strongly desired for studying ultrafast dynamics of a variety of (bio)molecular systems.

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