Project title: Induced infrared ultrashort pulse generation in guided media.

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Abstract:
In unpublished work by D. Faccio, they combined a strong pump pulse at 800nm and a week seed pulse at 400nm inside a cylindrical glass capillary filled with Argon to produce a signal pulse at 1300-1400nm. In a gaseous media in free space this effect is not seen because the predicted signal pulse is the DC component. Nonlinear effects (which have not been precisely determined, possibly including: phase matching geometric effects, cross phase modulation and plasma frequency shifting) are required to modify the phase matching to generate the signal pulse in the IR regime. By using ultrashort pulses, this process can potentially be used for create intense few cycle pulses in the IR spectrum.

The aim of the project is to introduce students to the mathematics and physics of nonlinear light propagation. Upon doing so, the students will analytically and numerically study the four wave mixing process to produce infrared pulses in guided media. To achieve this goal, one must:

a) Understand the linear EM wave solutions in cylindrical and planar geometry [1].

b) Understand the nonlinear optical properties, specificially Kerr polarization and plasma multiphoton ionization [2].

c) Understand how and when to use the unidirectional pulse propagation equation numerical software [3].

d) Investigate the infrared generation process.

Project development schedule

The project assumes that the team members will be able to run and understand the basics of the software, see ref. , within the first two weeks of the project. Also in the first two to three weeks, the geometry specific electromagnetic solutions (linear) and the effects of relevant nonlinear terms will be learned. Currently, numerical based software is running on parallel configurations on the ACMS machines. The remaining time will then be devoted to the study and documentation of the results.

References

A detailed description of nonlinear propagation in a capillary.
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Breif introduction to the physical effects of nonlinear optics.
[2] D. Faccio, A. Couairon, P. Di Trapani. *Conical Waves, Filaments and Nonlinear Optics*. Italy: Aracne 2007.

Overview of the numerical scheme and other propagation methods in nonlinear optics.
[3] M. Kolesik and J.V. Moloney, "Nonlinear optical pulse propagation simulation: From Maxwell's to unidirectional equations", **Phys. Rev. E, 70, (2004).**

Reference book on electrodynamics. Particularly boundry value problems in electrodynamics in cylindrical geometry.
[4] J.D. Jackson, *Classical Electrodynamics*. USA: Wiley, 1999.