Handling supercontinuum in the femtosecond regime by spectra generation and by optimization with genetic algorithms

M.Eng. Francisco R. Arteaga-Sierra

Photonics Division

Center for Research in Optics

Thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Science (Optics)

León, Guanajuato, México, November 2014.

Supervisors

Ph.D. Ismael Torres-Gómez, Center for Research in Optics

Ph.D. Miguel Torres-Cisneros, University of Guanajuato

Day of the defense: Nov 7, 2014.

Abstract

Supercontinuum generation has been the subject of extensive studies in optical fibers and its special spectral shapes are of many interest for a variety of applications. For input pulses in the femtosecond regime, the dynamics of supercontinuum generation generation can be broadly decomposed into two phases: an initial fission into an N soliton dominated by the Kerr effect and second order dispersion; and a subsequent redistribution of spectral energy where the Raman effect and higher dispersion orders also play a role. In this work, these two phases are exploited to numerically handle the spectral output in order to adequately apply the supercontinuum generation phenomenon to medical image techniques, specifically, optical coherence tomography. The First part is focused on the development of methods that use the properties of dispersive waves and the soliton self-frequency shift to obtain simultaneous spectral peaks tuned on specific frequencies, both of them sited on after the initial-fission scenario. Additionally, it is shown a method to obtain an ultra-flat spectrum based on self-phase modulation. The last effect is sited on before the initial-fission scenario. Based on these methods, the results of this thesis show that supercontinuum spectral output can be tailored to bell-shaped pulses to optical coherence tomography applications, ultra-flat to telecommunications or any proposed spectral forms (conditions permitting), resulting in a useful tool with great potential for many practical areas.

I would like to thank...

to God to give me health and well-being in everything I do, to my Parents; Francisco Arteaga-Peñaloza, María Guadalupe Sierra-Medina, to my brothers; Benjamín Antonio, Samuel and my sister Olivia Viridiana because their unconditional support every time, and I would like to thank with all my love to Helena Estefanía for sharing wonderful moments.

I would like to thank to Ph.D. Ismael Torres-Gómez and my always mentor Ph.D. Miguel Torres-Cisneros for being great advisors, for their patient reviewing my thesis and my work. I also would like to thank to Ph.D. Carles Milián, his ideas and tremendous support has the major influence on this thesis, he spent a lot of time helping me.

My thanks to Ph.D. Albert Ferrando for being a great collaborator, I learned a lot during my stand in his research group "Intertech" in Spain. I am convinced that all these knowledge will help me in the future like it did in this work.

At last but not least, I wish to thank my friends and colleagues in the Center for Research in Optics (México) and Universitat Politècnica de València (Spain) for the great moments that we had in all this time. I enjoyed the atmosphere, their friendship, and their support.

Thank you everyone.

Acknowledgements

TO THE INSTITUTIONS THAT SUPPORTED MY STUDIES

Thanks to the CONACYT for the support granted to the scholarship holder, Francisco Rodrigo Arteaga Sierra, under the number of registry 207588, during the period September-2009 to August-2013.

Thanks to the CONCyTEG and DAIP-UG for the scholarship-mix granted to Francisco Rodrigo Arteaga Sierra during the period September-2013 to August-2014, through the partial funding provided by the projects CONCyTEG (GTO-2012-C03-195247) and DAIP-UG 382/2014.

Thanks to the project: Fabricación y aplicación de fibras de cristal fotónico para fuentes de luz supercontinua (106764: CONACYT, CB2008) by the provided partial support.