Announcing the Final Examination of Zeinab Sanjabieznaveh for the Degree of Doctor of Philosophy in Physics

Date: Tuesday, March 07, 2017
Time: 10:00 a.m.
Room: CREOL, 103
Dissertation title:
High Power Fiber Lasers and Fiber Devices

Abstract:

Fiber lasers and fiber amplifiers have experienced considerable improvements in recent years and demonstrated remarkable power scalability. However, due to high optical intensity in the core, the performance of high power fiber lasers is limited by detrimental nonlinear processes, such as four-wave mixing, self-phase modulation, stimulated Brillouin scattering, and stimulated Raman scattering. To mitigate nonlinear effects, very large mode area (LMA) fibers, which exhibit a mode field diameter larger than 30 μm have been developed. However, for larger core sizes the discrimination capabilities of conventional fiber designs decrease, consequently, LMA fibers are not strictly single mode which ultimately at high average powers results in sudden degradation of the output beam of a fiber laser or amplifier, namely, modal instability (MI). To suppress higher order modes (HOMs) in LMA fibers, various techniques have been proposed such as large pitch fibers (LPFs), differential bend loss for HOMs, leakage channel fibers, mode filtering with tapers, and chirally coupled cores.

This thesis is divided into two parts. In the first two chapters, I focus on simulation, design and characterization of advanced high power fiber amplifiers. In the first chapter, I present numerical simulations of the MI effect in active LMA fibers. Using a high fidelity time dependent computer model based on beam propagation method (BPM), taking laser gain and thermal effects into account, I show that engineering pump scheme is a promising technique leading to an appreciable threshold increase in a fiber amplifier. As an example I demonstrate that bi-directional pump scheme increases the instabilities threshold by a factor of ~30% with respect to the forward pump configuration.

In the second chapter, I present a novel design of microstructured large pitch, LMA asymmetric rod-type fiber to achieve higher MI threshold. By eliminating mirror symmetries in the cladding of the LPF through six high refractive index germanium-doped silica inclusions, we reduce the overlap of the LP1m-like modes with the core region, which leads to strong HOM delocalization and enhanced preferential gain for the fundamental mode in active fibers.

The third and fourth chapters of this thesis are focused on all-fiber mode multiplexers for communication applications. In the third chapter, I present an all-fiber mode selective photonic lantern mode multiplexer designed for launching into few-mode multicore fibers (FM-MCFs). This device is capable of selectively exciting LP01, LP11a and LP11b modes in a seven core configuration resulting in 21 spatial channels, with less than 38 dB crosstalk and with insertion loss below 0.4 dB. This device can be a critical component for the evolution of high capacity, high-density space division multiplexing (SDM) transmission networks based on MCFs.

In the fourth chapter, I demonstrate for the first time, an all-fiber orbital angular momentum (OAM) mode multiplexer to efficiently generate and simultaneously multiplex multiple OAM modes within a broad spectral range of at least 550 nm. This innovative all-fiber passive design provides simultaneous multiplexing of multiple orthogonal OAM modes in a single fiber device with low loss and at low design complexity, therefore, it is of grand utility in variety of applications in classical and modern optical studies.

Outline of Studies:
Major: Physics

Educational Career:
M. S. University of Shahid Beheshti, Tehran, Iran
B. S. Teacher Training University, Tehran, Iran

Committee in Charge:
Dr. Rodrigo Amezcua Correa (Chair)
Dr. Zenghu Chang
Dr. Luca Argenti
Dr. Axel Schulzgen

Dr. Martin Richardson (External Committee Member)
Approved for distribution by Dr. Rodrigo Amezcua Correa, Committee Chair, on Feb 22, 2017.

The public is welcome to attend.