Università di Genova

Dipartimento di Fisica

ISTITUTO ITALIANO DI TECNOLOGIA OPTICAL NANOSCOPY

2019
2020

Annual PhD Report
PhD Course in Physics and Nanosciences
Curriculum Bio-Nanosciences

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Research Activity

I am carrying out my PhD research activity in the Nanoscopy&NIC Lab@IIT and my work concerns the improvement and the optimization of the illumination stage in a multimodal microscopy setup, known as Multi Messenger Microscope. This project aims to integrate several microscopy-imaging techniques in the same optical setup in order to realize a versatile instrument with tunable resolution and contrast formation mechanism.

Currently, I am studying the best strategies and methods to deal with polarization control of the laser beam so that we can able to project it properly for the polarization-based microscopy such as Circular intensity differential scattering (CIDS) and Mueller Matrix Microscopy. Particularly, I am developing a Zeeman Laser source, this device is able to generate a dual-polarization output associated to slightly different optical frequency. In Fig.1a is shown the Zeeman Laser System which I am developing. It is a Helium-Neon Laser tube consisting of a thin capillary containing the gas mixture, the resonator ending mirrors and the contact for the High Voltage Power Supply, is inserted in a custom mechanical holder. The support gives the laser source mechanical stability and the seats for positioning the magnetic bars that generate the longitudinal magnetic field. In a Longitudinal Zeeman Laser, the external magnetic field is applied parallel to the cavity axis and because of this, it is able to emit two orthogonal circular polarization states. The interest in this particular kind of emission is related to the CIDS (or m03 Mueller Matrix element) signal. It is the Circular Intensity Differential Scattering response of a medium interacting with Right and Left Circularly Polarized light. Therefore, this suggest that a laser source experiencing the Zeeman Effect can be effectively exploited in polarization-based microscopy techniques. This method can allow reaching modulation frequency of the polarization state in a range between hundreds of kHz and few MHz, depending upon the intensity of the applied magnetic field in the laser active medium. In the device I'm using it has been observed a frequency component moving approximately between 550 kHz and 700 kHz, as one can see in Fig.1b. This line represents the modulation frequency introduced by the beating of the two slightly separated optical components because of the Zeeman Effect. Its sweeping is due to the instability introduced by the thermo-mechanical expansion of the cavity length because of the heating dissipation that occurs during the pumping process of the laser.

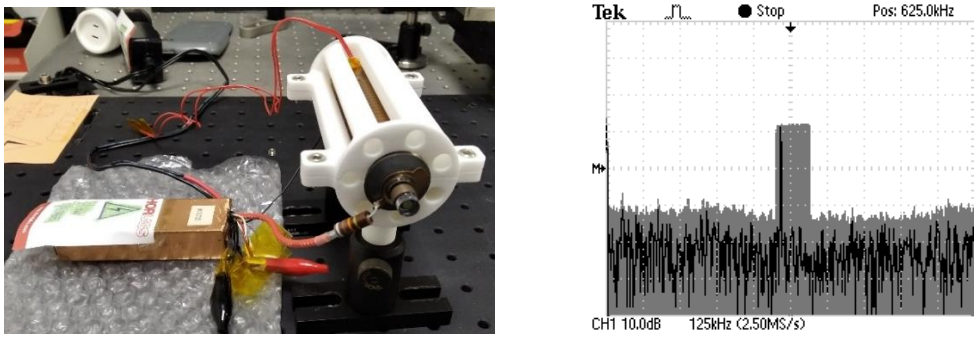

Figure 1. a (left) - Experimental Setup of the Zeeman Laser Source showing its main stages; the high voltage power supply, the laser tube acting as optical oscillator and the mechanical holder containing the magnets needed to excite the Zeeman Effect. b (right) - Spectral measurements of the laser emission at infinite persistence; the black line represents the position of the modulation frequency generated by the Zeeman Effect, whereas the gray faded trace is showing the frequency range among which the sweep of that modulation line had place

Obviously, the device needs further improvement in order to stabilize its optical emission in terms of both the amplitude and the frequency of the beating signal coming from the detection of the two optical components generated by the Zeeman Effect in the active medium.

Courses and Exams

1st Year	Course	Teacher	Hours	PhD Course	State
1	Electronics and Data Acquisitions	Fontanelli, Musico		DIFI	Done
2a	Advanced Optical Fluorescence Microscopy Methods	Bianchini, Diaspro	12	DIBRIS	Done
2b	Fluorescence Super-Resolution Microscopy: Basis, Applications and Perspectives	Vicidomini	9	DIBRIS	Starting Date (Updated): 17.09.202 State: In progress
3	First Order Optical System Design	A.Sullivan, R.McLeod	21	University of Colorado Boulder - Coursera	Done

School and Conferences

- CLEO 2020 (Conference on Lasers and Electro–Optics, 11-15 May 2020, online)
  This Conference offered several talks about innovative advances, research and new technologies on all the aspects of electro-optic technologies, having applications in a number of fields, from biophotonics to advanced manufacturing, telecommunications, and autonomous vehicles industry.

- StarTime (Orientamento all'AutoImprenditoria, 3-5 June 2020, online)
  In this web-event, I had the chance to follow seminars on several topics related to the first stages of a business idea and start-ups, like drafting of business-plans, pitch presentations, orientation to intellectual property, grants, incentives and funds. Beyond to these lessons, the participants were involved in team projects works with the aim to prepare an effective pitch presentation of a business idea.

- e-THE (e-Workshop on High Tech Entrepreneurship, 1-8-15 July 2020, online)
  This online workshop is addressed to who are keen to explore the commercial potential of technologies and scientific projects they are working on. These seminars dealt with the principal aspects of the business model, fundraising and intellectual property, in order to give a first overview to those would like to bring innovative business idea in the high-tech sector.

- ELISS2020 (Extreme Light Infrastructure Summer School, 26-28 August 2020, online)
  The main goal of ELISS is to provide a comprehensive overview of the generation and application of intense laser pulses and laser-driven particle and radiation sources. The core topics of this School were focused around the extreme performance of ELI laser lines (high peak powers, femto and attosecond pulses, UV and X-Ray spectral regions) and their applications.

- SIF Congress (Congresso della Società Italiana di Fisica, 14-18 September 2020, online)
  I joined this congress and I participated by sending a 10 min. video-slide communication on my current research work titled *"Application of He-Ne Zeeman Laser in Polarization-based Microscopy Techniques"*