Dipartimento di Fisica
Università degli Studi di Genova

ISTITUTO ITALIANO
DI TECNOLOGIA

PhD program in Physics and Bio-Nanoscience

Cycle: XXXV

PhD Student: Ali Mohebi
Nanoscopy & NIC@ IIT
Tutor: Prof. Alberto Diaspro

First year PhD Annual Report

Label-free nanoscopy based on polarized light scattering of biological macromolecules is the main subject of my research line. This interesting imaging technique provides interesting contrasts based only on the molecular conformation of the sample under illumination, reduces the operator dependence and does not require a priori knowledge. My work consists in implementing this technique on a multimodal optical microscopy imaging setup named Multi Messenger Microscope, in order to exploit the advantages of their different specify at the same time with tunable performances, coupled with super-resolution imaging method (optical and algorithmic from deep-learning).

First, the aim of this first year has been to work, on circular intensity differential scattering (CIDS) setup. Circularly polarized light (right and left), well known to present a high sensitivity to realize Mueller Matrix Microscopy (MMM) of chiral molecular organizations. CIDS based on polarized light scattering is a powerful super-resolution and noninvasive microscopy technique to crumble artificially the abbe optical resolution limit for studying and monitoring biological particles. We have tried some samples with known characteristics in terms of chirality features to examine our setup (Figure-1) and the state of the art is to analyze and interpret the results using analytical methods. In our work, a phasor plot approach is going to combine with CIDS microscopy to provide a molecular view of sample to recognize the presence of different molecular species in a pixel. The data in terms of polarization response at each pixel can be mapped to a single point called phasor. The phasor approach has also the potential to simplify the data analyzed in CIDS, paving the way for the analysis of large data sets and feasible to interpret for the non-expert in data analysis. We have characterized our phasor plot having the simulation of intensity of light detected from linear polarizer and wave plates with different orientations in order to apply as reference in our real samples (DNA chromatin).

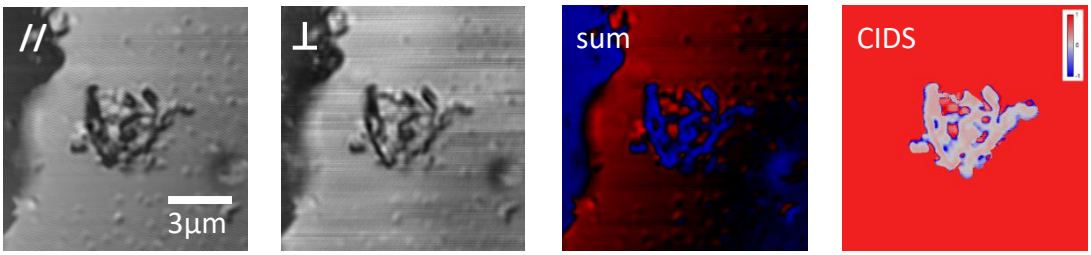

Figure-1: Microscopy images of cellulose from left to right; for parallel and perpendicular polarizations collected light, total intensity transmitted image (sum of the two polarized images) and CIDS chiral image.

The list of attended courses and exams given

First year	Title	Teachers	Status	Hours
1	Quantum Optics	Ferraro	To be done	20 h
2	Advanced Optical Fluorescence Microscopy Methods	Paolo Bianchini, Alberto Diaspro	To be done	12 h
3	Fluorescence Super-Resolution Microscopy: Basis, Applications and Perspectives	Giuseppe Vicidomini	In progress	9 h

Schools and conferences attended:

OSA Biophotonics Congress: Biomedical Optics, 20-23 April 2020; online

Remote participation; The Biomedical Optics Congress focused on technological solutions to medical challenges and medical applications. It covers diverse, cutting-edge research and innovative new tools and techniques.

CLEO 2020 Conference on Lasers and Electro–Optics, 11-15 May 2020; online

Remote participation; Several talks on 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.

SIF Congress, Congresso della Società Italiana di Fisica, 14-18 September 2020; online

Oral presentation; "Resolution improvement in circular intensity differential scattering scanning microscopy integrated with two photon fluorescence microscopy using a phasor plot approach"

Summer School 2020 on Computational Photonics held by Karlsruhe Institute of Technology (KIT) in Karlsruhe, Germany, 20-26 September 2020; on-site

I joined this summer school and attended the lectures in Karlsruhe, Germany. The computations were mostly done using python programing.