

Hybrid Teaching During a Pandemic of Advanced Labs and Their Lecture Classes

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Abstract: Three advanced lab classes were taught both “in person” and remotely through Zoom with recording lab videos: (1) Sources and Detectors; (2) Nanometrology (AFM, optical microscopy, electron microscopy); and (3) Quantum and Nano-Optics (entangled/single-photon sources). © 2021 The Author(s)

1. Introduction

Three advanced lab and their lecture classes were taught during a Pandemic of 2020-2021:

- *OPT 204 Sources and Detectors Labs* (11 totally remote students, 22 “in person”) contained following experiments: spectral measurements of several optical sources, spectrophotometry; mode-locked Er-doped fiber laser, fiber stripping, cleaving and fusion splicing; photon statistics measurements of a laser and a pseudothermal source; single-photon interference with a CMOS camera.
- *OPT 254/PHY 371 Nanometrology Laboratory* (1 totally remote student, 5 “in person”) contained 3 modules: atomic force microscopy; optical microscopy including single-nanoemitter confocal fluorescence microscopy and spectroscopy; and electron microscopy (SEM/TEM).
- *OPT 253/OPT 453/PHY 434 Quantum and Nano-Optics Laboratory* (11 students “in person”) contained following experiments: entanglement and Bell’s inequalities; single-photon interference with a EM-CCD; single (antibunched) photon source (confocal fluorescence microscopy and spectroscopy of single nanoemitters and a Hanbury Brown and Twiss correlator).

2. Hybrid Teaching in Small Lab Rooms

A requirement of a 1.5 m social distance permitted only two persons [one student and a teaching assistant (TA)] to be in one laboratory room simultaneously. Three “in person” scheduled lab attendants worked 1/3 of each lab time (usually 3 hours) in the lab and 2/3 of each lab time remotely through a Zoom video conferencing software. Figure 1, left shows a TA and a student in the lab with a protective equipment. The quality of video recording was very important, especially because of one half of two lab classes and the whole third lab class required darkness for measurements (Figure 1, right from a recorded video). A dynamic range of a Marshall Electronics CV610-UB video camera with a remote control (see Figure 1, left with this camera near a back wall) permitted to show all details of the lab experiments in darkness to remote students and to record videos of each lab session.

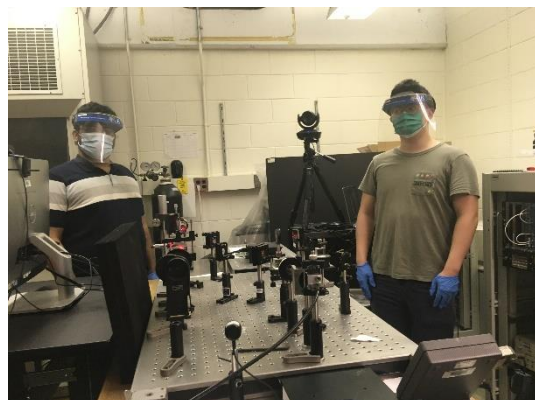


Figure 1. LEFT: A TA Surendar Vijayakumar and an undergraduate student in the lab on single-photon interference (a Marshall video camera is seen near a back wall). RIGHT: The same lab experiment recorded in the darkness.

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An option of “screen sharing” in a Zoom software also permitted participating in the experiments remote students. See, for instance, Figure 2, left (from a recorded video) of AFM imaging of topography of a plasmonic nanoantenna array metasurface. In addition, an insert at the right top corner of this screen shot shows (from top to bottom): a compact AFM with a controller, a student in the lab (with a mask and a protective plastic screen), and two other students taking the lab remotely and waiting for their time in the lab.

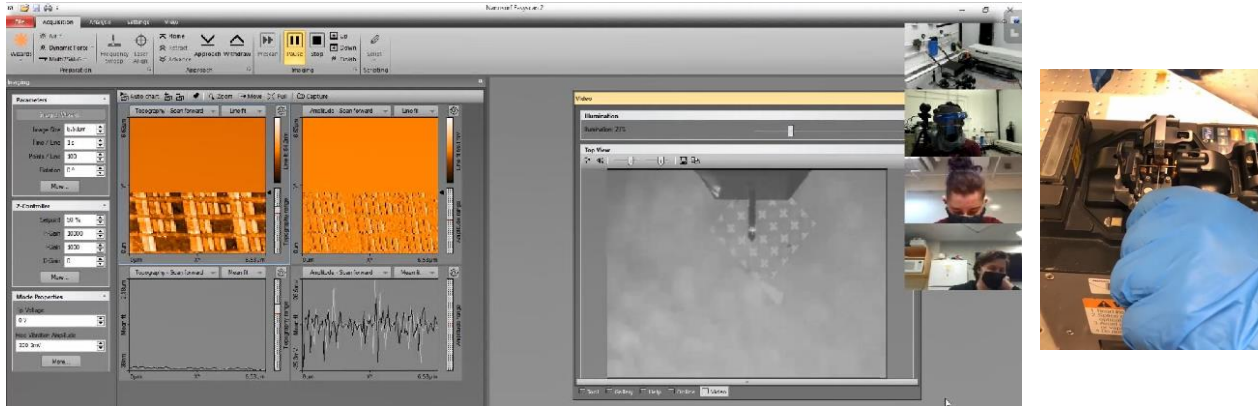


Figure 2. (From recorded videos). LEFT: A user interface of an AFM Easyscan 2 (Nanosurf). Insert from a Zoom software shows an AFM, a student in the lab and two remote students. RIGHT: Fusion splicing of the optical fibers recorded by an iPhone camera.

For remote teaching of some experiments with important small details we used an iPhone camera (see Figure 2, right) that provided also more mobility during an explanation of different parts of the lab equipment and procedures. In some classes we used simultaneously up to 6 monitors (including a separate host computer, a Marshall video camera computer, an iPhone, and 3 monitors of computers with different devices’ boards and software) with switching between them during the lab. A Jabra microphone with a bluetooth option was important for recording of TA or professor’s explanations during the labs.

3. Evaluation of Students’ Knowledge: Quizzes via Zoom

In addition to lab reports students had graded quizzes either before the each lab or after the lab (5 questions), and also BIG quizzes (20-25 questions). Each quiz consisted of two parts:

- (1) “written” with permission to use all lectures, lab videos, manuals and internet;
- (2) “oral” with questions from a written quiz during the lab sessions and at the separate Zoom meetings, personally with each student.

Hybrid format with recording lab sessions has advantages in assignments’ preparation: evaluation of all reports and quizzes showed higher grading of assignments and final grades in comparison with previous years. Very important aspect during a Pandemic is socializing remote students through Zoom: students with a “night” time zone attended the labs at a night time in their country voluntary and refused offering to watch the labs sessions alone, but at time convenient for them (they preferred to be in the team).