Ph/EE/BE/APh 118B – Spring 2019
Physics of Measurement
Tu, Th 2:30-3:55pm / W. Bridge 157
Make-up Lecture Times: Fridays, *time t.b.d.*

Prof.: Prof. Michael Roukes, x2916, 131 Bridge Annex, *roukes@caltech.edu*
Co-Lecturer: Dr. Laurent Moreaux, x2287, B126 Bridge Annex, *moreauxl@caltech.edu*
T.A.: Alice Hsu, x2914, B151 West Bridge, *ahhsu@caltech.edu*
***Class URL*:** http://www.its.caltech.edu/~ph118/

Ph/EE/BE/APh 118B – Spring 2019
Physics of Measurement: Probing Brain Function with Light

Course Description: In Spring term 2019 this course will explore concepts and principles of state-of-the-art photonic imaging applied to neural systems, with particular focus on the optical interrogation of brain circuit activity. The course will be carried out as a graduate-level seminar, with lectures from current literature by the instructor, senior scientists from Caltech and other institutions, and class participants. Topics covered will include advanced methods of free-space optics and integrated neurophotonics, including: optical fluorescence techniques, light perturbation of neural tissue (absorption/scattering), multiphoton imaging (2P, 3P, SHG), light-sheet microscopy, photoacoustic microscopy, optogenetic stimulation, functional imaging of neuronal activity (including electrophysiological and neurochemical activity) and of blood flow (neuro/vascular coupling). Recent advances in optical reporters and effectors (molecular and nanoparticle-based) enabling direct recording and stimulation of neural activity from the optical domain will also be surveyed.

Prerequisites: Suggested background is 2 years of undergraduate physics, a course in mathematical methods, statistical physics (APh105 or Ph127 or equivalent, and analog electronics (Ph105 or equivalent.) In Winter term 2016, familiarity with basic Fourier optics is also assumed, although this will be reviewed. Supplementary material may be provided to assist students lacking the aforementioned background, if needed. **For undergraduates**: to register must be working on laboratory research, and have your current research advisor send an e-mail of support to the instructor.

Raison d'être: This is a class designed for those embarking upon careers involving laboratory measurements in the physical and engineering sciences. It is taught at a level appropriate for beginning graduate students in physics or engineering, however students from other disciplines are welcome. The suggested prerequisites are 2 years of undergraduate physics, a course in mathematical methods, statistical physics (e.g. APh105 or Ph127) and analog electronics (e.g. Ph105)… but I'll say, unofficially, there are no prerequisites but the desire to work hard to learn the material, and a willingness to actively engage in asking questions in class. However, in my lectures I'll assume you're familiar with electronics and basic circuit theory, as well as Fourier analysis, auto- and cross-correlations, and concepts like spectral densities, etc. You'll probably find it a hard go without some knowledge of these. With sufficient interest, the TA may schedule tutorials on such topics. Additionally, the class will make a whole lot more sense to you, and be of obvious relevance, if you've already had some exposure to laboratory research involving hands-on physical measurements.

Units: 9 units (3-0-6); first, second, third terms.

Grading: Spring 2019 = pass/fail (ONLY).

Mtg #	*Date*	*Principal Topics*	*Lecturer*	*Location*
1	Tu 2 Apr	***Organizational Meeting / Course Overview*** **Physical Principles of Fluorescence Imaging & Microscopy, I**	*Prof. Michael Roukes*	***Special Location:*** *E. Bridge 114*
2	Th 4 Apr	**Physical Principles of Fluorescence Imaging & Microscopy, II**	*Prof. Michael Roukes*	*W. Bridge B157*
3	Tu 16 Apr	**Absorption and Scattering of Light in Brain Tissue, I**	*Prof. Michael Roukes*	*W. Bridge B157*
4	Th 18 Apr	**Absorption and Scattering of Light in Brain Tissue, II**	*Prof. Michael Roukes*	*W. Bridge B157*
5	Tu 23 Apr	**Two-Photon Imaging, I**	*Dr. Laurent Moreaux*	*W. Bridge B157*
6	Th 25 Apr	**Two-Photon Imaging, II**	*Dr. Laurent Moreaux*	*W. Bridge B157*
7	Tu 30 Apr	**Two-Photon Imaging, III**	*Dr. Laurent Moreaux*	*W. Bridge B157*
8	Th 2 May	**Two-Photon *Functional* Imaging**	*Dr. Laurent Moreaux*	*W. Bridge B157*
9	Tu 7 May	**Second Harmonic Generation**	*Dr. Laurent Moreaux*	*W. Bridge B157*

Mtg #	Date	Principal Topics	Lecturer	Location
10	Th 9 May	**Application of Second Harmonic Generation to Voltage Sensing**	*Dr. Laurent Moreaux*	*W. Bridge B157*
11	Tu 14 May	**Brain Structure**	*Anand Muthusamy*	*W. Bridge B157*
12	Th 16 May	**Optogenetic Reporters & Actuators**	*Alice Hsu*	*W. Bridge B157*
13	Tu 21 May	**Fluorescence Resonance Energy Transfer (FRET) & Applications**	*Jonathan White*	*W. Bridge B157*
14	Th 23 May	**NO CLASS**		
15	Tu 28 May	**Integrated Neurophotonics, I**	*Prof. Michael Roukes* *Dr. Laurent Moreaux*	*W. Bridge B157*
16	Th 30 May	**Integrated Neurophotonics, II**	*Prof. Michael Roukes* *Dr. Laurent Moreaux*	*W. Bridge B157*
17	Tu 4 June	**Optical Phase Conjugation & Time-Reversal Imaging** **Photoacoustic Microscopy**	*Duxing Hao* *Zack Blumenfeld*	*W. Bridge B157*
18	Th 6 June	**Super-Resolution Techniques & Applications** **Light-Sheet and Lattice-Light-Sheet Microscopy & Applications**	*Weilei Yu* *Dr. Xinyu Liu*	*W. Bridge B157*

Spring Term 2019 / Lecture Calendar

April 2019						
Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May 2019						
Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June 2019						
Su	Mo	Tu	We	Th	Fr	*Sa*
						1
2	3	4	5	6	7	*8*
9	10	11	12	13	14	*15*
16	17	18	19	20	21	*22*
23	24	25	26	27	28	*29*
30						

LEGEND:

- **- regular class meeting**
- **- SPECIAL SEMINAR** *(begins at 2pm)*
- **- Friday class** *(time TBD)*
- **- NO class meeting**

- **- Institute holiday**