Development a new fiberscope to measure and modulate neuronal activity in freely-moving mice along large fields of view and with high spatiotemporal precision.

Contact
Cathie Ventalon
IBENS, Ecole Normale Supérieure
46, Rue d'Ulm
75005 PARIS
cathie.ventalon@ens.psl.eu

An important goal of neuroscience is to determine the neural basis of perception, memory formation and behavior. To achieve this goal, it can be useful to manipulate and record the activity of neurons with cellular precision while the animal (e.g., rodent) performs a specific behavioral task. Such experiments can be performed with optical methods, using photostimulation of optogenetic actuators and fluorescence imaging of calcium reporters. To apply these optical methods to unconstrained mice, two approaches have been followed: a microscope can be fully miniaturized and placed on the rodent's head, or an image guide (fiber bundle) can be used as a relay between a benchtop microscope and the animal, thus partially overcoming the miniaturization constraints.

Using this second strategy, we have developed a fiberscope that allows selective photoactivation of neurons with near-cellular resolution in freely moving mouse [1]. We then developed a second system allowing fast fluorescence imaging with optical sectioning by multipoint or line scanning confocal microscopy [2]. Using this device, we have demonstrated fast (>100 Hz) fluorescence imaging of blood flow and neuronal activity in the brain of freely behaving mice with cellular resolution. The fiberscope also allows photoactivation following light patterns shaped with very high spatiotemporal precision. The field of view has a diameter of 240μm, which allows to access several tens of cells simultaneously.

In this project, the candidate will develop a new device allowing imaging and targeted photoactivation in freely-behaving mice, with a field-of-view 10 times larger. To do so, he/she will implement a microscope similar to the previous system, and he/she will test new image guides that are more flexible, with larger diameters, and with larger inter-fiber distances. The properties of these image guides (cross-talk between individual fibers, numerical aperture) will be characterized and compared, which will allow to choose the most suitable guide. Finally, the performance of the fiberscope for fluorescence imaging and photoactivation will be characterized.

[1] Szabo et al, Neuron 84, 1157–1169 (2014)
[2] Dussaux et al, Scientific Reports 8, 16262 (2018)