Thesis proposal:

Dynamics of the radiative decay of a hot electron gas generated in the feed of an electrically-driven optical nanoantenna

Scientific context: The scientific program of the thesis is aimed at gaining a better understanding of the light emitted by electron-fed optical antennas. From a general point of view, optical antennas are passive nanoscale devices used to interface far-field radiation to localized electromagnetic energy and vise-versa [1]. Compared to their radiofrequency counterpart ubiquitous in our daily life, optical antennas are not generally used for transduction, but merely serve as a wave-vector converter. Nonetheless, recent developments demonstrated that optical antennas can be electrically driven, and under some conditions can operate a bilateral transduction between electrons and photons [2,3]. The asset of such novel class of active optical antenna is their ability to be deployed as ultrafast nanoscale interface devices. They can be used to interconnect an electronic control layer and a photonic circuitry. In this proposal the focus is made on the electron-to-photon transduction. When electrically biased, optical antennas emit a broadband light spectrally tailing in the visible part of the spectrum. Different emission mechanisms are at play including inelastic electron tunneling and thermal relaxation of an out-of-equilibrium electron distribution.

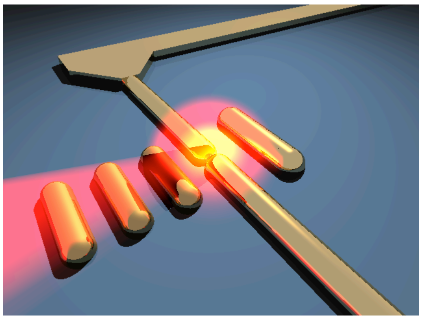

Figure 1: Drawing of an electron-fed optical antenna. The overall length scale is about 500 nm.

The thesis will investigate the time dynamics and statistics of the photons generated by the optical antenna when electrons are injected. In the context of a nanoscale light-emitting device involved in an integrated protocol of signal transmission [4], encoding the information is critical. The first objective is to assess how fast the emitted light can be modulated by an electrical command. The thermal relaxation of the electron gas is a fast process in metals, which enables an intrinsic ultrafast response of the optical antenna (ps) that will be characterized during the thesis. The second objective is the shaping of the emission diagram. The light emitted typically covers the visible to the near-infrared spectral region. An engineering of the bandwidth requires a structuration of the electromagnetic environment in which the radiation is emitted. The candidate will therefore integrate the optical antenna into resonant structure and investigate the coupling mechanisms between the modal landscape and the energy of the photons set by the applied bias.

[1] *Antennas for light*, L. Novotny & N Van Hulst, Nature Photonics 5 83 (2011)
[2]*Spontaneous Hot-Electron Light Emission from Electron-Fed Optical Antennas*, M. Buret et al. Nano Lett., *15*, 5811-5818 (2015)
[3] *Nonlinear Photon-Assisted Tunneling Transport in Optical Gap Antennas*, A. Stolz et al. *Nano Lett., 14*, 1-25 (2014)

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[4] *Optical wireless link between a nanoscale antenna and a transducing rectenna*, A. Dasgupta et al. Nature Commun., *9*, 1992 (2018)

Preferred profile: A Master in optics, electronics, mesoscopic physics. Nanofabrication and characterization techniques will be subject to specific trainings. This research program requires a profound taste for complex experiments. Curiosity, personal investment and team spirit are essential.

Keywords: optical antennas, plasmonics, electromigration, tunnel junction, fluctuations, emission diagram, hot electrons

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Facilities: The laboratory ICB (http://icb.u-bourgogne.fr/en/) is located in Dijon, France. The lab is divided in five departments gathering physicist and chemists under the same umbrella. The laboratory hosts the technological platform ARCEN Carnot. The platform operates a fully-accessible nanofabrication line in a clean-room environment including electron-beam lithography, thin film depositions and ion etching apparatus.

PhD: The position must be started before 31/12/2018. The thesis will last 3 years and will lead to a PhD in Physics delivered by the Université de Bourgogne Franche-Comté. The candidate will benefit from a sponsored research program by the region of Burgundy. Funding for conferences consumables & equipments is also present.

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