# Extreme spatiotemporal imaging and control of nanophotonic components and their neuromorphic applications

**L. Wittenbecher[1], D. Winge[1], V. Flodgren [1], N. Zaiats[1], K. Thelander[1], C. Verdozzi[1], A. L'Huillier[1], J. Vogelsang[2], D. Zigmantas[3], A. Mikkelsen[1]**

[1] *NanoLund and Department of Physics, Lund University, Sweden*

[2] *University Oldenburg, Germany*

[3] *NanoLund and Department of Chemistry, Lund University, Sweden*

During the past decade we achieved unprecedented abilities to probe and exploit light-matter interaction down to the nanometer and sub-femtosecond spatiotemporal scales. This opens for new fundamental physical insights as well as to rationally design of a variety of novel functional materials and devices with applications for energy harvesting and alternative computing. The presentation has two parts: First, we combine the femtosecond and attosecond time resolution of advanced laser systems with the nanoscale spatial resolution of PhotoEmission Electron Microscopy (PEEM). We use this to unravel the hot electron dynamics in InAs nanowires [1] and observe the dynamics of near-field enhancement in hybrid metal-semiconductor nanostructures [2,3]. We will include new works using very high fields on Ag nanowires and attosecond pulse excitation on ZnO.

Second, we propose an artificial neural network concept [4] in which the weighted connectivity between nodes is achieved by overlapping light signals inside a shared quasi 2D waveguide – a broadcasting concept. This decreases the circuit footprint by two orders of magnitude compared to existing optical solutions. The evaluation of optical signals is performed by neuron-like nodes constructed from efficient III–V nanowire optoelectronics. This minimizes power consumption of the network. Detailed simulations of the central network parts, demonstrate feasibility [4] and new experimental data on wire-to-wire on chip communication circuits will be shown.

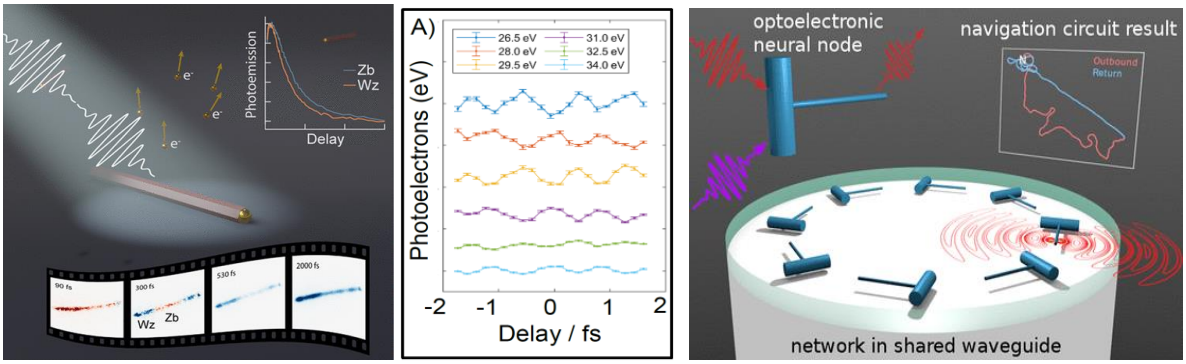


Figure. Left: Summary of PEEM imaging of femtosecond hot electron dynamics in InAs nanowires. [1] Middle: Attosecond spectra recorded in a PEEM on ZnO. Right: Summary of inner part of a nanowire neural network based on the insect brain central complex [4].

[1] L. Wittenbecher et al, ACS Nano 15 (2021) 1133.
[2] J. Vogelsang, ACS Photonics 8 (2021) 1607
[3] J.H. Zhong, et al. Nature Communications 11 (2020) 1
[4] D. O. Winge, et. al ACS Photonics 7 (2020) 2787

[+] Author for correspondence: anders.mikkelsen@sljus.lu.se