On behalf of the

University of Vienna / Electronic Properties of Materials

we cordially invite you to the following talk

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Exploring nanoscale materials with time-resolved electron spectroscopies

Abstract:

The evolution of technology drives the construction of increasingly complex and compact devices. Consequently, comprehending the physics underlying excitations and effectively controlling them in devices necessitates tools with precision at the nanometer or atomic scale. In this sense, spectroscopies in electron microscopes (electron energy loss spectroscopy, EELS, and cathodoluminescence, CL) have strongly impacted advances in nano-optics [1]. These spectroscopies have some penalties in comparison to photon experiments: lack of excitation energy control and polarization degrees of freedom and limited spectral resolution.

In this seminar, I will describe applications of electron spectroscopies to study 2D materials [2-5] and lead halide perovskites [6-8]. With this, I will try to exemplify how correlative measurements of structural, chemical and optical information at the nanoscale can solve problems not accessible to macroscopic explorations.

Following this, I will demonstrate innovative strategies to overcome electron spectroscopies inherent limitations by integrating them with a light injection/collection system, complemented by time-resolved experiments (using a ns-blanking system or a Timepix3 event-based electron detector).

Electron inelastic scattering in matter exhibits a broadband nature. As a result, the exchanged energy during each scattering event can only be determined through the detection of individual electrons with nanosecond time resolution [9]. With this, the energy losses leading to CL photon emission can be determined. This methodology, called cathodoluminescence excitation (CLE) spectroscopy, allows for the probing of excitation pathways leading to photon emission [10], similar to the approach in photoluminescence excitation (PLE) spectroscopy. CLE provides access to materials' relative quantum efficiency with nanometer precision. I will discuss the implications of these time coincidence experiments for phase shaped EELS [11].

Finally, if time allows, I will briefly mention a new spectroscopic method, called electron energy gain spectroscopy (EEGS), that allows for sub 10 µeV spectral resolution by coupling electrons and laser beams [12].

[1] A. Polman, *et al.* **Nat. Mater. 18**, 1158 (2019) ; [2] N. Bonnet, *et al.,* **Nano Lett. 21**, 10178 (2021); [3] F. Shao, *et al.,* **Phys. Rev. Mater. 6**, 074005 (2022); [4] S. Y. Woo, *et al.*, **Phys. Rev B 107**, 155429 (2023) ; S. Y. Woo, *et al.,* **Nano Lett.** Accepted (2024) ; [5] J. Hou, *et al.*, **Science 374**, 621 (2021); [6] M. Ghasemi, *et al.*, **Small 19**, 2304236 (2023); [7] X. Li, *et al.*, **Nat. Comm. 14**, 7612 (2023) ; [8] S. Collins, *et al.*, *in preparation* (2024) ; [9] Y. Auad, *et al,* **Ultramicroscopy 239**, 113539 (2021) ; [10] N. Varkentina, *et al*., **Sci. Adv. 8**, abq4947 (2022) ; [11] H. Lourenço-Martins, *et al.*, **Nat. Phys. 17**, 598 (2021) ; [12] Y. Auad, *et al.*, **Nat. Comm. 14**, 4442 (2023).

Date: Tuesday, 4th June 2024, 12.00
Location: Lise-Meitner-Lecture-Hall, 1st floor, Boltzmanngasse 5, 1090 Vienna

Prof. Paola Ayala, Prof. Thomas Pichler