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Mass spectrometry and optical traps join forces to chart the environment at the nanoscale

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At the nanoscale, our environment remains largely uncharted. Identifying, characterising, and understanding relevant particles that govern this space is akin to searching for a needle in a haystack. The challenges lie not only in detecting these particles but also in extracting sufficient multidimensional data to assess their properties and implications. Critical parameters such as size, molecular, and elemental composition must be resolved with high specificity. However, many relevant particles, both of natural and anthropogenic origin, are obscured by a complex background of unobtrusive colloids. Given the vast number and heterogeneity of these particles, the goal of characterising our environment at the nanoscale is only viable if individual particles are rapidly detected while simultaneously extracting high-dimensional data.

This presentation introduces novel paradigms for inductively coupled plasma - mass spectrometry (ICP-MS). Using a “single-particle” modality, it becomes possible to detect and study thousands of particles per minute in a one-by-one fashion. Over the last years, we have developed new ideas and methods to manipulate mass analysers and ion optics, enhancing ion transmission and facilitating the study of small and heterogeneous particles. Here, specific strategies for both quadrupole- and time-of-flight (TOF) analysers will be highlighted. Additionally, new non-target particle screening strategies and dedicated software solutions for navigating massive datasets will be discussed. Finally, a novel trimodal hyphenated technique—combining single particle ICP-MS, optical trapping, and Raman spectroscopy—will be introduced. This powerful platform offers unprecedented insights into environmental system, enabling a bottom-up understanding of key entities and processes.