Real-time spectroscopy of moving nanoparticles using holographic tracking

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Because of their high reactivity, metal NanoParticles (NPs) provide various promising applications such as catalysis, cancer treatment,... Many of their properties depend on their electrochemical behavior. At the macroscopic scale, nanoparticle properties are the average of many individual NPs, which can actually differ strongly. Studying electrochemistry at the single particle scale is therefore crucial, as well as challenging.

Since the beginning of 21st century, by reducing the electrode size, electrochemists managed to observe an electron transfer between a single NP and an electrode¹. However, this electrochemical signal does not provide sufficient information about the physical behavior of NP. Using digital holographic microscopy (DHM), we are now able to reconstruct the electromagnetic field scattered by single nano-objects. From this reconstruction, NPs can be localized in real time with sub-diffraction precision (up to 3x3x10 nm³ if the SNR = 70). With this optical observation, we can now correlate two signals: electrical current and the position of NP during the experiment which reveals the behavior of a single NP ²,³.

Besides, the spectral information of NPs in an electrochemical reaction is also required in the local chemical analysis. Unfortunately, spectral studies of single NP in situ are extremely difficult due to their Brownian motion. We have developed an 3D spectro-electrochemistry nanoscope which adds spectral observation to an electrochemical reaction. Using a confocal system in front of the spectroscope, only one NP is studied. In order to compensate the movement of NPs, the localization by DHM is used to drive an adaptive optical system and redirect the light scattered by the NP under study towards the spectroscopy (Figure 1). We can now track a single gold NP in real time, with a 20 Hz rate, and measure its spectrum. As a result, the interaction between a single NP and its environment can be detected in situ by the spectral shift. This new approach should find applications in many fields beyond electrochemistry, whenever the spectrum of the nanoparticle brings additional information. In this contribution, we will present the optical system as well as trajectory tracking and spectral measurements on single gold NPs in water and ionic liquids.

![Figure 1](image-url)

**Figure 1.** a) Experimental setup of 3D spectro-electrochemistry nanoscope. The localization is used to drive galvanometric mirrors and dynamics lens (variable focal length). b) Tracking of a single NP and its spectrum (small image)

References
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