# Force mapping and single-electron tunneling using NC-AFM

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The capability of quantitatively measuring tip-sample interaction forces has been realized already during the early days of non-contact atomic force microscopy (NC-AFM) [1]. Acquiring force-distance curves in a systematic manner allows for mapping the tip-sample interaction along all three spatial dimensions. However, the main measurement signal, namely the frequency shift $\Delta f$, is a convolution of the tip-sample interaction force with a weighting function due to the tip oscillation. Thus, calculating the physical force demands a numerical back conversion [2,3] using the actual $\Delta f$ data and several system parameters as input. Experimentally, a precise drift compensation strategy is necessary for the reproducible measurement of interaction forces, especially when aiming for dense three-dimensional data sets.

This lecture will discuss the experimental challenges faced in force spectroscopy experiments and specifically focus on drift compensation strategies. Furthermore, the numerical back conversion will be introduced based on two well-known schemes [2,3] including the calculation of vertical and lateral forces as well as the interaction potential. Possible artifacts will be illustrated.

In a second part of this lecture, the methodology of AFM-based single electron tunneling experiments [4] will be introduced. The AFM technique allows for measuring the Coulomb force acting on the probing tip – with sensitivity high enough to identify single electrons [5]. Successful experiments have been conducted where the transfer of single electrons into specific sample locations and their identification therat has been investigated. With his exciting approach, the identification of defect states and electronic properties in insulating systems is possible.

I will present the basic experimental setup and detection principle as well as describe the physical principles including a short introduction in the necessary theory of single tunneling experiments. Experiments involving quantum dots and defect states in oxide films will be discussed.

## References

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