Towards the quantitative mapping of the mechanical properties of materials by Dynamic AFM : beyond the observables !

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Over the past few decades, (nano)composites and functional polymeric materials have replaced metals in many applications from aerospace to sport gears, from automobiles to wind turbines and from circuit boards to civil structures such as bridges and buildings. Mechanical property mapping can provide critical insights into the fundamental processes at the local scale that lead to deformation phenomena in the materials. The relatively recent development of dynamic mechanical scanning probe microscopies allows well-adapted, fast, and versatile methods for the mapping of these mechanical properties at the nanoscale generating a huge amount of data.

In this context, Machine learning (ML) has been perceived as a promising tool for the design and discovery of novel materials for a broad range of applications. In this talk, we will discuss computational methods and ML algorithms dealing with data clustering (such as K-Means and Automatic Gaussian Mixture Model) that can be used to detect the different domains and (inter)phases in polymeric materials by partitioning the recorded data (i.e. the observables) into clusters according to their similarities.

Additionally, based on the Tabor coefficient calculation, we will also present protocols that can be easily implemented to determine which mechanical model(s) can be applied to accurately obtain the quantitative mapping of the mechanical properties for each local domain, phase, or interphase, practically at each pixel of the acquisition.

This algorithmically driven approach will enable analyze materials with more complex architectures and/or other properties (such as electrical ones), opening new avenues of research on advanced materials with specific functions and desired properties leading to the creation of functional and more reliable structural materials.

In this talk, we will illustrate our original approach through a series of chosen examples ranging from soft hydrogels, polymer blends, and nanocomposites.