FACOLTÀ DI SCIENZE MATEMATICHE, FISICHE E NATURALI
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MULTILAYER DIFFRACTION REVEALS THAT COLLOIDAL SUPERLATTICES APPROACH THE STRUCTURAL PERFECTION OF SINGLE CRYSTALS

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Abstract:
Colloidal nanocrystal superlattices are highly ordered aggregates of particles. Crystals are highly ordered aggregates of atoms. However, nanocrystal superlattices are not conventionally considered crystals. But where does the border lie? Previously, we reported that $CsPbBr_3$ nanocrystal superlattices have a structural perfection comparable with that of epitaxially grown multilayers, which can be considered as full-fledged single-crystals.[1]
In this seminar, we will discuss a novel approach to the characterization of periodically stacked colloidal nanocrystals, which was inspired by diffraction experiments on multilayers grown by molecular beam epitaxy.[2] Our method takes advantage of optical interference phenomena arising from the superlattice periodicity, which enrich the profile of Bragg peaks in structural information. By fitting these profiles, collected with a common lab-grade diffractometer, we can extract structural information usually requiring high-end setups such as synchrotrons. Our approach is especially suitable for bidimensional colloidal crystals like nanoplatelets and nanosheets, because they spontaneously assemble into stacked periodic structures thanks to their highly anisotropic shape. However, we expect that our approach can be also extended 2D-layered organic-inorganic materials, which are not considered superlattices but share with them the periodic alternation of different layers.
To demonstrate our approach, we analyzed nanocrystals and nanoplatelets of $CsPbBr_3$ and PbS measuring with high precision thickness, interparticle distance and even distortions in their atomic lattice. In addition, we demonstrated that such nanocrystal superlattices reach stacking displacements as small as 0.3-0.5 Å. This is comparable with atomic displacement parameters found in metal-organic bulk crystals, leading to intriguing questions. For example, how this method can improve the characterization of those fascinating materials? Can we apply to superlattices the same investigation techniques used for bulk crystals? In the end, are nanocrystal superlattices a new class of hybrid organic-inorganic bulk crystals?
1. Toso, S., Baranov, D., Giannini, C., Marras, S. & Manna, L. Wide Angle X-Ray Diffraction Evidence of Structural Coherence in $CsPbBr_3$ Nanocrystal Superlattices. ACS Mater. Lett. 1 (2), 272 - 276 (2019).
2. Fullerton, E. E., Schuller, I. K., Vanderstraeten, H. & Bruynseraede, Y. Structural refinement of superlattices from x-ray diffraction. Phys. Rev. B 45, 9292−9310 (1992).

Webinar

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