Exploring helical chirality in three dimensions by electron tomography

Chirality is a highly complex natural phenomenon observed at atomic and macroscopic levels that scientists have been trying to replicate and control in inorganic nanomaterials for decades. A chiral object is a system that cannot be superimposed on its mirror image, where human hands are the common example. This simple property changes dramatically the way the light interacts with material, altering the light polarization, which has been exploited in biomedical applications such as bioimaging and sensors. Now, those synthesis methods have been discovered to achieve high chirality in metallic nanoparticles, new techniques are needed to study the origin of the properties of these particles.

Dendritic gold nanorods prepared using a micelle-directed chiral seed approach display unparalleled chiral optical properties, however, the origin of this behavior was unknown. Nanoparticles displaying chiral properties have been previously investigated using electron microscopy by HAADF-STEM or SEM imaging, however, the 2D dimensional characterization provided by those techniques is insufficient to interpret and study the 3D morphology of these dendritic chiral features.

Here we present a novel technique to identify helical chirality within nanostructures using electron tomography. Taking inspiration from the revolutionary X-ray diffraction experiment, that was instrumental to discover DNA’s structure, we know that ideal helical structures result in X-shaped patterns. Thus, we applied fast Fourier transformations (FFTs) to our 3D reconstructions obtained by tomography to study the periodicity in the reciprocal space, observing a similar X- pattern. In this manner, the spots observed in the pattern can be linked to the corresponding chiral features in real space, so that the helical periodicity is visually highlighted and the handedness of each individual nanoparticle can be identified.

References

González-Rubio, Guillermo, et al. "Micelle-directed chiral seeded growth on anisotropic gold nanocrystals." Science 368.6498 (2020): 1472-1477.