Atomic Resolution 3D Dynamics of Helix Materials：present and future

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Advancements of aberration-corrected electron optics and data acquisition schemes have made TEM capable of delivering images with sub-Ångström resolution and single-atom sensitivity. However, three bottlenecks, namely, radiation damage, static imaging and 2D projection geometry are still challenging TEM imaging of soft materials at the atomic level. For a crystalline material, the 3D atomic information of was determined from the maximum propagation intensity of the atomic column wave relative to the vacuum wave and/or refined by the big-bang method.[1,2,3] The dynamics is obtained from tracking the 3D atom positions deduced from time-resolved exit wave functions reconstructed from sub-sets of defocus series of images [3]. This method well applied to crystalline materials where the atom columns are isolatedly resolved. However, because most of the projected spacings between atoms from an individual helix C60, carbon nanotube and DNA are beyond the resolution of the TEM, it is still difficult to directly resolve its atomic columns in the image mode. Furthermore when rather isolated atomic columns are resolved, the moiré pattern formed by the rolled-up graphene layer is clearly visible between two intense bright lines corresponding to the vertical tube walls. Each bright spot in the images may be associated with a cluster of atoms in the projection view.

In the present paper, we present advancements of electron microscopy methodology towards probing 3D atomic resolution dynamics of helix materials, CNT, C60/ CNT and DNA, at high temporal resolution and emphasize in particularly the role of controlling the electron delivery. We develop a genetic evolution method utilizing iterative simulation annealing and energy minimization (SA-EM) to extract all spatiotemporal information encoded in the transmission electron microscopy (TEM) data up to the limits of the counting statistics. In my talk, atom dynamics in 3D of CNT, C60 and DNA will be presented. And the future trend of noninvasive TEM on the 3 D atom dynamics will be also presented.

References

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