In this poster we discuss single atom electron energy loss spectroscopy (EELS) of lanthanides (La, Ce, Er and Eu). In particular we analyze the different possibilities of high spatial resolution spectroscopy at low primary electron energy (30 keV and 60 keV) and high electron energy losses (above 800 eV). Atomically resolved EELS experiments were performed in the JEOL-CREST double corrected microscope operated at 30 keV and 60 keV. The samples analyzed were lanthanide atoms (La, Ce and Er) encaged in fullerenes stored in carbon nanotubes and Eu atomic chains inside carbon nanotubes.

The use of low primary electron energies is beneficial due to the decrease in energy loss delocalization and the minimization of one possible sample damage mechanism (knock-on). Examples of the experiments performed at 30 keV and 60 keV are shown in Figure 1. Evidently, one can see that the fullerenes structure is maintained in the experiment at 30 keV, while it is modified at 60 keV. All experiments have been performed with acquisition times ranging from 20 ms to 200 ms.

To observe the effect of energy loss on delocalization, we have performed the parallel acquisition of the loss signal of the N_{45} and M_{45} edges of La and Ce at 60 keV. These edges can be observed at 117 eV (121 eV) and 832 eV (881 eV) for La (Ce). To estimate delocalization, we have measured the full width at 50% intensity (L) of profiles for the annular dark field image (ADF), N_{45} and M_{45} edges. For a single La atom we have observed L_{ADF} = (0.15±0.02) nm, L_{N_{45}} = (0.32±0.02) nm and L_{M_{45}} = (0.20±0.02) nm. The significant decrease is expected. However, the absolute values are smaller than those predicted by simple considerations.

Some effects of atomic movement on spectroscopy experiments will also be discussed.

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Fig. 1: 2D EELS maps identifying the position of La (blue), Ce (green) and Er (red) at 60 kV (a-c) and 30 kV (d-f). The maps presented are not the first on a series of acquisitions. For this reason, electron beam damage can be observed at 60 kV and not at 30 kV.