ESRF	**Experiment title:** **Electronic collective excitations in metallic carbon nanotubes investigated by inelastic x-ray scattering**.	**Experiment number**: HE-922
Beamline: ID16	**Date of experiment**: from: 20/9/00 to: 26/9/00	**Date of report**: 27/02/01
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Report:

Metallic carbon nanotubes are predicted to exhibit low-frequency plasmons, which may be due to the presence of free carriers at the Fermi level associated to subbands of low dimensionality. These excitations may play an important role in the magnetic, transport and thermal properties of these systems, but they have never been observed so far. In semiconducting carbon nanotubes or in graphite, such kind of collective electronic excitations do not exist. We proposed to investigate the energy loss spectrum of carbon nanotubes by high resolution non resonant inelastic x-ray scattering.

The experiment was performed on the inelastic x-ray scattering beamline ID 16 using a high resolution Raman setup. The spectrometer consists of a monochromator using two Si channel cuts (working respectively at the (111) and (440) reflections), which provides a bandwidth of 70 meV, a high resolution cross-grooved Si(111) analyzer bent on a spherical blank working in extreme backscattering geometry, and a Si pin-diode detector. A total resolution of 110 meV was obtained.

The high-frequency (graphite-like) plasmons of single wall carbon nanotubes were first investigated. The results, shown on figure 1, are in good agreement with previous electron energy loss spectroscopy data.

The figure 2 shows the spectra of the graphite, single wall nanotubes (SWNT) and multiwall (MWNT) nanotubes in the 0-2 eV energy range at q=1 $Å^{-1}$. With respect to the spectrum of graphite (solid line), a shoulder around 300 meV appears in the spectra of SWNT (open dots) and MWNT (open square). The intensity of this feature is more important for the single wall nanotubes than for the multiwall nanotubes. We interpreted the presence of low-energy excitations in the energy loss spectra as the existence of low-energy plasmons. The position in energy of these features is in good agreement with the calculations. This observation is further corroborated by the fact that such excitation is not present in graphite, as expected, and that this feature is enhanced in the SWNT which present a more 1D character than the MWNT.

The existence of a low-energy excitation in SWNT could also explain the asymmetric profile of the tangential Raman modes of metallic nanotubes, which can be described within the Breit-Wigner-Fano (BWF) profile [1]. Indeed, this peculiar lineshape traduces the existence of a coupling between a continuum of electronic states and the tangential phonons. The origin of the electronic excitations involved in the process is still in debate. Recently, the low-energy plasmons have been evoked. In agreement with that, it can be noticed that the profile of the Raman tangential modes of graphite is symmetric and that no low-energy electronic excitations were evidenced in IXS experiments on graphite. Because the energy of the plasmon and the energy of the tangential modes are in the same energy range, their coupling can be considered [2].

[1]- Alvarez et al, Chem. Phys. Lett 316 (2000) 186-190
[2]- Brown et al, Phys. Rev. B (2001, in press)

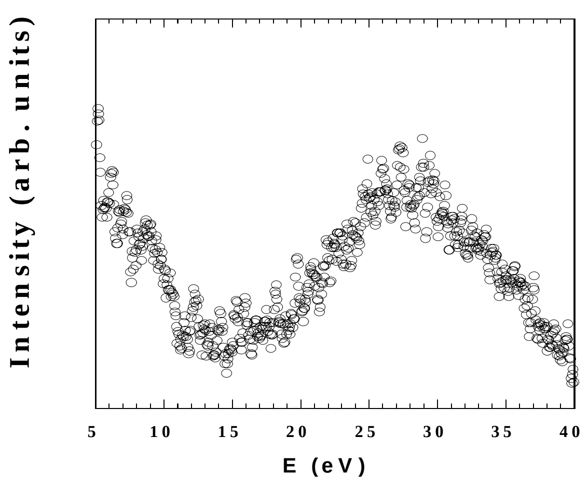

Figure 1: High energy plasmon of single wall carbon nanotubes

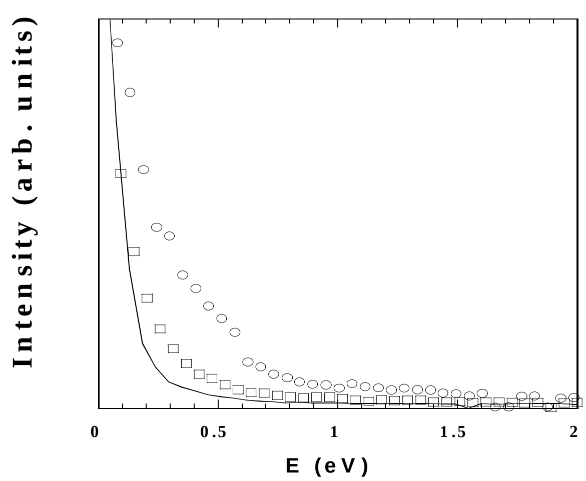

Figure 2: Low energy part of the IXS spectrum. SWNT (open dot), MWNT (open square), graphite (solid line)