A metallic magnetic calorimeter for measuring atomic fundamental parameters by X-ray spectrometry

Main author:

RODRIGUES Matias

Co-authors:

Loidl Martin, CEA / LNE-LNHB

Rodrigues Matias, CEA / LNE-LNHB

Atomic fundamental parameters (FPs) such as transition rates, Coster Kronig transition probabilities, natural line widths or fluorescence yields are key parameters for quantifying the amount of elements present in a sample using various X-ray analysis techniques. However, the uncertainties related to FPs can be large (up to several tens of percent for low atomic number elements), thus the contribution of the FP uncertainties can penalize the accuracy of the analysis results. Consequently, there is a need for new measurements and precise determination of FPs.

FPs can be calculated but some necessary simplifications and assumptions can lead to large systematic errors. Therefore experimental data are required to constrain the calculations. The main X-ray techniques used to determine FPs are EDXRS (energy dispersive X-ray spectrometry) with semiconductor detectors and WDXRS (wavelength dispersive X-ray spectrometry). The first technique has the advantage that its detection efficiency can easily be calibrated, which is important for measuring for example X-ray emission intensities; however it has a poor energy resolution due to the intrinsic limit of semiconductor spectrometers. Contrariwise WDXRS has an efficiency that is difficult to calibrate but a high energy resolution which is important for measuring natural line widths or X-ray energies.

Cryogenic detectors can be used for EDXRS technique providing both high resolution and well calibrated detection efficiency and thus give access to a large number of FPs with a unique technique. The Laboratoire National Henri Becquerel has developed a metallic magnetic calorimeter (MMC) made of 4 pixels with AuAg bi-layer absorbers optimized for X-ray spectrometry below 25 keV.

In this work, we will present the performances of this MMC characterized with Am-241 and Pb-210 sources in terms of energy resolution, detection efficiency, linearity and spectral response function, which are crucial experimental properties for X-ray spectrometry. Thanks to its energy resolution (FWHM of 26 eV below 60 keV) and its constant efficiency up to 25 keV, a large amount of information can be extracted from the measured X-ray spectra of Am-241 and Pb-210; then we will discuss the possibilities of measuring FPs. In addition, it must be noted that intense X-ray satellite structures are observed. Knowing that such structures are strongly related with FPs (transition rates, fluorescence yield and Coster Kronig transition probabilities), their study can also yield information about the FP consistency.