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Angle Dependent XRF for the analysis of Cultural Heritage Samples

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Due to their complex structure, cultural heritage (CH) related samples are often very challenging to analyze; besides, due to their rarity and their value these samples require to be studied by means of non-invasive or non-destructive techniques. The other great challenge in the CH artifacts analysis is the plethora of materials they are composed of, from metal to glass, to ceramic, paper, or textile; these material present different conditions in which they can be analyzed. Finally, the size or the nature of the sample does not always allows moving the samples, or putting them in vacuum chambers. Thus, in many occasions, in-situ analysis are preferred as the instrument can be brought to the museum or the archaeological site to perform directly the measurement.
XRF is a very useful tool to get elemental information on the sample in a non-invasive way, it is usually affordable by many laboratories, and compact spectrometers can perform in-situ analysis. XRF can give information on the first micrometers of the sample, in this sense, it is defined as bulk technique. In the case of layered samples, the fluorescence line intensity of an element depends on the layers'composition, and the position of the element inside the sample. Moreover, attenuation and self-attenuation of the fluorescence lines, depend on the geometry of analysis. In particular the angle of irradiation and detection influence the probed depth of the technique. Thus, angle dependent XRF techniques (Grazing Emission (GE), Grazing Incidence (GI), Angle Resolved (AR) XRF) can give information on the layers'structure and composition.
These techniques consist of a scansion of the sample, collecting XRF spectra at different angles. In the case of GE -XRF the detection angle is scanned around the critical angle of reflection of the fluorescence radiation; for GI -XRF the irradiation angle is scanned around the critical angle of reflection of the source radiation; while in AR-XRF the angle is greater than the critical angle, so no effects of reflection or interference are observed. As Grazing techniques require a small divergence in the solid angle of irradiation (for GI-XRF) or detection (for GE-XRF) they are usually applied in synchrotron facilities, where the high flux of the source compensates for the collimation, allowing to collect data with a good statistics in reasonable time.
The aim of my PhD work is to evaluate the capability of angle dependent techniques to analyze CH sample, starting with instrument that can ensure a high intensity (synchrotron or sources coupled with capillary lenses). The ultimate goal is to bring this application to laboratory instruments, to be more accessible and to perform in-situ analysis, more suitable conditions to analyze the great variety of samples that compose the CH family.

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