# ***Synchrotron radiation-based X-ray methods and vibrational spectroscopy techniques for the study of cultural heritage materials: a multi-method and multi-scale approach***

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Cultural heritage objects are multilayered and heterogeneous systems made up of amorphous and/or crystalline organic and inorganic compounds, that may be subjected to complex chemical transformations over time. Chemical investigations of artifacts and works of art are further complicated by the fact that their constitutive materials and degradation compounds may be present as layer and aggregates with sizes that can achieve the order of few hundreds nanometers. Thus, the systematic use of complementary analytical tools capable to provide spatially resolved elemental speciation and molecular/structural information at multiple scale lengths is usually required to get the maximum level of information from the object under investigation.

In this context, synchrotron radiation-based (SR) X-ray techniques, including XRF, XAS and XRD techniques (in point analysis and mapping/imaging mode), have been increasingly used within the last decades for their capabilities to provide spatially resolved elemental speciation and structural information down to the (sub)micrometre scale length [1-5]. The integration of these methods with vibrational spectroscopy techniques (e.g., IR and Raman) usually permit to acquire complementary knowledge about the molecular nature and spatial distribution of the constitutive materials and newly formed compounds in the analyzed object [6,7].

This lecture will focus on the presentation and discussion of recent studies, in which X-ray beams (employing SR and traditional sources) of (sub)micrometre to millimetre dimensions and molecular spectroscopic methods (*i.e.,* UV-Vis, IR and Raman) have been used for non-destructive/non-invasive analysis and characterization of the intrinsic properties and degradation processes of artists' pigments, paint micro-samples and/or entire paintings from 13th to 20th century painters.

***References:*** [1] K. Janssens et al., *Top. Curr. Chem.* **374** (2016), 77; [2] L. Bertrand et al. *Top. Curr. Chem.* **374** (2016), 1; [3] M. Cotte et al., *J. Anal. Atom. Spectrom*. **32** (2017), 477; [4] M. Cotte et al., *Comptes Rendus Physique* **19** (2018), 575; [5] V. Gonzalez et al., *Chemistry–A European Journal* **26** (2020), 1703; [6] F. Rosi et al., Recent trends in the application of Fourier Transform Infrared (FT-IR) spectroscopy in Heritage Science: from micro-to non-invasive FT-IR. In: Chemical Analysis in Cultural Heritage, 2020, De Gruyter, pp. 121-150; [7] F. Casadio et al. *Top. Curr. Chem.* **374** (2016), 161.