

## Accelerators and X-rays in cultural heritage studies

Heinz-Eberhard Mahnke

Fachbereich Physik and Excellence Cluster TOPOI, Freie Universität Berlin, Germany

A review will be given on the use of accelerators in non-destructive or minimally invasive studies connected to our cultural heritage. It focuses on making use of the production and detection of X-rays as a general tool. At “small accelerators”, the proton induced X-ray emission (PIXE), especially when combined with Rutherford backscattering spectroscopy (RBS), has been developed to a very versatile and powerful technique for near-surface investigations with  $\mu\text{m}$  resolution. It is well complemented by larger facilities, synchrotron radiation sources as well as medium energy ion accelerators for high energy PIXE. When high energy protons are used as inducing particles (with energies between about 20 and 100 MeV), elements deeply buried under several hundreds of micrometers of corrosion layers, can be identified, too. These techniques are complemented by X-ray fluorescence, which has recently been developed into a 3-dimensional micro analytical technique with a resolution of around 30 micrometers by employing multi capillary X-ray guiding lenses. The state-of-the-art methodology will be illustrated on examples from painted glass windows and luster ceramics closely related to basic research on nanometer sized metallic inclusions in glasses. Such metallic nanoclusters used for centuries in post Roman European culture are presently under intense research for photonic applications. Finally, the outlook will be given for a new generation under way of mono-energetic high-energy high-intensity X-ray sources being developed as “table-top” instrumentation with MeV-electron LINACS for complementary use of synchrotron radiation at GeV-electron or positron-storage rings in cultural heritage studies.

