Nuclear Techniques for the Cultural Heritage

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Basic Information
- Course Title: Nuclear Techniques for the Cultural Heritage
- Course Number: PHYS-UA 9800
- Instructor: Pier Andrea Mandò - University of Florence, mando@fi.infn.it
- Points: 4
- Class times: TBA

Description
Why, and how, to preserve the past in terms of artworks and artefacts? In Western cultures, a great value is increasingly attributed to the material mediums that constitute cultural heritage. A piece is authentic, original and has value when the original materials (stone, canvas, bricks, etc) are also preserved. Because of the importance of the material itself, a great effort is more and more often undertaken by experts to assess the objective aspects of a work (e.g. age, material composition and conservation state) both for a deeper knowledge, not only limited to its aesthetical aspects, and in order to decide the best approach to its restoration when needed. In some form, and to some extent, this attitude towards the past has always existed, and restorers, or curators, have recurring to the best knowledge of their times to approach the preservation and maintenance of their past. However, their choices were not always the best ones, and several pieces of art have been damaged -if not destroyed- in the attempt to preserve them. It is also worth to notice that issues of proper or improper preservation of cultural heritage objects have not only an academic relevance but also an important economical one. An equally important economic and academic impact is linked to the authenticity of cultural heritage objects: artworks and archeological findings, but also religious relics, etc. This potentially questionable concept, authenticity, means in this context that the origin, the materials, and/or the creator of the object correspond to what is being declared about the object itself (typically by the seller, by a museum, a religious institution, etc). This impact justifies the resources put, on one hand, in assessing
the authenticity of the object, and on the otherhand, in forging fake objects that may attract the same amount of economical (sometimes also academic or cultural) interest as an original object. In summary, tools that can enable the assessment of the physical and chemical state of an artefact, its age, and its origin, may have a significant role in the cultural heritage research and business. This course addresses precisely some of these tools. In particular, it describes the revolution undergone by the cultural heritage disciplines when technologies taken from physics, and in particular nuclear physics, started being used for investigating artwork and archeological findings. This revolution starts in the late 40s, when William Libby proposes the idea of radiocarbon dating (later obtaining a Nobel prize for it), and continued flourishing, as more and more techniques from physics were found to be extremely useful in cultural heritage applications. This course will describe some of these techniques, explaining their physical underpinnings, and showing what knowledge they permit to attain, when used properly, on different kinds of cultural heritage objects. For instance, in some cases, scientific technologies definitely allow to establish the non-authenticity of the piece under study! However, there also limitations, and - as well as it is important to be acquainted with the possibilities and the potentials offered by scientific investigations in this field - it is equally important to be aware of their limits. We will first illustrate the theoretical bases of the current approach to preservation and restoration in Europe and particularly in Italy. Second, we will show how a team of experts, encompassing a wide range of disciplines, approaches an artwork that has to be analysed or restored. A close collaboration between scientists and cultural operators (art-historians, archaeologists and restorers) must be always established to obtain the best results. Third, we will more closely and extensively examine some of the technologies that allow these analyses to be made, putting the relevant experts in the condition of intervening on the artifact en ‘connaissance de cause’, based on a deeper scientific analysis and not only relying on empirical experience (which however remains an important ingredient!). A large fraction of these technologies fall under the domain of physics, and many important ones more specifically of nuclear physics. Ion-beam analysis (IBA) and X-ray fluorescence (XRF) permit to determine the elemental composition of the surface layers of an artefact, offering direct insight, for instance, on what sort of ink or paint was used by the artist. C-14 measurements and thermoluminescence allow to date an artefact. To put the students in a more direct contact with the work of experts, the course will include a visit to the Laboratorio di Tecniche Nucleari per l'Ambiente e i Beni Culturali- LABEC, a laboratory of the National Institute of Nuclear Physics in Florence, dedicated to this kind of investigations through the use of a particle accelerator, besides portable equipment. A visit to the restoration laboratory of the Opificio delle Pietre Dure, one of the most prestigious public Institutions in the world for the restoration of artworks of all kinds, is also envisaged.

Learning outcomes

Students will learn:
• the basis of modern restoration theory
• the basis of practical restoration
• the physics of ion beam analysis, X-ray fluorescence, $^{14}$C dating;
• the basics of ion acceleration and X-ray production;
• the main points of data interpretation
• the basics of thermoluminescence dating.
• the basics of optical techniques such as IR reflectography and laser ablation.

Teaching and learning methodologies

The course is based on lectures. The lectures will cover the techniques used as well as practical case studies. Data from case studies (using the various techniques illustrated in the course) will be used for in-class exercises and homework sets.

Grading

The grading scheme will be as follows:

• Attendance, participation 30%.
• Assignments: 40%.
• Final: 30%

Assignments

Assignments may be comprised of multiple choice quizzes, and brief reports on topics explained during lectures.

Textbook

There is not an official textbook. Notes by the teacher will be made available.

Final exam

The final exam will consist in a presentation by each student on a topic of her/his choice, chosen among the areas covered in the course. Questions on other topics may be asked during the presentation.
Academic Integrity

As set forth in NYU Academic Integrity Policy, the relationship between students and faculty at NYU is defined by a shared commitment to academic excellence and is grounded in an expectation of fairness, honesty, and respect, which are essential to maintaining the integrity of the community. Every student who enrolls and everyone who accepts an appointment as a member of the faculty or staff at NYU agrees to abide by the expectation of academic honesty. The full policies and procedures relating to Academic Integrity may be found on https://students.nyuad.nyu.edu/campus-life/student-policies/community-standards-policies/academic-integrity/ and on http://www.nyu.edu/about/policies-guidelines-compliance/policies-and-guidelines/academic-integrity-for-students-at-nyu.html

Topics

• week 1: Preserving the past: the meaning of authenticity in modern restoration theory

• week 2: Strategies for approaching artwork restoration

• week 3: The role of science for art and cultural heritage; basic notions of atomic and nuclear physics.

• week 4: Basics of ion acceleration; the tandem accelerator; x-ray production; interaction of radiation and matter.

• week 5: Radiocarbon dating, its basic techniques and achievable precision; preparation of the samples.

• week 6: Radiocarbon dating II, case studies.

• week 7: The concept of non destructive analysis; overview of available techniques to approach artwork.

• week 8: Ion beam analysis and particle-induced x-ray emission (PIXE)

• week 9: Ion beam analysis: particle-induced gamma-ray emission (PIGE)

• week 10: X-ray fluorescence.

• week 11: X-ray fluorescence and case studies.

• week 12: Radiography and computer tomography

• week 13: Infrared reflectance spectrometry, laser ablation

• week 14: Review