UNIVERSITY OF NEBRASKA–LINCOLN
Physics & Astronomy

Introduction to Synchrotron and XMCD-PEEM

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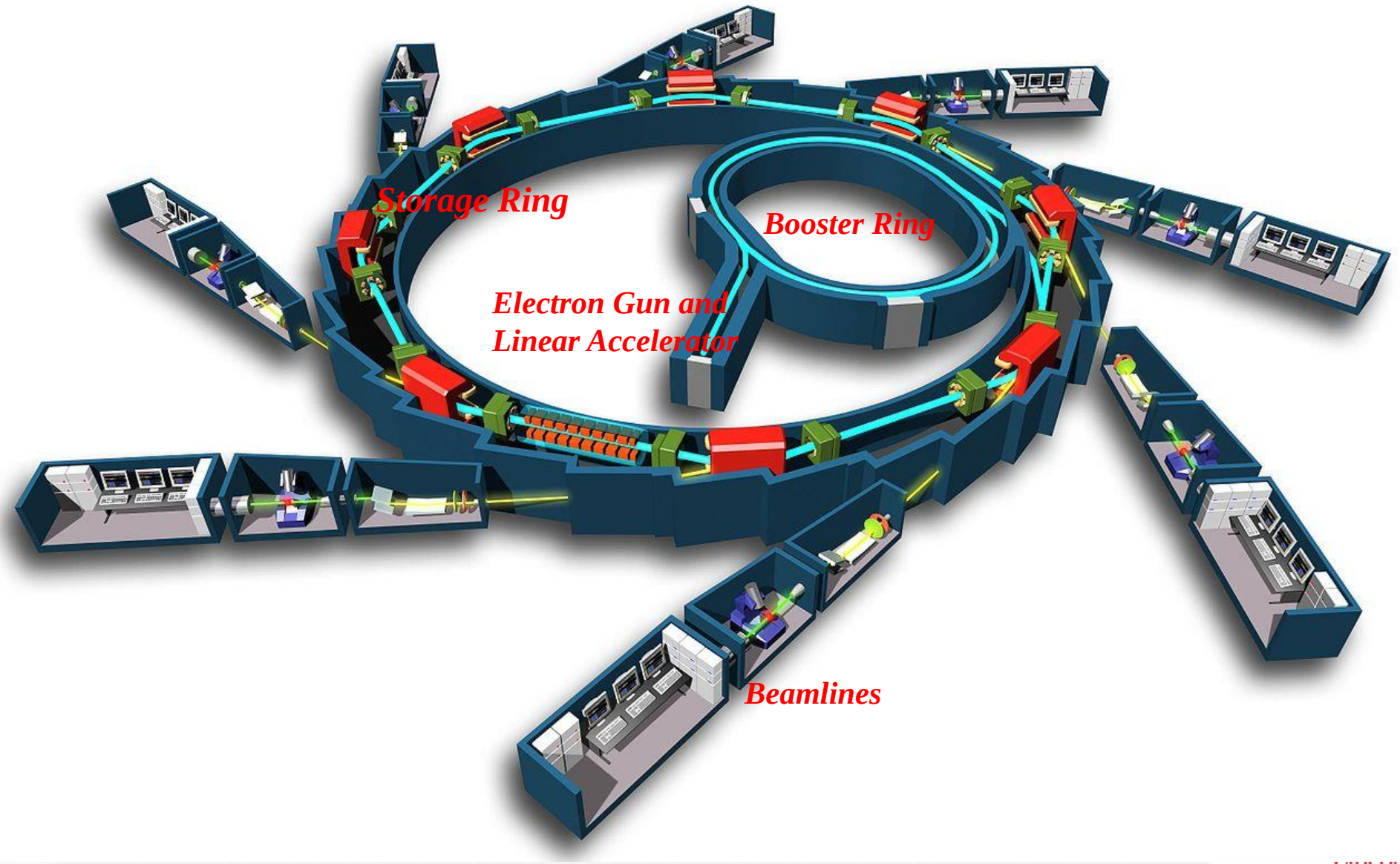
What is a Synchrotron?

Image from Canadian Light Source (CLS)

What is a Synchrotron?

- A synchrotron is a particular type of cyclic particle accelerator, descended from the cyclotron, in which the guiding magnetic field (bending the particles into a closed path) is time-dependent, being synchronized to a particle beam of increasing kinetic energy

What is a Synchrotron?



What is a Synchrotron?

A synchrotron light source is a source of electromagnetic radiation (EM) usually produced by a storage ring, for scientific and technical purposes. First observed in synchrotrons, synchrotron light is now produced by storage rings and other specialized particle accelerators, typically accelerating electrons.

PhotoEmission Electron Microscopy (PEEM)

- Photoemission Electron Microscopy or PEEM is an imaging technique that uses the secondary electrons emitted from a sample surface upon absorption of photons.
- For low-energy photons, like the ones coming from a laser or a mercury lamp, a chemical contrast can be obtained if elements with different work functions are present at the sample surface (typically, metallic islands on a semiconductor substrate).

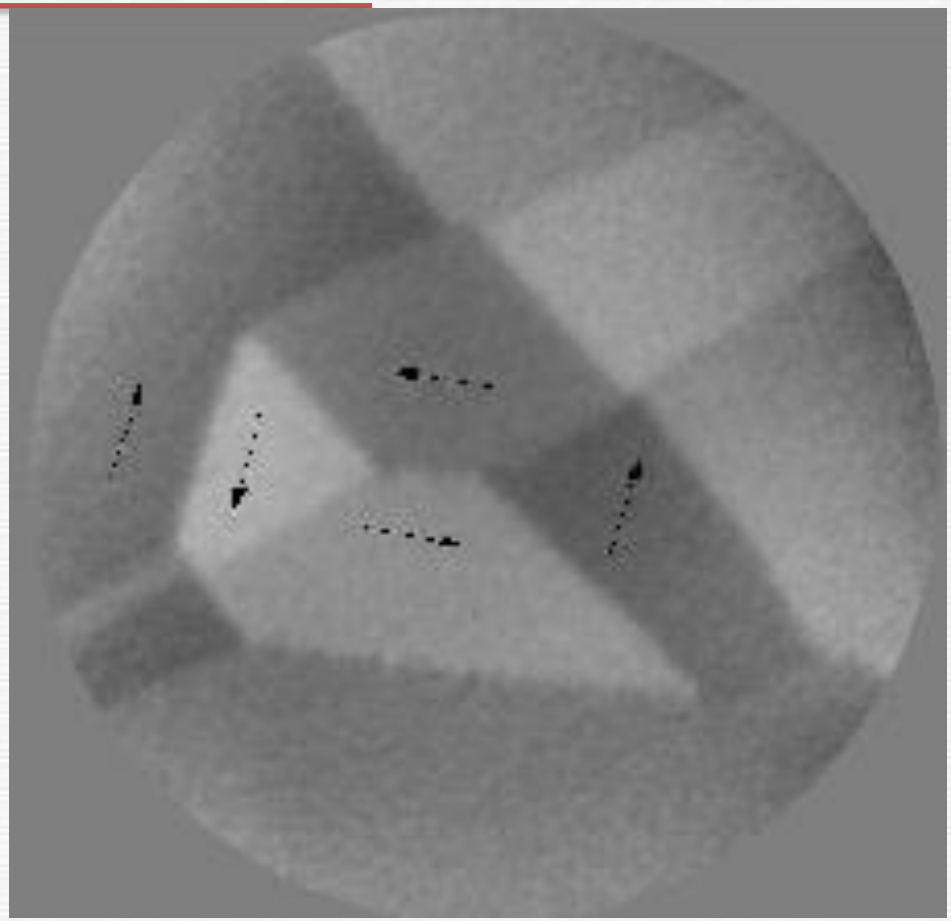
PhotoEmission Electron Microscopy

- Synchrotron x-rays provide a direct chemical contrast using the element-selectivity of x-ray absorption edges or x-ray photoemission.
- Magnetic sensitivity can be added using circularly polarized x-rays, through the X-ray Magnetic Circular Dichroism (XMCD) effect.

Application of PEEM

- Element- and magnetic sensitivity of XMCD-PEEM provides a Powerful technique for investigating magnetic multilayered systems, like used in magneto-electronic devices (spin-valves, magnetic random access memories).
- In these devices, where several ferromagnetic (FM) layers are separated by non-magnetic or antiferromagnetic spacer layers, the domain patterns in the two FM layers, as well as their correlation and interaction, can be observed separately

Application of PEEM



Magnetic domain image of 50 nm of Fe on MgO (001) (sample courtesy C.Tiusan, Nancy) taken with the french PEEM/LEEM instrument at ELETTRA (Italy). The field of view is about 15 µm.

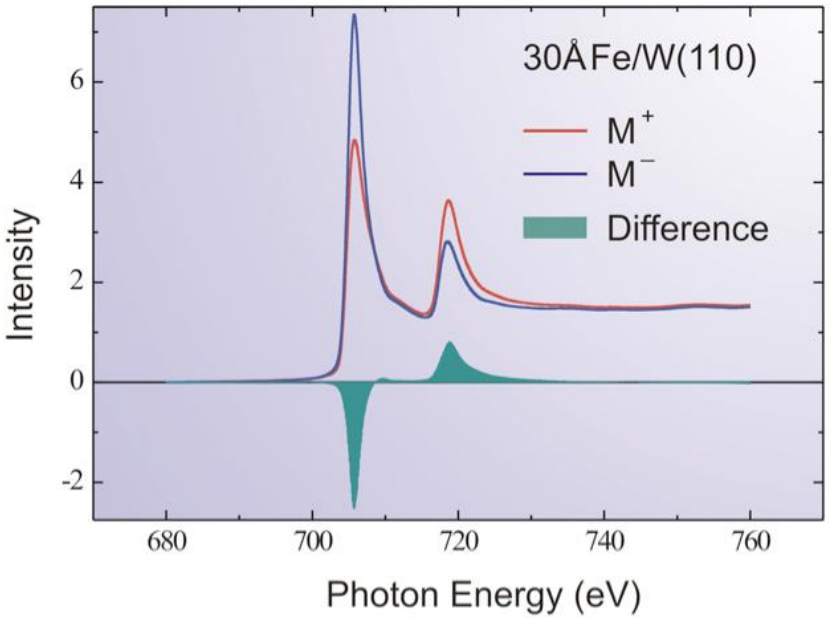
X-ray magnetic circular dichroism XMCD

X-ray magnetic circular dichroism is a difference spectrum of two x-ray absorption spectra (XAS) taken in a magnetic field, one taken with left circularly polarized light, and one with right circularly polarized light. By closely analyzing the difference in the XMCD spectrum, information can be obtained on the magnetic properties of the atom, such as its spin and orbital magnetic moment.

Application of XMCD

In the case of transition metals such as iron, cobalt, and nickel, the absorption spectra for XMCD are usually measured at the L-edge.

This corresponds to the process in the iron case: with iron, a 2p electron is excited to a 3d state by an x-ray of about 700 eV. Because the 3d electron states are the origin of the magnetic properties of the elements, the spectra contain information on the magnetic properties.



Summary

Why PEEM?

- XAS is helpful for us to determine the basic structure of our sample, LFO and YbFO
- Visualize the chemical different of our sample
- Try to find magnetic domains in our sample, and we can see it use PEEM


Thank you for your time!