Introduction to the interaction between matter and radiation

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In this lecture I will describe the fundamental physical concepts which are the basis of all experimental synchrotron radiation and FEL methods. I will use both phenomenological and first principle approaches, emphasizing physical understanding rather than mathematical derivations.

Radiation – matter interaction can be described in a macroscopic approach using the frequency dependent dielectric function and index of refraction. The real and imaginary parts of these functions determine dispersion and attenuation of electromagnetic waves in matter. I will describe a simple model for the dielectric response of matter based on damped harmonic oscillators and make a brief discussion of the Kramers – Kronig dispersion relations.

I will then discuss the principal interaction mechanisms in a microscopic (particle) description. In a phenomenological approach, I will describe elastic and inelastic scattering, photoelectric absorption, absorption edges and the decay processes following core hole creation and the relevant nomenclature.

Finally, I will discuss the semi – classical theory of the interaction between radiation and hydrogen – like atoms, which contains all the basic physics of matter – radiation interaction in general. Starting from time – dependent perturbation theory, I will derive the cross sections for photoelectric absorption and scattering.