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Synchrotron Radiation: Fundamental Notions and Impact on Science and Technology

Over the past five decades, synchrotron radiation has become a gigantic worldwide scientific and technological enterprise. It is now used by tens of thousands of scientists for applications in a wide variety of fields, including many of practical interest for industry, the economy, health care and the environment.
Such a widespread use by an interdisciplinary community requires simple approaches to explain the emission mechanism and the basic properties of the radiation. Indeed, users with different backgrounds must be able to understand the essential notions without dealing with complicated formalism and advanced theoretical physics.
Fortunately, this objective is feasible because of the relativistic nature of the phenomena. Whereas a comprehensive theory is very complicated, the extreme relativistic case of emitting electrons moving at almost the speed of light becomes, paradoxically, much simpler.
We shall use this approach to introduce the radiation emission by different sources: undulators, bending magnets and wigglers. We shall then explain, also on simple terms, fundamental properties like the wavelength spectrum, flux, collimation, brightness, polarization and coherence.
This knowledge will be exploited to introduce important examples of synchrotron radiation applications including x-ray imaging, absorption spectroscopy, photoemission spectroscopy and x-ray scattering. In general terms, such examples will illustrate how broad is the range of applications of synchrotron facilities.
Finally, we shall introduce a new class of sources, the x-ray free electron lasers (x-FELs). Using again an extreme relativistic approach, we shall explain the optical amplification mechanism, the geometry and time characteristics of the x-ray pulses and recent frontline technical achievements such as seeding.



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