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Nuclear resonant scattering of synchrotron radiation

The use of synchrotron radiation (SR) as a source for nuclear resonant scattering experiments has led to many new studies of physical problems that could not be investigated satisfactorily with radioactive sources in "classical" Mössbauer spectroscopy. This is due to the remarkable properties of this new source.

SR is emitted from electron clouds (bunches) circulating in storage rings. The linear dimension of these bunches, perpendicular to their direction of motion, is, in modern storage rings, in the range of some μm, thus yielding a nearly pointlike source. Due to the relativistic motion of the electrons the SR is emitted in a narrow cone in the foreward direction. The brilliance measured in photons/s/solid angle/energy bandwidth surmounts the brilliance of strong radioactive sources typically by ten orders of magnitude. The counting rate within an energy band given by the natural width of the nuclear transition is comparable with the counting rate in "classical" experiments. In the direction of motion the bunches are extended a few cm only, corresponding to $\sim$100 ps durations of the SR-pulse, thus suggesting time experiments. Indeed, the observation of quantum beats in the time spectrum of nuclear resonant scattering became the standard observation technique in this field. Moreover, SR is nearly 100% linearly polarized.

Last but not least the rapid development of modern beam handling and detector techniques gave further impetus to the development of the field. High resolution monochromators were developed which allow us to select and tune by pure electronic means energy bands of less than 1 meV width and mirrors and lenses allow us to focus the beam to the size of the electron source. Avalanche photodiodes allow the observation of delayed events after a few nanoseconds, even in the presence of a huge prompt background.

The combination of this source with the unique energy width of nuclear resonant transitions has opened a lively field of "nuclear resonant scattering of synchrotron radiation", which converts not only "classical" (energy) Mössbauer spectroscopy to a spectroscopy using a time (frequency) scale but opens new fields of research not accessible with standard techniques.

The editors had realized the great importance of a book on applications of the new spectroscopy already a few years ago, when it had become clear that properly filtered synchrotron radiation could be used as a source for many new experiments.

The first successful demonstration of a synchrotron source was in 1984 in Hamburg. Now, 15 years later, developments are still in full swing, but we believe that the time is ripe for publishing a book that will provide a background for the many

physicists now engaging in experiments with synchrotron sources and will assist them in achieving their goals much more readily.

But also for those with more esoteric intentions the book has much to offer. Up to date accounts are given of the theory of elastic scattering of synchrotron radiation. Also, applications of a specific nature and methodological developments are given ample attention. At the end of the book, data evaluation is treated, leading to discussion of the much used popular analysis programs CONUSS, PHOENIX, MOTIF, EFFINO and DOS. All of them are freely available from the authors and on the net.

More complete information about the various synchrotrons and beam lines used for Mössbauer spectroscopy can be found in:
http://www.esrf.fr/
http://www.esrf.fr/exp_facilities/ID18/homepage/homepage.html
http://www.aps.anl.gov/
http://www.aps.anl.gov/sricat/3id.html
http://www.spring8.or.jp/
http://www.spring8.or.jp/ENGLISH/facility/bl/PublicBeamline/BL09XU/index.html
http://www.spring8.or.jp/ENGLISH/facility/bl/JAERIBL/BL11XU/index.html
http://www-hasylab.desy.de/
http://www.rrz.uni-hamburg.de/hfww/welcome1.html
http://www-hasylab.desy.de/science/groups/petra_group/start.htm

More than forty authors have devoted much time and effort to writing the 40 chapters that together form this book. The editors are very grateful to them for writing and also for going patiently through the editors' wishes for changes and corrections. This is, by all means, an edited volume. As is unavoidable for such a book, there is some overlap here and there, and also there are differences in approach between authors at different locations and/or backgrounds. The editors have been well aware of this throughout the fulfilment of their unifying and corrective tasks. However, they are convinced that diversity in approach has, on the whole, had a positive effect. It has helped to improve the depth of penetration into the material treated. In this respect the book compares positively with one essentially written by one or just a few authors.

Since, as has already been remarked, the development of the field covered in this book is still in full swing, it does not give final answers. Undoubtedly more reviews of the field will appear in due time. However, we believe that, in view of the expertise of the present authors, they could hardly be more authorative.

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