

Book Review of Mössbauer Spectroscopy and Transition Metal Chemistry: Fundamentals and Applications

Mössbauer Spectroscopy and Transition Metal Chemistry: Fundamentals and Applications. By Philipp Gütllich (Universität Mainz, Germany), Eckhard Bill (MPI für Bioanorganische Chemie, Mülheim, Germany), and Alfred X. Trautwein (Universität zu Lübeck, Germany). Springer: Heidelberg, Dordrecht, London, New York. 2011. xvi + 570 pp. \$259. ISBN 978-3-540-88427-9.

Mössbauer spectroscopy is special because it is one of only a few named spectroscopic techniques—only Raman and Auger spectroscopy also spring to mind. Thus, it was especially sad for the Mössbauer scientific community to learn of the death of Rudolf L. Mössbauer in 2011, 50 years after he received the Nobel Prize in Physics in 1961 for his discovery.

This book is a revised, extended, and updated version of the 1978 edition by Gütllich, Link, and Trautwein. Because Mössbauer spectroscopy has developed into a mature analytical and spectroscopic technique, graduate-level courses in solid-state physics, chemistry, and materials science typically cover Mössbauer spectroscopy in some detail. The predominant goal of the authors is to provide a textbook for such courses. As a result, it concentrates on the fundamentals and applications of Mössbauer spectroscopy, derived mostly from the work of the authors, but provides rather little theoretical background. There are new chapters on computational methods and synchrotron radiation studies in this edition, however. An included CD-ROM provides several hundred power-point slides that can be used by an instructor in a course as well as a pdf file of the earlier edition. The book also contains nine appendices in Chapter 10 and a 10-page index. Each chapter is followed by an extensive list of references that have been updated to approximately 2008.

The first four chapters cover the fundamentals of Mössbauer spectroscopy, from its discovery in 1958 through the first observation of hyperfine interactions to the use of these interactions to better understand a compound's electronic and magnetic properties. Some shortcomings were encountered in the first two chapters that may well perturb the potential reader, however. To give a couple of examples, there appears to be a mixture of classical and quantum physics in the description of the Mössbauer effect, and the low- and high-temperature approximations of the temperature dependence of the recoil-free fraction on page 15 are actually those of the logarithm of the recoil-free fraction as is illustrated in Figure 2.5. Also, sadly, there are typographical errors in several equations. These problems were annoyingly obvious to this reviewer but may be less apparent to some readers.

In contrast, I found Chapter 3 on the experimental aspects of Mössbauer spectroscopy to be very instructive. It should prove very useful to anyone starting to use this technique. Too often as a referee, I have come upon poorly executed Mössbauer experimental work. If scientists new to the field carefully read and follow the recommendations found in Chapter 3, they will avoid

many pitfalls and obtain reliable Mössbauer spectra. The reader will also find a section on the miniaturized Mössbauer spectrometer that was used to measure the first ever extraterrestrial Mössbauer spectrum on Mars.

Chapter 4, which deals with the various chemical properties probed by hyperfine interactions through Mössbauer spectroscopy, suffers from similar problems as found in Chapter 2, i.e., equations that cannot be derived, typographical errors, and changes in notation. Fortunately, this reviewer found Section 4.7, which deals with iron-57 Mössbauer spectroscopy of paramagnetic complexes through the use of the spin-Hamiltonian, well presented.

There is a change of pace in Chapter 5, a chapter that reports recent advances in the computation of Mössbauer spectral hyperfine parameters. This chapter is based upon the work of Neese and co-workers. Most beginning students, especially if they are more experimentally oriented, may be discouraged by the mathematical aspects of this chapter and may need help in following the intricacies of the computational methods. The sections on the correlations between experimental and computational results will be the most interesting for the average reader. Unfortunately, in this chapter there are also disturbing editorial problems. For instance, in the caption for Figure 5.2 the green and red are reversed, and Figure 5.12 shows the radial distribution functions for a neutral iron atom but the caption says they are for the neutral manganese atom—the same error is repeated in Figure 5.13. Another figure is of very poor quality, and the arrows cannot be found.

Chapter 6 on magnetic relaxation phenomena is, unfortunately, restricted to rather early work and would have benefited from an extensive revision covering more recent work.

To the reader who wonders which nuclides are Mössbauer active and, perhaps more important for the chemist, what chemical information will the spectra provide, Chapter 7 will be very useful. The sections on nickel, zinc, ruthenium, and gold will probably be the most interesting to many chemists, as answers to specific problems can be found in these sections. I am often asked where can the Mössbauer spectra of a given element be obtained. Unfortunately, many of the noniron Mössbauer nuclides are no longer studied as is revealed by the dates of many of the references in this chapter.

The examples of iron-57 Mössbauer spectroscopy found in Chapter 8 are largely limited to the excellent work of the authors on electronic spin-state transitions, unusual spin and valence states, and applications to earth and space science. Rather wisely, the authors have not attempted an exhaustive review of the ~60 000 papers on iron-57 Mössbauer spectroscopy. Because the authors restrict the book to transition metals, there is no discussion of the important tin and antimony Mössbauer nuclides.

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With the recent development of nuclear resonance scattering of synchrotron radiation, a new chapter on this topic (Ch 9) has been added. The reader will find examples of problems that have been treated previously by transmission Mössbauer spectroscopy; the parallel between the time and energy domain experiments is well explained and documented.

In conclusion, this book is a valuable addition to the literature on Mössbauer spectroscopy and its applications. Some of the chapters will be most useful to a scientist new to the field, and some very specialized chapters, 5 and 9 for instance, are of interest even to the experienced Mössbauer spectroscopist. In view of the rather large number of typographical errors and editorial problems found in this book, I would recommend that the authors create a Web site that will provide the reader with the needed corrections.

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