The real spherical harmonics (Arfken, 1970)

$$u_{lm\pm} = P_l^m(\cos\theta)\,{}^{\cos(m\varphi)}_{\sin(m\varphi)}, \quad l=0,1,\ldots, \quad m=0,1,\ldots,l \quad (3)$$

[where $P_l^m(x)$ is the associated Legendre function] have been tabulated in the literature for $l \leq 7$ (Paturle & Coppens, 1988; Coppens, 1993). Table 2 lists those $u_{lm\pm}$ ($8 \leq l \leq 10$), with their normalization factors, which appear in the expressions for K_{lj} ($8 \leq l \leq 10$).

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Book Reviews

Works intended for notice in this column should be sent direct to the Book-Review Editor (R. F. Bryan, Department of Chemistry, University of Virginia, McCormick Road, Charlottesville, Virginia 22901, USA). As far as practicable, books will be reviewed in a country different from that of publication.

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P. P. Ewald and his dynamical theory of X-ray diffraction. (IUCr Monograph on Crystallography No. 2.) Edited by D. W. J. Cruickshank, H. J. Juretschke and N. Kato. Pp. xi + 161. Oxford: International Union of Crystallography/Oxford Univ. Press, 1992. Price £37.50. ISBN 0-19-855379-X.

This is an opportune time to re-examine the dynamical theory of X-ray diffraction by Ewald. The advent of synchrotrons all over the world has given new impetus to diffraction and scattering studies and with them a new demand for the understanding of basic diffraction theory. This new monograph by the IUCr is therefore timely, offering a concise presentation of Ewald's work for the specialist with a thorough grounding in physics and mathematics. With the rapid growth of X-ray and neutron studies of biological systems, it also would be extremely helpful if the major aspects of the dynamical theory could be presented in a manner understandable to scientists who are nonphysicists. We may hope that someone will now attempt that.

Ewald as a great scientist and gentle person comes to life in this book, with the authors presenting some glimpses into his private life and providing a well rounded presentation of his major scientific contributions.

The monograph begins with an introductory chapter by Kato on the significance of Ewald's dynamical theory. This is followed by four contributions constituting Section *B*, 'Ewald as seen by others'. This section is of particular interest and brings the man to life - a different person from the formal, rather Germanic, scientist encountered by the audience of his lectures. Since one of us (JFM) spent many hours with Ewald, both in Australia and elsewhere, we approached this book with a deep respect for his brilliance and deep insight into the physical basis of crystal optics and crystallography. What we had only glimpsed, and what underlies many of the comments and revelations in this book, is the humanity of the man - even humility, yet without any display of false modesty. He knew he was foremost in his field, but had great tolerance of the difficulties experienced by others, even senior scientists in crystallography, in understanding his work. He often came up with appropriate comparisons from other fields, such as the *Pendellösung* fringes described well in this monograph. Reading his history, one marvels at the range of his interests and contributions to science. It is difficult enough today to try to understand subjects like his dynamical theory, or the quantum-mechanical approach to the interaction between matter and radiation; how much more difficult it must have been without the knowledge of crystal structure that we now possess and the myriad of related experiments from so many other fields. A lot of his personal charm and diplomacy was revealed at a NATO conference on direct methods, organized by Michael Woolfson and held in Parma, Italy. Parma was then a stronghold of the Communist movement in Italy, with very vocal representation by the students of the University. Martin Buerger was lecturing when a group of students entered and disrupted the meeting. Buerger was furious and looked like providing provocation for a confrontation, these being only too common at the time. However, Woolfson, who chaired the session, calmed down Buerger and invited a few of the troublemakers to talk things over. He managed to propitiate some of the delegation, but a very pretty and fiery young woman still protested against 'fascists in a NATO-sponsored conference' using their university. At this stage, Professor Nardelli, host of the conference, wanted to call in the police, but Ewald interceded and asked if he might talk to the demonstrators. The organizers could hardly refuse this request from an elder statesman of science. None of the demonstrators spoke English, but some of them understood French, and Ewald explained in fluent French that many of the participants in the meeting were from non-NATO countries, including the Soviet Union, Hungary, Yugoslavia *etc.* The students left quietly and presented no further problems. The conferees continued to use the university dormitories, but moved the lectures to an hotel. That little episode was typical of Ewald, demonstrating his ability to identify the key issue and provide a solution.

Seven contributions, covering major aspects of Ewald's work and their legacies, are offered in Section *C*. That by Cruickshank highlights the origin of the Ewald sphere and the reciprocal lattice as a result of the dynamical theory and not as the geometrical construction most of us have accepted as the cornerstone of crystallography. We have to say that it is easier to comprehend reciprocal-lattice problems from the geometrical interpretation than from the very complex derivation that brought Ewald to this singularly striking and so useful result. Largely unknown to crystallographers is the work by Ewald on lattice sums and the Madelung constant, a concept widely used in electrostatic calculations of crystals and briefly described by David Templeton. A lucid description of X-ray topography, by André Authier and Bernard Capelle, describes the importance of the dynamical theory and demonstrates how basically this theory explains fundamental interactions of radiation with matter. We draw special attention to the chapter by Colella on multiple diffraction and the phase problem. This chapter perhaps describes best the very fundamental nature of the dynamical theory and its core contribution to much of modern diffraction physics. One wonders what Ewald would have done if access to modern synchrotrons and perfect crystals had been possible a few decades ago! Cowley and Moodie explore how Ewald's two-beam approximation of the propagation of X-rays through crystals is equally valid for electron diffraction and how his dynamical theory influenced the foundation of early electron diffraction theory. This is an elegant exposition of how a well founded theory can lead to crucial experiments to probe the atomic nature of matter and provide the theorist with clear-cut data to elucidate and refine our understanding of it. This section of the monograph also includes a commentary on Ewald's dynamical theory by Hellmut Juretschke, who has also provided some of the long-awaited English translations of Ewald's early papers. This chapter also provides insight into the concepts underlying the complex nature of Ewald's work, and should be of particular interest to scientists using diffraction techniques who are not specialists in diffraction theory, who may shy away from the formidable complexity of Ewald's mathematical presentation. In the last chapter of this section, R. K. Bullough and F. Hynne offer an exposition of the extinction theorem as applied to amorphous matter. This is a general extension of the dynamical theory to the analysis of dielectric phenomena and nonlinear optics. The authors point out that 'perhaps the most spectacular feature of the nonlinear extinction theorem is its possibility for dynamical chaos' - a fact of nature discovered with Ewald's elegant and all-embracing dynamical theory.

Section *D* - 'Ewald Speaks for Himself' contains five of his more fundamental papers, including a welcome translation, by Juretschke, of his trendsetting paper on the contributions to the theory of the interferences of X-rays in crystals. The book concludes with a bibliography of Ewald's publications, also compiled by Juretschke, and useful name and subject indices.

This is a remarkable monograph, and should be a 'must-read' study for everyone interested in scattering problems.

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