

INTERNATIONAL UNION OF CRYSTALLOGRAPHY

IUCr Newsletter

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Original article text and available illustrations

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LETTER FROM THE PRESIDENT

Letter from the President

I am very proud to report on the successful implementation of an IUCr initiative for developing countries. At its meeting held in Nancy in 2000, the Executive Committee agreed that support of up to USD 6,000 per annum for five years would be appropriate for PhD students from southern African countries to enable them to work in a South African university. Additional financial support might be obtained through other grants programs, the South African NSF, South African industry and charities. In 2004, Bernard Omondi from Kenya was selected as the first recipient of the award (see Page 10). Recently, I heard that he had completed his PhD successfully at the U. of Witwatersrand of Johannesburg.

In March of this year the Finance Committee meeting was held at Grenoble in France and the accounts for 2006 were discussed (and subsequently approved by the Executive Committee). I would like to give you a brief explanation of the financial state of the IUCr. The total income for 2006 was 5,043,909 Swiss Francs. As shown in Fig. 1, the income comprises: 3% membership subscriptions; 89% sales of publications; 3% investment income; and 5% income from advertisements and royalties. On the other hand, the total expenditure was 5,068,339 Swiss Francs. There was therefore an operating deficit of 24,430 Swiss Francs last year. However, the amount (approximately 0.5% of expenditure) is not so serious, since at the same time the assets increased during the year by 393,670 Swiss Francs. As shown in Fig. 2, the expenditure is attributable to: 69% production of publications; 3% young scientists' support, Visiting Professorships and President's Fund; 2% Publications and Journals Development; 11% programming and development; 3% promotion; 4% administration including General Assembly, accountancy and legal charges; 7% secretariat office; and 1% Committee meetings.

Expenditure 2006 (Swiss Francs)

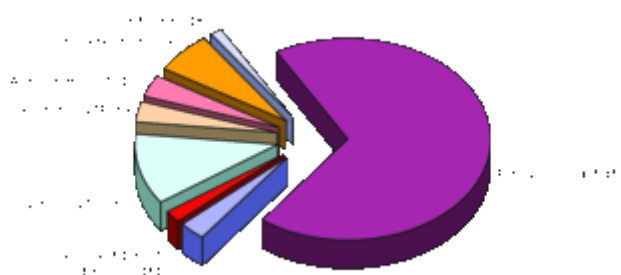


Fig. 2

Income 2006 (Swiss Francs)

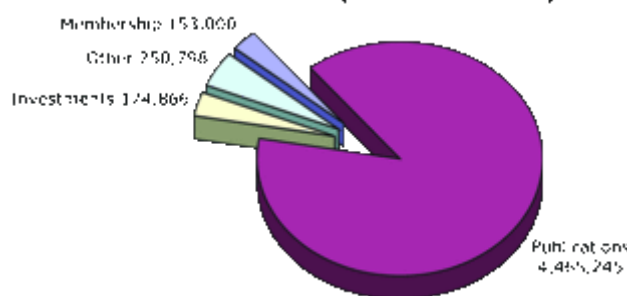


Fig. 1

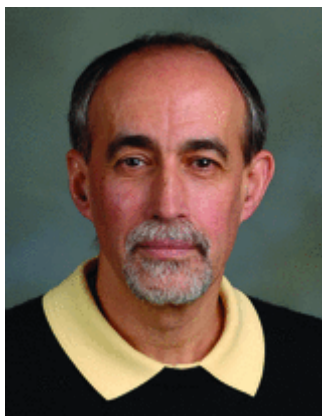
The above figures appear somewhat complicated. However, it may be simpler to say that about 90% of income is from the sale of Journals, International Tables and Books, and 10% is from other sources, including membership subscriptions. For expenditure, about 85% is attributable to publications and 15% to management including young scientists' support. This indicates that about 5% of the income from

publications is used for management. This is an excellent quality of the IUCr. I have heard that many scientific associations suffer from a deficit due to journal publications. However, the number of subscribers to IUCr journals is also gradually decreasing. A small increase of the subscription fee will not be able to compensate for the deficit in future. We are awaiting good ideas from all crystallographers on how to improve the financial state without a decline in activity.

Yuji Ohashi, yohashi@spring8.or.jp

FEATURE ARTICLE

Quo vadis structural biology?



Maturity in our personal lives and in science is a double-edged sword. On one side, it is quite satisfactory to reach the middle state in our lives with a sense of accomplishment and pride and look ahead to the next stage. Similarly, it is comforting to see the young and revolutionary science that structural biology was in the early sixties reach a point of maturity, and look around at its accomplishments as represented by the thousands of macromolecular structures deposited at the PDB. More important is to examine the critical insights that these structures have provided into all branches of biology, chemistry, medicine and drug discovery. However, the question is inevitable: What lies ahead? Is it a calm and subdued middle age going to be followed by death, or will there be a rejuvenation and rebirth? Will the future of structural biology lay dormant within the many branches of science that it has helped to advance (biochemistry, cell biology, medicine and others), or will it experience a rebirth by developing new methods to explore the complexity of the living organisms?

This issue has been explored in the last few years by several members of the community. How far and deep we have been able to penetrate into the molecular machinery of biological systems at the beginning of the 21st century, from Vesalius to Palade and Perutz has been insightfully reviewed (Harrison, 2004). After the anatomical discoveries of the renaissance, the structural cell biology tradition of Palade in the first part of the 20th century extended naturally into the structural molecular biology represented by Perutz that we practice today. Harrison's analysis is thoroughly well reasoned and compelling suggesting that the fusion of 'structural molecular biology' and 'structural cell biology' will provide an extended framework for the understanding of biological systems in the next decade. He discusses the roles of structural genomics and computational modeling in that context (Harrison, 2004). This suggested fusion of the two structural traditions represented by Perutz (molecular) and Palade (cellular) will undoubtedly aid in a better understanding of certain biological processes.

The impact of more traditional, well-focused, and slower (i.e. systems-oriented) approaches to discovery in relation to the high throughput, more expedient (i.e. discovery-oriented), structural genomics strategy was discussed in more detail by Stevens soon thereafter (Stevens, 2004). More recently, Dauter has superbly reviewed the current state and prospects of macromolecular crystallography with a detailed review of the methods and techniques currently in use and the ones that will be appearing in the near future. Both Stevens and Dauter seem confident that the two approaches (high-throughput and specific focus) will continue to provide a constant stream of macromolecular structures that will continue to add to our databases of biological structures and will expand our understanding of living systems (Stevens, 2004; Dauter, 2006). Will this be enough?

I am skeptical that the simple 'structural' extension from molecules to cells will provide the full answers to the complexities of biological systems. A recent essay has been published (Abad-Zapatero, 2007) that

provides a historical and scientific context to support this viewpoint. What else do we need? I think that what we need is to put the living systems within the proper set of physico-chemical principles under which they operate. What is the conceptual framework that encompasses these open, highly heterogeneous and complex systems? The technical term is *dissipative structures*. The term was coined by R. Landauer in 1961 but has been studied, analyzed, and disseminated in the scientific literature by the work of the late Prof. Prigogine (1917-2003) and his coworkers at the Free U. of Brussels and the University of Texas at Austin.

In the end, it is the interplay among the conservative molecular entities that we study by single-crystal diffraction methods and the dissipative structures that these molecules make possible that results in the magic of life. This broader conceptual framework suggested above will help us put all this information in the context of systems biology. The concepts of non-equilibrium thermodynamics and dissipative structures have to enter into the domain of modern structural biology if it is to proceed to the next level of understanding. These are concepts that go beyond the commonly accepted notions of intermolecular interactions (be it protein-protein, or protein-nucleic acids) because they include the ideas and notions of flows (fluxes) of matter, energy and information and the sharing of metabolites and chemical intermediates as effectors or facilitators of those interactions. New generations of structural biologists should be introduced to these concepts so that little by little they percolate into the fabric of structural biology and form a part of its intellectual framework. This extension should bring the methods, techniques and *modus operandi* of biochemistry back to the forefront in a novel and more comprehensive way.

Biochemistry is important and I do share the view expressed recently by Arthur Kornberg and others that biochemistry matters “because it does something that genomics, proteomics and other ‘omics’ cannot yet do” (Kornberg, 2004). As he argues, in the past we have used *in vitro* cell-free systems to gain insights into fermentation, transcription, translation and so many other biological processes. What are those ‘cell-free systems’ but stable dissipative structures that we can control, manipulate and study their inputs and outputs to infer their complex behavior? We need many more of those self-sustaining systems to gain a deeper understanding of the subtleties of biological systems. This has also been suggested by Harrison (Harrison, 2004) to understand processes ranging from clathrin coating to the motions of the mitotic spindle and beyond. Using the sophistication and experience of traditional biochemists, we need cell-containing or cell-free systems to assay processes such as various biological oscillators, biological clocks, kinase cascades, cell replication and robust, reproducible and self-sustained signal-transduction systems as well as many other critical biological processes that we do not understand yet at the molecular or cellular level. We may understand the ‘parts’ but the ‘whole’ still eludes us.

The use of the concepts and methods of non-equilibrium thermodynamics will aid in understanding the stability, dynamics and control of these open thermodynamic systems and in the design and implementation of new ones. This will open doors to a better understanding of the results obtained by genomics, proteomics and any other ‘omics’ that we might invent, and will extend to true ‘systems biology’. Systems biology modeling should be more than the catalog, description and computer modeling of interactions, no matter how intricate (Giot *et al.*, 2003). It should include the detailed spatial and temporal mapping of all components, interacting forces and corresponding fluxes acting on the system. Steven Strogatz, a well known mathematical biophysicist has expressed this idea very concisely: “Our models of complex systems will never advance beyond caricatures until we can find a way to infer local dynamics from data” (Strogatz, 2002).

The insights and understanding gained within this expanded framework will take us from the detailed study of the individual parts at the molecular and pathway level into the true meaning of systems biology, well beyond the simple notion of protein-protein interactions or even protein-nucleic acid interactions (Giot *et al.*, 2003). It is conceivable that by expanding our vision of structural biology to

include stable, fully integrated dissipative structures, we could open the door to understanding the deregulation existing in the multitude of pathologies associated with cancer, immune disorders, depression and others complex diseases for which our knowledge is still rather limited.

Cele Abad-Zapatero

References: Abad-Zapatero, C. (2007) *Acta Cryst.* **D63**, 660-664; Dauter, Z. (2006) *Acta Cryst.* **D62**, 1-11. Giot, L., Bader, J., Brouwer, C., Chaudhuri, A., Kuang, B., Li, Y. *et al.* (2003) *Science* **302**, 1727-1736. Harrison, S. (2004) *Nat. Struct. Biol.* **11**, 12-15. Kornberg, A. (2004) *Nat. Struct. Biol.* **11**, 493-497. Stevens, R. (2004) *Nat. Struct. Biol.* **11**, 293-295. Strogatz, S. Fermi's "Little Discovery" and the Future of Chaos and Complexity Theory. In *The Next Fifty Years. Science in the First Half of the Twenty-First Century*. p. 121. Edited by John Brockman. Vintage Books. A Division of Random House Inc. New York. 2002.

The mean-square Friedel intensity difference in P1 with a centrosymmetric substructure

The mean-square intensity difference between Friedel opposites is given by

$$\langle D^2(hkl) \rangle = \left(\langle |F(hkl)|^2 - |F(\bar{h}\bar{k}\bar{l})|^2 \rangle^2 \right) \\ = 4 \sum_{m=1}^N \sum_{n=0}^N \Delta_{mn}^2 - 4 \sum_{m=1}^Q \sum_{n=0}^Q \Delta_{mn}^2$$

where $\Delta_{mn} = f_m f_n - f_n f_m$, and N and Q are respectively the number of atoms in the whole unit cell and in its centrosymmetric substructure.

The mean-square Friedel intensity difference in P1 with a centrosymmetric substructure

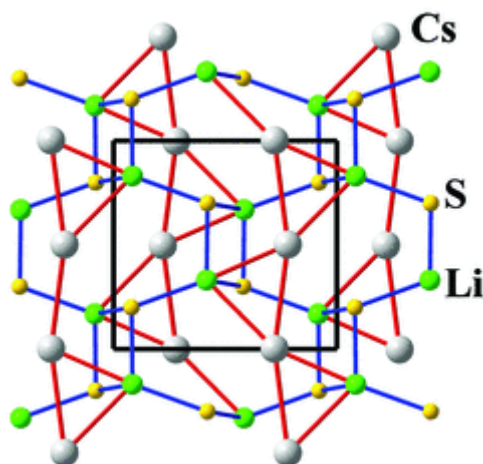
Acta Cryst. (2007). A63, 257-265 [doi:10.1107/S0108767307002802]

For non-centrosymmetric crystals one may observe and calculate a *Friedel difference* in intensity between $I(hkl)$ and $I(\bar{h}\bar{k}\bar{l})$ due to the action of resonant scattering. However, it is known that a non-centrosymmetric crystal structure of elemental Se shows no Friedel differences and that a centrosymmetric substructure does not necessarily decrease the Friedel differences. Flack and Shmueli have undertaken a detailed statistical analysis of rms Friedel differences. A resulting Bijvoet intensity ratio provides an estimate of the rms Friedel difference relative to the mean intensity. Applications are in the fields of structure solution by MAD, SAD, etc. and in absolute-configuration determination.

H.D. Flack and U. Shmueli

Pseudoatoms and preferred skeletons in crystals

***Acta Cryst.* (2007). B63, 339–345 [doi:10.1107/S0108768107019167]**



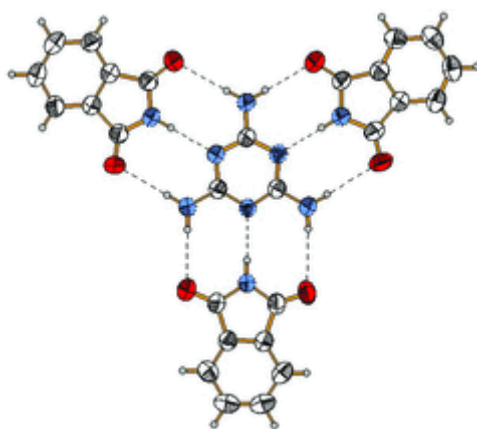
In CsLiSO_4 , cations form a cotunnite-like structure with trigonal prisms of Li and Cs atoms (red lines) centred by S. If Cs donates one electron to Li, the (LiS)- subarray (a pseudo-II–VI compound) forms a four-connected net of the SrAl_2 -type (blue contacts).

The GZKC (generalized Zintl–Klemm concept) seems to be the universal key to interpret and understand crystal structures of alloys as well as cation arrays of oxides. This generalization suggests a concerted electron transfer between cations (even if they are of the same kind) to produce cationic skeletons mostly coincident with either elements or pseudo-elements of group 14 as if some sort of “(IV)–(IV) rule” holds in the formation of a given compound. In oxides, the O atoms locate close to the bonding zones.

A. Vegas and V. García-Baonza

IUCR JOURNALS NEWS

2,4,6-Triamino-1,3,5-triazine-1H-isoindole-1,3(2H)-dione (1/3)



2,4,6-Triamino-1,3,5-triazine-1H-isoindole-1,3(2H)-dione (1/3)

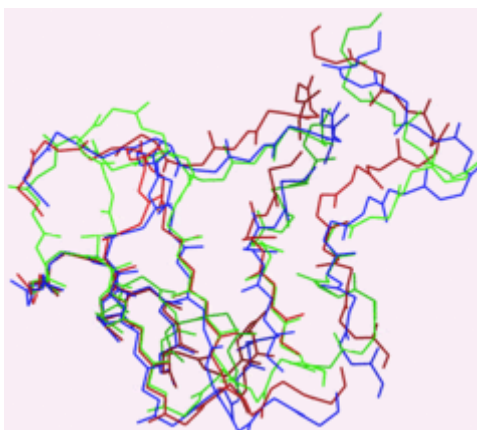
***Acta Cryst.* (2007). C63, o301-o302 [doi:10.1107/S0108270107015880]**

This article describes the crystal structure of small organic molecules containing complementary arrays of hydrogen-bonding sites. The components of the crystal, i.e. melamine and phthalimide molecules, are interconnected via almost linear N-H $\cdots$ N and N-H $\cdots$ O hydrogen bonds into essentially planar C₃H₆N₆ · 3C₈H₅NO₂ aggregates with pseudo-threefold symmetry. These aggregates, related by a twofold symmetry screw axis, interact *via* C-H $\cdots$ O contacts forming chains parallel to the *b* axis, whereas those related by a translation along the *c* axis interact *via* π - π interactions between the π clouds of aromatic rings forming a stacked structure. Both types of interactions, i.e. hydrogen bonding and π - π , stabilize the crystal structure.

G.J. Perpétuo and J. Janczak

Automated search-model discovery and preparation for structure solution by molecular replacement

***Acta Cryst.* (2007). D63, 447-457 [doi:10.1107/S0907444907002661]**



Protein LqhIT2 (final model in green) is solved by one choice of search model (blue, RMS 2.52 Å) but not by another (red, RMS 3.23 Å).

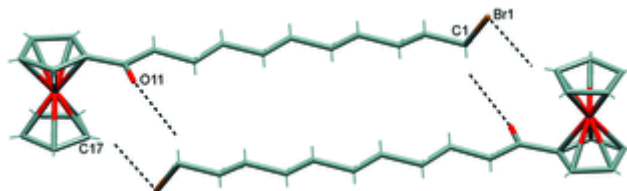
The success of structure determination by molecular replacement (MR) often depends on the choice of search model and the details of the model edits applied, and as the Protein Data Bank continues to grow rapidly it becomes increasingly difficult to cover all possibilities. We describe *MrBUMP*, an automation scheme for generating a set of search models, and trying all in MR. We present three examples of its use including two novel structure determinations. *MrBUMP* makes use of established crystallographic programs and is available for general use.

R.M. Keegan and M.D. Winn

IUCR JOURNALS NEWS

11-Bromo-1-ferrocenylundecan-1-one

***Acta Cryst.* (2007). E63, m1362 [doi:10.1107/S1600536807016510]**



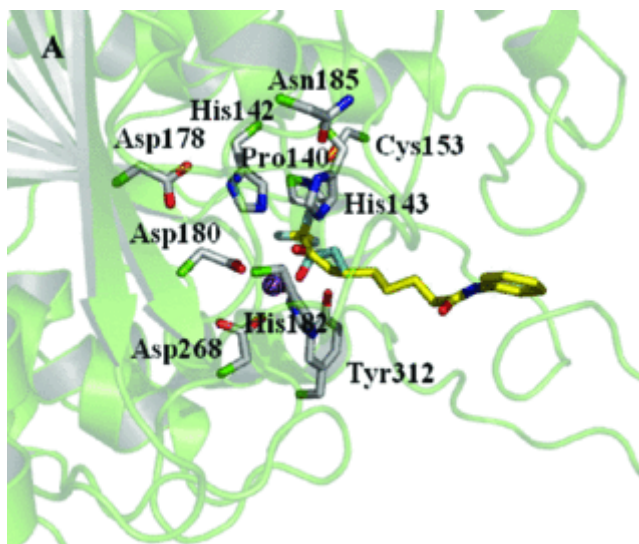
Inversion-related dimers formed by adjacent molecules in the crystal.

This molecule is a useful precursor to redox active surfactant systems and has the longest unsupported methylene chain to have been examined crystallographically in a ferrocene compound. The undecanone chain is beautifully ordered and bows towards the iron atom. C–H⋯O and C–H⋯Br interactions link adjacent molecules in a head-to-tail fashion to stabilize the structure. These dimers assemble further into zigzag chains through C–H⋯ π interactions involving both cyclopentadiene rings.

C.J. McAdam, B.H. Robinson and J. Simpson

Complex structure of a bacterial class 2 histone deacetylase homologue with a trifluoromethylketone inhibitor

***Acta Cryst.* (2007). F63, 270-273 [doi:10.1107/S1744309107012377]**



Active site of the bacterial HDAC-like enzyme with bound 9,9,9-trifluoro-8-oxo-N-phenylnonanamide inhibitor. The inhibitor exhibits two conformations (colored yellow and cyan, respectively). Histone deacetylases (HDACs) are involved in the regulation of gene expression and are thus attractive targets in the development of novel anticancer drugs. We have determined the crystal structure of a bacterial HDAC-like enzyme with bound trifluoromethylketone inhibitor 9,9,9-trifluoro-8-oxo-N-phenylnonanamide representing a novel type of nonhydroxamate inhibitor for HDACs. This structure not only reveals details of the inhibitor-enzyme interaction, but also provides hints on how to improve the inhibitor.

T.K. Nielsen, C. Hildmann, D. Riester, D. Wegener, A. Schwienhorst and R. Ficner

IUCR JOURNALS NEWS

Determination by high-resolution X-ray diffraction of shape, size and lateral separation of buried empty channels in silicon-on-nothing architectures

***J. Appl. Cryst.* (2007). 40, 338-343 [doi:10.1107/S0021889807003603]**

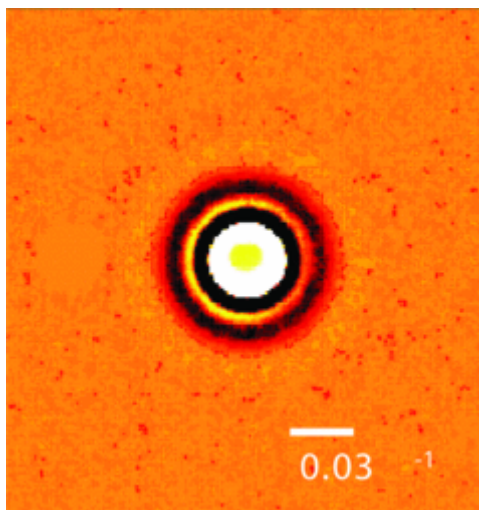
Silicon-on-nothing samples, made by a 1D periodic planar array of buried empty channels, were studied by high-resolution, multi-crystal X-ray diffraction. If the channels are normal to the scattering plane, Fraunhofer diffraction occurs in a scan normal to the reciprocal lattice vector (relv). By analysis of this scan and the scan along relv , the latter in terms of the static Debye-Waller factor, the period of the buried empty channels and their shape, size and lateral gap were determined and compared with the cross-section SEM image (Figure).

M. Servidori

IUCR JOURNALS NEWS

Small-angle pump-probe studies of photoexcited nanoparticles

J. Synchrotron Rad. (2007). **14**, 288–294 [doi:10.1107/S0909049507011144]



Time-resolved SAXS pattern of laser-excited gold nanoparticles showing the formation of nanobubbles on the subnanosecond scale. The difference between excited and nonexcited states is plotted in false colors (yellow/white: intensity increase, black: intensity decrease).

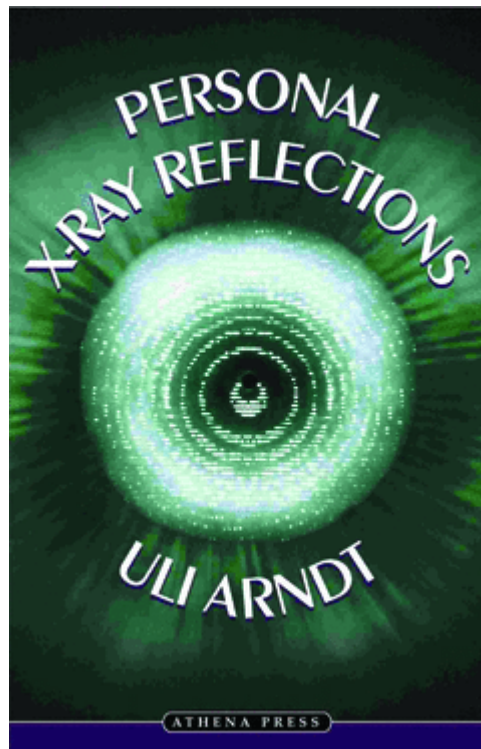
Nonequilibrium femtosecond laser excitation can lead to very fast structural dynamics in nanoparticle suspensions. The mesoscopic scale of vapor bubble formation and particle ablation has been resolved by pulsed X-ray scattering at the time-resolved beamline at ESRF. The threshold process of bubble formation reveals the explosive boiling of the superheated water layer. A projection to future free-electron laser capabilities makes single-shot, single-particle probing at high resolution realistic.

A. Plech, V. Kotaidis, K. Istomin and M. Wulff

BOOK REVIEW

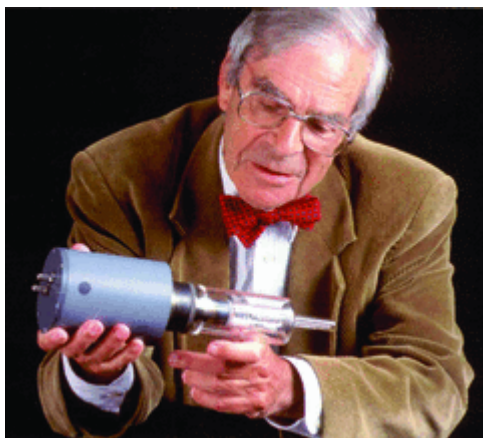
Personal X-ray Reflections an Autobiography by Uli Arndt

ISBN-10:184416943, 2006, 200 pp, Athena Press Pub. Co.



Uli Arndt was born in Berlin in 1924. His parents emigrated from Nazi Germany to England in 1936 where he received a “privileged education”. He lived a rich full life, made many significant contributions to crystallography and collaborated and consorted with many of the leading crystallographers of the past 90 years. In his eightieth year he lost his wife Valerie with whom he had shared his interests, concerns and ideas for 47 years. In an attempt to fill the void created by her death he taught himself the use of dictation software and dictated his autobiography. It is a wonderful story rich with his perspectives on the history of his times and the growth of the field of crystallography. It is filled with humorous and delightful anecdotes. He tells us that in the 1930’s “schoolwork was sometimes used as a method of detecting any anti-Nazi attitudes of parents. We were once required to write an essay on what my parents talk about after I have gone to bed”.

His education in England is described against a background of world events, local weather conditions and cultural activities. In order “to fill time” he enrolled at Birmingham University for a year “joined numerous clubs, learned to drink beer and smoke a pipe and went to weekly dances at the student union”. He describes his time at Emmanuel College, Cambridge as including eccentric and philandering professors, and local young ladies of unsavory reputation. He participated in a Debating Society that tackled such issues as “men are clay and women make mugs of them”.



His first job was as a research fellow in the Birmingham U. Dept. of Metallurgy constructing a “proper” X-ray powder spectrometer for the investigation of metal structures. This was part of his thesis which he defended with Bill Astbury from Leeds on his thesis committee. He tells us that he never actually applied for a job because he was lucky enough to be offered a new job whenever he needed one. The field of crystallography benefited tremendously from his pioneering work in designing X-ray and neutron sources, detecting devices and ultimately synchrotron facilities. Early in his career he worked in the Davey Faraday Lab in the basement of Royal Inst. in Albemarle Street, London. With a Geiger counter he discovered a highly radioactive area five feet in diameter in the lab floor that was the result of a collaboration between Sir James Dewar and Marie Curie twenty years earlier.

We learn of the famous labs he worked in, books he read and the operas he attended (running into Hans Freeman on two continents). He tells us of Jack Dunitz intentionally giving incorrect directions to tourists in Holland if he didn’t like their accent, and of his having to share a double bed with an elderly stranger in a bed and breakfast while on holiday in Scandinavia. He offers candid opinions of the various countries he visited for sabbaticals, meetings, collaborations, and holidays. At Brooklyn Poly in 1957 he ran into Francis Crick and John Kendrew. He describes a “stormy” meeting of the Apparatus Commission of the IUCr in 1958 with an unnamed American chairman at “daggers drawn” with both the German and French delegates. Arndt tried to resolve the conflict since he was the only member who spoke all three languages.

In 1962 Max Perutz invited him to join the newly formed Medical Research Council (MRC) lab of Molecular Biology. He describes his participation with John Kendrew in the early days of not only the MRC but of the European Molecular Biology Lab and Inst. Laue Langevin in Grenoble. He tells of attending an ACA meeting at the U. of Virginia to deliver an after dinner speech as a “stand in” for Nobel Laureate Bill Lipscomb, and of a round the world trip to give invited lectures in Japan, Australia, and South Africa. He continued to work and travel in retirement and met an unnamed “real live astronaut” in Huntsville, AL, USA.

The penultimate chapter of the autobiography is a review of the books he had read over the course of his life. He contrasts the blood chilling German children’s literature (presumably intended to offer life lessons) to the gentler books (ie Winnie the Pooh) that he read from each night to his three daughters. The German children’s stories included “Shock-headed Peter” who had his fingers cut off because he would not stop biting his nails (clearly illustrated with blood dripping from the stumps) and Max and Moritz, little German rascals who were ground up and fed to the chickens by a farmer in retaliation for their pranks. Max and Moritz were the role models for Hans and Fritz in the US comic strip ‘The Katzenjammer Kids’.

Uli has written a warm, wonderful, entertaining and educational story of his life, the world in which he lived, the scientific field he played a critical role in advancing and the people he met and with whom he worked and played. I recommend this book as a good read for anyone, but especially crystallographers

who will find familiar names and perhaps a number of people that they have met personally in the course of their lives. I also hope that the book will inspire other crystallographers to make good use of their retirement years to record their life stories and further enrich our crystallographic heritage with their Personal X-ray Reflections.

William L. Duax

MISCELLANY

Support for third world science

The Third World Academy of Science (TWAS) was established in 1983 to support science and research in developing countries. Each year TWAS makes as many as 16 awards and prizes to leading individual scientists living and working in developing countries. TWAS awards in basic science and in applied sciences are for \$10,000 each and the Trieste Science Prizes are for \$50,000 each. TWAS encourages individual countries to develop a “scheme of TWAS prizes for young scientists in their country”.

TWAS also sponsors research grants of up to \$10,000 to cover equipment, materials and literature. TWAS provides support for international scientific meetings, restricted to those held in third world countries, in the form of travel grants to principal speakers from abroad and/or participants from the region. This program could complement the IUCr support for student attendance at international meetings held in developing countries.

Another noteworthy program involves grants to institutions for joint research projects. With financial support from the OPEC Fund for International Development, the Third World Network of Scientific Organizations (TWNSO) has established a competitive joint research project scheme designed to encourage and support research projects involving two or three research and training institutions from different countries with an aim of fostering cooperation between the best research centers. At *least* one of the cooperating institutions in any proposed project must be located in a *least* developed country. Only joint research projects involving institutions with well-established expertise and adequate basic equipment will be considered for the grants. The list of 79 countries identified by TWAS as lagging in science and technology and a list of 50 countries identified as least developed by the United Nations can be found on the TWAS and TWNSO websites (www.twas.org).

Since one of the major goals of the IUCr is to support the development of crystallographic science in developing countries it is noteworthy that none of the 79 countries identified as lagging in science are members of the IUCr. Currently copies of this newsletter are being distributed in only 14 of these countries. We will contact the TWAS and TWNSO about getting the names and addresses of any library in the country to which we can offer to send complimentary copies of the Newsletter.

William L. Duax

REGIONAL NEWS

Crystallography in South Africa



Bernard Omondi came to South Africa from Kenya. He has been doing his PhD at the U. of the Witwatersrand for the past four years and has now graduated. I would like to thank the IUCr for the support that they have given him in this time. As far as I know he is the first, if not the only, PhD student to benefit from the IUCr Africa program to date, a program that was initiated by Jan Boeyens during his time on the IUCr Executive Committee together with Henk Schenk. During the course of his MSc and PhD research projects Bernard has published a number of papers in *Acta Cryst.* and other journals, with several more articles to come. He has been a great inspiration to young African scientists and I have no doubt that he will continue his leadership and mentoring role during his post-doctoral fellowship at the U. of Johannesburg and beyond.

Crystallography is well established in South Africa, with centres at the U. of Cape Town and U. of the Witwatersrand having been in operation since the 1930's. Today, there are crystallographers active at these two universities as well as at the U. of Natal, U. of Stellenbosch, U. of Johannesburg (formerly Rand Afrikaans U.) and U. of Pretoria. The recent installation of a rotating anode/image plate diffractometer suitable for protein crystallography at the U. of the Western Cape (February 2003) will enhance the capacity in South Africa in this important component of crystallography. Research capabilities in the area of materials science and solid-state chemistry were also advanced with the installation of high-temperature and high-pressure attachments to the diffractometer at the U. of the Witwatersrand.

In 1996 Jan Boeyens (U. of Witwatersrand, Johannesburg, South Africa) joined the Executive Committee (EC) of the IUCr and proposed that a crystallographic network should be set up in the southern part of Africa and he offered to be the coordinator. The EC and the IUCr agreed with this proposal and decided to provide financial sponsorship to the Africa Initiative in Crystallography (AICr). Jan was given a free hand to implement the procedure in the most productive way possible. He started things off by establishing the African Affiliated Centre (AAC) for the use of the Cambridge Structural Database (CSD) in Africa and, secondly, arranged that an excellent and active experimental facility could be set up at the U. of Nairobi, Kenya. This first activity, the AAC of the CSD, was sponsored by the Cambridge Crystallographic Data

Centre (CCDC), the South African National Research Foundation (NRF) and the IUCr. Groups from all over Africa have free access to the database through the Centre. The other achievement was the UNESCO-sponsored transfer of a generator and single-crystal XRD cameras from the CCDC to Nairobi, where it is now working well. The CCDC is delighted that the instrument, which was no longer being used by the CCDC, has found a new life for primary research activities in Africa (Africa, with its many unknown natural products, is an ideal destination). After the successful installation of the single-crystal facility in Nairobi, there was a strong scientific reason to extend the facility with powder diffraction equipment. A Debye-Scherrer powder XRD camera was donated by the U. of the Witwatersrand, and installed by the local technician in Nairobi with the assistance of Jan Boeyens and Robert Bogadi (an MSc student from the U. of the Witwatersrand). This initiative has been strongly supported by crystallographers in South Africa, and has included staff training programs for lecturers from Kenya, Zambia, Lesotho, Nigeria and Zimbabwe (hosted by the South African Universities named above). In Nancy, France, August 2000, the EC of the IUCr evaluated the results very positively and also reviewed possible extensions of the program. The EC decided to ask Jan to continue the program and to concentrate within the AICr on three major projects: AAC. The already very well established AAC of the CSD is a success and should continue. It is a great advantage that the African scientific world has access to the 3D structural data (especially the most recent) of molecules and crystals. This will enable 3D atomic and molecular studies of high quality to be made. CrEA: Crystallographic Equipment in Africa. The successful set-up in Nairobi should have a follow-up in other countries in Africa. APPCr: the African Post-Graduate Program in Crystallography. As a matter of course the Africa Initiative should have a firm knowledge base. Therefore the EC agreed to establish a post-graduate program in crystallography to ensure that this knowledge base continued to grow and be an important part of capacity building in southern African countries. It is for the latter program that we now seek ICSU support. No science network will be successful without a knowledge base. In general, knowledge is concentrated in people working in universities. Therefore if we want a strong crystallographic network in Africa we should concentrate on the knowledge of people. The PhD-programme will enable capacity building in crystallography by sponsoring PhD positions for promising students from countries in southern Africa. These positions will be in collaborating Universities in South Africa. On completion of their studies, the students will return to their home countries as graduates. This will strengthen the AICr-network in two ways: more knowledgeable scientists, and, equally important, scientists who have good scientific connections in a country with a well established crystallographic community. The South African crystallographic groups are very enthusiastic about this program and happy to cooperate. The IUCr EC are committed to providing up to USD 30,000 over a five-year period to support two PhD students and are convinced that with additional financial support a lively and sizeable postgraduate program can be established.

Demetrius Levendis

MISCELLANY

New imgCIF dictionary for review

The 2006-2007 academic year has been a time of increasing acceptance of the IUCr Image CIF (imgCIF) and Crystallographic Binary File Dictionary (CBF) dictionary, `cif_img.dic`. This dictionary extends the IUCr Macromolecular CIF (mmCIF) dictionary to handle raw synchrotron data images. There have been two very productive workshops, one at the ACA meeting in Hawaii in August 2006 and one at Brookhaven National Lab. in May 2007. A third workshop is scheduled to be held in August 2007 at BSR 2007 in Manchester and at Diamond. (For more detail on the workshops, see www.medsbio.org/meetings).

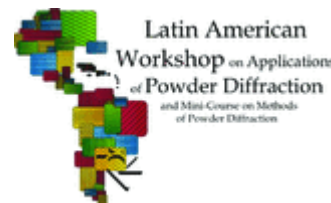
Because of this work, some improvements and additions to the imgCIF dictionary have been proposed. The axis system has been clarified and extended to deal with experimental setups that do not have goniometers. The binary format has been extended to handle additional compression types, and to handle maps and other 3D data. Comments and suggestions would be greatly appreciated. The current draft of the dictionary can be reviewed as html at www.bernstein-plus-sons.com/software/CBF/doc and as text at www.bernstein-plus-sons.com/software/CBF/doc/cif_img.dic.

Comments should be sent to the imgcif discussion list (imgcif-l@iucr.org) or Herbert J. Bernstein (yaya@bernstein-plus-sons.com).

I. David Brown

MEETING REPORT

Latin American workshop on applications of powder diffraction and mini-course on methods of powder diffraction



São Paulo, Brazil April 16-20, 2007



Lecturers and some organizers: C. Giacovazzo, J. Kaduk, S. Billinge, Brian Toby, Bob von Dreele, Bill David, Andy Fitch, Armel Le Bail, Silvia Cuffini, Iris Torriani, Ernesto Estevez-Rams, Eduardo Granado. The more than 100 participants in the workshop and minicourse on methods of powder diffraction included researchers, young scientists and students from the USA, Canada, Colombia, Uruguay, Peru, Venezuela, Brazil and Argentina. The event included plenary lectures on the state-of-the-art in theory, computer and experimental methods given by some of the most renowned specialists in the field. Poster sessions were held every day. Most of the presentations of the Mini-Course were recorded (voice+computer screen), and are available at www.lnls.br/lawpd. Click on Recorded Lectures and chose from the following fantastic list:



Peter Stephens: Powder to the people, Andy Fitch: Experimental procedures, Jim Kaduk: Phase identification with powder diffraction, Peter Stephens: Tutorial on the physical and mathematical descriptions of powder diffraction lineshapes, Carmelo Giacovazzo: Space group determination and *ab initio* phasing in EXPO2007, Brian Toby: A casual introduction to least-squares fitting: A [mostly] descriptive approach, Bob Von Dreele: Refinement strategies in the Rietveld Method, and GSAS & EXPGUI and GSAS Demo: SeqGSAS & Seqplot, Juan Rodríguez-Carvajal: Introduction to magnetic structure determination and refinement using neutron powder diffraction, Simon Billinge: The Atomic Pair Distribution Function method: beyond the crystal structure, Brian Toby: Judging quality in Rietveld fits: R-factors and graphical analysis, Carmelo Giacovazzo: EXPO2007: a powerful tool for crystal structure solution and refinement from powder data, Brian Litteer: Advances in transmission powder X-ray diffraction.



This event was a great success. The Organizing committee, Chaired by Eduardo Granado (Unicamp / LNLS) did a wonderful job. The sponsorship of several institutions and commercial firms (Lab. Nacional de Luz Síncrotron (LNLS), the IUCr, the Brazilian Crystallographic Assn (ABCr), the Research Foundations of the State of São Paulo (FAPESP) and of Minas Gerais (FAPEMIG), Centro Latino Americano de Física (CLAF), the International Center for Diffraction Data (ICDD), Bruker AXS, Rigaku Corp. and Panalytical) was critical to the success of both the Workshop and the Mini-Course and is very much appreciated. A touch of originality was provided by a soccer match organized the day of a visit to the synchrotron (NSLS) between the “locals” and the “visitors”. There is no agreement as to who were the winners of this match, but the crystallographic community has no doubts that they were all winners for attending this outstanding event.



Iris Torriani and Eduardo Granado

MEETING REPORT

Basic school on crystallography

Siena, Italy, August 27-September 2, 2006



Photo of hands-on tutorial session at the IUCr Siena 2006 teaching school

A Basic School on Crystallography was hosted in “La Certosa di Pontignano” an old convent now belonging to the U. of Siena (www.unisi.it/servizi/certosa/certosa_ingl/index.html). Fifty participants mainly from Europe but also from North America, the Middle East, Africa and India attended the school. The Program Committee was composed of G. Chapuis (coordinator, EPFL, Lausanne, Switzerland, gervais.chapuis@epfl.ch), A.J. Blake (Nottingham, UK), A. Gavezzotti (Milan, Italy), and R. Neder (Wuerzburg, Germany). The Local Organizers were Marcello Mellini (U. of Siena, mellini@unisi.it), and Paola Spadon (U. of Padova, paola.spadon@unipd.it). Because basic crystallographic curricula are disappearing in most academic institutions, the Executive Committee of the IUCr proposed that its teaching Commission (www.iucr.org/iucr-top/comm/cteach/) organize an International School on Basic Crystallography. The result was an intensive one week course in Siena. The organization of the first school was based on the model used by the British Crystallography Assn (BCA) which has been extremely popular since its inception. The school was supported by the IUCr, the BCA, the Italian Crystallographic Assn and the U. of Siena.

The topics were presented to the students in two roughly equal forms, namely *ex cathedra* teaching and tutoring. The lecturers were experienced crystallographers with extensive experience in teaching. After a general introduction to crystallography, the students acquired elementary notions of matrices and group theory to familiarize them with the concept of space group symmetry. This led to a description of crystalline structures based on space group, lattice constants and atomic coordinates followed by discussions of various X-ray and neutron diffraction techniques based on single crystal and powder methods. Techniques of data acquisition, structure solution and refinement followed by the derivation and interpretation of results were also presented. Finally, they were introduced to the retrieval of information from numerous crystallographic databases. Following the presentation of each topic, tutors worked with the students in small groups to solve practical exercises.

Lecturers and specific topics: Peter Main (York, UK) math refresher, direct methods and refinement; David Watkin (Oxford, UK) refinement, Bob Gould (Edinburgh, UK) symmetry and Fourier/Patterson; Jacqueline Cole (Cambridge, UK) data acquisition and neutrons/synchrotron; Sandy Blake (Nottingham, UK) data acquisition, Gervais Chapuis (EPFL, Switzerland) databases; Giovanni Ferraris (Milano, Italy) twinning; Giuseppe Cruciani (Ferrara, Italy) introduction to diffraction and powder studies; Tony Linden (Zurich, Switzerland) derivation of structural results, analysis and interpretation; and Bernd Schweizer (ETHZ, Switzerland) databases.

The students could download the teaching materials including lecture notes and a set of exercises for each topic before arriving. After the school, the students could download the presentations and the solution of the exercises.

Gervais Chapuis



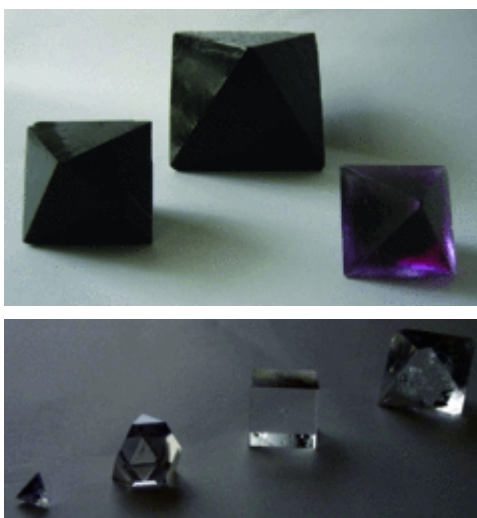
IUCr Siena 2006 teaching school participants

MEETING REPORT

7th Singapore National Crystal Growing Challenge



Singapore, September 21-23, 2006



Some of the prize winning crystals.

The Singapore National Crystal Growing Challenge was started ten years ago jointly by the Dept. of Chemistry at the National U. of Singapore and Singapore National Inst. of Chemistry (SNIC) for secondary school, junior college and polytechnic students. It was held annually until 2000 when it was changed to a biennial event. The number of entries is increasing in every event and we had a record number of 189 participating teams from 87 secondary educational institutions in Singapore for the 7th crystal growing competition which was held September 21-23, 2006 at the National U. of Singapore.

Growing single crystals is still an art requiring much skill and patience. Hence growing very big and aesthetically pleasing single crystals is not just associated with intelligence. The students are excited when crystals with wonderful colors and well-developed faces with sharp edges start growing before their eyes. They are proud and happy; it is as if they had grown diamonds and rubies and above all crystal growing is lots of fun. It is no wonder that this challenge has become the most popular event among secondary educational institutions in Singapore!

Once again the students had an opportunity to demonstrate their creativity and to learn more about the science of this art of crystal growing. They displayed their crystals very artistically and it was very hard for the judges to select the best crystals. The final exhibition and prize distribution held at the National U. of Singapore on 23 September was attended by more than 400 students and teachers.

There were three categories for this competition, junior (for secondary school students), senior (for junior college and polytechnic students) and open. For each category, there were first, second, third and two meritorious prizes carrying cash awards \$400, 300, 200 and 50 (x 2) respectively in addition to trophies for the top three crystals. For the junior level category, the students were asked to grow potassium aluminium sulphate, dodecahydrate. The senior level students were challenged to grow colorless sodium

bromate crystals. The students for the open level were given the task of growing cubic single crystals to exercise their creativity, individuality and scientific knowledge but they could not use the crystals for the other two categories.

There were 116 entries from 69 secondary schools for the junior level, 31 entries from 18 junior colleges and polytechnics for the senior level and 42 entries from 21 institutions for the open category. Some of the prize winning crystals are shown in Figure 2. Hian Kee Lee, the Deputy Head of the Department of Chemistry gave the welcoming address and a special address was given by Guan Huah Yeoh, Vice-President, Singapore National Inst. of Chemistry. The guest of honour for the prize presentation ceremony, Eng Chye Tan, Dean of the Faculty of Science, inspired the audience by highlighting the research achievements of the two time Nobel Prize winner Linus Pauling, one of the greatest scientists of the 20th century. This year's competition was sponsored by Bruker Singapore Pte Ltd. and the Faculty of Science. Details are available at the website: www.chemistry.nus.edu.sg/events/ncgc/index.html.

Jagadese Vittal and Feng Xu



Prize winners, teachers of the winning teams and organizers with the guest of honour Eng Chye Tan, Dean of Faculty of Science (6th from right).

MEETING REPORT

Unprecedented remote data collection tested at TID workshop

Poznan, Poland, November 28 - December 2, 2006



Participants and tutors at the The 3rd Workshop on Structural Biology and Synchrotron Radiation in Poznan, Poland.

The Poznan Training, Implementation and Dissemination (TID) Centre operating within the European BioXHIT project has organized its 3rd Workshop on “Structural Biology with Synchrotron Radiation”. The Workshop took place on November 28 - December 2, 2006, in the Center for Biocrystallographic Research (CBB), Inst. of Bioorganic Chemistry, Polish Academy of Sciences, where the TID Centre is affiliated. Twenty students from six European countries (Belgium, Czech Republic, Germany, Poland, Russia, Slovakia) participated in theoretical lectures and in hands-on practicals conducted in small groups. In addition to CBB staff (Mirek Gilski, Mariusz Jaskolski, Wojtek Rypniewski, Michal Sikorski), the instructor team included Wladek Minor (U. of Virginia, USA), Santosh Panjikar and Sasha Popov (EMBL, Hamburg), and Andrew Thompson (Soleil, France). In the tutorials the students were familiarized with protein crystal handling, cryofreezing and testing (Wojtek Rypniewski), with data collection strategies (Sasha Popov), with DNA (automated collection of data) (Mirek Gilski), and with the pipelining concept and structure solution on-the-fly (Wladek Minor - HKL3000, Santosh Panjikar - AutoRickshaw). The participants had a unique opportunity to eye-witness the first-ever live testing of remote data collection at a synchrotron site. For this purpose, Mirek Gilski in Poznan and Olof Svensson at beamline ID14 at the ESRF in Grenoble (France), both donning headphones and mikes and surrounded with computer screens and yards of cables, established an internet connection which enabled Mirek to remotely control synchrotron data collection via the DNA software. The procedure was quite spectacular and ended successfully with applause from the Poznan audience. This experiment has demonstrated that automated data collection controlled from a remote personal computer is perfectly feasible and we may soon see real synchrotron radiation experiments being conducted this way. In addition to learning protein crystallography and modern applications of synchrotron radiation in structural biology, the students also had an opportunity to listen to a recital of organ music, to take part in a gala dinner, and to explore a little bit of a fog-shrouded Poznan.

Mariusz Jaskolski



Mariusz Jaskolski (standing) watches as Mirek Gilski (seated) runs the data collection DNA system from Poznan. Olof Svensson (on the screen) watches the experiment at the ESRF site in Grenoble.

MEETING REPORT

Synchrotron radiation research forum in the Asian-Oceania region

Tsukuba, Japan, November 24-25, 2006



Oral and poster sessions

The 1st Workshop of the Asian-Oceania Forum for Synchrotron Radiation Research (AOFSSRR) was held at the High Energy Accelerator Research Organization - Photon Factory (KEK-PF) in Tsukuba, Japan on November 24-25, 2006 under the sponsorship of the Japanese Soc. of Synchrotron Radiation Research (JSSRR), KEK, PF, The Australian Synchrotron Research Program, SPring-8 and the IUCr. 114 scientists and engineers as well as 13 students from the Asian-Oceania area participated (Australia: 10, China: 14, Korea: 16, Singapore: 1, Taiwan: 11, Thailand: 2, Japan: 73). The participants enjoyed lively discussions in the 4 oral sessions (18 invited talks); “Recent Progress of Light Source”, “Scientific Highlights at Asian-Oceania Forum synchrotrons”, “Discussion for Organization and Steering of AOFSSRR” and “New Facility Plans” together with a poster session (57 presentations). 20 facility reports were also presented and 11 companies participated in a technical exhibition.

At the council meeting the Australian Synchrotron Research Program (Director: Richard F. Garrett), the Chinese Soc. of Synchrotron Radiation Research (President: Hongjie Xu), the INDUS/India (Director: Rajendra V. Nandedkar), the JSSR (President: Osamu Shimomura), the National Synchrotron Radiation Center, Thailand (Director: Weerapong Pairsuwan), the National Synchrotron Radiation Research Center, Taiwan (Director: Keng S. Liang), the Pohang Light Source (Director: In Soo Ko), and the Singapore Synchrotron Light Source (Director: Herbert O. Moser), entered into an agreement to organize the Asia-Oceania Forum for Synchrotron Radiation Research (AOFSSRR).

The objective of AOFSSRR is to establish a general framework for collaboration in the development of science and technology of mutual benefit to advancing the research goals of the parties and to promote comprehensive cooperation in the Asia and Oceania region. Then, collaborative activities can be arranged with responsibilities agreed upon between the Parties. The following activities are envisaged:



- (1) Organization of scientific meetings.
- (2) Exchange of information between the facilities and their associated user groups.
- (3) Provide a framework for cooperative activities.
- (4) Arrange other activities that with enhance synchrotron radiation research in the region.

The new council elected for AOFSRR was: President: Yoshiyuki Amemiya (Japan), Secretary: Masaki Takata (Japan), Vice President: Keng Liang (Taiwan), Treasurer: Richard Garrett (Australia), Past President: Osamu Shimomura (Japan), Members: In Soo Ko (South Korea), Herbert Moser (Singapore), Rajendra Nandedkar (India), Weerapong Pairswan (Thailand), Hingjie Xu (China).



Signing Ceremony creating AOFSSR (Herbert O. Moser, Hongjie Xu, In Soo Ko, Osamu Shimomura, Richard F. Garrett, Keng S. Liang, Weerapong Pairsuwan).

The 2nd AOFSRR workshop will be held November 2-3, 2007 at Hsinchu, Taiwan (Chair: Keng Liang). The 1st AOFSRR summer school (Cheiron School) is planned for September 10-20, 2007 at SPring-8 in Japan.

M.Takata

AWARDS AND PRIZES

ECA 2007 Awards

Lewy-Bertaut Prize

The European Crystallographic Assn (ECA) and the European Neutron Scattering Assn have awarded the 2007 Lewy-Bertaut Prize to Henrik M. Rønnow (EFPL, Lausanne, Switzerland).

For a young scientist Henrik already has a brilliant scientific track record. His work has concentrated on the experimental and theoretical aspects of quantum magnetism (spin dynamics in the two-dimensional magnet CFTD, in copper germanate as well as in high T_c cuprates). He has also been involved in the development of neutron instrumentation and simulation and data analysis software. Despite his yet early career, he has made significant contributions to neutron scattering science and has become a renowned expert in polarized neutron scattering techniques. His major publications in the highest ranking journals are frequently cited and have brought him considerable esteem among his peers.

Max Perutz Prize



David Stuart (U. of Oxford) has been awarded the 2007 Max Perutz Prize Award. He received the award 'As one of the pioneers of virus crystallography and in recognition of his impact in this field, and his contributions to the structural chemistry of disease at the atomic level'. Further information on this Award will be available on the ECA website www.ecanews.org.

AWARDS AND PRIZES

2006 Struchkov Prize

Fourteen young crystallographers from 7 cities in Russia and Ukraine submitted their papers for the Struchkov Prize competition in 2006. The papers were scored by 12 experts who represented the majority of the crystallographic labs of Russia and the former Soviet Union. The Prize was awarded to N.A. Sennova (St. Petersburg U.) for “High-temperature crystal chemistry of sodium and lithium borates in connection with their properties” and D.B. Krivolapov (A.E. Arbuzov Inst. of Organic and Physical Chemistry, Kazan) for “The peculiarities of conglomerate crystallization of β -adrenoreceptor blocking agents”.

Also presented were two Supplementary Awards – T.N. Rudneva (Inst. of Problems of Chemical Physics, Chernogolovka) and A.G. Ivanova (Moscow State U.) and four Special Supplementary Awards – O.N. Kazheva (Inst. of Problems of Chemical Physics, Chernogolovka), O.A. Gurbanova, P.A. Plachinda (both from Moscow State U.), and N.V. Kurat’eva (Inst. of Inorganic Chemistry, Novosibirsk).

In 2006 the Struchkov Prize Society received contributions from 23 members, currently working in 8 countries (Armenia, China, France, Russia, Sweden, Switzerland, UK, and US) with a total of \$2600. This sum was used as a prize fund for the competition. Each winner received \$800 and each recipient of the supplementary and special supplementary awards received \$300 and \$100 respectively.

NOTICE

ACA meeting to be climate neutral

Science is the search for an objective understanding of the way things are and work. The best scientists are intellectually ambitious, rigorous, and creative. They are independently minded and instinctively look for the weaknesses and alternative explanations in the work of others. Therefore, when scientists in a large and dynamic field reach a consensus their collective opinion should be taken very seriously. So it is with Global Climate Change, where strong scientific consensus states that human activity is on track to cause worldwide challenges that within a few tens of years are likely to be very serious and possibly catastrophic.

Motivated by this concern, members of the ACA have joined in an effort to make their 2007 annual meeting Climate Neutral. We cannot prevent all greenhouse gas emissions, but we can ensure that the net result of our activities decreases rather than increases the amount of CO₂ in the atmosphere. We therefore aim to offset the CO₂ released as a consequence of attendees and vendors flying to the meeting and using the conference center and hotels by supporting a wind energy program that will displace the use of coal.

Most of our electricity is produced from burning coal, a process that causes more than 30% of the total CO₂ emissions in the US. While methods are available to sequester the CO₂ from these plants, no technology has been developed to effectively utilize this carbon source. More research is needed. Furthermore, use of coal to produce electricity causes 40% of all mercury pollution in the US and the Environmental Protection Agency recently announced that one sixth of USA women of childbearing age carry mercury above their level of concern for the fetus. In contrast, production of electricity from wind has very low environmental impact, it is highly cost effective, and the potential for its increased utilization is huge. According to the US Department of Energy we could produce 150% (yes, 150%!) of our electricity from wind, although the current amount is just 0.6%. In contrast, Denmark currently makes more than 20% of its electricity from wind and has recently announced plans to increase this to 50% by 2025.

Therefore, for ACA 2007 meeting, the ACA Council established a wind energy campaign. The original donation to offset the meeting was made by a small number of ACA members and friends, and now that the campaign has been established anyone can contribute to offset additional consequences of CO₂ emissions. Total contributions to the ACA campaign will be updated and posted monthly (windpower.utah.edu). Our campaign is run through the U. of Utah and, to the best of our knowledge, it is the most cost effective way for individuals to fund wind energy in the country. The donations fund construction of new wind turbines that serve the Western USA grid and, because of the 1978 energy act, they will necessarily displace the use of fossil fuels, especially coal. The program costs just \$3 per mwh and represents a 5% increment on the standard residential electricity rate. The impact of an average domestic US flight would be offset by a donation of \$5 (\$3 if accounting for just your own coach class seat but not considering empty or first class seats) and the total impact of an average attendee at the meeting (conference center and hotel) would be offset by an additional \$2. This campaign is also an effective mechanism to mitigate other sources of emission. For example, electricity used by an average university worker (\$30/year), an average USA household's electricity (\$30/year), an average USA family's total direct fossil fuel use, excluding air travel, (\$90/year).

Conservation is an essential complement to the development of alternative energy sources. Typically this includes thoughts of fuel-efficient vehicles, telecommuting, public transportation, compact fluorescent light bulbs, and turning off lights, printers, and computers when not in use, all of which are important. One important approach to conservation would be to support a tropical rainforest preservation/ reforestation program. These programs allow local people to develop out of poverty through activities such as highly sustainable harvesting and ecotourism, thereby preventing the release of CO₂ through

burning/clearing of forest for unsustainable harvesting of wood or for agriculture. This mechanism is effective in preventing CO₂ release and, as with most good ideas, there is more than one benefit. Destruction of rainforests has caused more than 20% of all CO₂ emissions in recent years. In 1950 tropical rainforests covered about 14% of the earth's land surface, today it is about 7%, and it is projected that at the current rate of loss they will have largely disappeared in 40 years. Rainforests have been called the lungs of the planet and may be home to more than 50% of the world's species. Their loss would be an epic calamity.

It is appropriate that scientists take a lead on this issue. Should the organizers of other crystallographic meetings wish to do something similar there are many other programs to consider in addition to the one that we are using, including: www.terrapass.com -www.gocarbonzero.org -www.carbonfootprint.com -www.carbonfund.org- www.nativeenergy.com - www.paxnatura.org - www.climatecrisis.net -www.carbontradewatch.org (note that we are not in a position to endorse any particular program).

Christopher P. Hill

(Robert Bau , Connie Chidester, Catherine Drennan, Judy Flippen-Anderson, Stephan Ginell, Marvin L. Hackert, Jim Kaduk, Lisa Keefe, Brian N. Kelly, Roger D. Kornberg, Christopher D. Lima, Bernard D. Santarsiero, Heidi L. Schubert, Thomas C. Terwilliger, Liang Tong, Jill Trehwella)