The Tenth Ewald Prize and aperiodic crystals

The Ewald Prize was established by the International Union of Crystallography (IUCr) in 1986 for recognizing outstanding contributions to the science of crystallography. It was first awarded in 1987 to J. M. Cowley (Tempe, Arizona, USA) and A. F. Moodie (Clayton, Victoria, Australia) for their exceptional contributions in the areas of electron diffraction and electron microscopy. Their pioneering work on the dynamical scattering of electrons and the direct imaging of crystal structures and structural defects by high-resolution electron microscopy is worth mentioning. The name of the Prize was chosen in the honour of Paul Peter Ewald for his remarkable contributions to the foundations of crystallography and to the founding of IUCr. This award is presented once every three years during the triennial International Congresses of Crystallography, organized by IUCr. It is pertinent to point out that G. Ramachandran was the first from India to receive the Ewald Prize (fifth in the series) for his landmark contributions in the areas of DNA structures, during the Glasgow Congress in August 1999. His outstanding achievements in the field of crystallography in the area of anomalous scattering, its use in the solution of the phase problem and the famous 'Ramachandran Plot' for conformation and validation of macromolecular structures are among his many other significant contributions. This year (2014), IUCr under the presidentship of G. Desiraju (IISc, Bangalore) has announced that the Tenth Ewald Prize will be awarded to A. Janner and T. Janssen for their contributions in the area of aperiodic crystals. Both the scientists are from the Institute for Theoretical Physics, University of Nijmegen, The Netherlands. Their pioneering work on the development of 'superspace' approach (i.e. analysis of crystal structure in higher dimensional space) has been well recognized even before the establishment of a separate 'Commission on Aperiodic Crystals' by IUCr. It can be clarified that incommensurate crystals or quasicrystals do not show any periodicity in 3-dimensions, but the periodicity can be recovered in higher dimensions. Hence the approach of 'superspace' is a convenient framework to understand the crystal structure and to correlate with physical properties of the incommensurate and quasicrystal phases. It implies that the concept of crystal symmetry has to be extended to higher dimensional space.

Historically, it is relevant to point out that P. M. de Wolff first observed the incommensurate modulation in the structure of soda[1] and provided a description in terms of a 4-dimensional space in 1974 (ref. 2). In Nijmegen, the group led by Janner and Janssen studied the symmetry of space and time-dependent electromagnetic fields in terms of 'generalized magnetic space–time groups' since 1965 and had published the first full list of these groups, now called as 'superspace groups' in 1968 (ref. 3). Thus, Janner and Janssen developed the superspace formalism for 1-dimensionally modulated phases, and subsequently for more dimensions for incommensurate composites and quasicrystals. It has been shown that the concept of superspace structure formulated and advocated by Janner and Janssen[4] is extremely useful to understand incommensurate crystal (IC) phases, modulated crystals involving a periodic deformation of a basic structure with space-group symmetry and intergrowth crystals. It is relevant to point out that until the discovery of quasicrystals, this approach was applied to incommensurately modulated crystals. However, after the discovery quasicrystals in 1982 by Shechtman (reviewed in ref. 5), the approach utilized for ICs was not adequate to unravel their structures. Thus the superspace approach was further extended and successfully applied for structural modelling of quasicrystals (QCs). It may be noted that QCs can be distinguished from incommensurately modulated crystals due to the fact that their diffraction pattern contains no clear subsets of strong Bragg peaks (main reflections) and weak spots ('satellites') unlike that of ICs. In fact, the importance of hyper-dimensional approach was highly appreciated and developed after the discovery of QCs. In 1991, IUCr changed the definition of crystals to accommodate quasicrystal structures and the new area of 'aperiodic crystals' was born to accommodate all types of ICs and QCs[6]. The Commission on Aperiodic Crystals came into existence replacing the earlier one on 'Modulated Structures, Polytypes and Quasicrystals (MOSPOQ)'. A conference entitled MOSPOQ-88 was organized at Banaras Hindu University (BHU), Varanasi by P. Ramachandra Rao, S. Lele and D. Pandey in 1988. It is nice to recall that Janner participated in this conference, and Janssen visited BHU and Bangalore on some other occasion to share the work on hyperdimensional crystallography using superspace approach. After 1994, the Commission on Aperiodic Crystals organized a series of conferences, triennially in several parts of the world. 'Aperiodic 2000' was organized by Janner and Janssen in Nijmegen[7] in 2000. Thus, their work has been highly discussed, documented and appreciated at various levels in all the conferences organized under 'MOSPOQ' and subsequently under 'Aperiodic Crystals' of IUCr in addition to their published work in various reputed journals. Many Indian scientists got the opportunity to interact with Janner and Janssen on several occasions. It is highly satisfying and encouraging to note that two deserving scientists have been chosen for this prestigious award. Their contribution to the analysis of the structures of complex materials by invoking the superspace approach is phenomenal. The presentation of the Ewald Prize will be made during the Montreal Congress Opening Ceremony of IUCr on 5 August 2014. Earlier, the community of researchers on aperiodic crystals got the opportunity to celebrate the award of the Nobel Prize to Danny Shechtman (in 2011 in Chemistry) for the discovery of quasicrystals. Now the 'Aperiodic Community' has got another opportunity to rejoice the award of the Tenth Ewald Prize to Janner and Janssen.

1. Brouns, E., Visser, J. W. and de Wolff, P. M., *Acta Crystallogr.*, 1964, **17**, 614.
2. de Wolff, P. M., *Acta Crystallogr. A*, 1974, **30**, 777–785.
3. Fast, G. and Jannsen, T., *J. Comput. Phys.*, 1971, **7**, 1–11.
4. Janner, A. and Janssen, T., *Phys. Rev. B*, 1977, **15**, 643–658.
5. Mukhopadhyay, N. K., *Curr. Sci.*, 2012, **103**, 1392–1394.
6. Report by ICUr, *Acta Crystallogr.*, 1992, **48**, 922–946.
7. Mukhopadhyay, N. K., *Curr. Sci.*, 2000, **79**, 1637–1638.

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