of crystals. As important as the space groups themselves are their subgroups. Here, we review how they have improved our understanding of the space groups themselves, how they have proved useful in solving various problems of crystallography and how they have been used to define new groups. Furthermore we give an outlook of what still has to be done. One of the most important subgroups is the group T of lattice translations, which we can use to construct the quotient group P=G/T, which is better known under the name point group. We start our presentation by reviewing the work of E. Ascher and A. Janner, who have shown how to view space groups as extensions of P by T. We pass on to more general subgroups and discuss coset and double coset decompositions and how they have been applied to phase transitions and twins in crystals. Closely connected to coset decompositions are colour groups, which have been studied among others by J.J. Burckhardt. A special kind of colorings are Bravais colorings, which leads us to similar sublattices and the group of similarity rotations, which is a supergroup of the point group. In between these two groups is the group of coincidence rotations, thus we arrive at coincidence site lattices (CSLs) and grain boundaries and return to twins. Last but not least we discuss the connections between colorings and CSLs, thus arriving at current research topics.

Keywords: space groups, colourings, coincidence site lattices

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J.J. Burckhardt's contributions to crystallography

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Johan Jakob Burckhardt, who died in 2006 at the age of 103, was deeply interested in crystallography all of his life and made invaluable contributions to the mathematical foundations of space group theory. After first studying mathematics in Basel and Munich, he was so impressed by Andreas Speiser's *Die Theorie der Gruppen von endlicher Ordnung* that he moved to Zurich to study with Speiser the year after its publication. There he also attended lectures of Paul Niggli and (explicitly recommended by Speiser) Leonhard Weber.
On the basis of his acquired mathematical background, Burckhardt developed a new derivation of the 230 space group types which placed the earlier work of Schoenflies and Fedorov in the modern algebraic context of cohomology theory. His approach via Frobenius congruences in particular freed space group theory from dimensional constraints. For example, he determined the space groups for cyclic, symmetric and alternating permutation groups (in their natural permutation representation) for arbitrary degree. Burckhardt's work on space groups culminated in the publication of *Die Bewegungsgruppen der Kristallographie* in 1947 which is still a standard reference in mathematical crystallography. Together with Bartel Leenert van der Waerden he published a short but crystal clear article about colour symmetry which clarified the somewhat obscured ideas around that topic and influenced a generation of researchers. Burckhardt also became a historian of mathematical crystallography, and helped to illuminate its long and multi-lingual, multi-disciplinary path. Perhaps most important of all, Burckhardt corresponded widely with mathematicians and crystallographers all over the world, helping to create the community that this symposium implicitly celebrates.

Keywords: J.J. Burckhardt, space group theory, colour symmetry

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Heterogeneous cylinder packing: Space group on periodic structures with <110> six directions

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Several cylinder packing structures were found by authors around 1995. We gave equations of structures and calculated packing density. But we have left their space group undetermined for many years.
In this talk, we report space group on periodic structures of cylinder packing with <110> six directions. All the cylinders are congruent and the length of the cylinders is infinite and their directions are restricted to only six directions of <110>. Each cylinder is fixed by cylinders of other directions, so that the whole structure sustains mechanical stability. The space group tell us each structure is not homogeneous. But they have ingenious feature: parallel cylinders in six directions form equivalent two-dimensional rhombic lattice respectively.

Keywords: cylinder packing, rod packing, space group

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Life sciences at Diamond Light Source and prospects with new light sources

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Diamond Light Source was commissioned for users in 2007. The machine consists of a 100 MeV linear accelerator, a 3 GeV booster synchrotron and a 3 GeV storage ring, together with interconnecting beam transfer lines. The storage ring (circumference 562 m) based on 24 cells is run at 300 mA. The electron beam emittance is 2.7 nm rad with bunch length (FWHM) 25.6 ps. The accelerating voltage is provided by two superconducting cavities based on inductive output tubes (IOTs) each capable of delivering a maximum total output power of 300 kW. In Phase I, 7 insertion devices were installed: 5 in-vacuum undulators, one variable polarisation device and one superconducting wiggler. At the end of Phase II (2011) Diamond will have 22 experimental stations for research in both the life sciences and physical sciences, 7 beam lines in Phase I (completed 2007) and 15 beam lines in Phase II. This talk will consider the impact of synchrotron radiation on life sciences research and will attempt to assess the future demand for new X-ray sources. Diamond will have 8 beam lines dedicated to life sciences research: 5 macromolecular crystallography beam lines, a non-crystalline diffraction and solution scattering beam line, a circular dichroism beam line and an infrared microspectroscopy beam line. These will provide for exciting and