Aperiodic crystals and beyond

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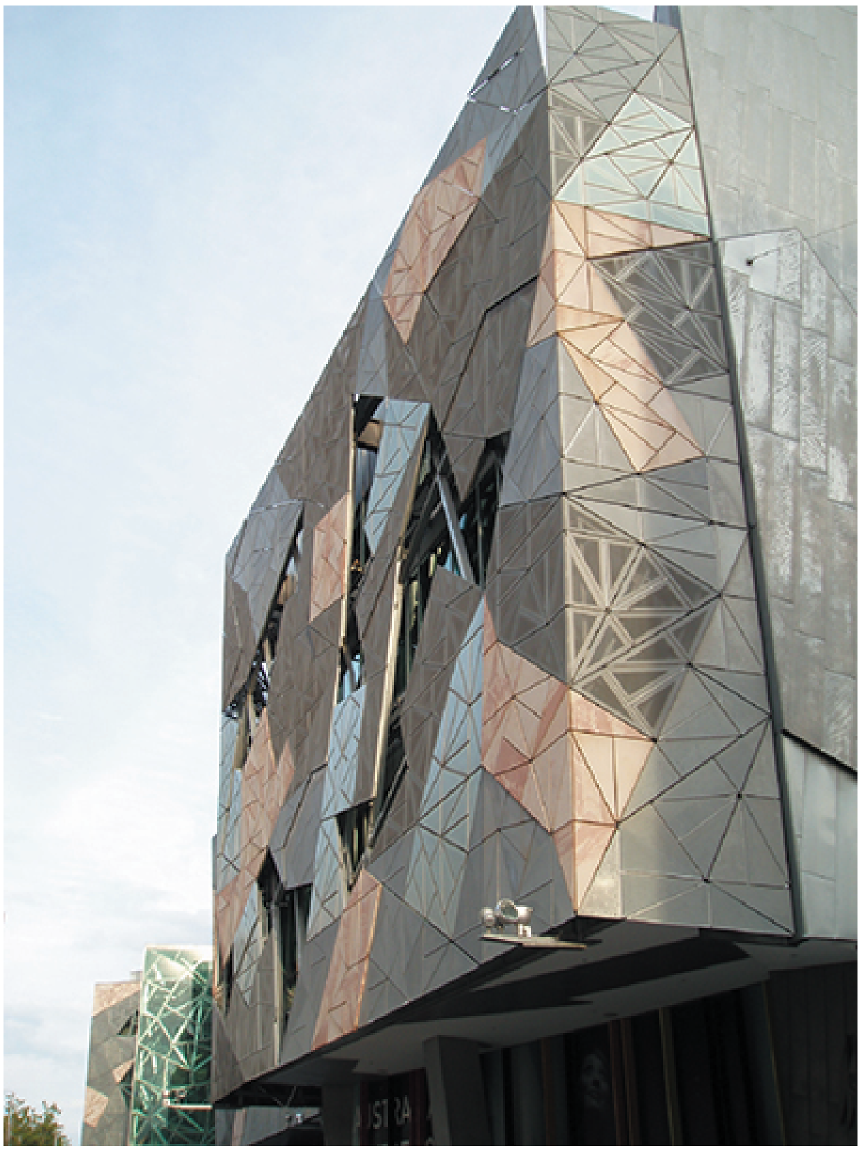

A building at Melbourne's Federation Square features a pinwheel tiling façade.
Credit: Uwe Grimm

Once a contradiction in terms, aperiodic crystals show instead that "long-range order" has never been defined. Whatever it means, decades of intense research have shown it to be more complex and surprising than anyone suspected [Senechal (2015). *Acta Cryst*. B71, 250-251; doi: 10.1107/S2052520615009907]

The human brain is very skilled at detecting patterns and recognising order in a structure, and ordered structures permeate cultural achievements of human civilisations, be it in the arts, architecture or music. The ability to detect and describe patterns is also at the basis of all scientific enquiry.

Crystals are paradigms of ordered structures. While order was once seen as synonymous with lattice periodic arrangements, the discoveries of incommensurate crystals and quasicrystals has led to a more general perception of crystalline order, encompassing both periodic and aperiodic crystals. The current definition of crystals rest on their essentially point-like diffraction.

Considering a number of recently investigated model systems, with particular emphasis on non-crystalline ordered structures, the limits of the current definition are explored in a paper [Grimm (2015). *Acta Cryst*. B71, 258-274; doi:10.1107/S2052520615008409].

The current definition of a crystal is based on the currently known catalogue of periodic and aperiodic crystals. Scientists currently do not know of any materials that have aperiodically ordered structures beyond incommensurate crystals and quasicrystals. The definition of a crystal also reflects the lack of understanding of what constitutes order in matter, and in this sense should be seen as a working definition that may well need to be revised in the future. In crystallography, order is linked to diffraction, which makes sense because diffraction is the method of choice to experimentally determine the structure of a solid. Grimm demonstrates that there are ordered structures which are not captured by the current definition, either because their pure point diffraction fails to be finitely generated, or because they do not have any non-trivial point component in their diffraction.

While we do not know whether such structures are realistic in nature, it should become possible to manufacture materials with purpose-design structure and properties. In this sense, these are structures that are relevant and should be considered to be within the realm of crystallography.

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