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Polytope Typology B: Core–Shell, Core–Multi-shell, and Interlayer Configurations of the Polyhedra According to the Separation of Faces

Robert C. Meurant

Director, Institute of Traditional Studies; Adjunct Professor, Seoul National University PG College of Eng.; Exec. Director, Research and Education, Harrisco Enco • rmeurant@gmail.com • http://www.rmeurant.com/its/

Abstract

In this paper, I apply my 2.5D cubic schema of polyhedra by the separation of faces (*SoF*), and rhombic schema of faces (*RSoF*), to generate core–shell and core–multi-shell geometries for Class II of {2,3,4} symmetry, with respect to the interlayer cells they generate. This morphology of polyhedra by symmetry class with the inclusion of a null element *VP* recognizes 8 Primary Polyhedra (*PP*s) (or Primary Polytopes, *PT*s) for each of 5 classes, 3×3D, and 2×2D. Each *PP* (or *PT*) consists of facial polytopes (*FT*s) that are considered to include 0-dimensional (0D) vertices (1-gons), and 1D edges (2-gons), as well as 2D polygons (n-gons), considering as principial only those *PT*s that lie normal to (or vertices (*VT*s) lying on) the axes of symmetry. By locating the smaller *PP* within the larger *PP*, core–shell configurations are then developed for pairs of concentric *PP*s that share an edge of the cubic (zonahedral) schema, where both are of unit edge length, and coaxial, sharing common negative (−ve), neutral (ntrl), and positive (+ve) axes. In the exemplary Class II, these conveniently correspond to the facial, mid-edge, and verticial axes of the cube ((100), (110), & (111)), respectively. Restricting the pairings to the shared edges of the cubic schema abstracted from the *SoF* reduces the possible cases in each class from 56 to 12, so ensuring their compatibility. The interlayer between inner and outer *PP*s is then partitioned into radial prismatic (*PRS*), pyramidal (*PYR*), and truncated pyramidal 'frustal' (*TFM*) (i.e., cupola) elements of (0, α | β, or 2) frequency/orientation according to the *FT* (Fig. 1), where 0 refers to the *VT*; α | β in the −ve and +ve cases to facial rotation (truncation), α being the *FT* of frequency *n* of the polar (*OH* or *CB*), β of the quasi-regular (*CO*), and in the ntrl case, α | β refer to the PL^{+}–PL^{-} orientations of ntrl edges (*EG*)s; and 2 refers to the 2*n* double frequency case. Inner *VT*s project to outer *VT*s, *NE*s, or *n*-gons to form 0-*PRS*s, ntrl 2-*PYR*s, or *n*-*PYR*s, respectively; inner *NE*s project to outer *NE*s or squares (*SQ*s) to form 2-*PRS*s or 2-*TFM*sm respectively; and inner *n*-gons project to outer *n*-gons or 2*n*-gons to form *n*-*PRS*s or *n*-*TFM*s, respectively, while 2*n*-gons project to 2*n*-gons to form *n*-*PRS*s. These are all radial, on the main symmetry axes, and combine to fill the interlayer space. The heights of these elements are derivable from the inradii of the concentric *PP*s, and show constant increase by gender and axis of the cubic schema. Core–multi-shell configurations are also developed, by abstracting 4 or 3 consecutive sequences of coaxially aligned, concentric *PP*s from the cubic schema, thus using the core *VP* and/or outer *GR*, respectively; each of the 3 or 2 interlayers thus formed is completely filled by the corresponding *PRS*, *PYR*, and *TFM* elements. The geometries developed might find application to nanoarchitecture, e.g., of electrode catalysts, and in space structures.

Keywords: core-shell, core-multishell, polyhedral order, nanostructure, separation of faces, structural morphology

1. The rhombic schema and the separation of faces in the cubic schema

Following Critchlow [1], Grünbaum & Shephard [2], and my earlier research [3], the rhombic schema that I earlier developed [4] shows the progression that faces undergo as the steps of the cubic schema progress from *VP* to *GP* (Fig. 1). The 0-faces are *VT*s; they first progress to α or β faces; −ve & +ve α faces being the (non-verticial) faces of the correspondingly gendered *PL*, with −ve & +ve β faces being the corresponding faces of the *QR*, and being rotated (truncated) versions of either α face; ntrl α & β faces being the −ve & +ve ntrl faces (edges) of the −ve & +ve PL, respectively.