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Average N-hedra as Descriptors of 3D Network Cells

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Space filling in 3-d networks is both basic and of long-standing interest. Network cells represent physical entities, such as grains in polycrystals or bubbles in foam. Topology and integral geometry impose requirements that the total spherical image for network cells is conserved. The theory represents cells with N neighbors by proxies called average N-hedra, satisfying space filling and equilibrium. Average N-hedra are symmetric topological equivalents of network cells. Analysis yields estimates of the metrical, energetic, and kinetic properties for isotropic foams and polycrystals as functions of the number of neighbors, N. Kinetics for area rates of change in 2-d networks (von Neumann-Mullins) has an exact analog in 3-d: $\frac{dA}{dt} = -\gamma M \oint_{faces} K dA$, where γM is the reduced boundary mobility, and K is the Gaussian curvature. Similar analogs exist in 3-d for the total network free energy. Additional expressions for the volumetric rates of change are found and checked accurately against simulation data.

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