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Geometric and Physical Modeling Born from Two Sciences: Algebra & Geometry

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I shall describe the solution to two problems where conversant knowledge of algebra & geometry paves the way for computational efficient solutions in geometric and physical modeling of spherical shell assemblies.

First, through the use of the theory of polyhedral symmetric groups, root systems, and their extensions, one is able to generate all regular and semi-regular symmetric tilings (tesselations) of a sphere. This characterization enables a 6D parameterization of the search space via symmetric decorations of periodic and aperiodic planar tilings, and thereby the first polynomial time solution to automated prediction and design of 3D shell assemblies of varying sizes. Moreover, this theory provide a generalized subdivision procedure for spherical polyhedra, wherein increased facet complexity preserves local symmetries.

In a second half, Ill show how desingularization theory of algebraic curves, and especially the constructive application of monoidal transformations to blowup a singularity, allows for a general procedure to achieve robust numerical quadrature/cubature of singular / hyper singular integrands (kernels). Ill show how effective use of this provides for a stable solution of the boundary derivative solutions of the Poisson-Boltzmann equation using algebraic splines in an isogeometric sense.

The two seemingly diverse problems are intertwined in that they provide feasible solutions to the nano-design of drug delivery mechanisms, besides potentially other applications.

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