SPHERES + CUBES = x^n+y^n+z^n = 0

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Abstract

One of the topologies that I am currently exploring is Triply Periodic Minimal Surfaces TPMS or Infinite IPMS, this term has been coined by Alan Schoen at NASA in the 1960s. These surfaces can be observed in nature, exhibiting the behavior and properties of bubbles that make up foam structures. In foams, when bubbles join in mass and in random polydispersion, as observed in nature, they collectively behave unpredictably. The dynamics of these independent regions comprising foam masses, which transfers energy from one polyhedral node to the next articulated by their intersecting plateau borders is intrinsic to my creative thinking.

Within the past fifteen years I have been exploring 3D computational graphics to define and represent the underlying forms in nature. Through observation, developing a new series of intuitive mathematical sculptures, I use a hybrid of differential geometry and algebraic equations to define minimal and complex surfaces. Mathematica is one of the software programs I use to generate these 3D digital surfaces for parametric plots such as Calabi-Yau spaces. To generate mathematical sculptures I use mainly implicit, parametric, equations in the form of source-code programming in Mathematica, Surf-X, K3DSurf, and an array of additional CAD-CAM software in order to prepare 3D files, and ultimately to fabricate sculptures by using rapid prototyping and CNC-milling techniques. This forward thinking belief that the new wave of computational 3D graphics in the arts and sciences will bridge the imminent field of computational aesthetics and nanotechnologies.

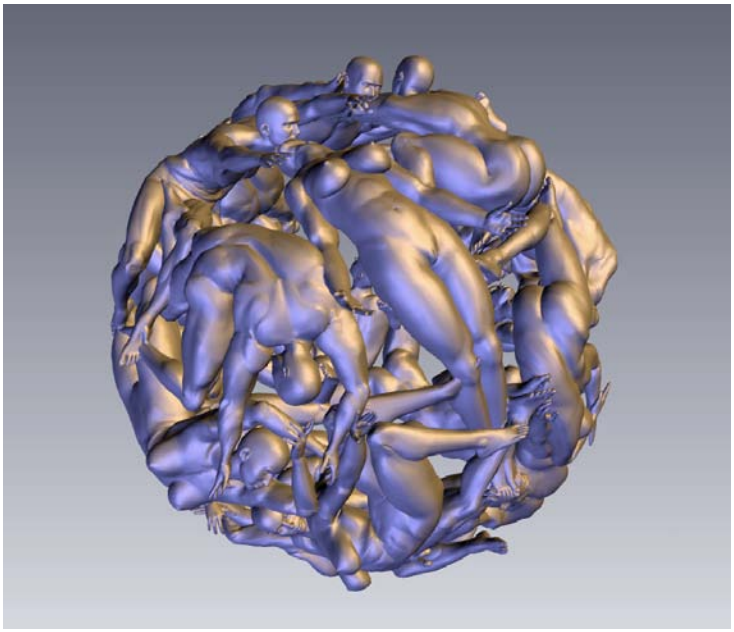

Figure 1: *Anthroshpere*

Prior to exploring 3D computational graphics, I have developed a series of interconnected human figure compositions *Anthrosphere*, [1], an extension of my earlier sculpture aesthetic representing the human form. The link to my current findings involves combinatorics, an idiom that best describes my creative process: the optimization of discrete and combinatorial elements arranged in a combinatorial order. Essentially the geometric forms that I am working with are spheres and cubes; homotopically, when combined form an asymmetric though dynamic structural arrangement. The two solids unify nicely when applying implicit iso-surface equations in K3DSurf Math application: a rudimentary example of a minimal surface with a level set of zero mean curvature is Schwartz's P surface:

cos(x) + cos(y) + cos(z) = 0

A more complex yet highly symmetrical with similar attributes would be:

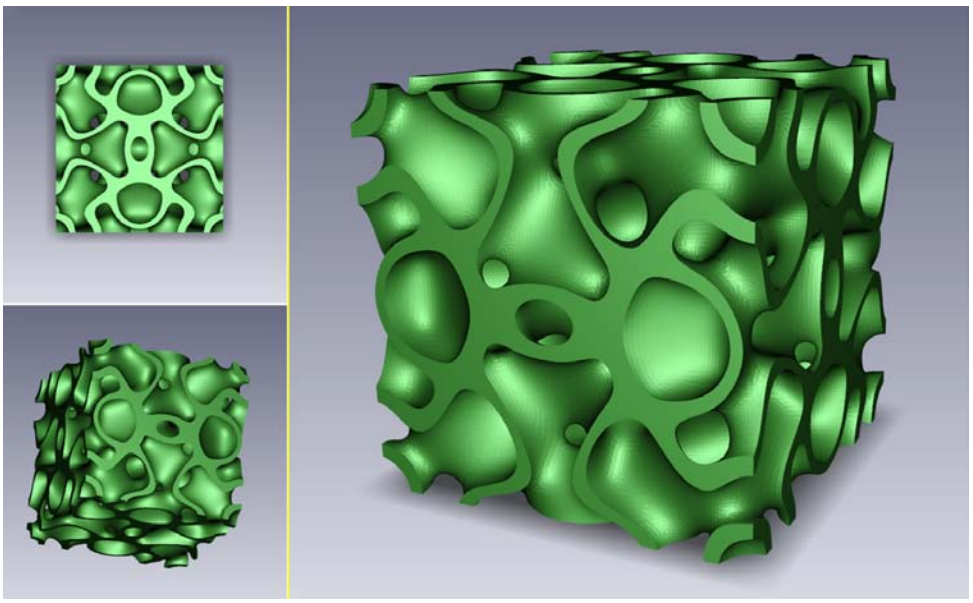

Figure 2: *P-Box*

if((x^100 + y^100 +z^100 < 3*(3.5^100)),(log(cos(x + (1+sqrt(5))/2*y) + cos(x - (1+sqrt(5))/2*y) + cos(y + (1+sqrt(5))/2*z) + cos(y - (1+sqrt(5))/2*z) + cos(z - (1+sqrt(5))/2*x) + cos(z + (1+sqrt(5))/2*x)))+.7,(x^100 + y^100 +z^100 - 3*(3.5^100))) plot range: -x,x,-y,y,-z,z,= = 6

We use the "if" function [2] as a conditional statement: "If *a* is true, then *b* is true", ("*a* implies *b*") thus "if" is integrated into the equation as a "capping off" and a blending of two or more *implicit* surfaces to create a water-tight differentiable manifold surface.

A combinatorial or Hybrid version [3] of the very same P surface, that is to say combined sphere and cube non-intersecting orientable surface:

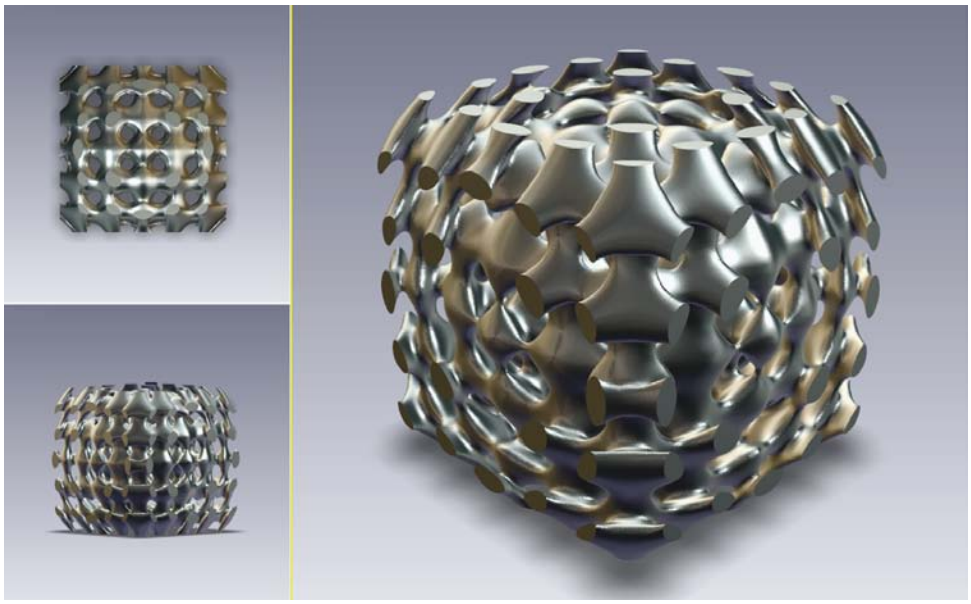

Figure 3: *P-Surface Onion*

cos(abs(x^2 + y ^2 + z^2-1)) +cos(4*x)+cos(4*y)+cos(4*z)-0.2

A more compartmentalized [4] and variation on P+D Surface is:

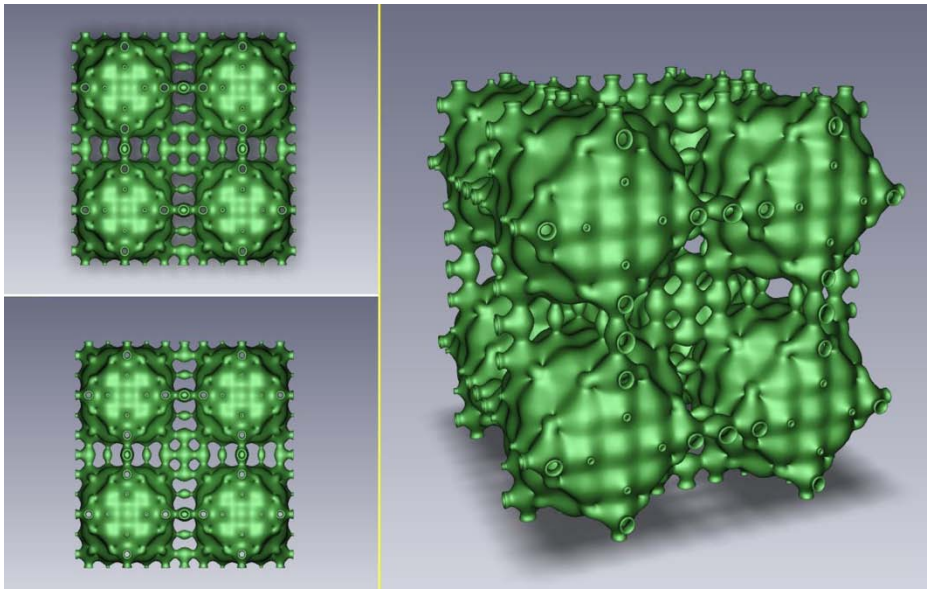

Figure 4: *Holes P-D-surface*

(abs(x^2+ y ^2 + z^2) -(cos(4*x) +cos(4*y) +cos(4*z))+5*(cos(x) + cos(y) + cos(z)) + 6* cos(x) * cos(y) * cos(z) -.4-(x^2 + y ^2 + z^2))+2

Conclusion

The synergy of sculpture and math in terms of an object-oriented medium is the essence of nature as a static representation. Looking at why things rationally are the way they are as opposed to the way they appear. I have spent most of my life creating representations of the human form. People ask me why I have embarked in this new direction. Why has my work become "abstract"? The answer is that the mathematics of the physical world is more representative of reality than our subjective interpretation, since our perception of reality is only a close approximation of what actually exists.

There are innumerable minimal periodic surfaces yet to be discovered but there is scarcely one that is not intriguing. So in tribute to all the great Scientists who in the past never gained the opportunity to observe in 3D form the theoretical and cerebral aspects of their works, nevertheless we are now able to appreciate them as objects of aesthetic significance. Likewise, as we are able to appreciate music of composers of the past, such as Beethoven who never had the luxury to hear his later compositions in full symphonic form.

By following this new direction I have been looking at the big picture representing the fundamental laws of how the cosmos is constructed-- a kind of artistic TOE (Theory of Everything); everything that exists in the universe from the vast spaces of intergalactic gravity to the infinitesimally small spaces that exist in string theory. As it turns out, many of these exquisite surfaces are elegantly representative of the physical and discrete laws that exist in our day-to-day human scale experience. Utilizing the computational techniques of CADCAM and rapid-prototyping I can create hand-held 3D printings in direct stainless steel as well as larger human scale versions. The "Human Sphere", or Anthrosphere, was the transitional piece that led to investigate the topological surfaces, spheres, and nodal cubes of level set surfaces.

"It was in the early 1990's when my wife Farifteh was working on her PhD in Health Services Research at Johns Hopkins School of Public Health when I first encountered the potential of computers and computational graphics to further the natural progression of my art."

References

[1] William F. Duffy, *Anthrosphere, interconnected sphere series, Synergy-I-II,* Balimore,MD 1990

[2] H.A.Schwarz, *Gesammelte Mathematische Abhandlungen*, Vol. 1, Julius Springer, Berlin, 1890.

[3] A. L. Mackay, *Flexi-crystallography: curved surfaces in chemical structures*, Current Science, Vol. 69, pp. 151-160. 1995.

[4] A.H. Schoen, *Infinite periodic minimal surfaces without self-intersections*, NASA Technical Report TN D-5541, Washington DC 1970.