SCIENCE AND CULTURE

Mathematics in metal

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A mathematical surface known as the Klein bottle is like a mischievous, mathematical cousin of the Möbius Strip, where the inside and the outside are the same side. Among topologists, the Klein bottle is well known as an example of a closed, nonorientable surface. Thanks to artist Bathsheba Grossman, whose sculptures bring mathematical abstractions into the real world, this curious surface has also become the life of many a party.

Grossman's best-selling piece of art is a bronze-tinted, stainless steel Klein bottle opener that can both remove a bottlecap and start a conversation. The surface can be physically realized only in four dimensions—an impossibility for anyone, partygoer or not—but a 3D model like hers is close enough to get people talking.

"There are a lot of math geeks in the world, and most of them drink beer and have money," Grossman says from her studio in Santa Cruz, California. "You need a substantial amount of money before you'll buy a $72.00 bottle opener."

Grossman turns topological and geometric abstractions into solid art. Among her dozens of pieces is a 3D projection of a dodecaplex, or 120-cell, which is the 4D analog of a dodecahedron. She calls that piece a "tried and true classic," and credits mathematical sculptor George Hart for first introducing her to it.

Underlying many of her sculptures is the idea of the minimal surface, which is the smallest possible surface area that can exist within a given boundary. Soap films naturally form minimal surfaces, for example, within bubble wands of any shape. Some of Grossman's pieces, like the twisted, pointy "Gyroid," have triply periodic surfaces, which means they're composed of minimal surfaces that repeat, almost like tiles, in all three spatial dimensions.

"She is a genius," says renowned sculptor Erwin Hauer in New Haven, Connecticut. Grossman cites him as an early influence and says that as an undergraduate college student, she entered his studio a math major and left a sculptor. Hauer's minimalist works embody repetitive elements and have similarly drawn attention from topologists and geometers. He says Grossman's deep knowledge of geometric forms serve as a point of departure for her work.

"In many cases, the inscribed polyhedron is not in obvious evidence, but she invents forms that sort of spiral through space and link up in imaginative ways," he says. "The order in which they are arranged is informed by her mathematical knowledge, but the execution is sculptural."

Grossman says she's a programmer at heart; her sculptures begin as a piece of computer code that dictates how the metal-printed parts fit together. She's been using 3D printing for 15 years to forge her work and says the recent surge in popularity of the technology has opened up a few new opportunities. Now, for example, lower-cost, plastic replicas of her works are available through the company Shapeways.

Grossman doesn't limit herself to math. In addition to her abstract metal pieces, Grossman uses laser etching to craft designs within glass solids. That technique is the opposite of her math sculptures: instead of building, she subtracts—glass, point by point—from the interior. Her laser-etched crystals include models of the Milky Way, the universe as recorded by the Sloan Digital Sky Survey, Earth's magnetic field lines, DNA's double helix, and the chemical structure of a caffeine molecule.

A bronze-tinted, stainless steel Klein bottle opener is one of many mathematical structures given physical form by Bathsheba Grossman. Image courtesy of the artist.

Grossman's most recent creations, however, are also her favorites: they're biomorphic figures that merge topologically interesting forms infused with biological bulges and cavities. They look like bizarre and impossible living critters.

"They walk the line between creepy and geometrical," she says. "The unifying principle is that no one will want to buy them. I kind of like them a lot."