About the Cover

Digital Visions from the Subatomic Realm

Gary Singh

When talking about his art in relation to information visualization, Eric J. Heller said, “We needn’t stick to literal renditions of data, as long as it is clear we are doing art. Good science-based art not only inspires others to join us in our efforts—where would chaos theory or quantum dots be without the images they generate?—but it is a strong form of outreach to the public.”

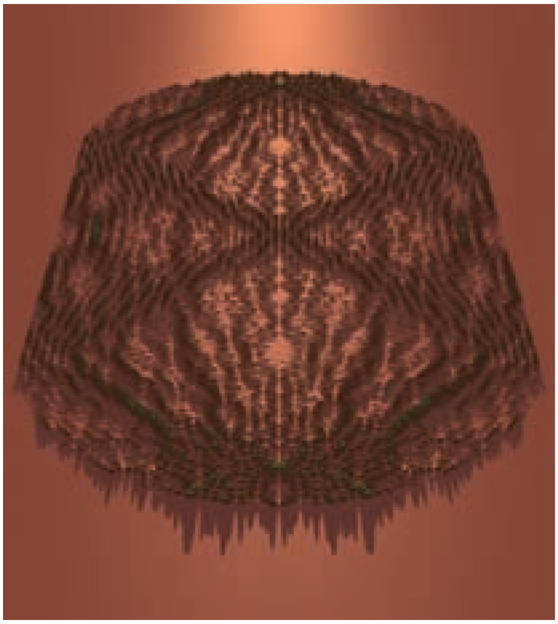
Heller said his graphics are meant to be expressions more than anything else, so the viewer only needs to have a general understanding of the phenomena generating the patterns, nothing more. “If [the images] lead to further and more quantitative inquiry on the part of the viewer, the tools and literature are there to help.”

Early exploration

Heller first combined graphics, art, and science while working at Los Alamos National Laboratory, where he was a staff scientist from 1982 to 1984. “They took graphics seriously,” he explained, “and they still do.”

While at Los Alamos, Heller made the first in a series of significant discoveries while creating images purely for aesthetic reasons. By using the graphical tools as Los Alamos, Heller discovered the phenomena of “scarring” waves, something that had eluded other investigators before him. The discovery was purely a graphical one, later backed up with theory he worked out that explained why the scars had to be there. The image and the theory, having to do with unstable periodic orbits in a sea of chaotic nonperiodic orbits, were published in *Physical Review Letters* in 1984 (vol. 53, pp. 1515-1518). “These unstable orbits have no ‘weight’ in classical physics,” Heller elaborates, “but exert their disproportionate effect on the quantum states, many of which are ‘scarred’ along the periodic orbits.”

Figure 1 shows a modern version of those early images: *Double Diamond*, which is a scarred wave function.



1 *Double Diamond.*

Classical collisions

Nowadays, Heller sets up shop in the Departments of Physics and Chemistry at Harvard University, where he got his PhD in chemical physics in 1973. Many times while tinkering away and studying something like collisions in physics, for example, he winds up discovering ways to manipulate the algorithm to produce art. This is how *Rotating Rotors II* (the cover image) was born.

Usually, Heller’s images begin with low-level code in Fortran, but for *Rotating Rotors II*, he began with MSC Software’s Interactive Physics (IP), a set of tools for making physically realistic simulations with any objects that live in a 2D plane. To generate the image, rotators consisting of four segments (rigid bars hinged to each other at their ends) were set to spin and gyrate chaotically.

Because IP only displays at screen resolution and has no file capture, Heller decided to run a huge simulation in blocks and divide the scene into tiles. Heller computed each tile, complete with all the layering in IP, and then later, after each tile was screen captured, stitched it to the other tiles. “I can only use screen capture to get the images, but by repeating the same run over and over and looking in different ‘windows,’ I can build a large, high-resolution image after sewing it together.” Because IP overwrites older events with new ones at a given location, the towers’ apparent 3D structure is actually the result of time—whichever rigid bar came by last gets to be on top. Heller then applied color gradients in Adobe Photoshop to each rotator’s path to complete the mountain-desert landscape.

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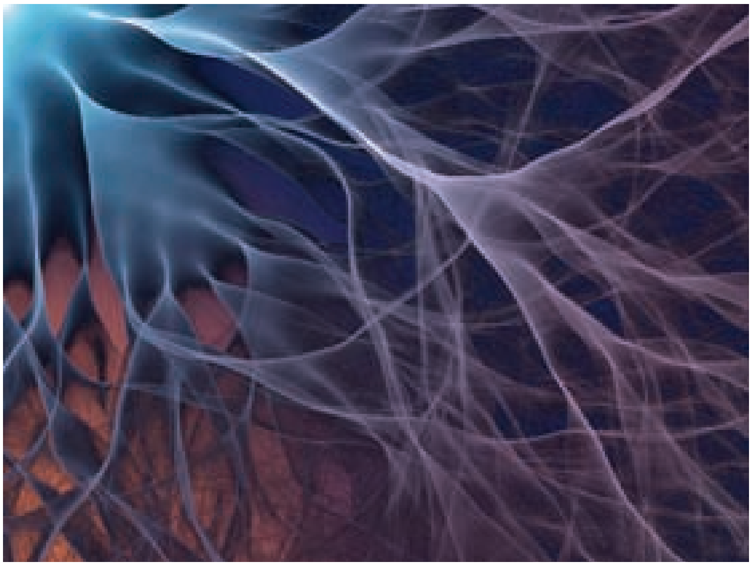
Electron flow on a micron scale

Heller has also created a series of images based on electron flow on a micron scale. These images render electron flow paths in a "2D electron gas" and are based on the actual flow patterns for electrons riding over a bumpy landscape. Figures 2 and 3 are part of this series, titled *Transport*, and were inspired by experiments by Mark Topinka, Brian LeRoy, and Bob Westervelt at Harvard. The group worked out an experimental method for directly imaging the electron flow with the "precise movement of a charged needle so fine that it has only a few atoms at its tip. This charged needle was used to image the electron flow, and remarkable branching of the flow was discovered for the first time." This particular branching behavior of electrons riding over a bumpy surface hadn't been known to exist before these initial experiments.

The theorists then immediately set to work trying to understand the branching's origin by modeling on a computer. Heller's student Scott Shaw had written C code to see the electron flow's branching, and Heller wrote new versions in Fortran. The code produced raw byte unformatted files that contained information for imaging the electron flow. They then used Photoshop to read the files and perform further manipulations.

"As I saw more and more of the electron branching images, I began to feel they were almost universal forms, things that could be used to produce a variety of types of art. Like watercolor on paper, electron branching patterns are universal structures that are seen elsewhere in nature, which lend themselves to illustration and art," Heller explained.

2 *Transport III.*



3 *Transport VI.*

Future prospects

Regarding the future, Heller said he is sticking to the science he knows best, and he is producing new images at a steady pace. Even though he believes there is much more to be done with the forms he's already worked with, like the *Rotators* or the *Transport* series, he is experimenting with new forms. His latest foray is into the patterns produced by the "nodal" properties of waves.

Prints of Heller's images are available in museum quali[illegible]nd large format. They are [illegible]erColor Luminage Direct-Digital Prints produced on a CSI LightJet 5000 printer using high-resolution RGB lasers to expose RA 4 photographics print materials, for the highest resolution color output available. (Readers can order them through his Web site http://www.ericjhellergallery.com.) His prints have been part of numerous traveling exhibitions and will also be at the National Academy of Sciences in Washington, D.C., and the Peggy Ne[illegible]t Nature Museum in the Chicago Academy of Science in 2002.

"My image[illegible] not directly from my research, but rather are inspired by it, with intent to convey impressions and even excitement of the weird quantum and chaotic worlds many scientists study. I am traveling in a place that is difficult to get to, and I take my easel along to bring back impressions to show others." ■