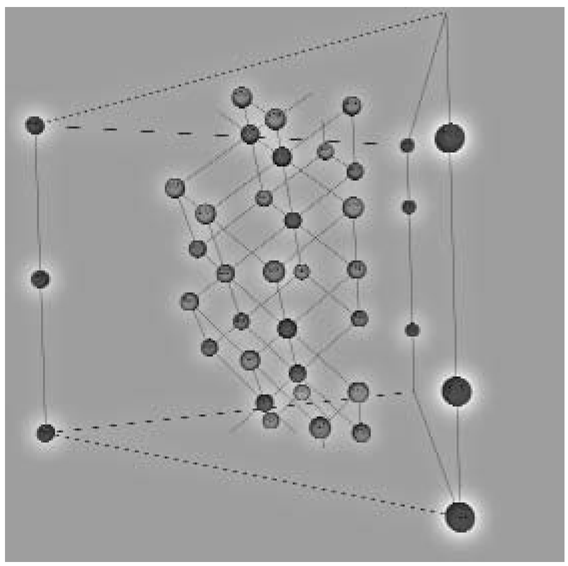
SCIENCE & TECHNOLOGY

The Music of the Spheres

THE SOURCE: "The Geometry of Musical Chords" by Dmitri Tymoczko, and "Exploring Musical Space" by Julian Hook, in *Science*, July 7, 2006.

Discoveries by the ancient Greek philosopher Pythagoras (c. 569–c. 475 BC) forged an unbreakable link between music and mathematics. Pythagoras showed that a string two feet long would vibrate with a certain tone, and that a string half as long would yield a tone an octave higher. Further divisions, into fifths, thirds, and quarters, unlocked the 12 tones—C, D, E, etc., along with intervening sharps and flats—that make up the 12 notes in an octave, the basis for Western music. Given how long this system has been in place, says Julian Hook, a music professor at Indiana University's Jacobs School of Music, "it is perhaps surprising that our understanding of the mathematical structure of the spaces in which musical phenomena operate remains fragmentary." Now Dmitri Tymoczko, a music theorist at Princeton University, has developed a way of viewing those spaces that may reveal some of their mysteries.

Hook points out that a conventional musical score is itself a kind of "graph whose vertical axis represents pitch and whose horizontal axis represents time." Plotting the positions of those tones, he says, and their internal relations to one another reveals something fundamental about the structure of music. Hugo Riemann (1849–1919) invented one such map, called a Tonnetz, based on the work of mathematician Leonard Euler. The Tonnetz is a two-dimensional model of a musical piece showing the links between individual notes and chords: Perfect fifths get linked diagonally, major thirds vertically, and minor thirds horizontally. A section of a Beethoven string quartet, perhaps not surprisingly, yields a Tonnetz with an elegant geometric structure, like the honeycomb of a bee.



In this prism-shaped segment of musical space, known as an orbifold, notes (represented by dots) are shown along with their related tones.

What of modern composers, such as Arnold Schönberg (1874–1951) and his successors? Schönberg rejected the notion that any of the 12 familiar tones ought to be more dominant—one might also say pleasing to the ear—than any other, and his work opened the way for experimentation with the spaces between tones, which the Tonnetz cannot describe.

Tymoczko's solution is to create a new kind of musical map, one based on a geometric shape called an orbifold.

To mimic the structure of an octave, each half of Tymoczko's map is a reversed mirror of the other, with a half-twist in the middle; this is easiest to visualize in two-note chords, in which the pathway resembles a Möbius strip. Traveling 12 notes in any direction brings one back to the original tone, as the map loops back upon itself. As additional notes are added, and the chords become more complex, the map expands into multiple dimensions, creating a unified framework for all possible chord progressions.

Although the relationships of perfect fifths and thirds lie within Tymoczko's orbifold map—and retain their geometric structures—infinite spaces within the 12 tones now emerge, made up of subtones, or fractions, of the intervals between the notes. Notes from music that sounds jarringly dissonant, tellingly, are clustered in very tight spaces in the corners of Tymoczko's orbifolds. Major chords, on the other hand, lie toward the center, allowing them efficient linking with minor keys and inverted chords. Many composers exploit such connections to inject counterpoint into their compositions.

Using the orbifold map, says Tymoczko, it is possible to track common chord progressions in classical music and see that they lie along a predictable trajectory. He can discern, for instance, how certain chords—C, D-flat, E-flat—and chords closely related to them define the music of Schubert, Wagner, and Debussy. "My geometric models show us that there are important strands of commonality running through the last thousand years of music," Tymoczko says, that previously went unrecognized. Tymoczko also believes that his system is invaluable for studying the music of non-Western cultures, which frequently employ tones and pitches off the 12-tone scale. The orbifold map might even open up new tonal possibilities for contemporary composers to explore, though with no guarantee that they will inspire listenable music.

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Splog Alert

THE SOURCE: "Spam + Blogs = Trouble" by Charles C. Mann, in ***Wired***, Sept. 2006.

With all the hype surrounding the rapidly expanding blogosphere, a world where anybody can write interminably on anything, it may come as a surprise that something far less familiar or friendly is growing even faster: the splogosphere.

Splogs are sand in the machine of the Internet, and they could cripple the online world, warns Charles C. Mann, a science journalist. A splog (from "spam blog") is a bogus blog website containing nothing but gibberish and advertisements. The gibberish is full of keywords carefully selected to lure users of search engines such as Google and Yahoo.

Sploggers work on the principle that once Web surfers arrive at their site, a few will click on one of the accompanying advertisements. Each click sends a few cents into the splogger's bank account. And since any one splogger can run thousands of splogs, the scam can apparently be rather lucrative. One splog partnership claimed $71,136.89 in earnings from August to October 2005.

To be sure, Google and its search engine peers are rushing to fight off the splogs, teaching their search engines to distinguish between legitimate blogs and spam. It's a tricky business; computers just aren't as good as people are at recognizing junk. For every tweak Google makes in its search algorithms, the sploggers tweak back, with a protracted "Google dance" the result.

More ominous possibilities are raised by other techniques sploggers employ to snare Web surfers, such as using robo-software to implant links to their sites in the comment sections of legitimate

EXCERPT

To See or To Think

Cats have iridescent tapeta in their eyes for gathering the palest traces of light; but all that gathered scattery light in their eyes, then, prevents cats from perceiving fine details. And hawks detect details, but since they do not have tapeta for collecting flickers, they must depend on the sun to boom down obvious light for them to see by. Your blessing is your curse and your curse is your blessing. Because you see details, you cannot see hints of light; because you see hints of light, you cannot see details. You would need diverse eyes if you wished to be equally penetrating and sensitive.

You would need to have eyes like the box jellyfish, with its 16 light-sensitive eyes and eight acute camera-like eyes—all 24 eyes hanging down on stalks.

However, you would also need a brain.

But maybe that is not possible; maybe, in fact, the brainlessness of the box jellyfish is a direct consequence of its tremendous powers of sight. Perhaps neither the animal nor the prophet has been invented who could process so thorough a vision.

—**AMY LEACH**, an Evanston, Illinois-based writer, in ***A Public Space*** (Summer 2006)