Bridges London, 2006

Mike Field

What Is Bridges?

Bridges London was the ninth meeting of the annual Bridges conference. The common thread running through Bridges meetings has been mathematics and how it intertwines with art, sculpture, architecture, music, poetry.... A Bridges meeting is structured so that there can be fruitful and stimulating interaction between people from very diverse fields. For a mathematician, Bridges can be a fascinating experience: just listening and talking to sculptors (who often have no formal mathematical background) and seeing the astonishing range and power of their mathematical visualization. Educational outreach is an important component of Bridges, and all Bridges meetings have had programs and workshops for teachers, usually with a geometric theme (London did not disappoint in this respect). Bridges meetings also include live performed music and theater as well as excursions, often to locations with a strongly geometric theme.

The seeds for Bridges were most probably sown during the "Art and Mathematics" (AM) conferences organized by Nat Friedman at the State University of New York at Albany from 1992 to 1998 (the last meeting being the AM 98 meeting held at Berkeley and coorganized with Carlo Séquin of the University of California, Berkeley). These meetings had a focus on art, especially sculpture, and architecture, and later evolved into ISAMA (International Society of the Arts, Mathematics, and Architecture). Reza Sarhangi (then of Southwestern College, Winfield, Kansas) participated in many of these meetings and concurrently was developing interdisciplinary courses on art and mathematics at Southwestern College that were an inspirational mix of art, mathematics, and education.

The first Bridges conference was organized by Reza Sarhangi and held in 1998 at Southwestern College, with the title "Bridges: Mathematical Connections in Art, Music, and Science". Under his leadership and direction, Bridges has been an annual event ever since. For several years the conference was held in Winfield, but after Reza Sarhangi's move to Towson University, Bridges has been held at Towson (2002), Granada (2003, joint with ISAMA), Winfield (2004), Banff (2005), and London (2006). In 2007 the meeting will be held July 24–27 at the University of the Basque Country, San Sebastian, Spain.

As the subtitle "Mathematical Connections in Art, Music, and Science" suggests, Bridges conferences are eclectic affairs. One gets some of the feel by reading through the list of contents of a Bridges proceedings. For example, in the 1998 proceedings there are papers ranging from "A Symmetry Classification of Columns" (by mathematicians Martin Golubitsky and Ian Melbourne) through "Continuum, Broken Symmetry and More" (by sculptor Charles Perry) to "The Mathematics of Steve Reich's Clapping Music" (by mathematician Joel Haack). However, the proceedings by themselves do not give the full sense of the depth, range, interest, or atmosphere of a Bridges conference. At the Winfield conferences, the international virtuoso violinist Corey Cerovsek played for the audience after plenary sessions in the morning, often preceding his performance with an extempore talk on a topic from physics or mathematics (concurrently with his musical studies, Corey completed all the coursework for a Ph.D. in mathematics when he was about sixteen). Aside from the music, there would usually be theater shows as well as teacher workshops, held at the end of the conference. Participation in these early meetings was about sixty. I had the pleasure of being at the 1999 and 2000 Winfield meetings and can testify to the great atmosphere of these meetings, where artists, mathematicians, computer scientists, and educators would talk into the early hours. As the years passed, the meetings have become larger, the number of parallel sessions in the afternoons greater (four parallel sessions as well as teacher workshops ran in London), but the underlying themes and dynamics have stayed the same.

Some Highlights of Bridges London

The Format and Organization

The 2006 meeting of Bridges was hosted by the Institute of Education, University of London. The

Mike Field is professor of mathematics at the University of Houston. His email address is mf@uh.edu. *Supported in part by NSF Grant DMS-0600927.*

local organizers were John Sharp and Philip Kent (both of the London Knowledge Lab, part of the Institute of Education). Overall coordination and finances were handled as usual by Reza Sarhangi.

The conference ran August 4–9, and all the lectures and talks were held in the superb Institute of Education main building in Bloomsbury. The conference comprised 8 one-hour plenary sessions held in the mornings; about 90 twenty-minute talks held in four parallel sessions in the afternoons; a series of teacher workshops, "Bridges for teachers, teachers for Bridges", held in the afternoons; and a (mathematics) musical evening. The conference concluded with a very well-attended Bridges family day, which included mathematical master classes, a Zometool workshop, and a mathematics activities event for children. There were also a mathematics and art exhibition organized by Robert Fauthner and several major excursions. I attempt below to convey at least some of the flavor of this very successful and interesting meeting.

The Talks

The eight plenary talks were given in the morning sessions and covered topics ranging from architecture through sculpture and computer science to more mathematical (and visual) presentations such as "Non-Euclidean Symmetry and Indra's Pearls" (Caroline Series, Warwick). I was particularly fascinated by the talk given by Brady Peters and Xavier DeKestellier from the Specialist Modeling Group (SMG) of the internationally renowned London-based architects Foster and Partners. Some of the more than one hundred major projects to which the SMG has contributed include the new Beijing Airport and the current Smithsonian Institution project in Washington, DC. Anyone who has visited London recently will have seen the "Gherkin" (more formally, 30 St Mary Axe or the Swiss Re building) and perhaps also the new London City Hall, situated close to the Tower of London. Both buildings were designed by Foster and Partners with input from the SMG. They are visually very striking and incorporate complex geometric forms (see the pictures accompanying this article and also the Foster and Partners website, `http://www.fosterandpartners.com/`). Both buildings were designed with energy conservation and ecological factors to the fore. The unusual deformed sphere shape of London City Hall optimizes energy conservation, and the building was designed using advanced computer modeling techniques. The "lean back" of the building provides shading for naturally ventilated offices, and the building's cooling systems utilize ground water pumped up from boreholes. Overall, the building uses only a quarter of the energy of a typical air-conditioned office building. As a mathematician, I found it particularly interesting to see the ways in which geometric form entered into the design process of these buildings: for example, through minimization of the generation of vortices and turbulence caused by a tall building like the Gherkin and by choosing geometries that optimize energy conservation and air flow within the building.

Approximately ninety talks were given in the afternoon sessions together with ten teacher workshops. The talks ranged over a wide area including music, architecture, tilings, polyhedra, puzzles, and Islamic art, all with a mathematical connection. Rather than attempt to describe a subset of the talks, I recommend consulting the more than 650-page *Bridges London Proceedings* (2006, published by Tarquin Press in Europe and available from `http://www.mathartfun.com` in the USA).

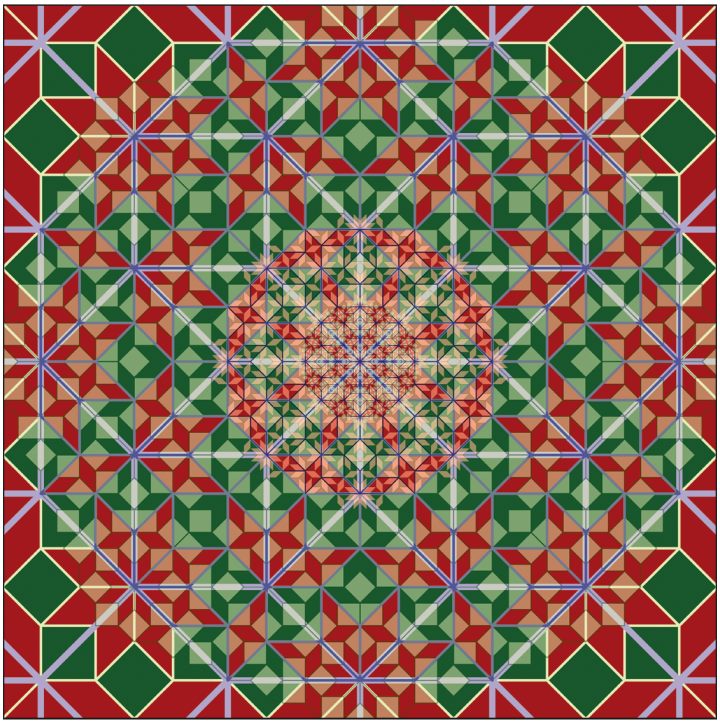
Top, "The Gherkin", 30 St Mary Axe, London. Bottom, London City Hall. Both buildings designed by Foster and Partners.

Workshops and Geometry Master Classes

Bridges has always included workshops for teachers. Bridges London introduced a new innovation: mathematical master classes, organized in conjunction with the Royal Institution. These were held during the morning of the final family day and included master classes on "Mathematics and Perspective" (Christopher Zeeman, FRS), "Anamorphic Art" (Alan Davies), "Mathematics and Juggling" (Colin Wright), and "Celtic and African Art" (Christopher Budd). The meeting concluded with an afternoon of mathematical activities for "children from 5 to 95", which ranged from mathematical origami to Zometool. More than 350 people, including many families, took part in the family day activities, and the event was sponsored by the Clothworkers' Foundation and the London Mathematical Society.

Excursions

August 5 and 8 were reserved for excursions. I took the opportunity of visiting the Ismaili Centre



Ammann Scaling, by Edmund Harriss, Imperial College, London.

in Kensington with a group of about twenty conferees led by John Sharp. (Although I had spent the previous year visiting Imperial College—just up the road—and had heard much about the Ismaili Centre, I never actually got to see inside.) The Ismaili Centre in London is a religious, social, and cultural meeting place for the Ismaili community in the United Kingdom and was the first center to be built for the Ismaili community in the West. The center has been open to the public since 2005 but only on certain days or for organized group visits. As might be expected, the geometry and design used in the center are exquisite. A very notable theme is the evolution of the complex carpet design as one moves through the building upwards towards the meeting and prayer areas (I wish I could show some pictures but no photography was allowed).

The Art Exhibit

In parallel with the conference, there was a mathematical art exhibit in the Institute of Education Building. There were more than fifty exhibitors covering a wide range of mathematically influenced sculpture, polyhedral models, and two-dimensional and fractal art. All of the works shown (and many others) can be viewed on the Bridges website, `http://www.bridgesmathart.org`. Rather than make a selection or discuss any of these works, I have included a picture by one of the younger exhibitors, Edmund Harriss from Imperial College London (his field of research is, not surprisingly, substitution tilings and quasi-crystals). The image shown, titled *Ammann Scaling*, is an Ammann-Beenker tiling and is an eightfold version of the famous Penrose tiling. Like the Penrose tiling, it can be generated by a cut-and-replace or substitution rule. In the image, several layers of the generation of the tiling have been placed on top of each other so as to show the construction and the resulting scaling symmetry.

Some Thoughts and Conclusions

There is a longstanding debate about the nature of art in mathematics and mathematics in art. In its purest form this is expressed by G. H. Hardy's comment in *A Mathematician's Apology* (Cambridge University Press, 1993) that "A mathematician, like a painter or poet, is a maker of patterns" (interestingly, his next sentence "A painting may embody an idea but the idea is usually commonplace and unimportant…," gets less attention in the mathematics press). My own view is that there is much scope for the use of mathematical forms in art, especially sculpture, but that the forms in themselves do not constitute art—they need to be transformed into art through the efforts, skill, and inspiration of the artist. In this respect it was refreshing to see so much innovation and new, mathematically inspired, art at the London meeting of Bridges.

Bridges has much to offer those interested in mathematics education. Everywhere in a Bridges conference there are examples and suggestions of how mathematics not only plays a role in everyday life but is an essential tool in understanding, interpreting, and indeed even *seeing* the world around us. The ideas discussed at a Bridges meeting seem to me to be quite central to the problem of developing successful general mathematical education as well as in overcoming the increasing alienation and hostility of many students and members of the general public towards mathematics and science.

Acknowledgments and Links. Thanks to Reza Sarhangi and John Sharp for providing information about Bridges and the organization of Bridges London. More information about Bridges may be found at `http://www.bridgesmathart.org`. Information about the forthcoming 2007 Bridges meeting in San Sebastian may also be found on the Bridges website. Thanks to Edmund Harriss for providing details about his work *Ammann Scaling*. The photographs of 30 St Mary Axe and City Hall, London, were taken by Nigel Young and are kindly reproduced with the permission of the copyright holders, Foster and Partners, London.

Last but not least, a very recent addition and resource for the art and mathematics community is JMA, the *Journal of Mathematics and the Arts* (editor-in-chief, Gary Greenfield, University of Richmond; publisher, Taylor and Francis). Many of the associate editors of JMA have a long association with Bridges.