The 17 Worlds of Planar Ants

Canada Math Camp, July 2014.

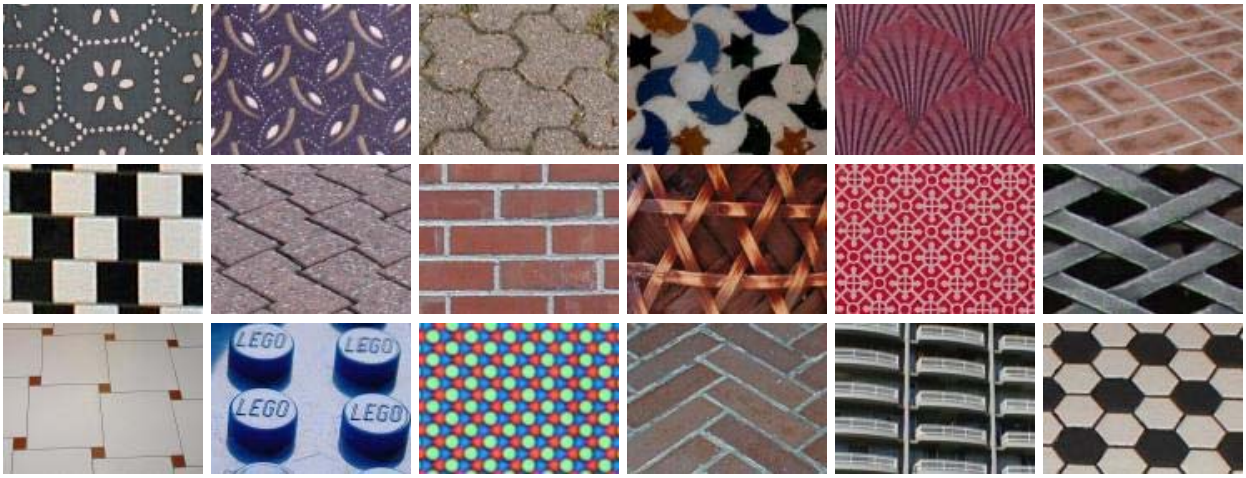
Abstract. Back in early 2000, I got my first digital camera and set out to take pictures of my kids and of symmetric patterns in the plane. There are exactly 17 of those, no more, no less. It is an addicting challenge to walk around looking at buildings, brick walls, people's ties, fabrics, what's not, and to try figure out which of the 17 is each one.


cloud-covered planet Venus


Lou Kauffman


Lou Kauffman's tie

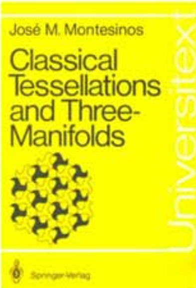
What would history look like if we were living on Venus?
What do the ants on Lou Kauffman's tie think?
Which symmetry group appears twice in the pictures below?



4-page handout.

More info: http://www.math.toronto.edu/~drorbn/Gallery/Symmetry/Tilings/Talk/CanadaMathCamp-1407.html

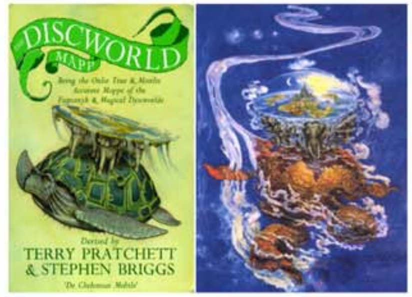
Recommended reading ...



Mariner 10 Image of Venus

Image taken from http://www.solarviews.com/raw/venus/venusmar.htm

The Earth is flat?



Images taken from ftp://ftp.lspace.org/pub/pratchett/images/bookcovers/the-discworld-mapp.jpg and http://kanne.usc.dsi.unimi.it/mapp/image.html
See also http://www.flat-earth.org/ and http://www.lhup.edu/~dsimanek/fe-scidi.htm

Image taken from http://www.fourmilab.ch/earthview/vplanet.html

The earth as we know it.

More on the base this Earth is standing upon is here.

Lou Kauffman's Tie

in my office, Jerusalem January 2002

The Jerusalem Renaissance Hotel

November 2000

A Torus

Image taken from http://www.suven.net/~dougtan/puzzles/hexagon/100.html

A building near lake Merrit

Oakland March 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The ** Group

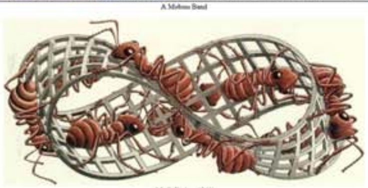
A building near lake Merrit, Oakland March 2000. Pixels on an LCD monitor showing a Subpixel Font sample, August 2000. A wall design at the Honolulu International Airport, July 2000. A quilt at the Beth El Nursery School, Berkeley July 2000. (Ignore drawings) UC Berkeley's Tan Hall, April 2000.

The quotient orbifold for the group ** is an annulus - that is, a transparent tube (transparent so that the same picture, except for orientation, is seen on both sides).

Wallpaper in Racha Cafe, a Thai restaurant on Berkeley's Telegraph Avenue

April 2000

A Mobius Band



(M. C. Escher, 1963)

A tie design at Fry's Electronics

June 2000

The oo Group

Alan Weinstein's table mat, Berkeley June 2000. A tie design at Fry's Electronics, June 2000. A tie design at Sears, Roebuck and Co., June 2000. The guest room wallpaper at the Shannon-Szczepanski's, June 2000. Maya Bar-Hillel's tablecloth, Jerusalem December 2000.

The quotient orbifold for the group oo is a Klein bottle. (This one courtesy of ACME Klein Bottle).

My sister in law's shirt

Jerusalem October 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The *2222 Group

A fence on Arch Street, Berkeley, March 2000. A garage door on Spruce Street, Berkeley, April 2000. A car's front grill, Berkeley, April 2000. My sister in law's shirt, Jerusalem October 2000.

The quotient orbifold for the group *2222 is disk with four order 2 corners on its (reflecting) boundary - that is, it is a rectangle triangle made of a transparent material.

Floor tiles seen by Dylan at Pizzeria Uno

Harvard Square, October 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The *632 Group

A hex game board at the Lawrence Hall of Science, Berkeley March 2000.

A cactus seen on Walnut Street, Berkeley July 2000.

Water pipes at a construction site on Arch Street, Berkeley July 2000.

Assaf's bicycle's light reflector, November 2000.

Entryway to The Double Building, downtown Berkeley, March 2000.

A soak drainer at MSRI, March 2000.

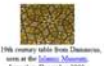
A hallway shopping cart, Berkeley, March 2000.

Built-in speaker on a Y2K Mercury Sable, June 2000.

A footstep in the sand, Rehovot, August 2000.

Floor tiles seen by Dylan at Pizzeria Uno, Harvard Square, October 2000.

A hot pad and a coffee pot, November 2000. (Respect shape but ignore color)



A 19th century table from Damascus, seen at the Islamic Museum, Jerusalem December 2000.

The *442 Group

A building on Walnut street, Berkeley March 2000.

Bathroom tiles at MSRI, March 2000.

The queen of the red hearts, July 2000.

A climbing net at the Jerusalem Zoo playground and bus, September 2000.

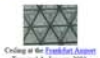
Eowyn Rathe's shirt as seen by Dylan, Cambridge October 2000.

The quotient orbifold for the group *442 is disk with two order 4 corners and an order 2 corner on its (reflecting) boundary - that is, it is a 45-45-90 triangle made of a transparent material.

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The *333 Group

Assaf blowing a balloon, seen through a kaleidoscope. At the Mojo Postaurant's, Berkeley, June 2000. Another variant

Pixels on a CRT monitor showing the latest pentarose, August 2000.



Ceiling at the Frankfurt Airport Terminal A, January 2001.

The quotient orbifold for the group *333 is disk with three order 3 corners on its (reflecting) boundary - that is, it is a 60-60-60 triangle made of a transparent material.

A bed cover and Annie

November 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 2222 Group

A sports field fence at UC Berkeley, June 2000.

The animator's cage at the San Francisco Zoo, July 2000.

Tire threads and a lemur, at the Jerusalem Zoo, September 2000.

A bed cover and Annie, November 2000.

Road tiles at Bethlehem PA, June 2000.

The beaker postal on a Toyota Corolla, July 2000.

The fence around the Berkeley Adventure Playground, August 2000.

A pattern on a Sarah Remkioff shirt, Berkeley August 2000.

Embossed pattern on a Hoefle-Kamberly brand toilet paper, October 2000.

A pothole cover in Sorgen, Germany, January 2001.

The 442 Group

A Nature Conservancy adaptor tee at a Tai Rack store, SFO June 2000.

Floor tiles at Lahabika Jerusalem Mall, September 2000.

Sharon and Yizhar's shower basses, December 2000.

Bathroom tiles at the Kathdin's, August 2001.

A paper towel seen at MSRI, June 2000.

Sidewalk tiles in Sorgen, Germany, January 2001.

External wall tiles on a building in Rehovot, February 2001.

A braided mosaic in Caesarea, January 2002.

A pattern seen at Alhambra. Spoon by Brian Sanderson

(Ignore color, respect brightness)

A woven basket on the grass in Berkeley's Live Oak Park

June 2000

A sidewalk near the Beth El synagogue

Berkeley March 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 4*2 Group

A bench near the Berkeley-Richmond JCC, March 2000.

Brunne Brunt's necklace, June 2000.

A non-slid surface on a Berkeley Fire Department fire engine, July 2000.

A glass wall at the Sorgen Hauptbahnhof, January 2001.

A sidewalk near the Beth El synagogue, Berkeley March 2000.

Floor tiles seen by Dylan at the Charles River Reservation, Waltham

October 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 2*22 Group

A brick wall

Oxford St between Cedar and Vine, Berkeley March 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 2*22 Group

A brick wall, Oxford St. between Cedar and Vine, Berkeley March 2000.

Metal grating near Evans Hall, home of the UC Berkeley math department, March 2000.

Floor tiles at the Ashby BART station, Berkeley June 2000.

The Prudential Building, Boston June 2000.

Gesa and Reza's picnic basket, July 2000.

A brick partition in Tel Aviv, August 2000.

Outside wall of the Academy of the Hebrew Language, Jerusalem October 2000.

Outside support wall of the Har HaMenuhot cemetery, Jerusalem October 2000.

Yizhar and Sharon's old radio, December 2000.

Davis July 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 22* Group

Bathroom tiles at the San Francisco Exploratorium, May 2000. (Notice the optical illusion!)

Pentagonal bathroom tiles made by Włodzimierz Kuperberg, seen at the Kuperberg-Zorys.

A design on Nicholas K. Zorys's shirt, July 2000.

Wall tiles in the Kyoto Karasumaoike Subway Station, September 2001.

The quotient orbifold for the group 22* is a disk with two order 2 corners - that is, a plastic bag

Oxford street

Berkeley March 2000

Dror Bar-Natan's Image Gallery:Symmetry:Tilings:The 22o Group

An entryway on Oxford street, Berkeley March 2000.

A cleaning cloth at the Kahanovich Weinhall's, June 2000.

A woven bench back, outside Yifa's Cafe, Berkeley August 2000.

A woven footstool, August 2000 (Foot courtesy of Brewster Kahle)

Tiles on the under side of the Knapp Memorial Arch, Downtown Washington DC, June 2000.

Parking lot tiles in Sorgen, Germany, January 2001.

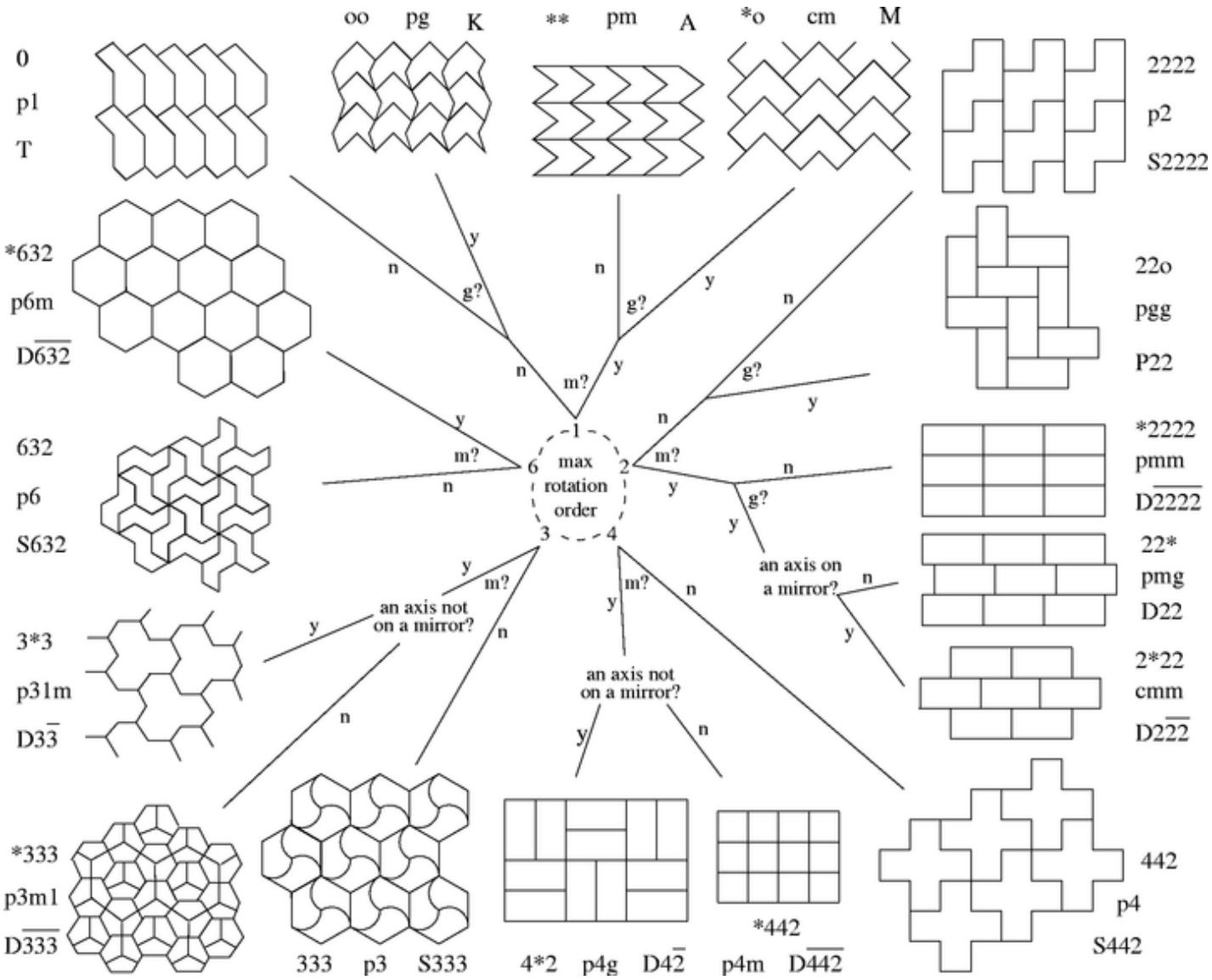
The 230 Worlds of Spacial Monkeys

(The 219 Worlds of Monkeys that Can't Tell their Left from their Right)

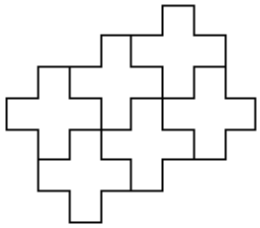
(See Mineralogy Database: Crystallography and arXiv math.MG/9911185)

Brian Sanderson's Pattern Recognition Algorithm

Is the maximum rotation order 1,2,3,4 or 6? Is there a mirror (m)? Is there an indecomposable glide reflection (g)?
Is there a rotation axis on a mirror? Is there a rotation axis not on a mirror?



Note: Every pattern is identified according to three systems of notation, as in the example below:



442: The Conway-Thurston notation, as used in my tilings page.

p4: The International Union of Crystallography notation.

S442: The Montesinos notation, as in his book Classical Tesselations and Three Manifolds

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