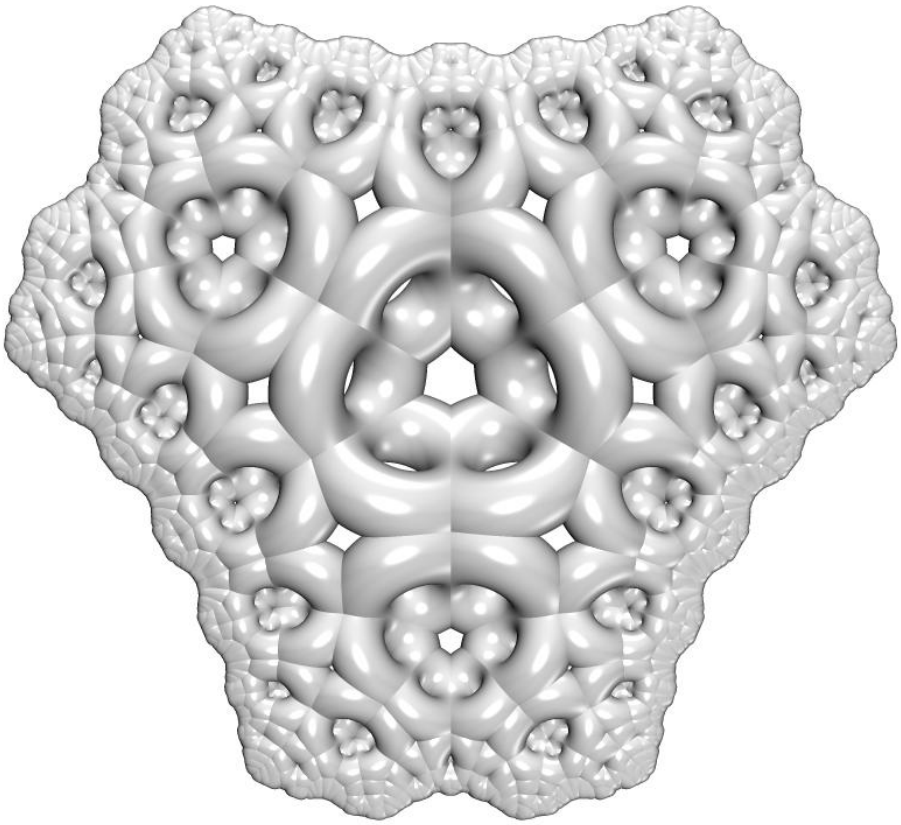
Making Fractal Pendant in ShapeJS



Vladimir Bulatov,

Shapeways

G4G12

March 31,2016

Good Old Times

BASIC code for Mandelbrot set fractal

```
2000 REM Initialize the color palette
2030 LET L = 100
2040 FOR I = 0 TO 100
2050 FOR J = 0 TO 100
2060 LET U = I / 50 - 1.5
2070 LET V = J / 50 - 1
2080 LET X = U
2090 LET Y = V
2100 LET N = 0
2120 LET R = X * X
2130 LET Q = Y * Y
2140 IF R + Q > 4 OR N >= L THEN GOTO 2190
2150 LET Y = 2 * X * Y + V
2160 LET X = R - Q + U
2170 LET N = N + 1
2180 GOTO 2120
2200 IF N < 10 THEN LET C = "black" ELSE LET C = P[ROUND(8 * (N-10) / (L-10))]
2210 PLOT I, J, C
2220 NEXT J
2230 NEXT I
2240 END
```

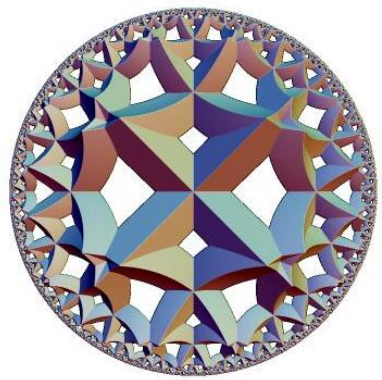
Modern Times

ShapeJS web based IDE

Scene | Model | Render | Help

gpu-public-us-west-1b | Material

```
    var x1 = Math.sqrt(r1*r1 + r*r);
    var y2 = Math.sqrt(r2*r2 + r*r);

    var splanes = new Array();
    var count = 0;
    splanes[count++] = new ReflectionSymmetry.getPlane(new Vector3d(0,-1,0), 0.0);
    splanes[count++] = new ReflectionSymmetry.getPlane(new Vector3d(-1,0,0), 0.0);
    splanes[count++] = new ReflectionSymmetry.getSphere(new Vector3d(x1,0,0), -r1);
    splanes[count++] = new ReflectionSymmetry.getSphere(new Vector3d(0,y2,0), -r2);

    return splanes;

}

function makePart(size, thickeness){

    var union = new Union();

    var boxX = new Box(0,0,0,thickeness, thickeness, size);
    union.add(boxX);
    return union;
}


function main(args){

    var a = 25*MM;

    var voxelSize = 0.1*MM;

    var cz = 20.0*MM;
    var cx = 5.0*MM;
    var cy = 5.0*MM;

    var part = makePart(30*MM, 5*MM);

    part.setTransform(new Rotation(new Vector3d(-1,1,0), 3*Math.PI/8));
```



GENERATE | SAVE MODEL | RESET PARAMS | CHECK MODEL

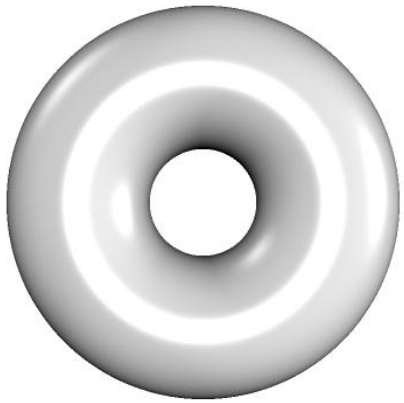
Model Title | UPLOAD

Main | Printability

Material None

```
Eval time: 6 Op count: 7 Op size: 80 Data size: 1
```

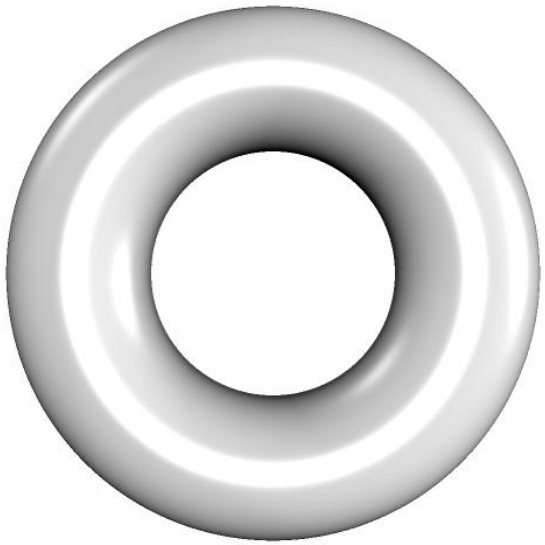
Simple shape



a torus

```
function main(args) {
  w = 12*MM;
  Rout = 5*MM;
  Rin = 2*MM;
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout);
  scene = new Scene(shape,bounds);
  return scene;
}
```

Simple shape



larger torus

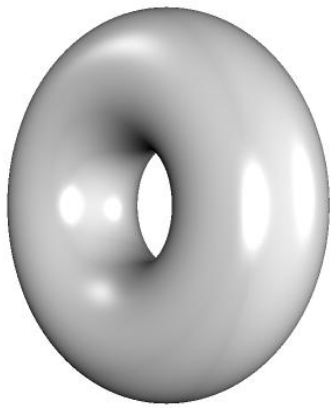
```
function main(args) {
  w = 12*MM;
  Rout = 8*MM;
  Rin = 2*MM;
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout);
  scene = new Scene(shape,bounds);
  return scene;
}
```

Simple shape

fatter torus

```
function main(args) {
  w = 12*MM;
  Rout = 5*MM;
  Rin = 5*MM;
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout);
  scene = new Scene(shape,bounds);
  return scene;
}
```

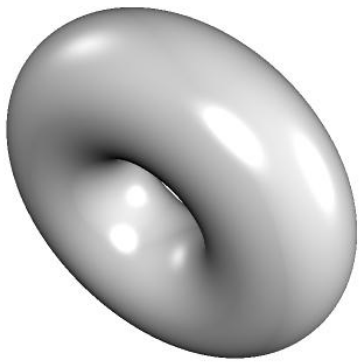
Simple shape



tilted torus

```
function main(args) {
  w = 12*MM;
  Rout = 8*MM;
  Rin = 2*MM;
  axis = new Vector3d(-1,0,1);
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout, axis);
  scene = new Scene(shape,bounds);
  return scene;
}
```

Simple shape

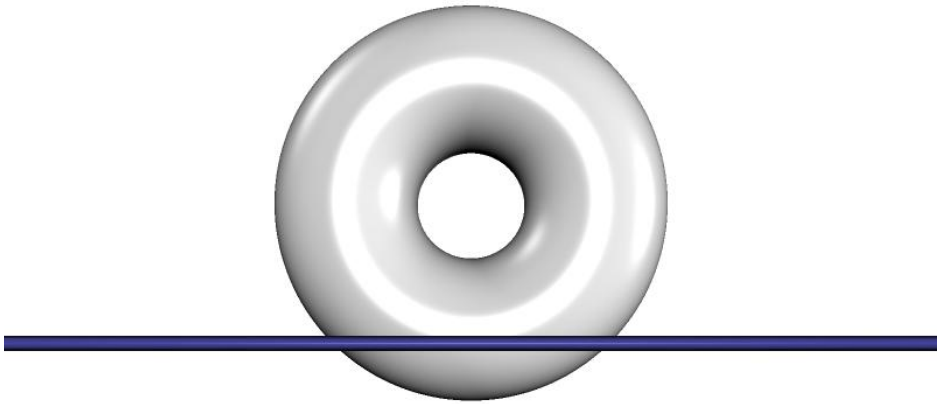


twisted torus

```
function main(args) {
  w = 12*MM;
  Rout = 8*MM;
  Rin = 2*MM;
  axis = new Vector3d(-1,-1,1);
  bounds = new Bounds(-w,w,-w,w,-w,w);
  shape = new Torus(Rin, Rout, axis);
  scene = new Scene(shape,bounds);
  return scene;
}
```

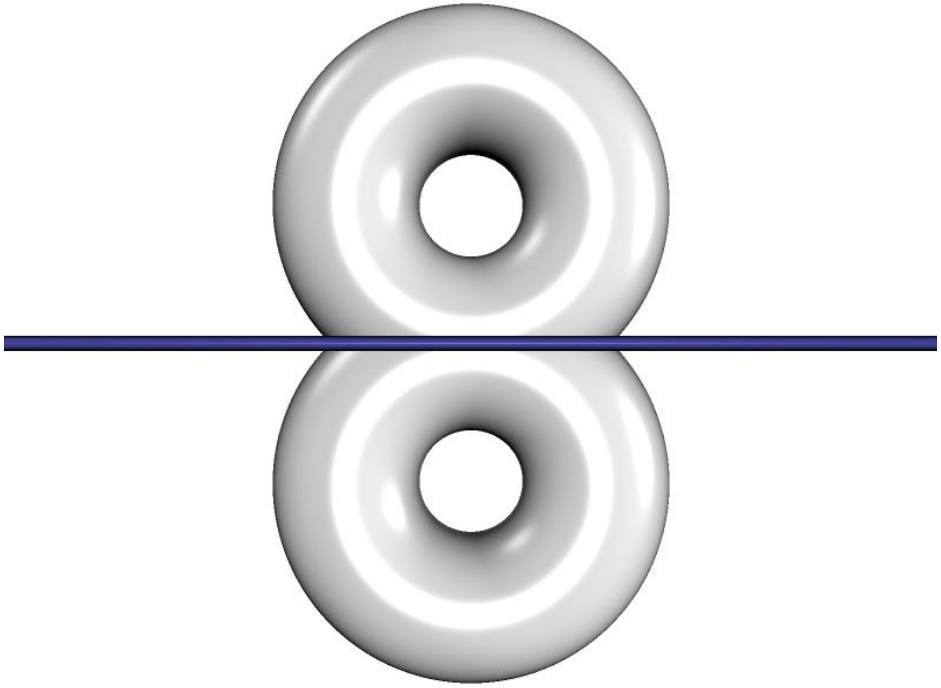
Not much fun

Torus + Mirror



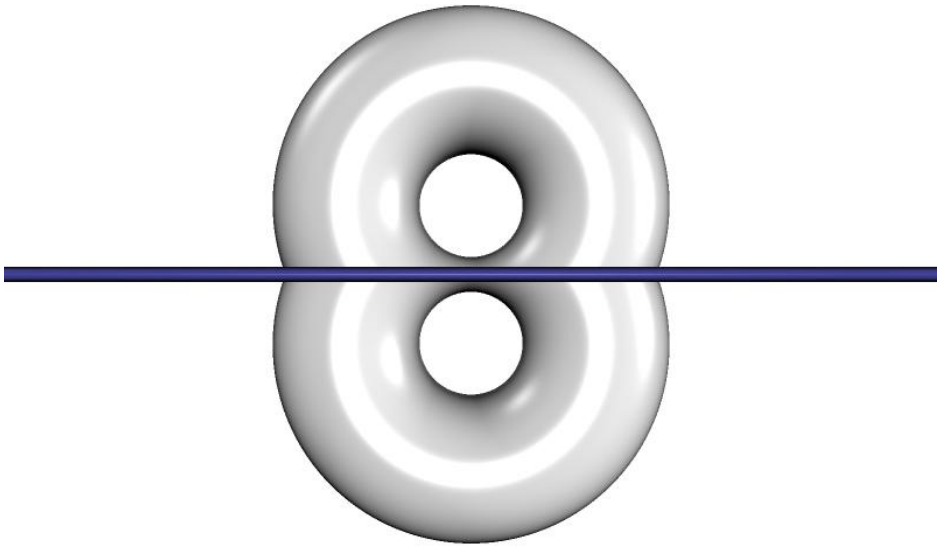
Torus and mirror

Torus + Mirror



Torus and it's siamese twin

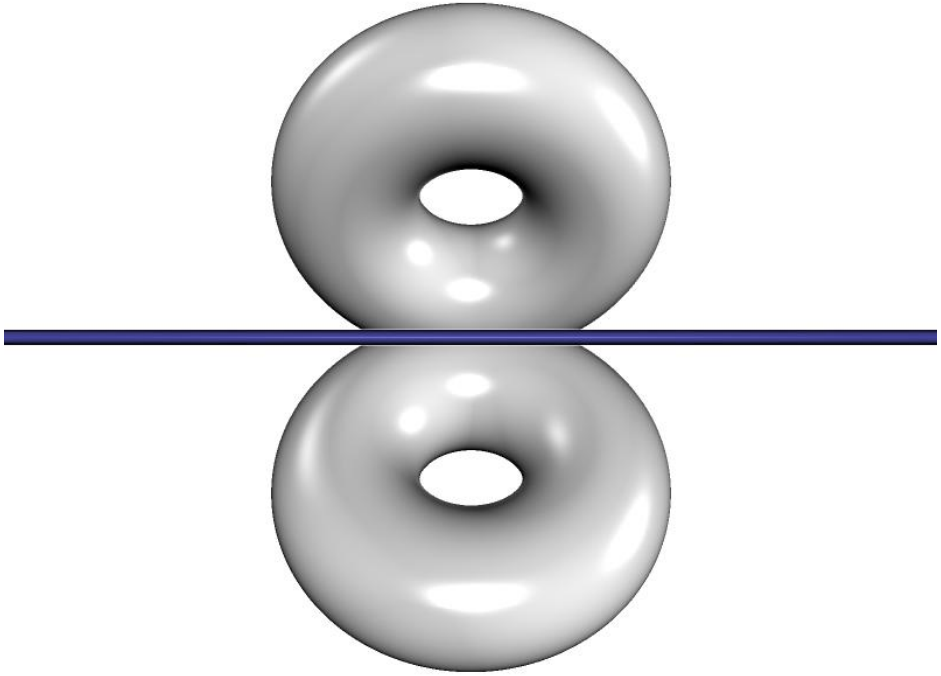
Torus + Mirror



Moving original torus.

It's twin moves in opposite direction

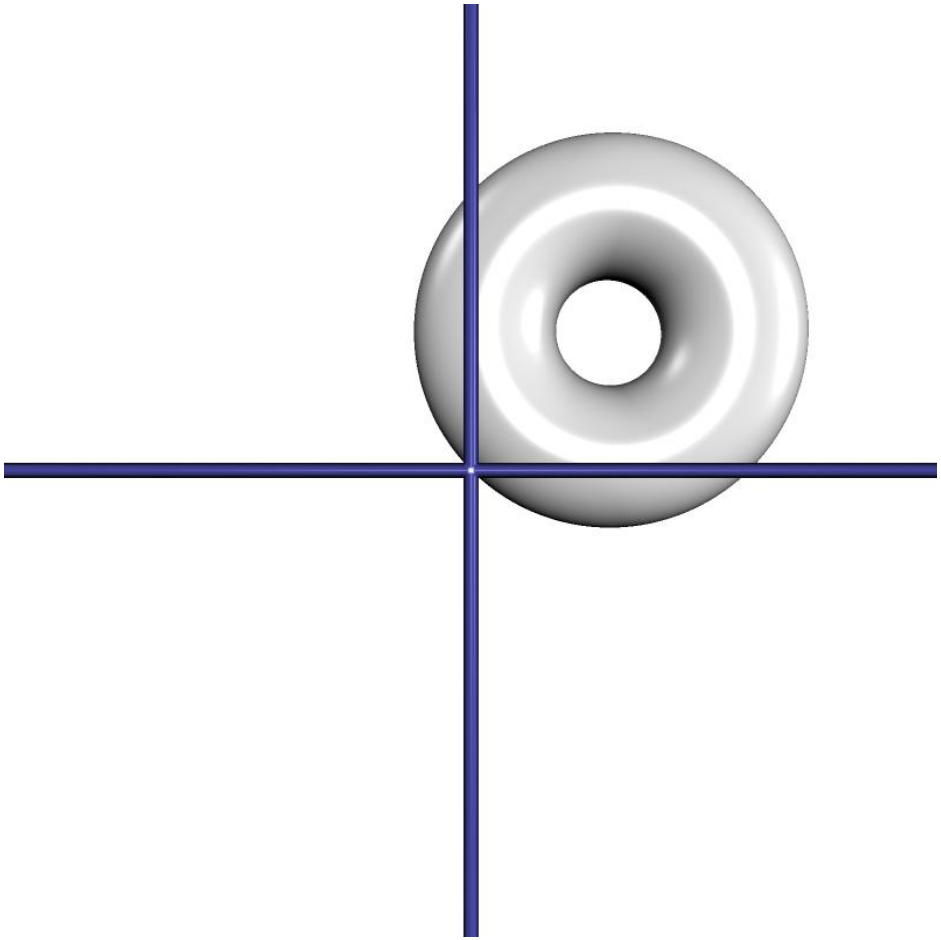
Torus + Mirror



Tilting original torus.

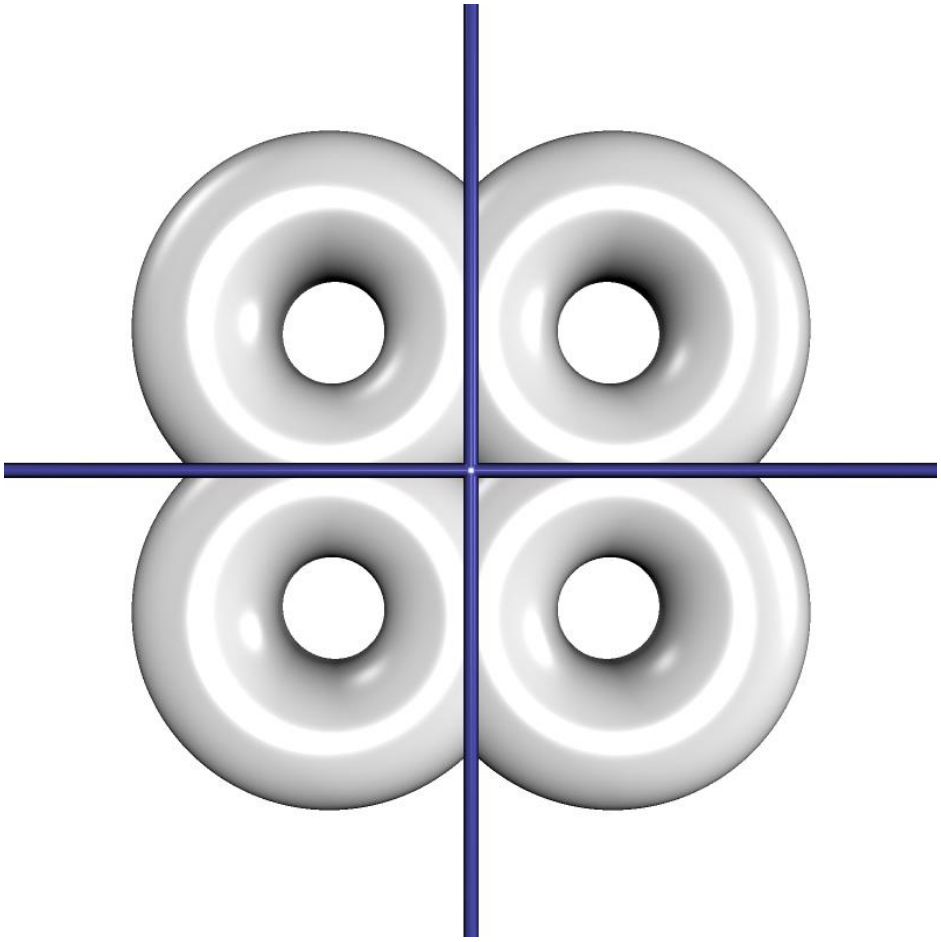
It's twin tilts in opposite direction

Torus + 2 Mirrors



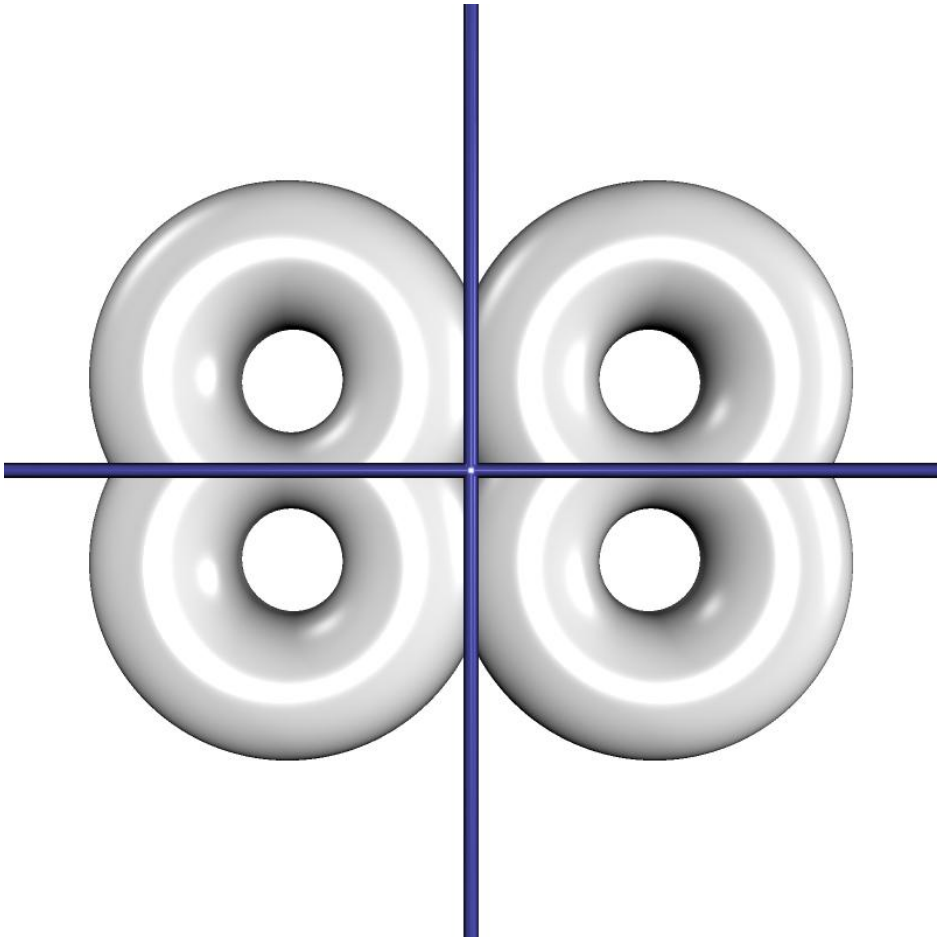
Going wild - 2 mirrors

Torus + 2 Mirrors



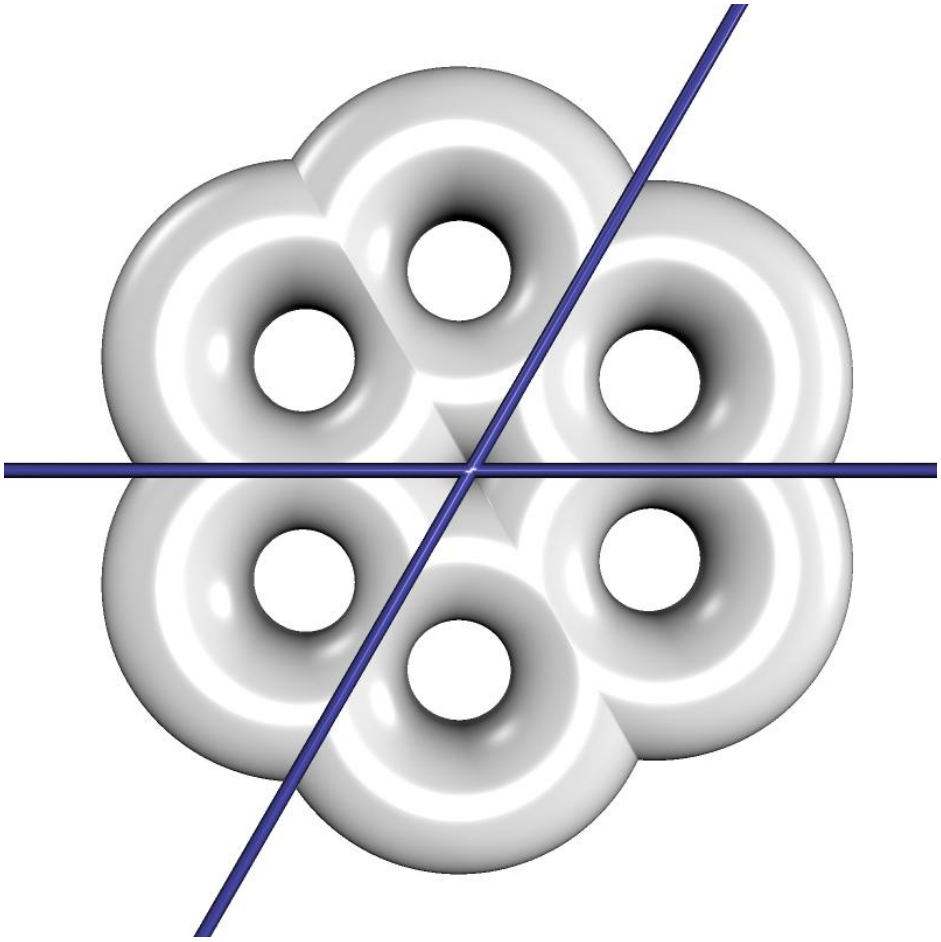
family of quadruplets

Torus + 2 Mirrors



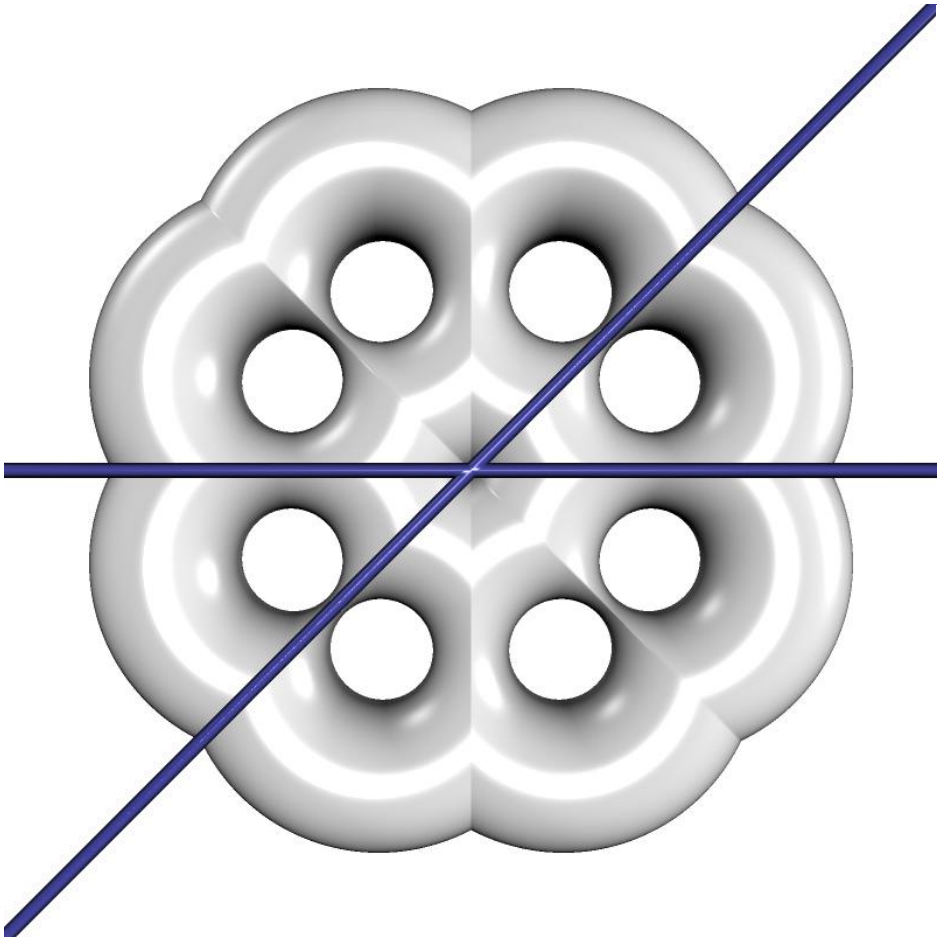
Motion of original torus moves all siblings

Torus + 2 Mirrors



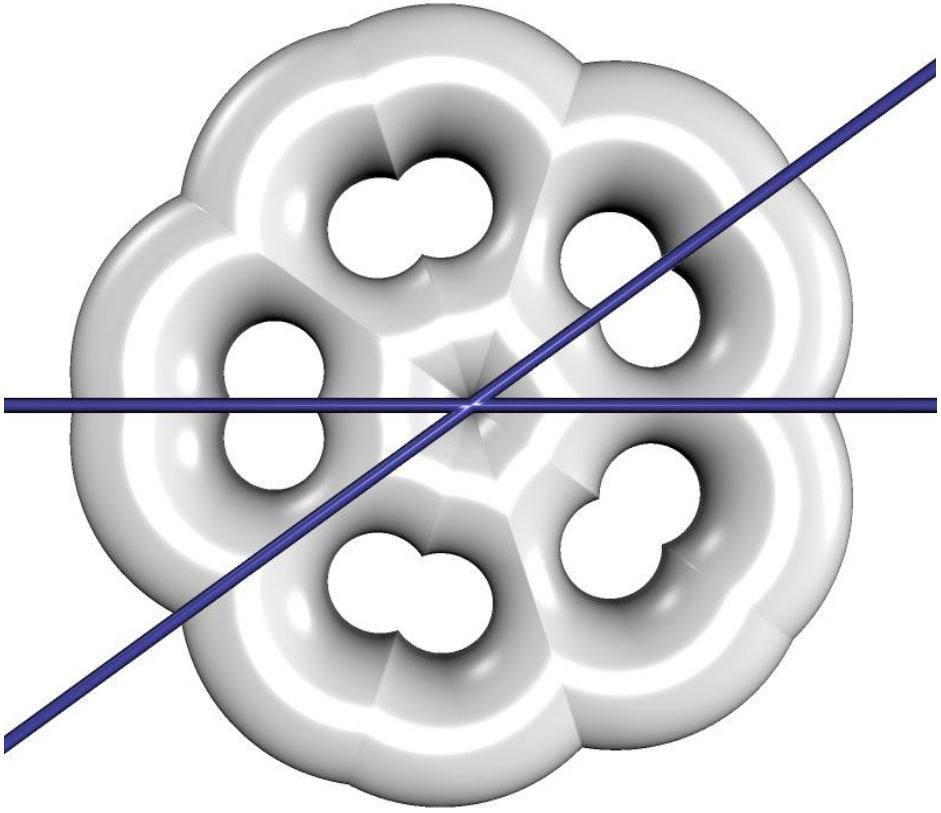
Changing mirror angle makes larger family

Torus + 2 Mirrors



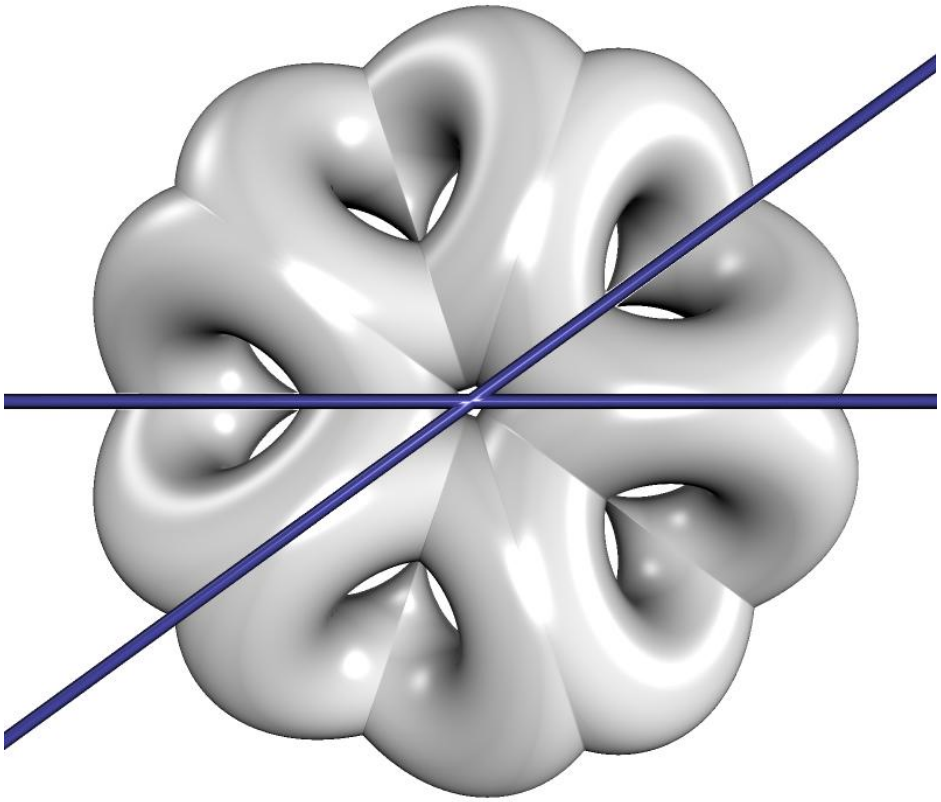
Changing mirror angle makes larger family

Torus + 2 Mirrors



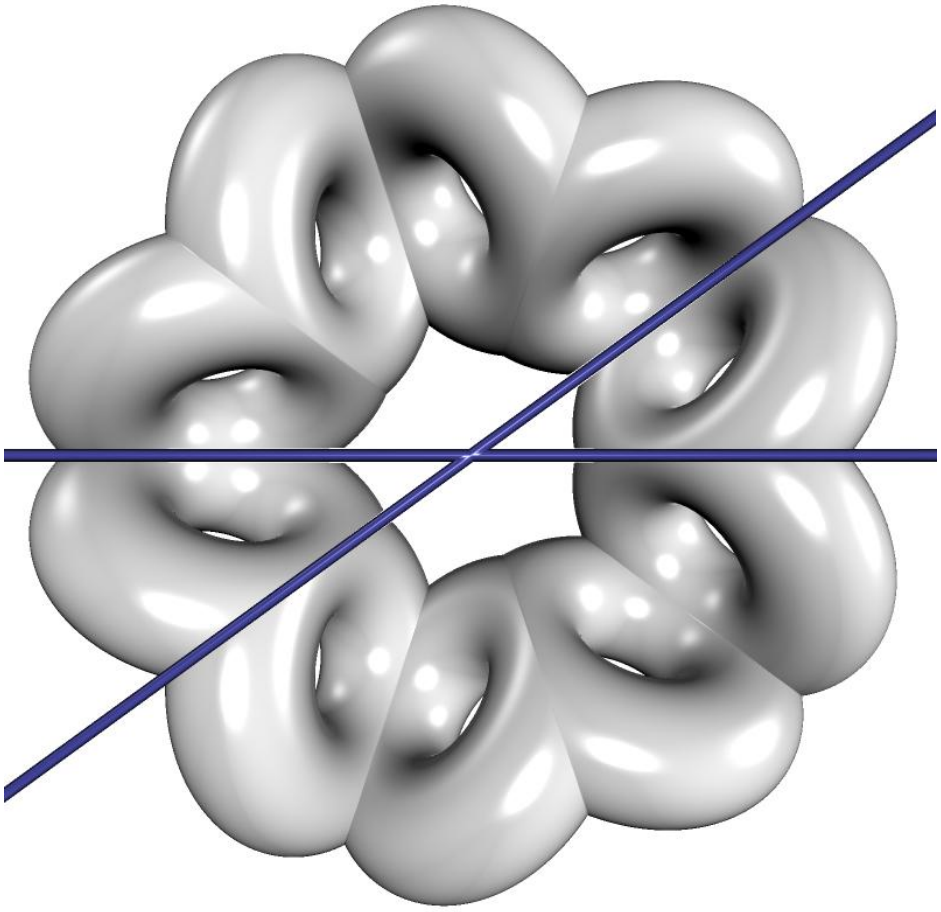
Changing mirror angle makes larger family

Torus + 2 Mirrors



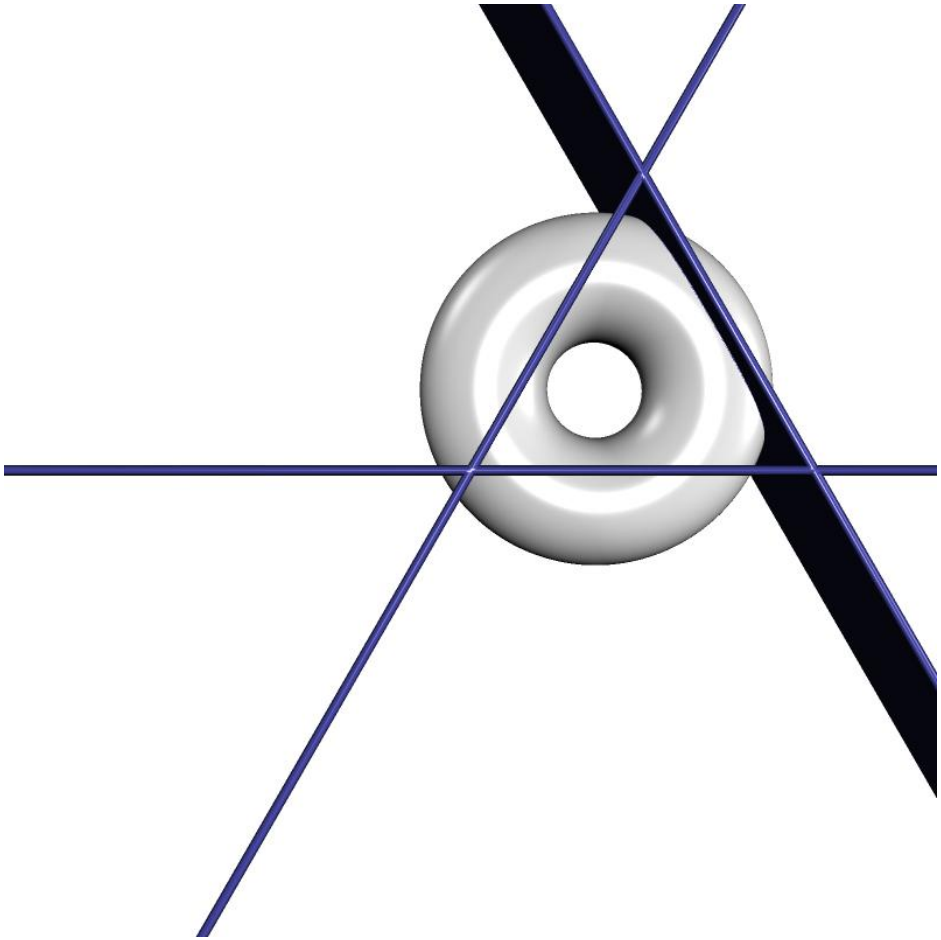
Moving one family member changes the look of the whole family

Torus + 2 Mirrors



Moving one family member changes the look of the whole family

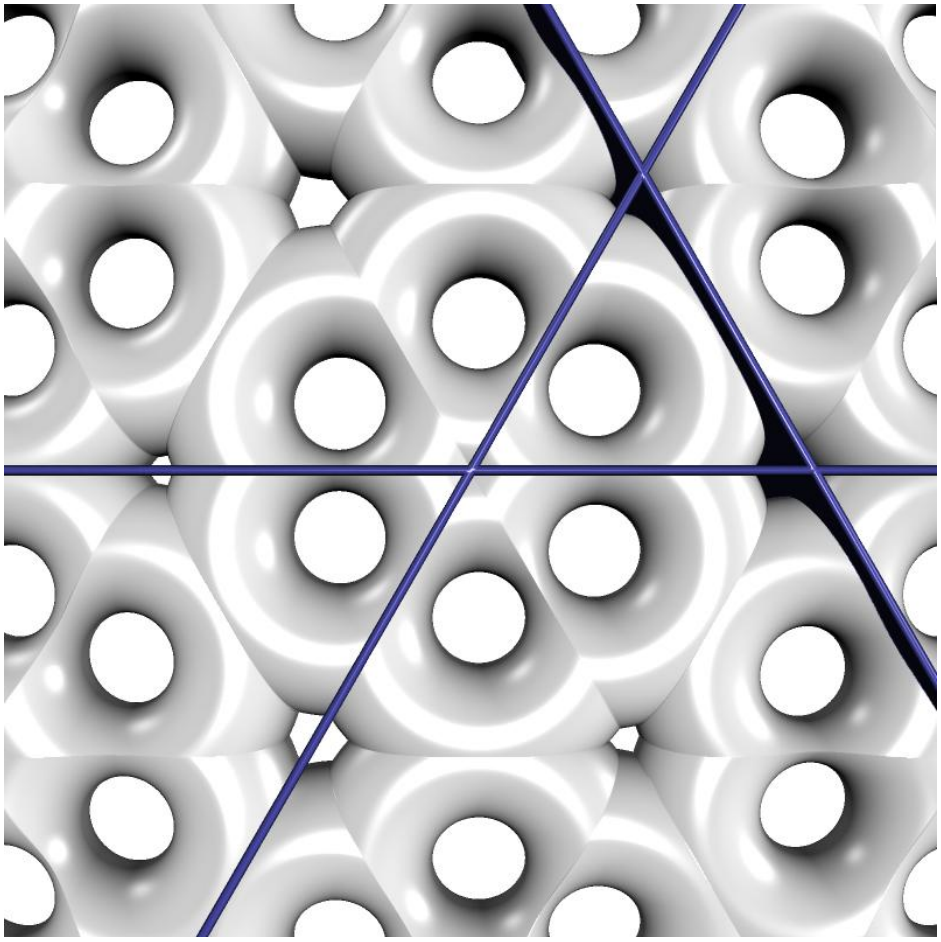
Torus + 3 Mirrors



Going insane!

Using 3 mirrors

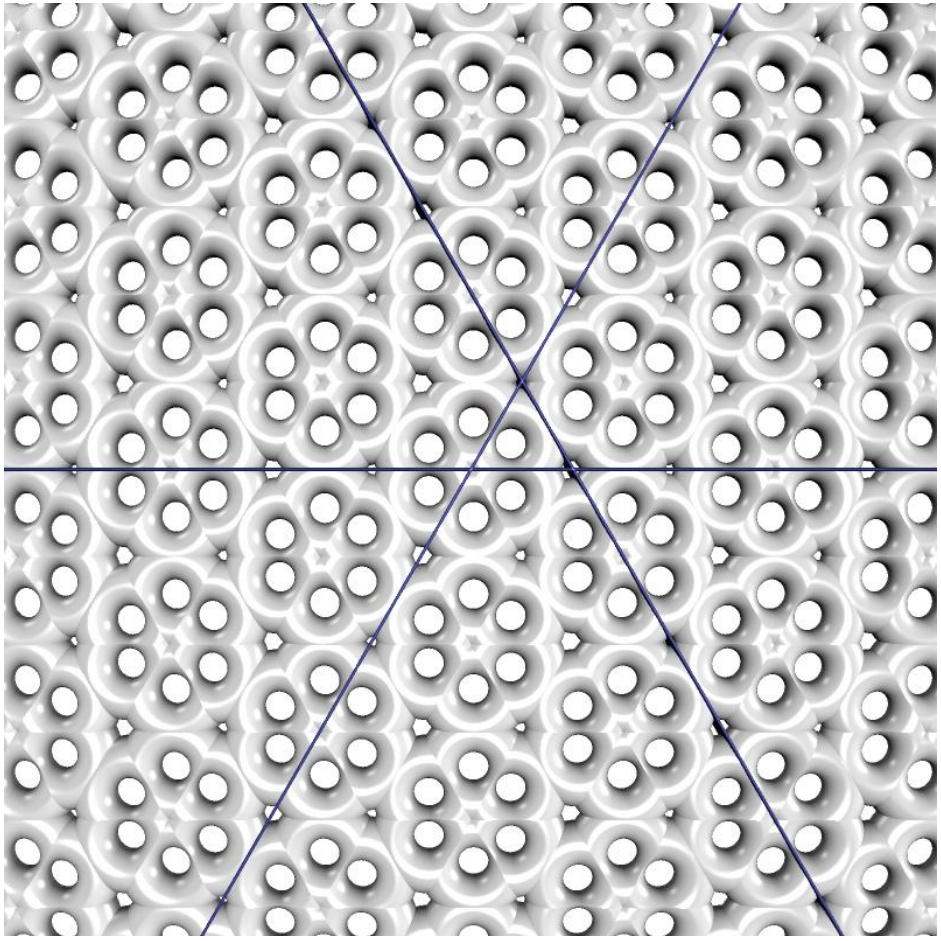
Torus + 3 Mirrors



Got infinite family.

But the family is rather orderly and boring

Torus + 3 Mirrors

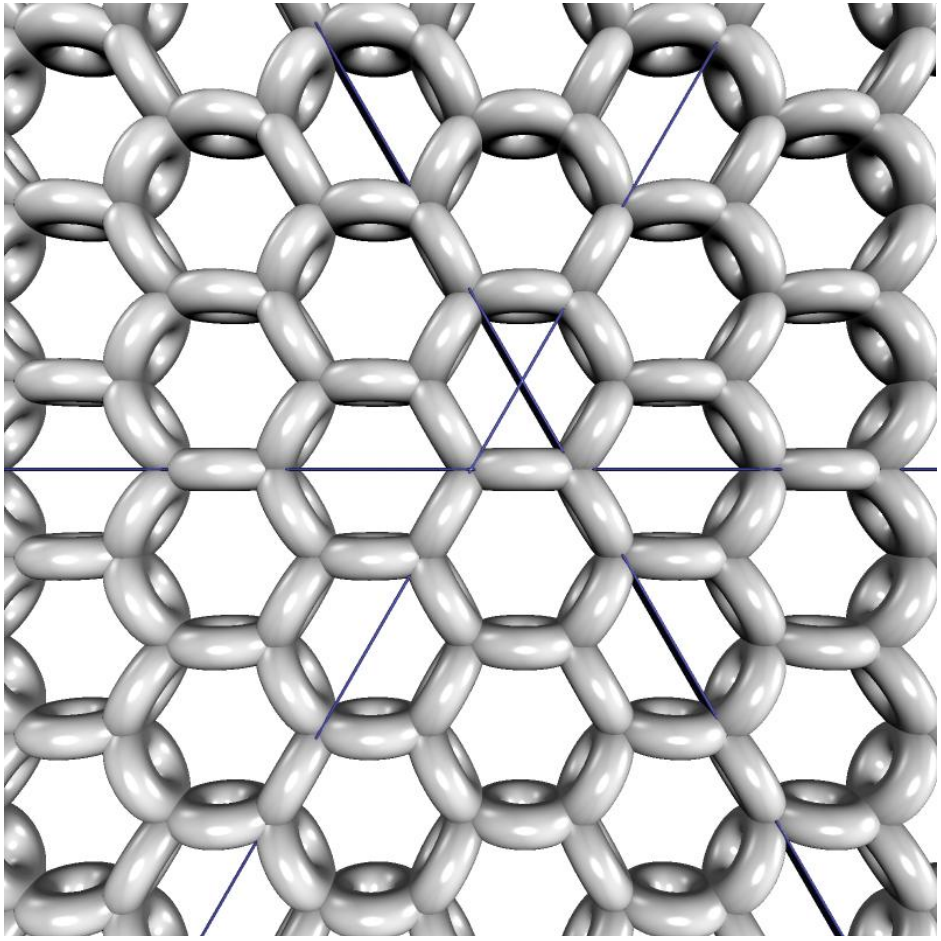


Got infinite family.

But the family is rather orderly and boring

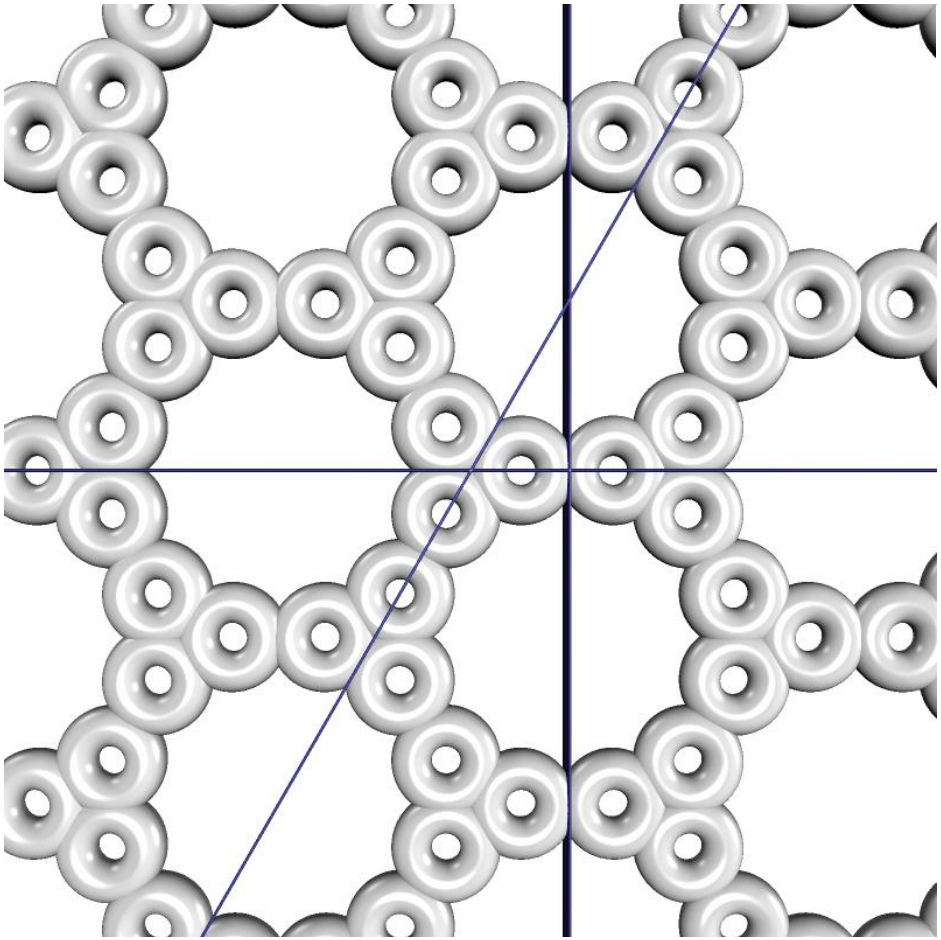
Very predictable

Torus + 3 Mirrors



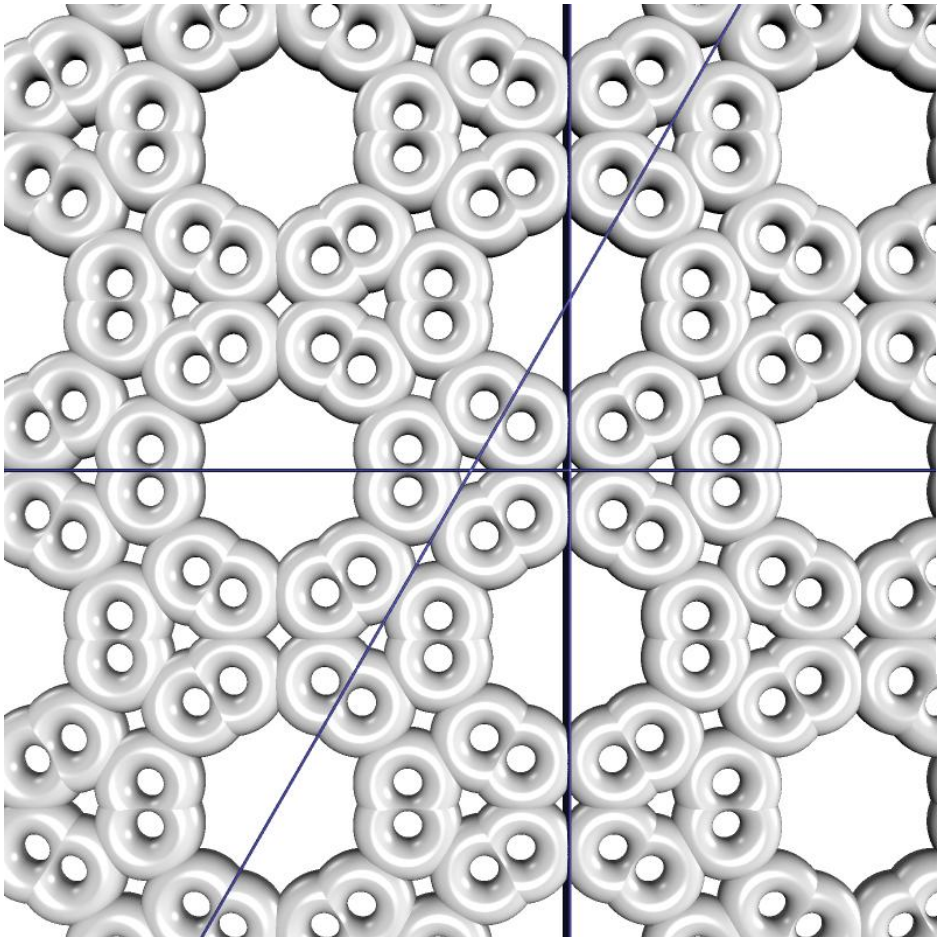
Twisting one sibling makes all family do the same

Torus + 3 Mirrors



Another family made with 3 different mirrors

Torus + 3 Mirrors

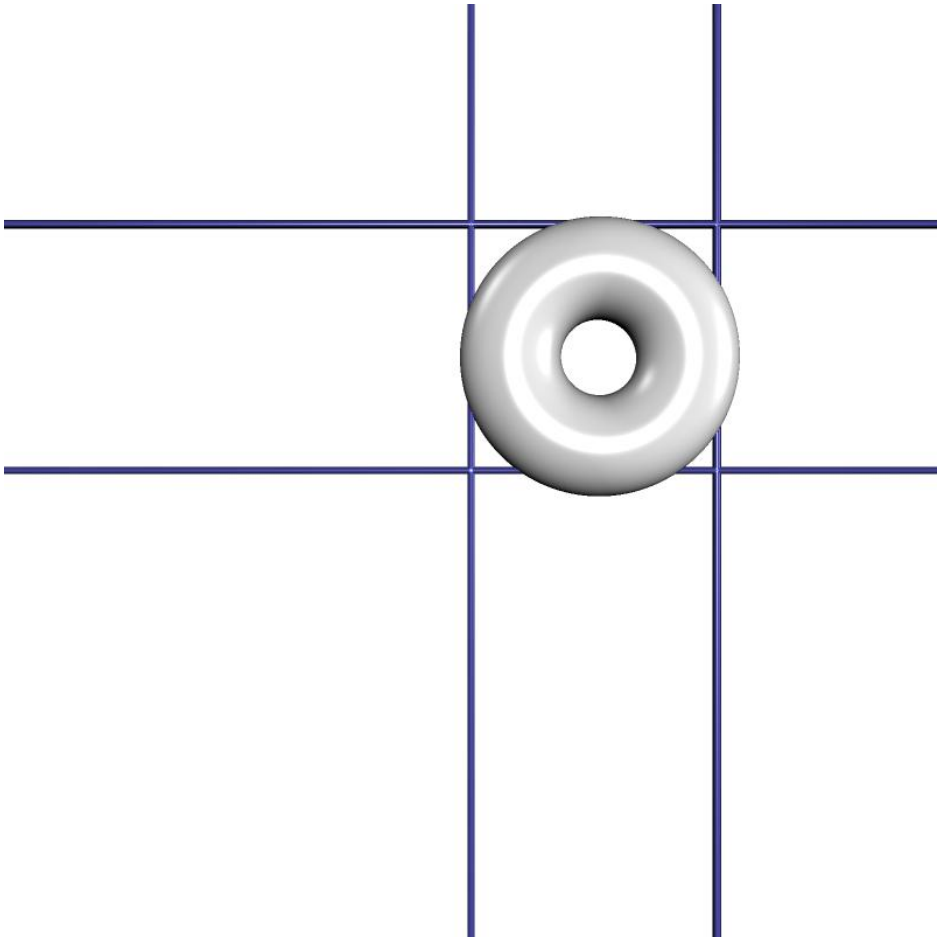


Another family made with 3 different mirrors

There are only 3 such families

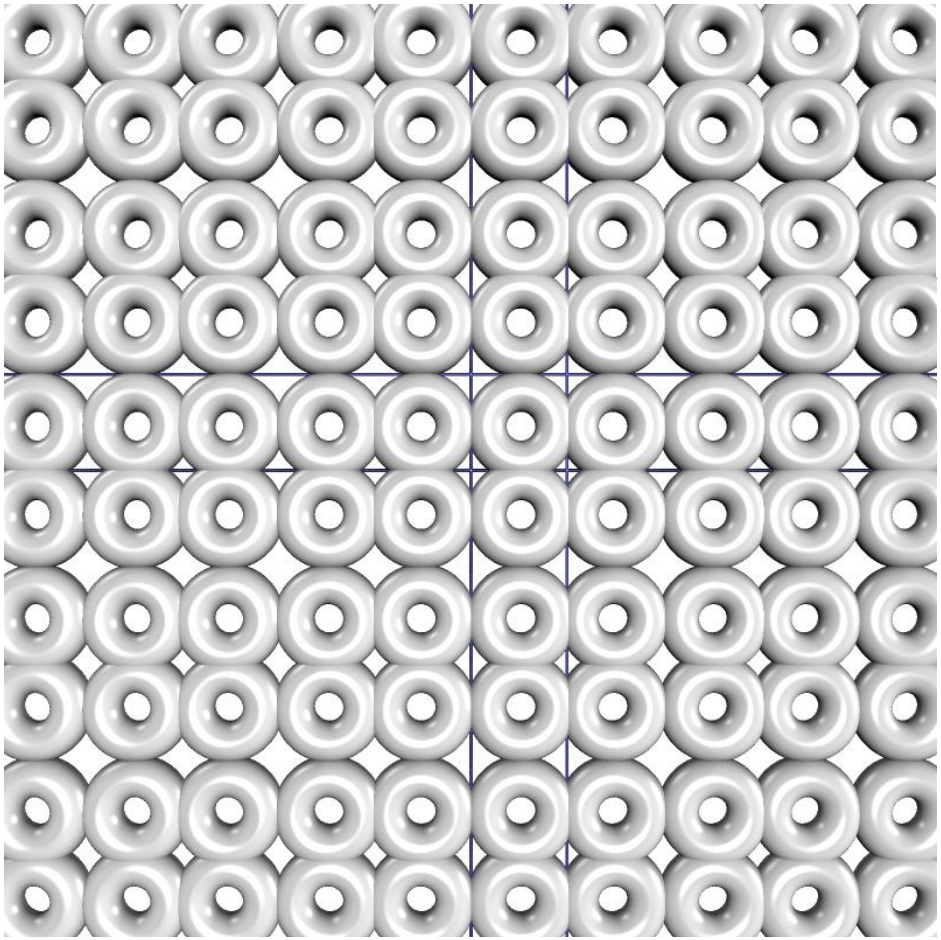
- $\left(\frac{\pi}{3}, \frac{\pi}{3}, \frac{\pi}{3}\right)$
- $\left(\frac{\pi}{2}, \frac{\pi}{3}, \frac{\pi}{6}\right)$
- $\left(\frac{\pi}{2}, \frac{\pi}{4}, \frac{\pi}{4}\right)$

Torus + 4 Mirrors



Can we do better with 4 mirrors?

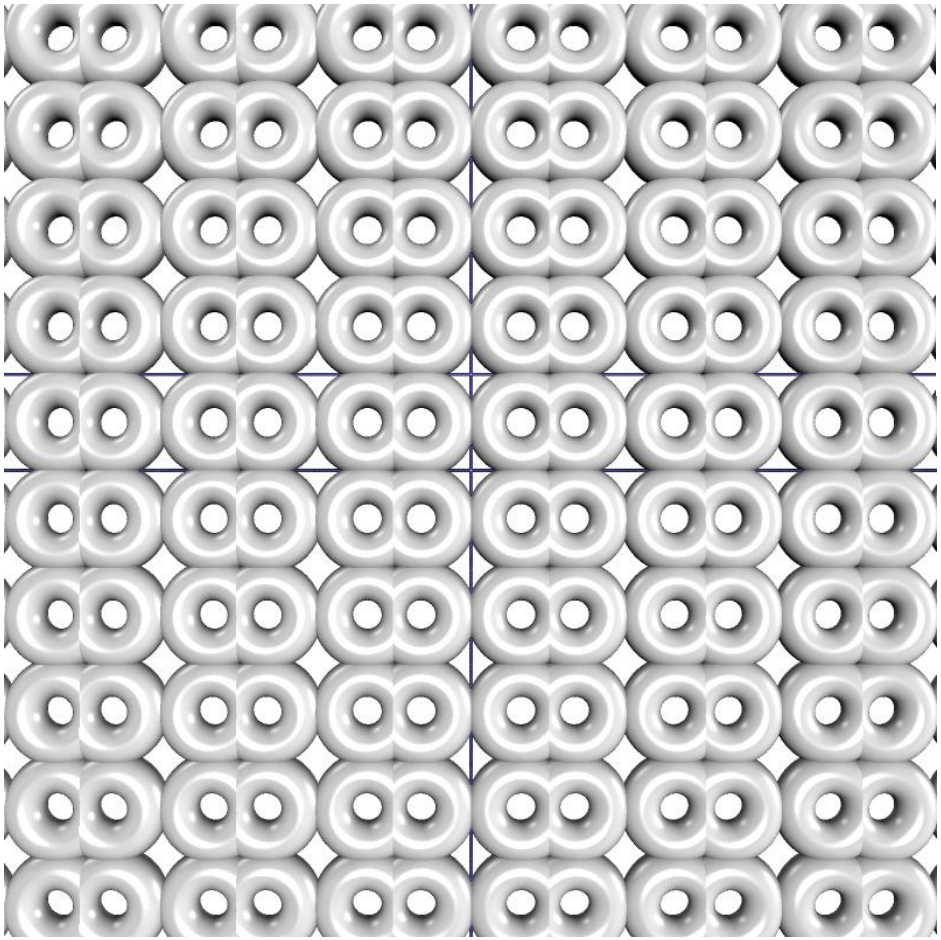
Torus + 4 Mirrors



4 mirrors

boring

Torus + 4 Mirrors

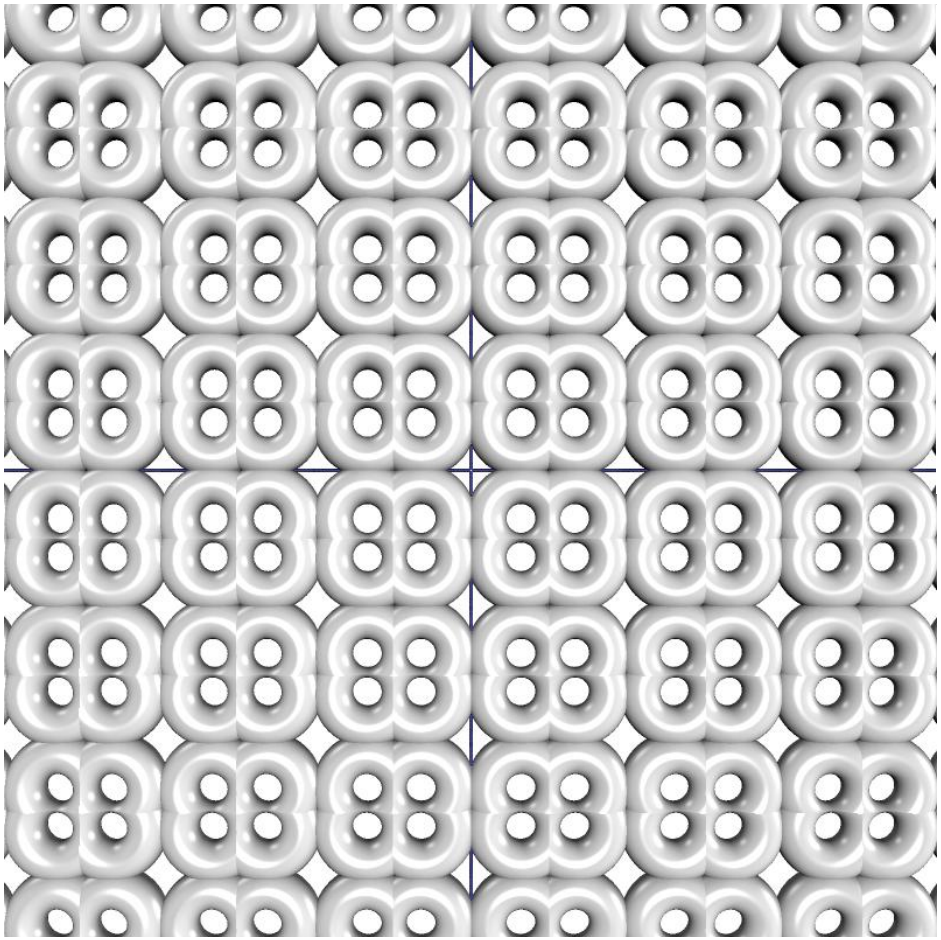


4 mirrors

boring

BORING

Torus + 4 Mirrors



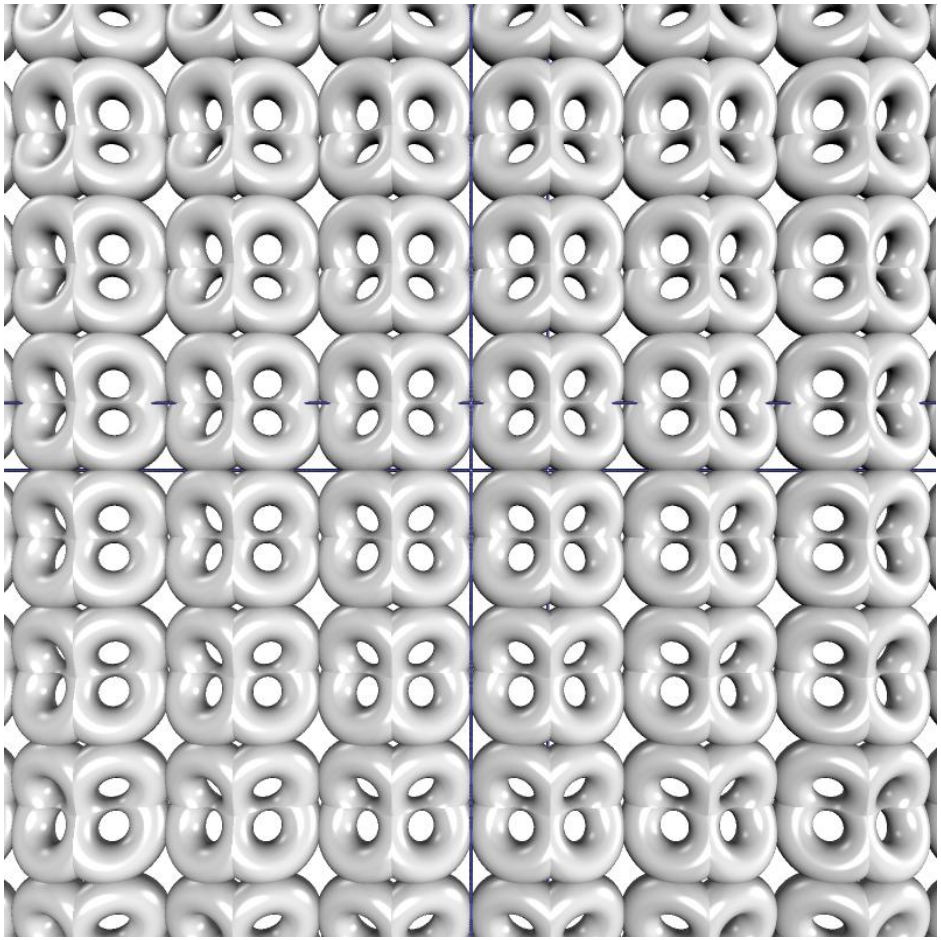
4 mirrors

boring

BORING

BORING

Torus + 4 Mirrors



4 mirrors

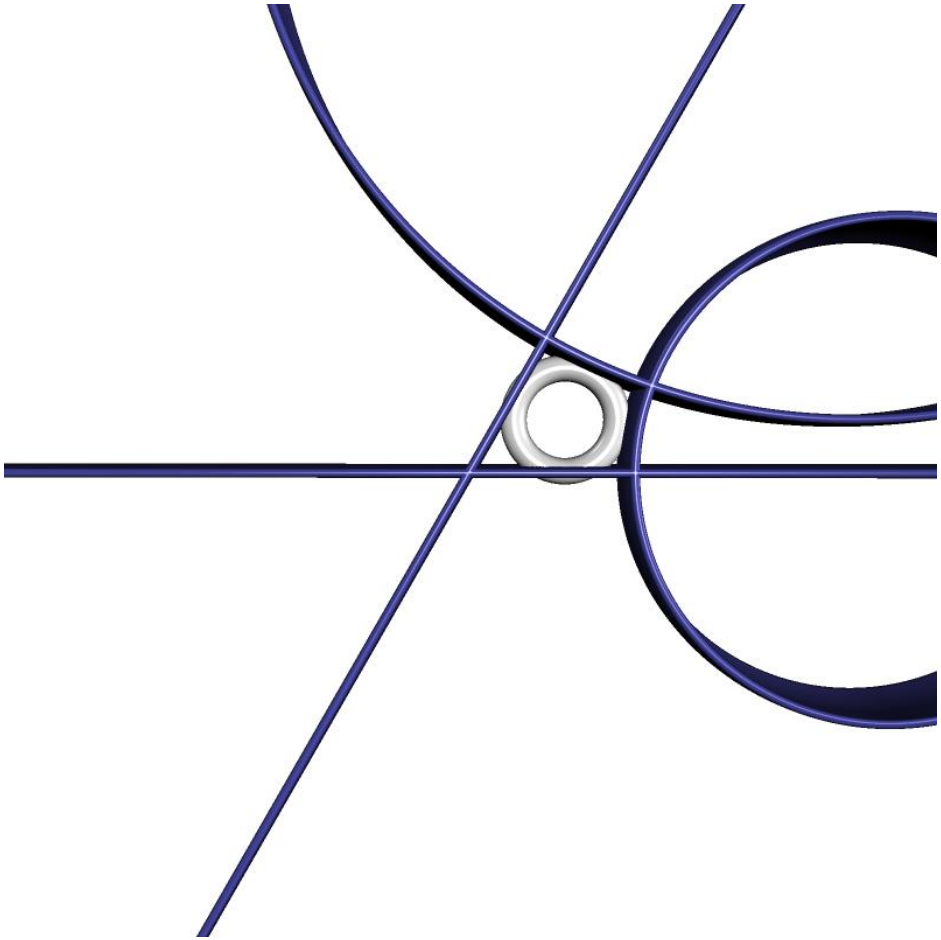
boring

BORING

BORING

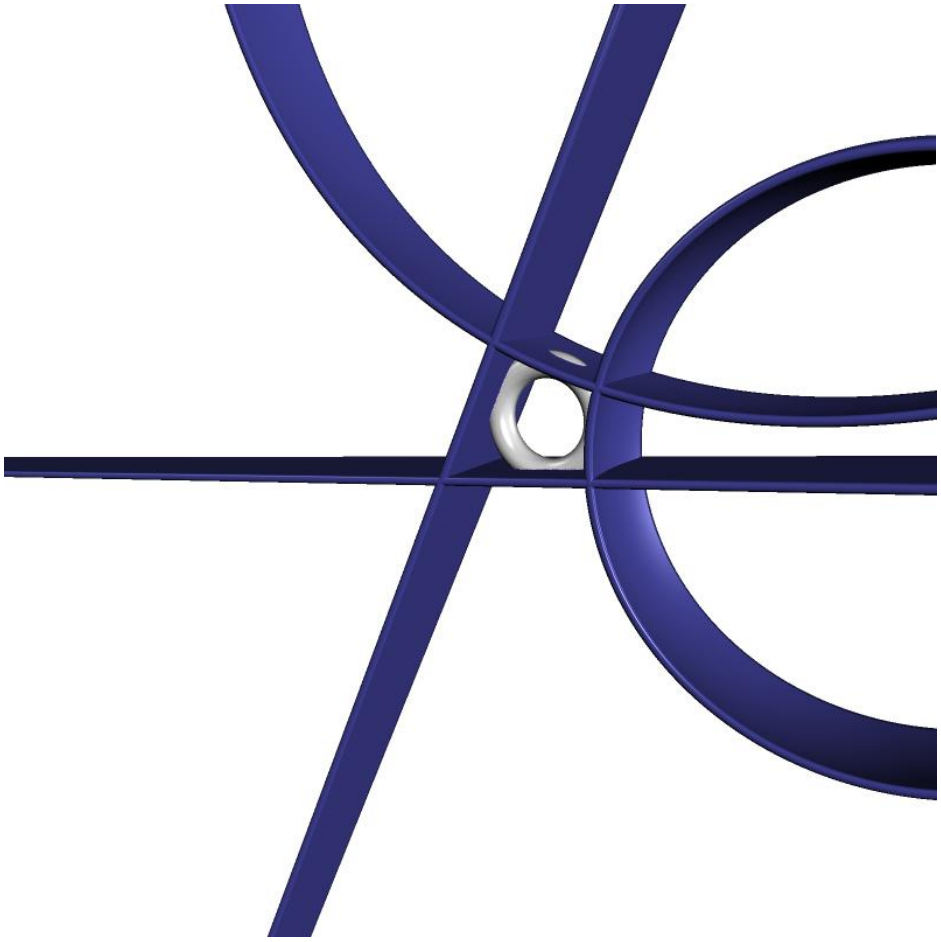
BORING

Spherical Mirrors



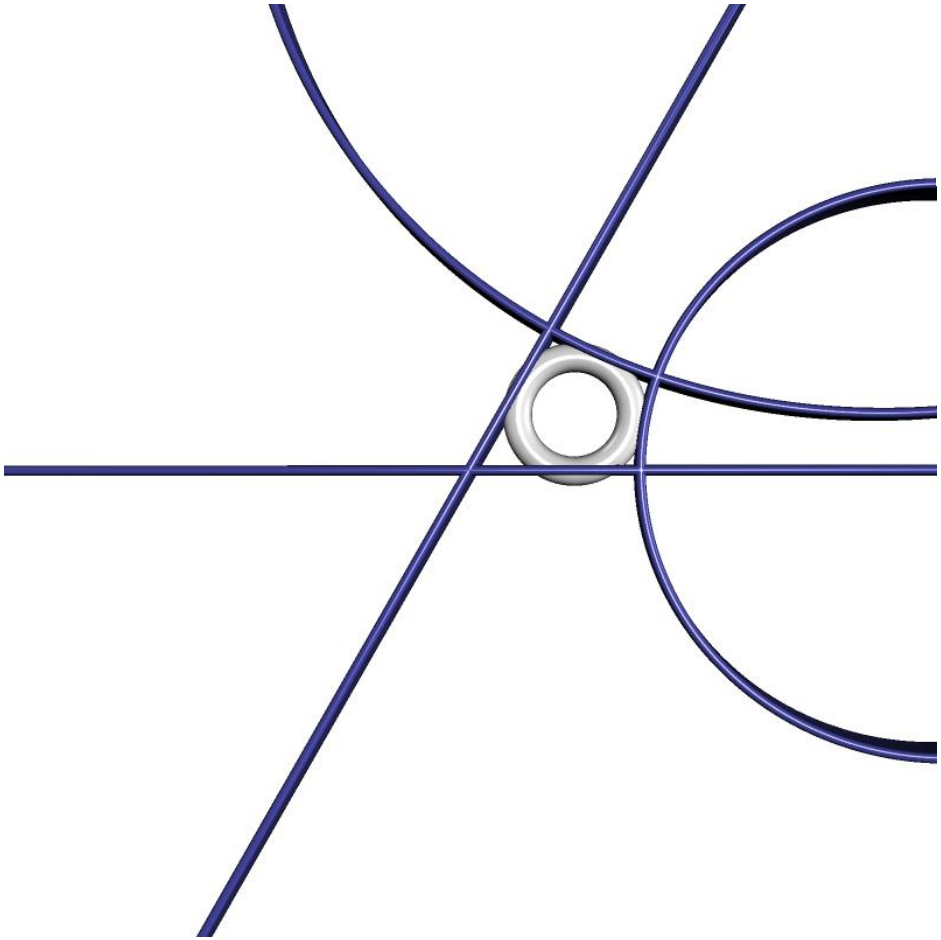
Magical spherical mirrors!

Spherical Mirrors



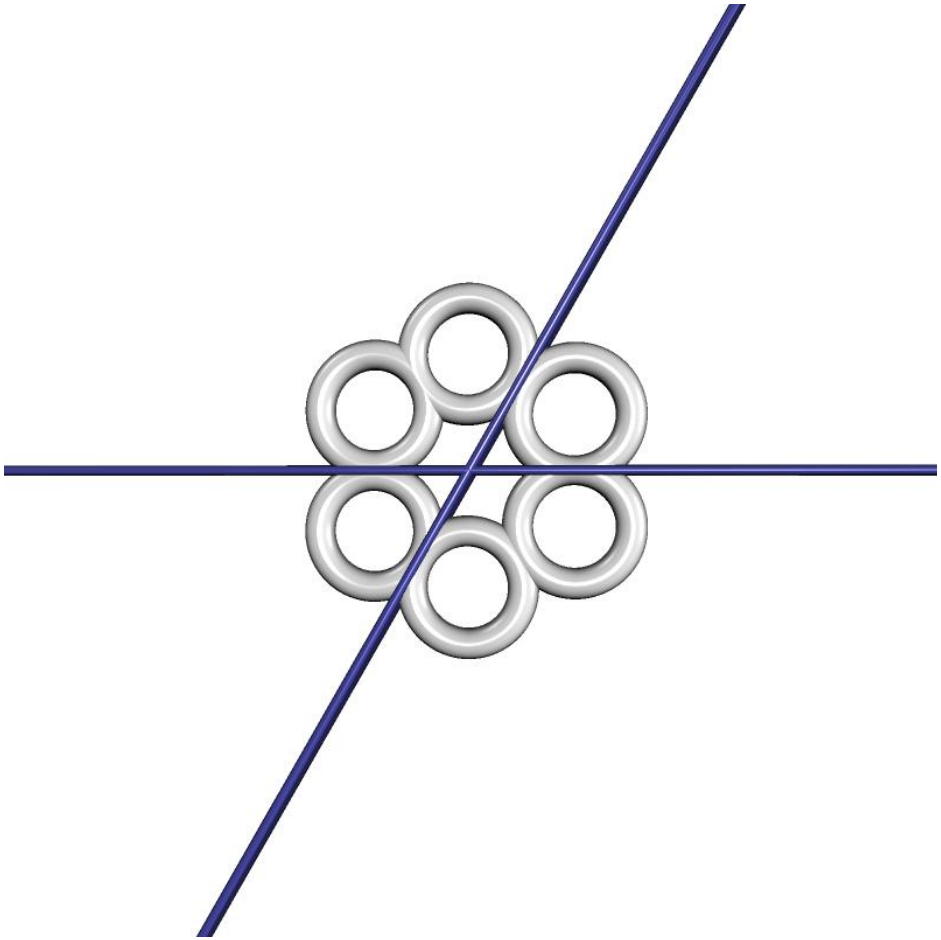
Magical spherical mirrors!

Spherical Mirrors



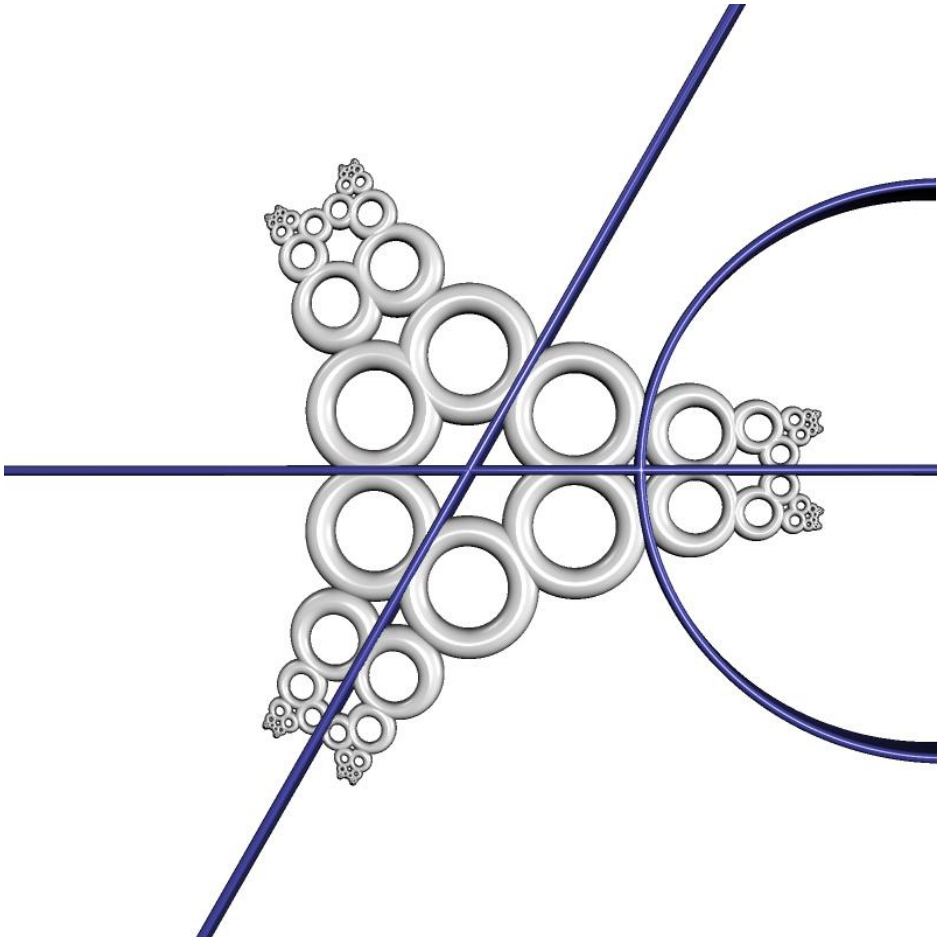
Magical spherical mirrors!

Spherical Mirrors



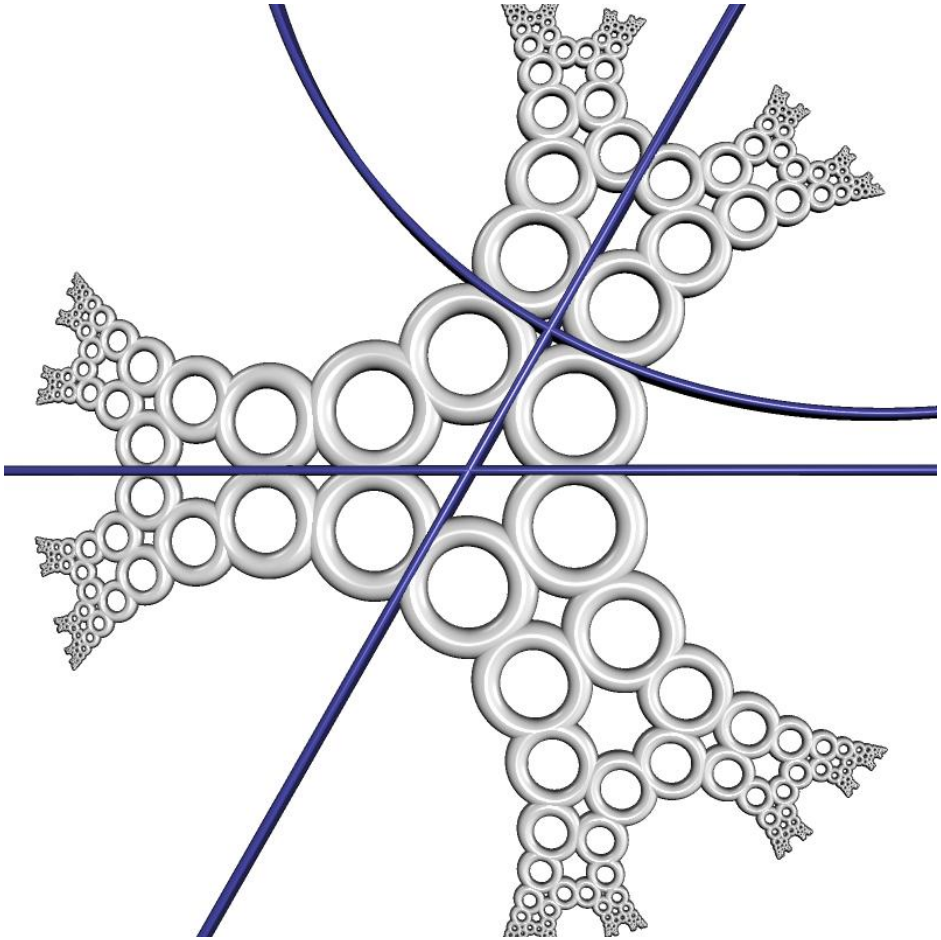
Reflection in 2 flat mirrors produce familiar result

Spherical Mirrors



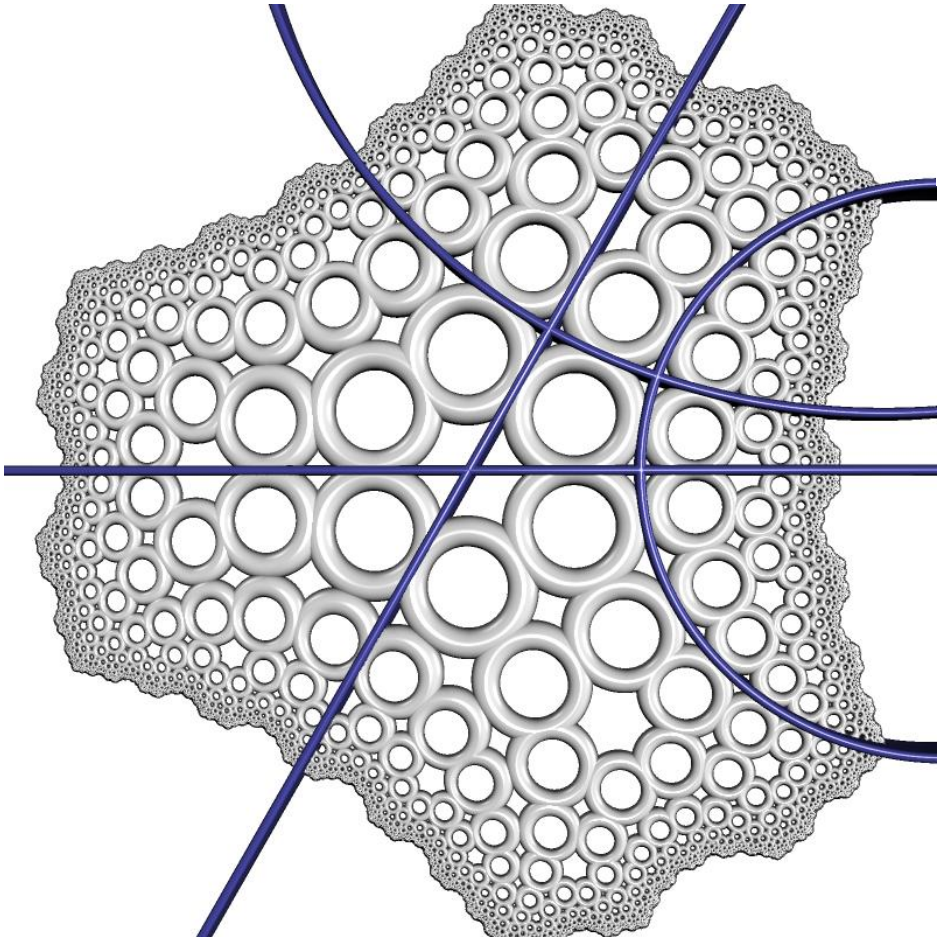
Addition of 3rd spherical mirror gives something new

Spherical Mirrors



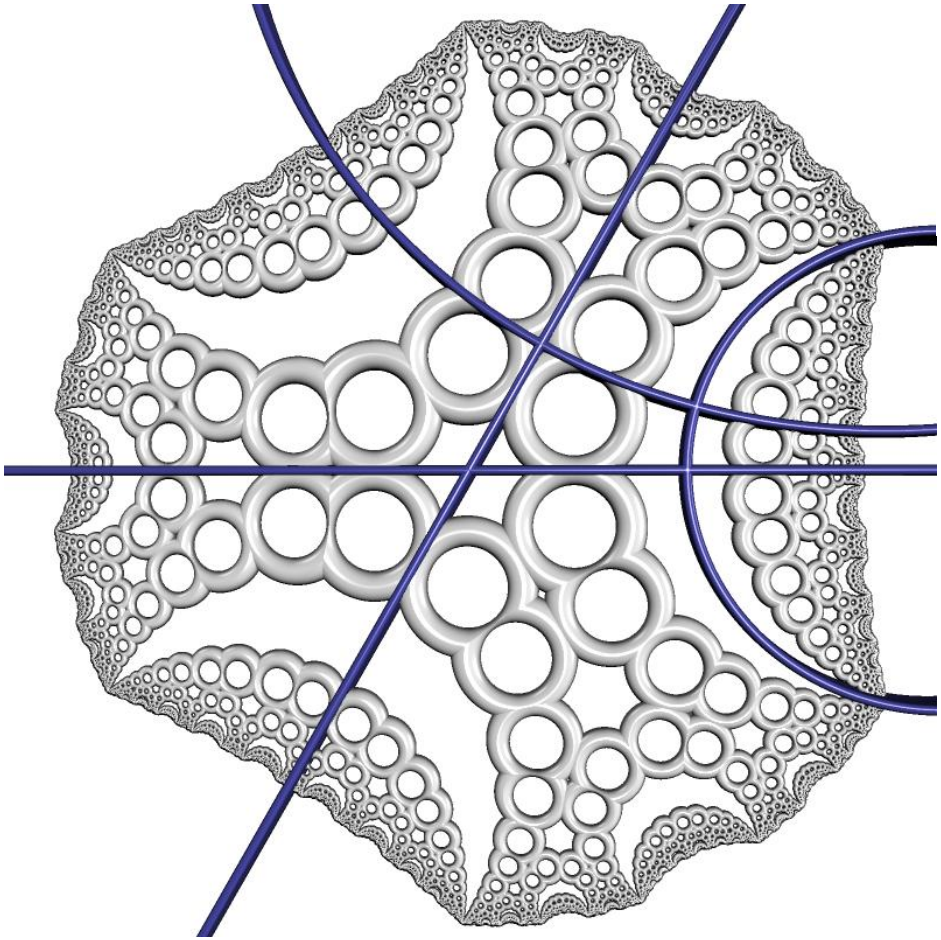
Addition of 3rd spherical mirror gives something new

Spherical Mirrors



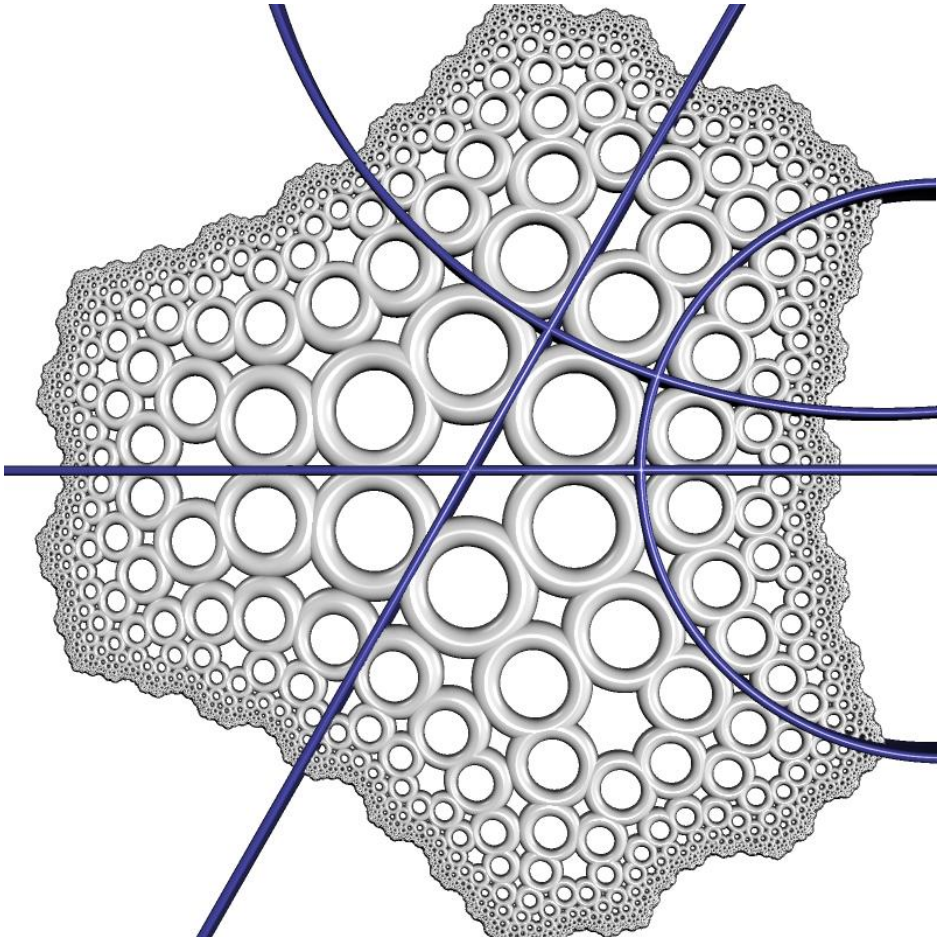
All 4 mirrors make shape with fractal boundary

Spherical Mirrors



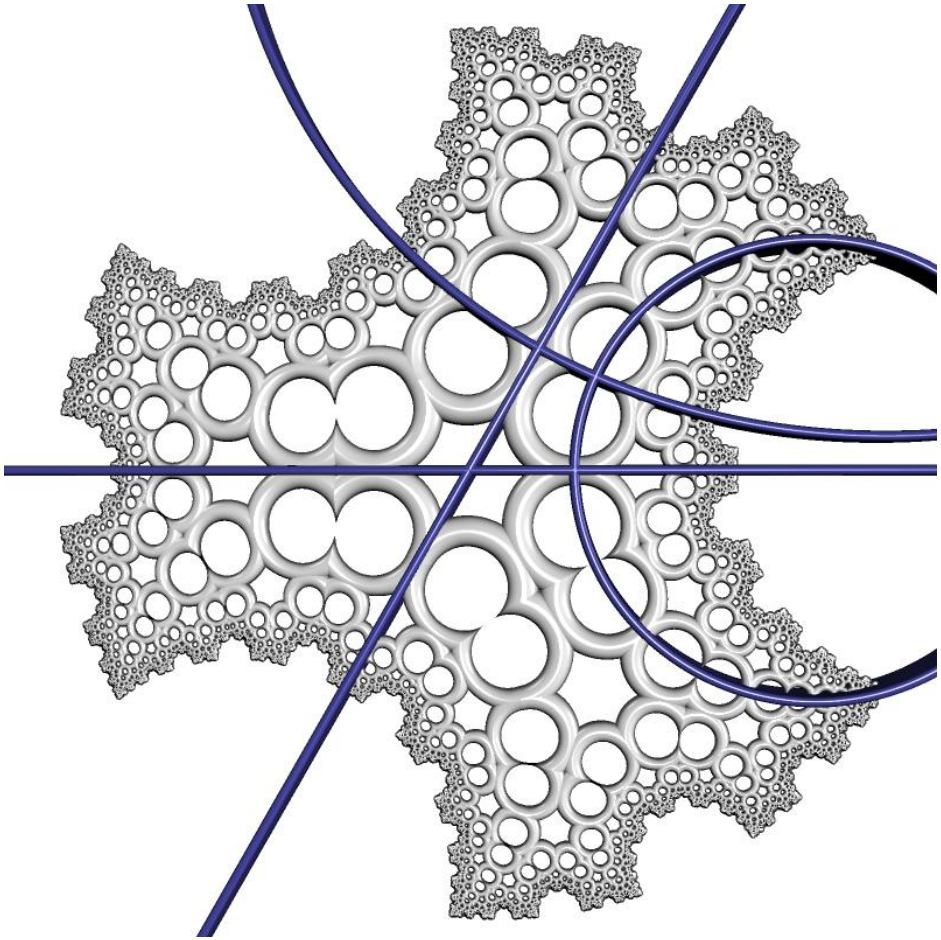
Deformation of mirrors arrangement makes non trivial change of shape

Spherical Mirrors



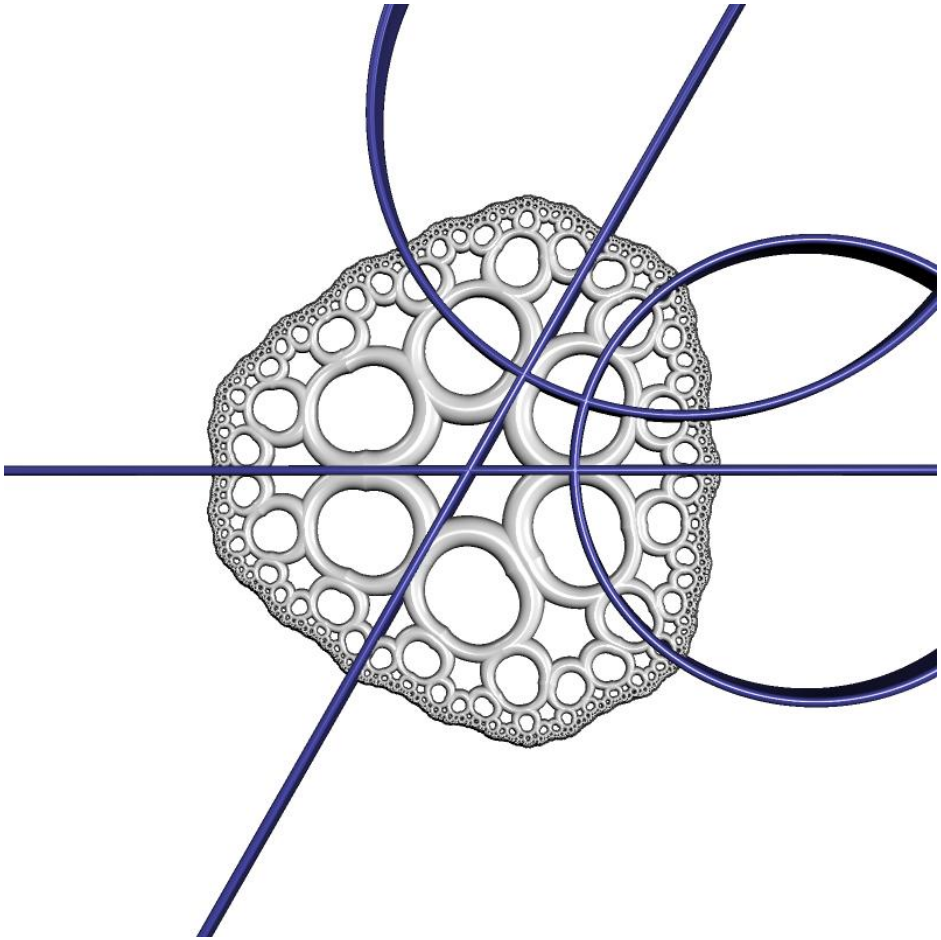
Deformation of mirrors arrangement makes non trivial change of shape

Spherical Mirrors



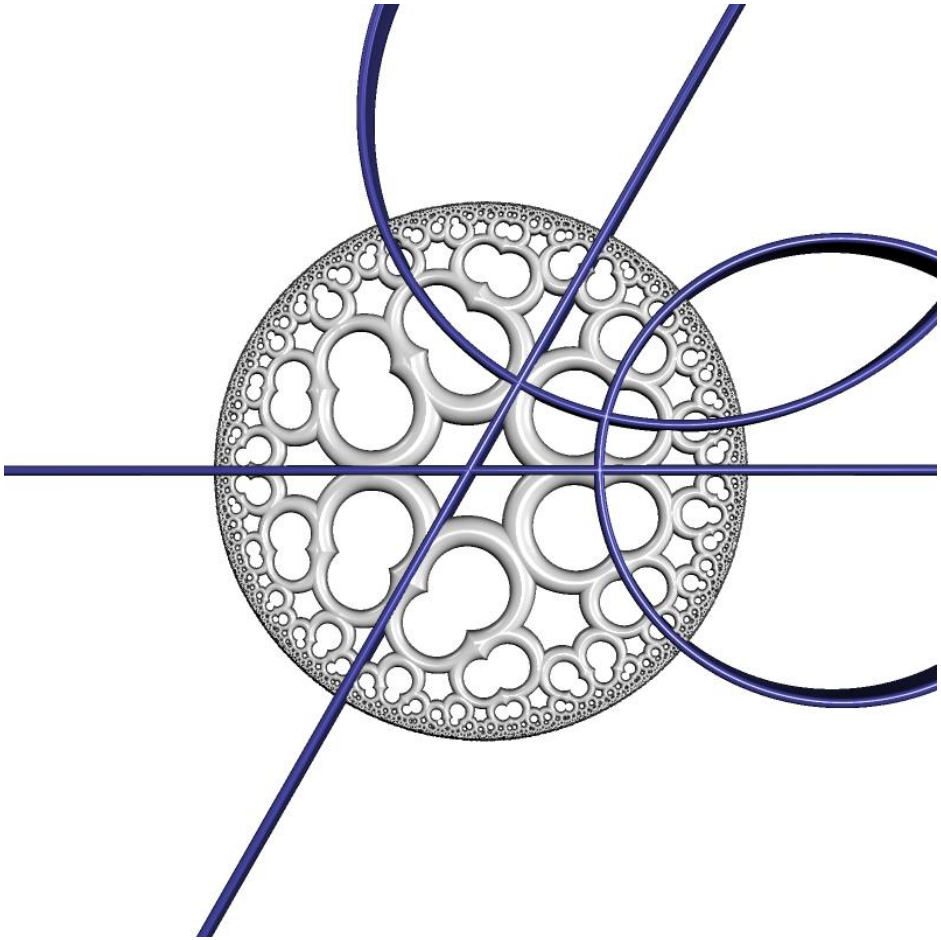
Deformation of mirrors arrangement makes non trivial change of shape

Spherical Mirrors



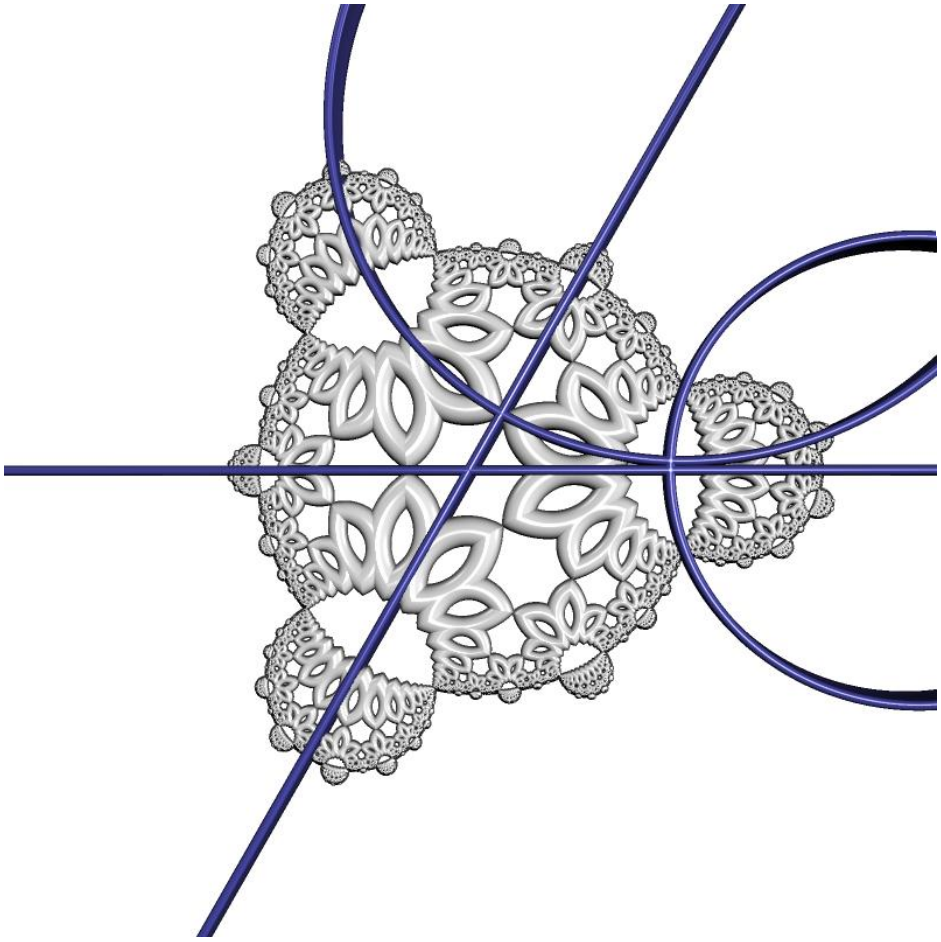
Deformation of mirrors arrangement makes non trivial change of shape

Spherical Mirrors



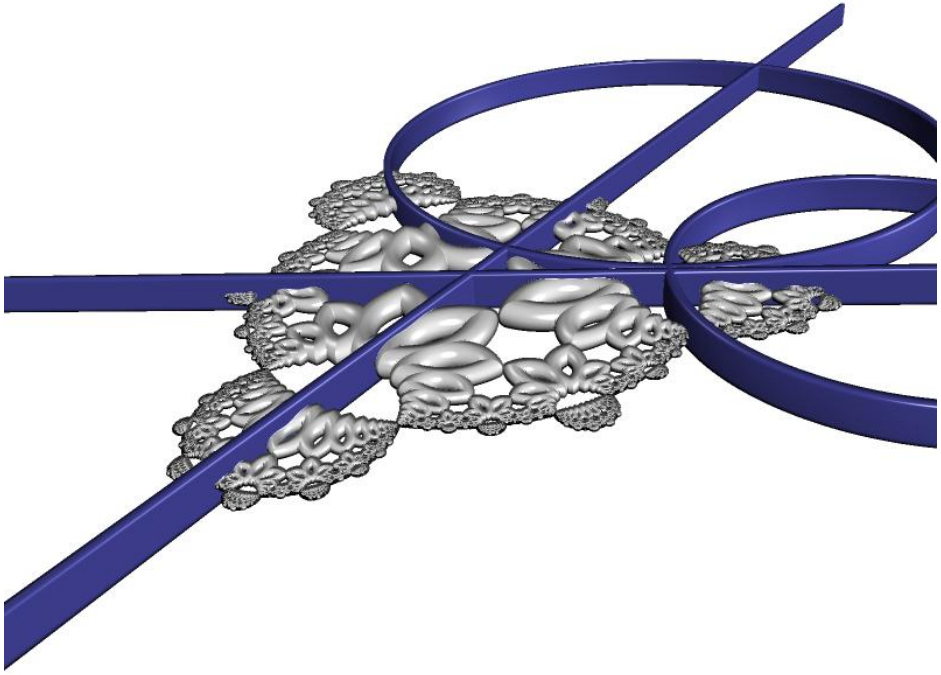
Deformation of mirrors arrangement makes non trivial change of shape

Spherical Mirrors



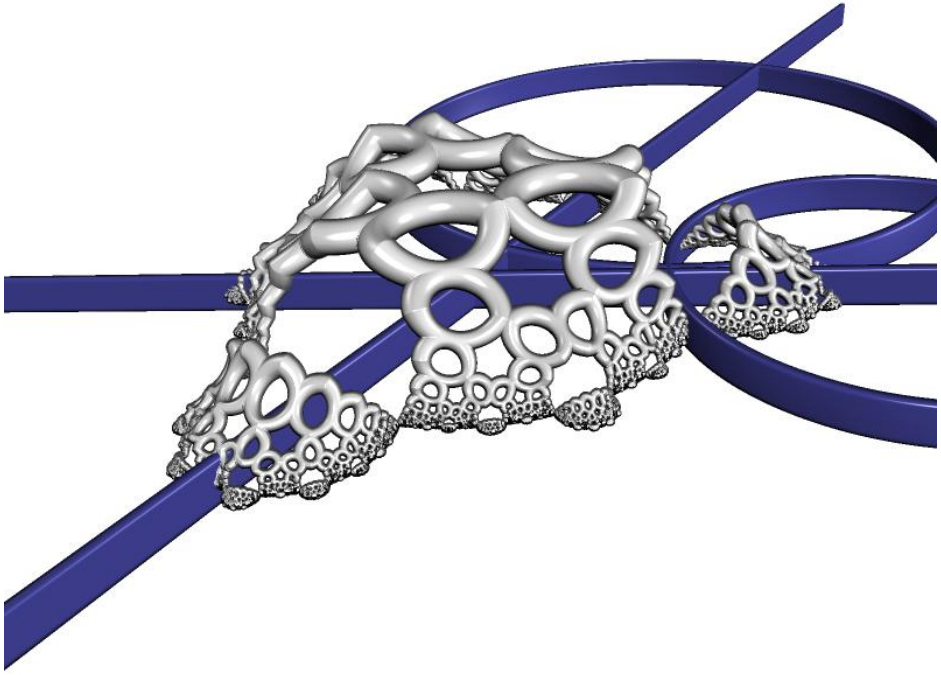
Deformation of mirrors arrangement makes non trivial change of shape

3D view



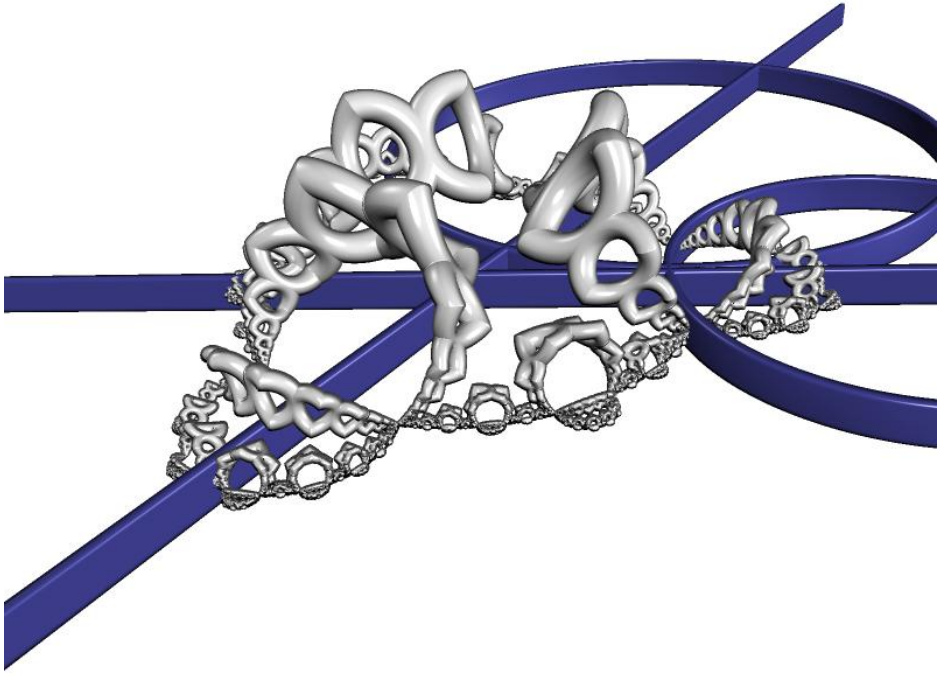
The shape is three dimensional

3D view



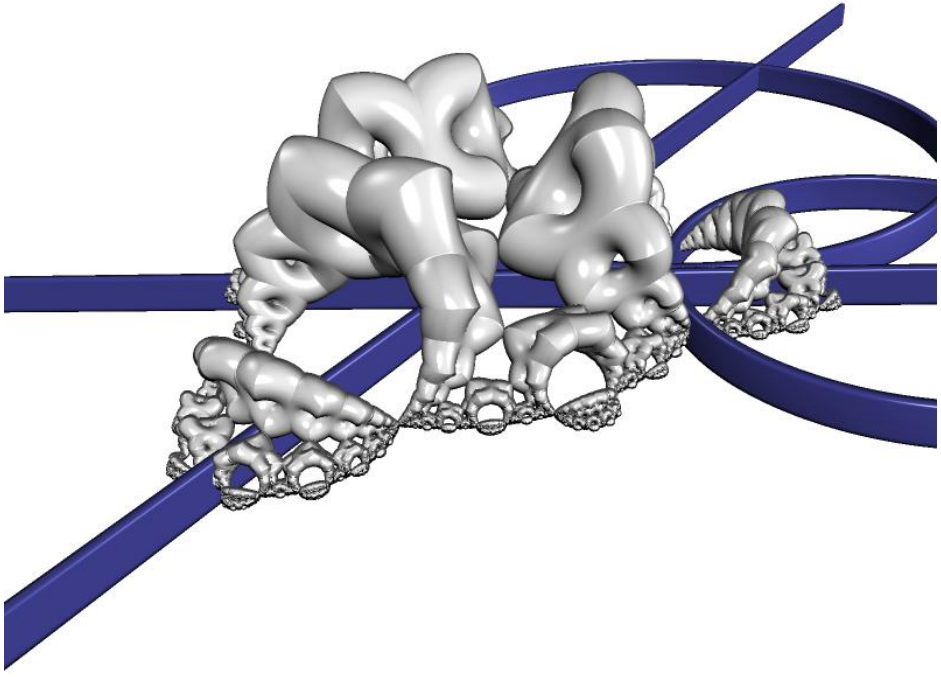
The shape is three dimensional

3D view



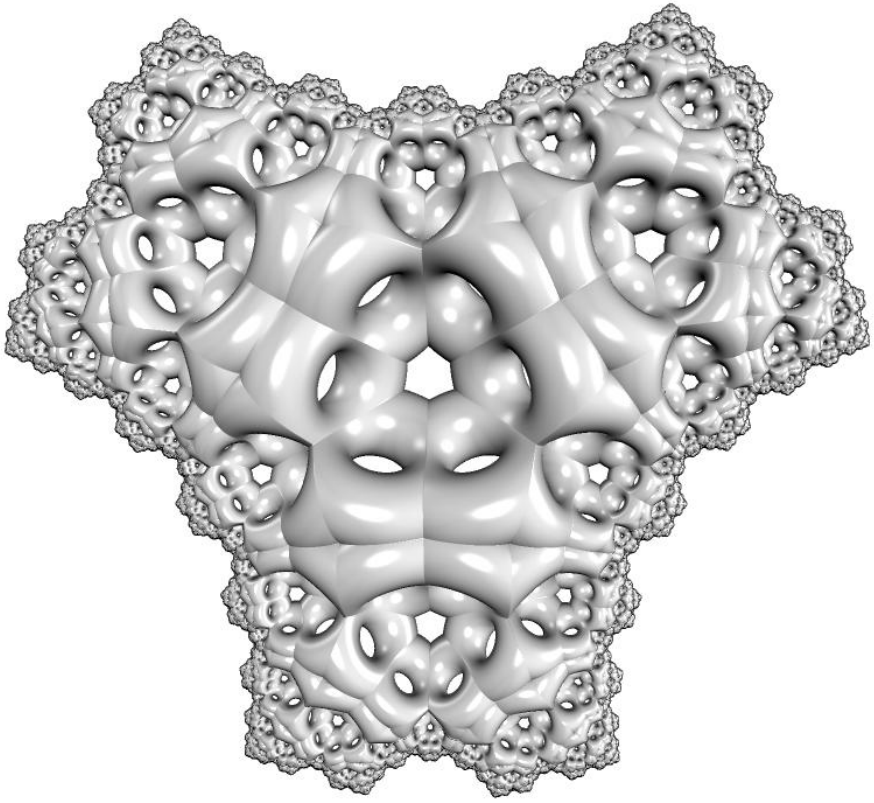
The shape is three dimensional

3D view

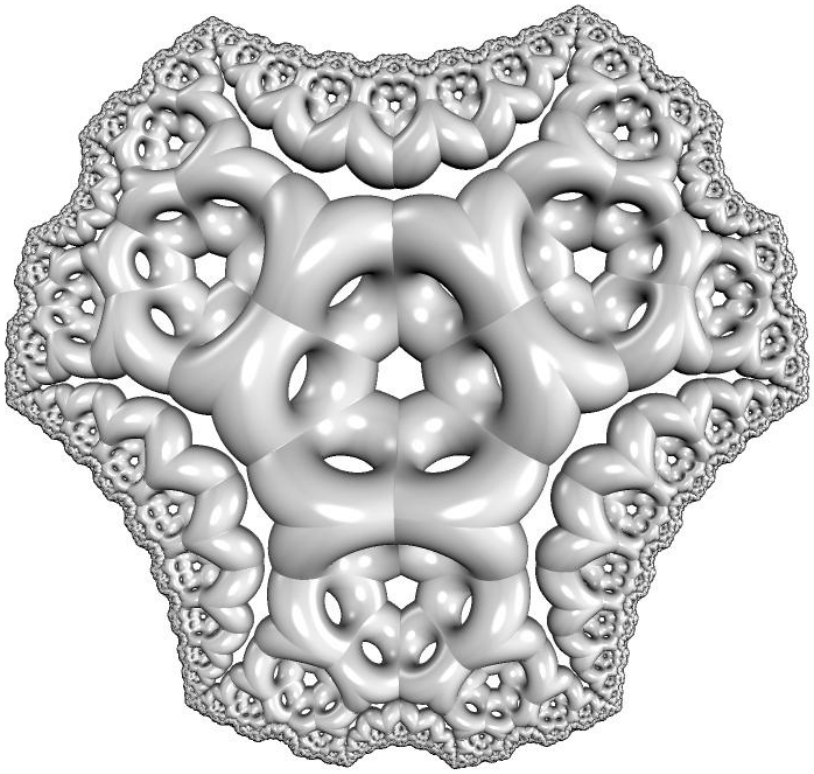


The shape is three dimensional

Samples



Samples



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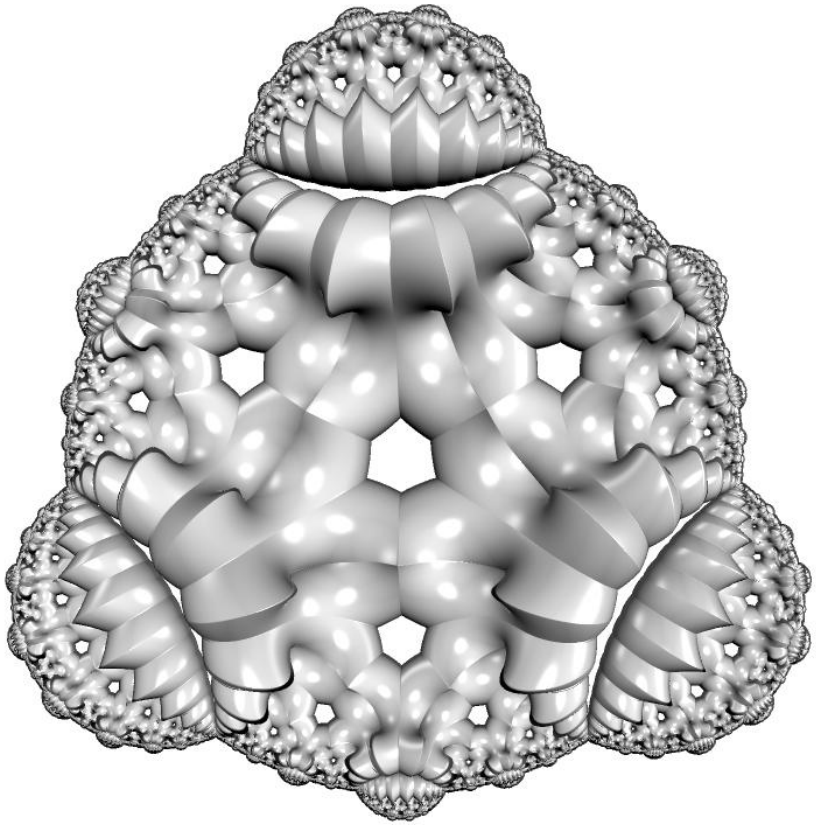

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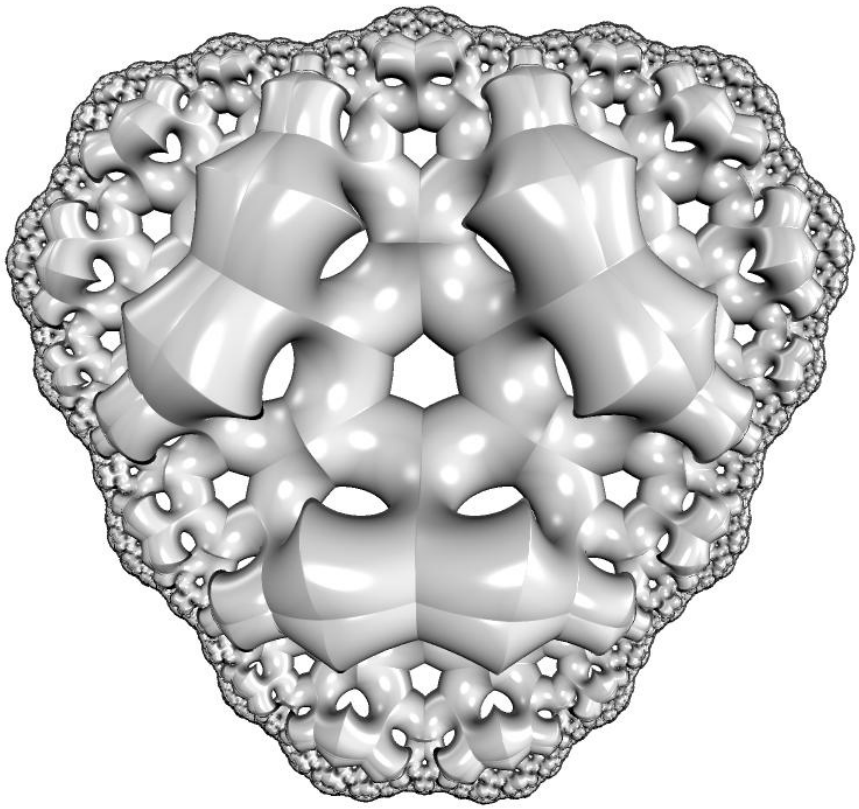

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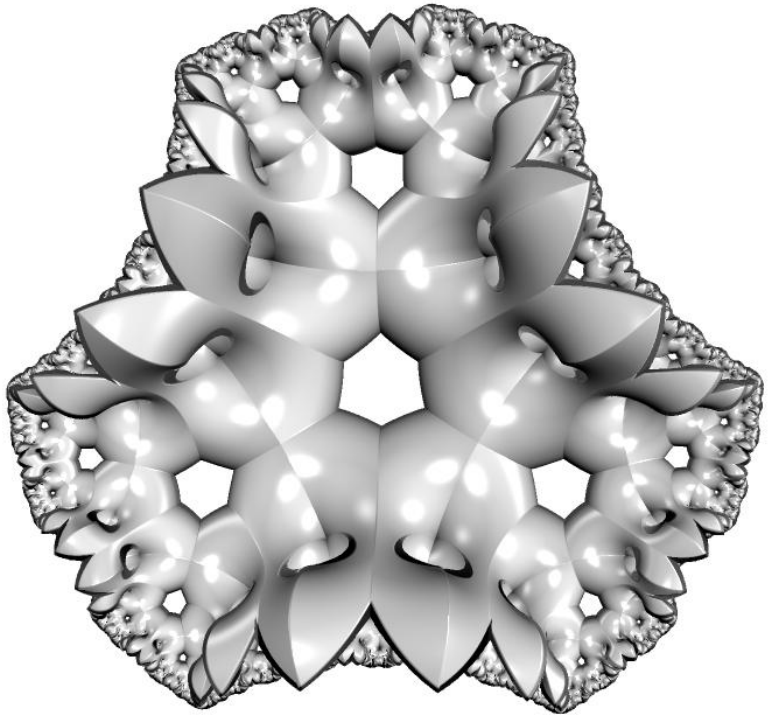

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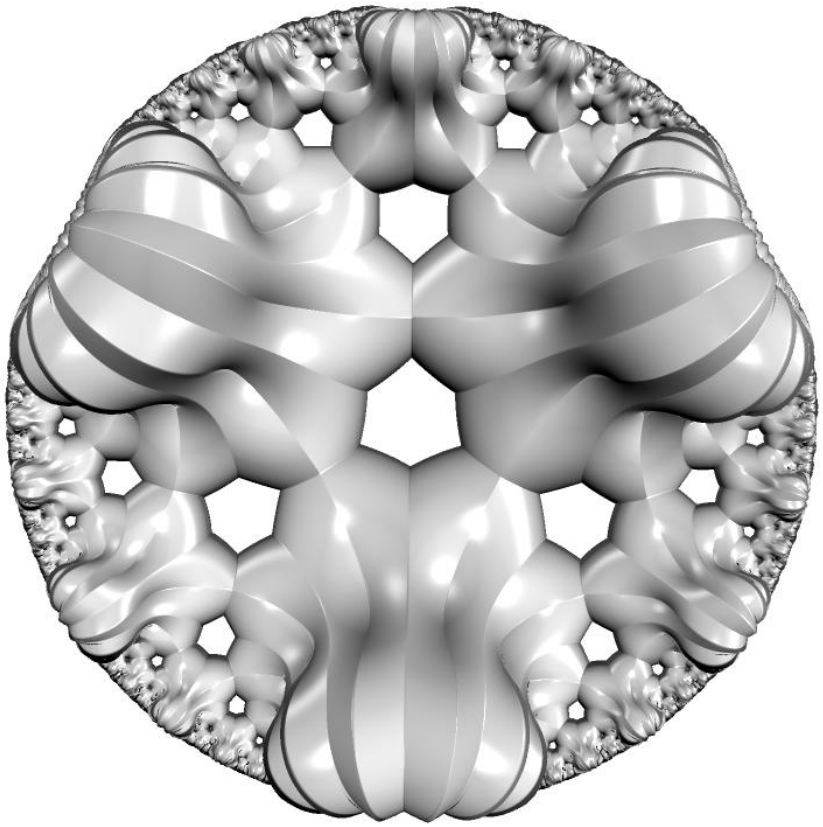

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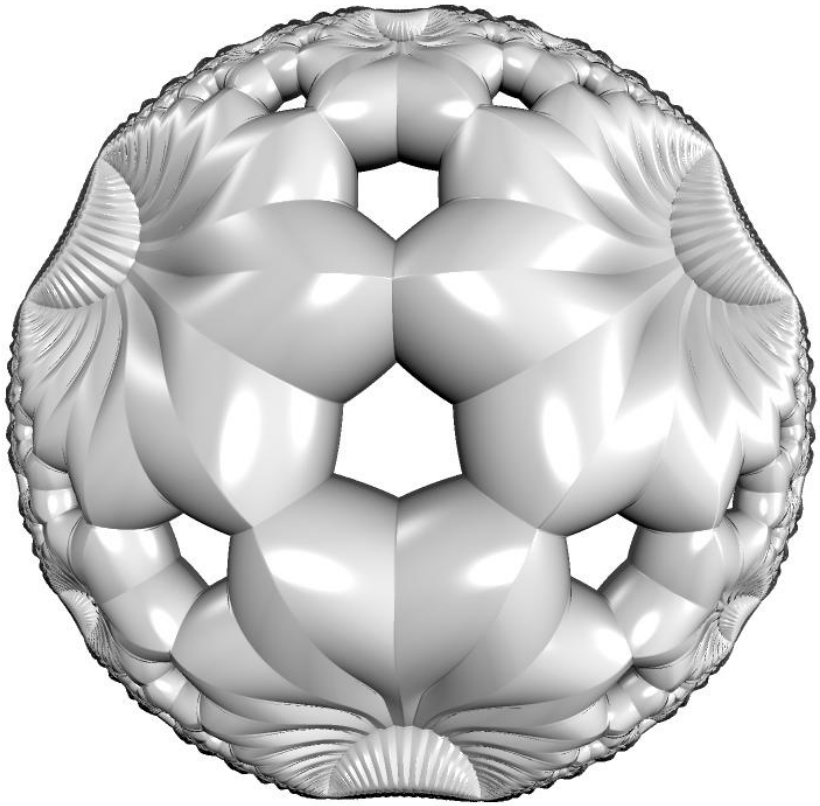

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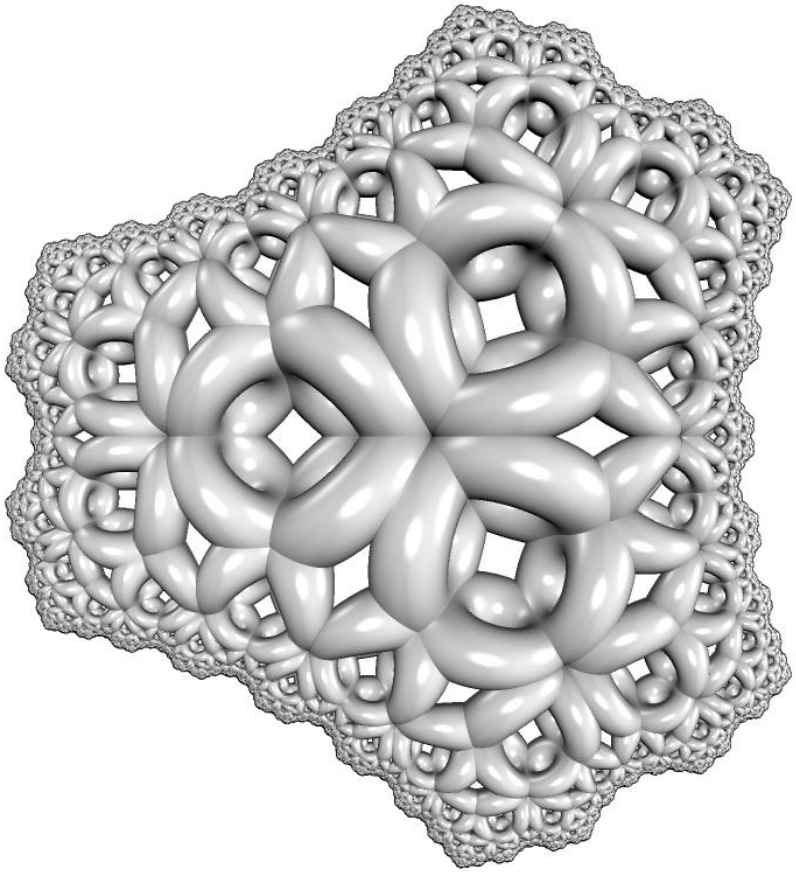

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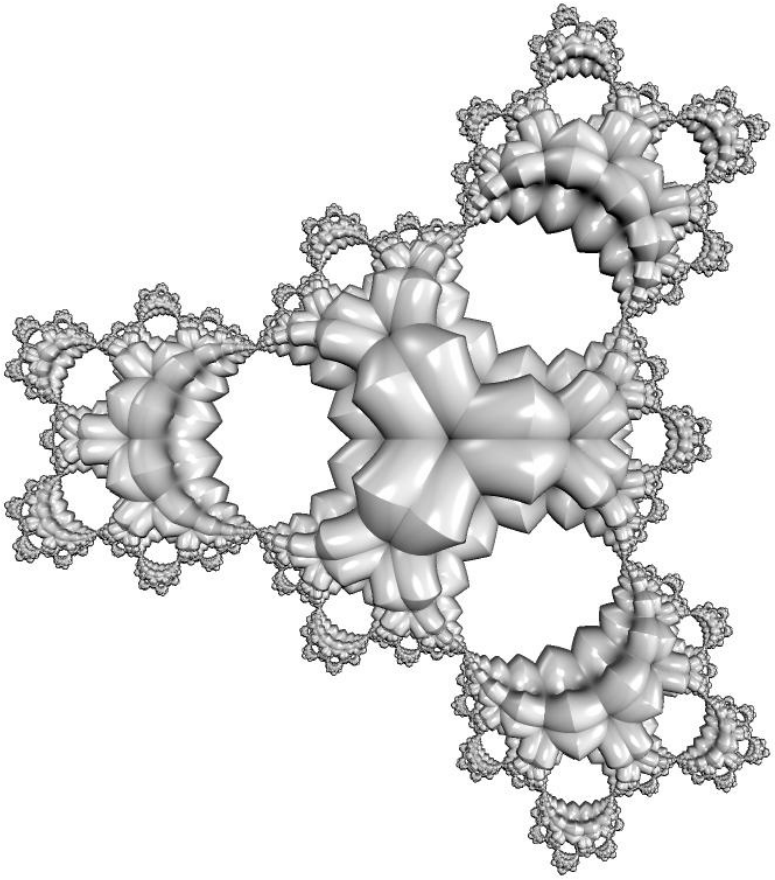

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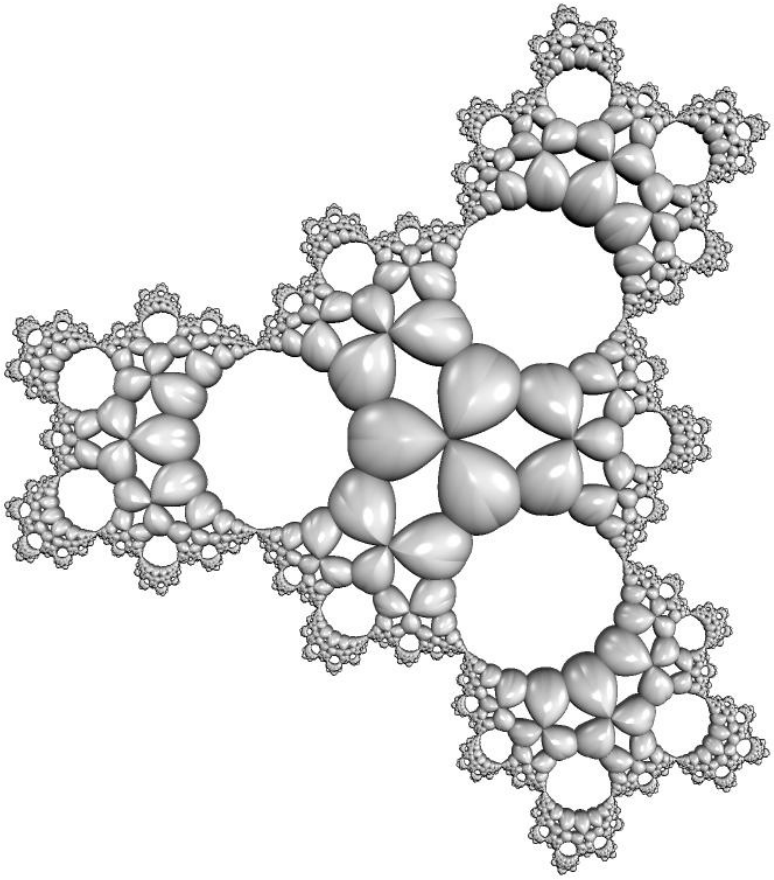

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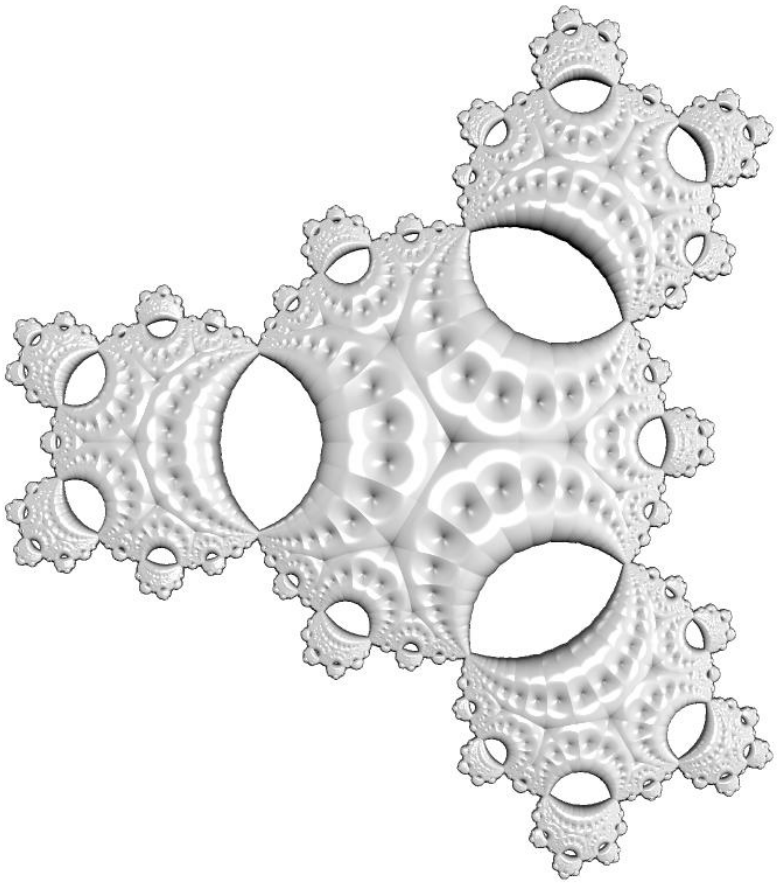

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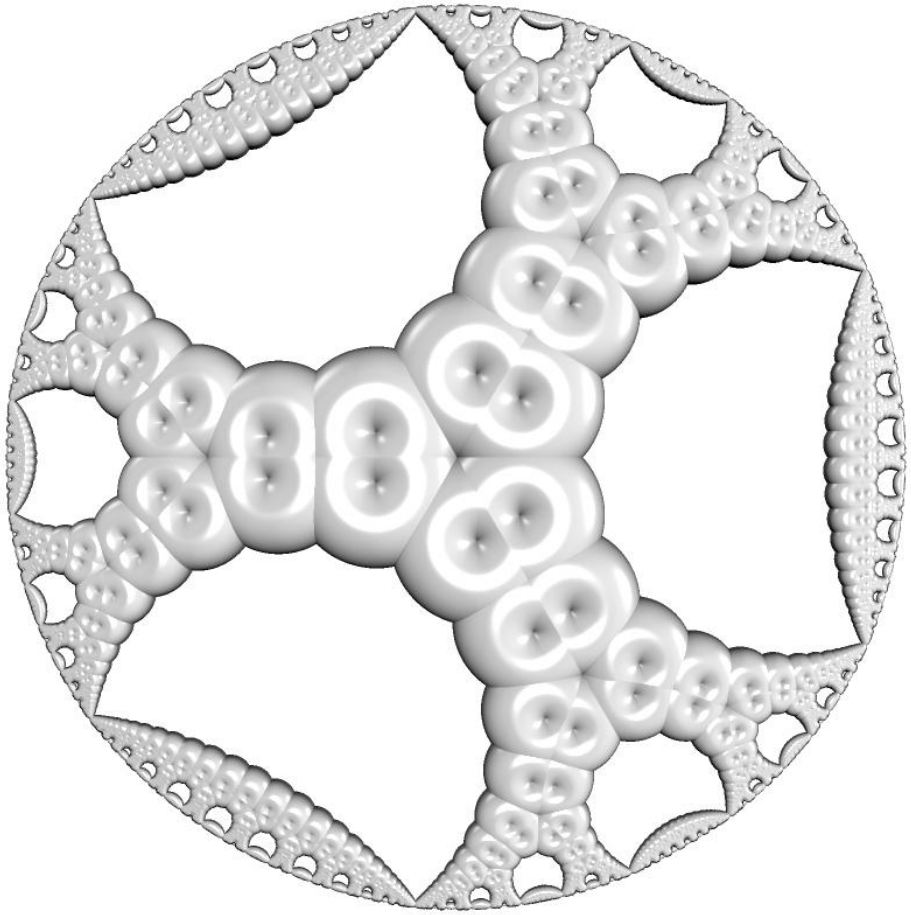

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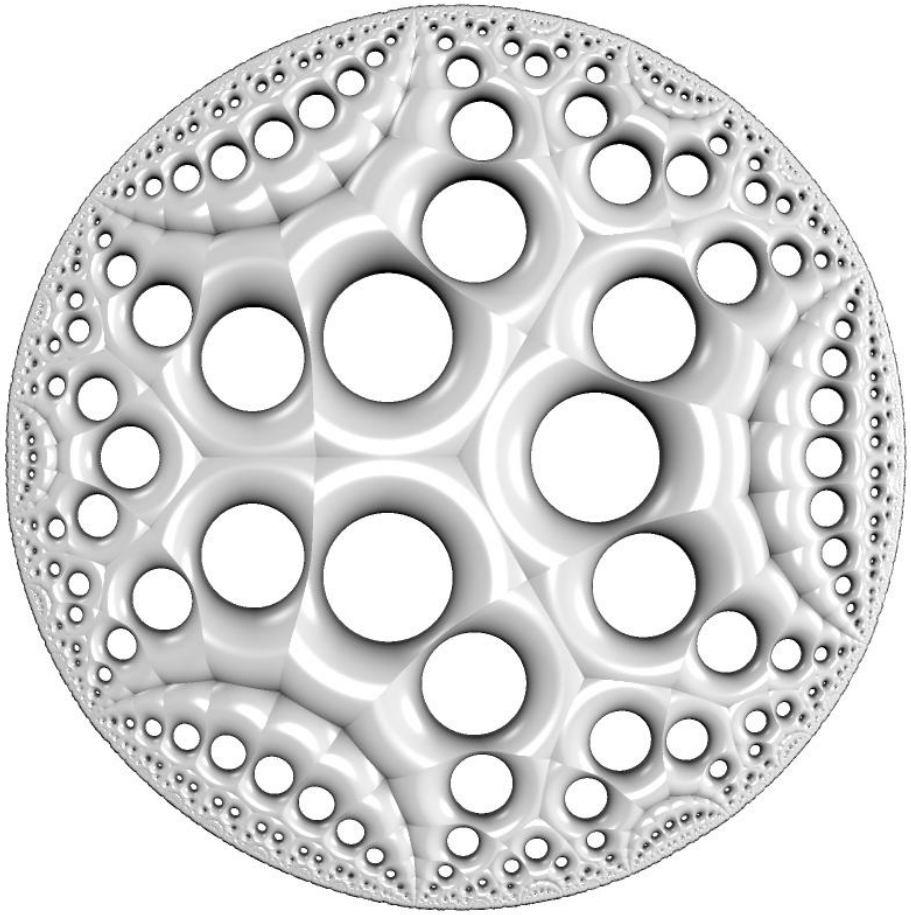

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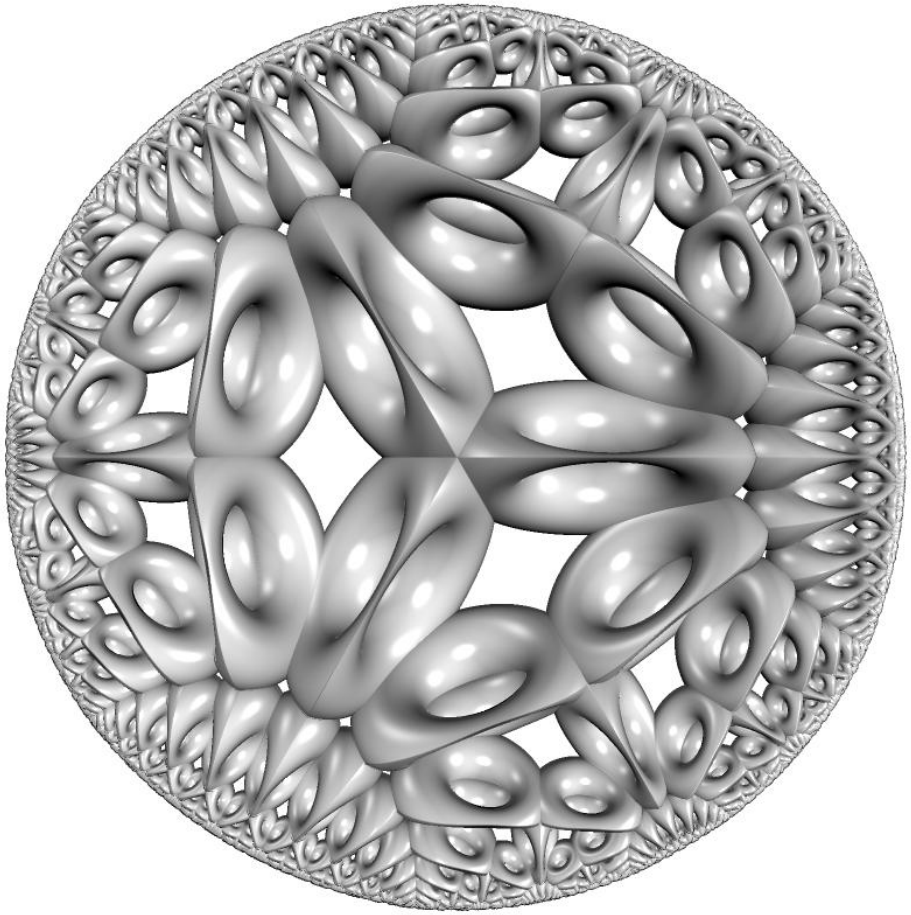

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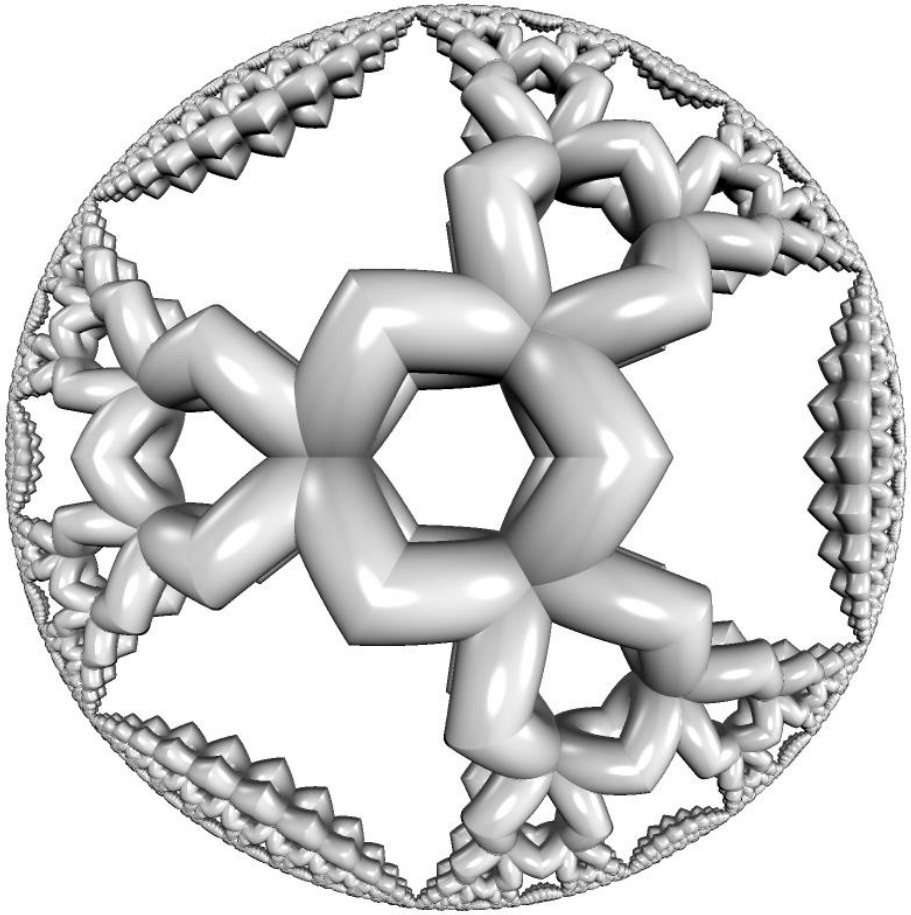

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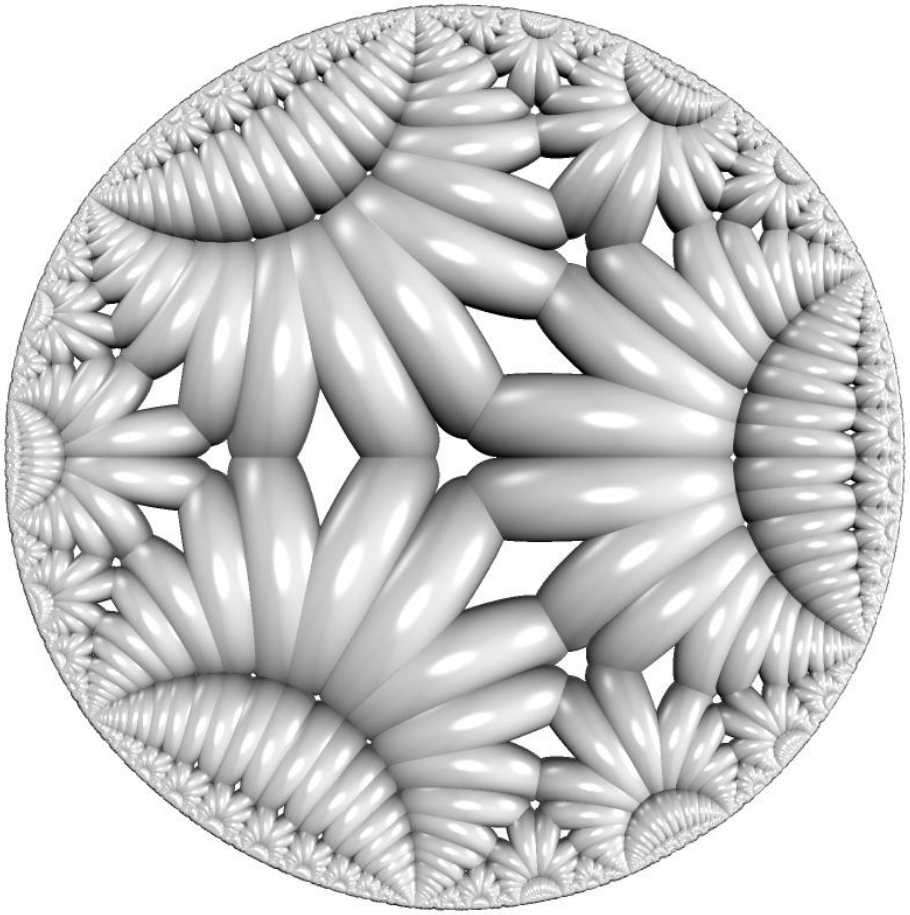

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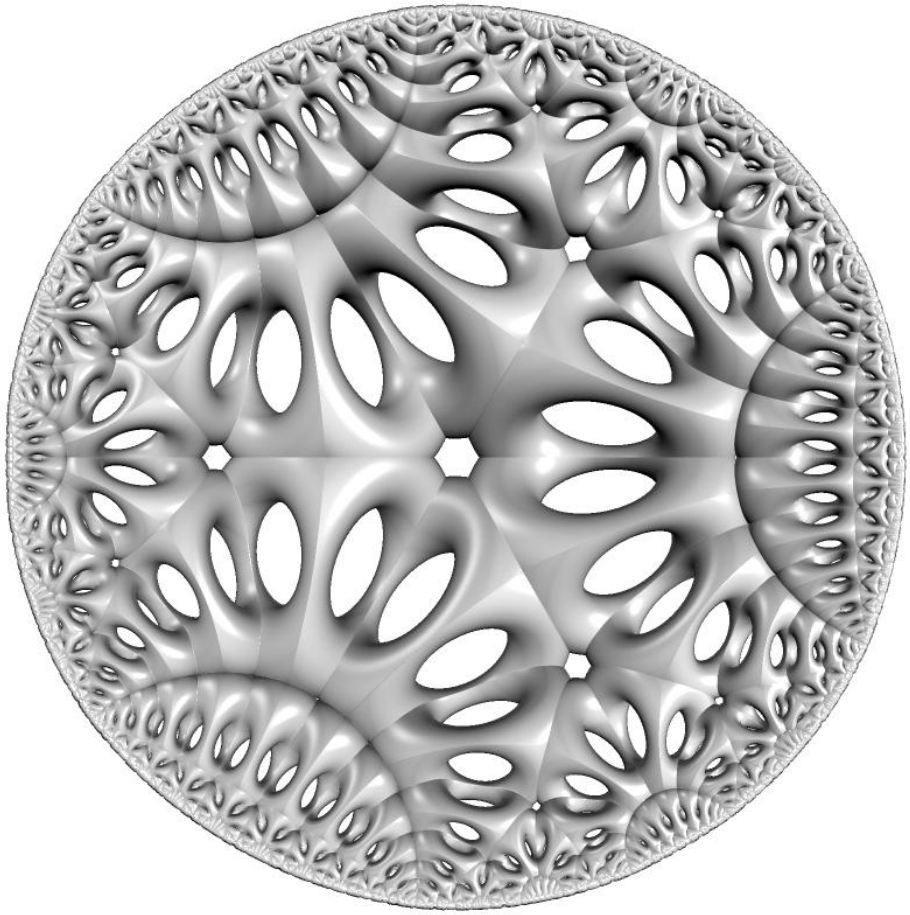

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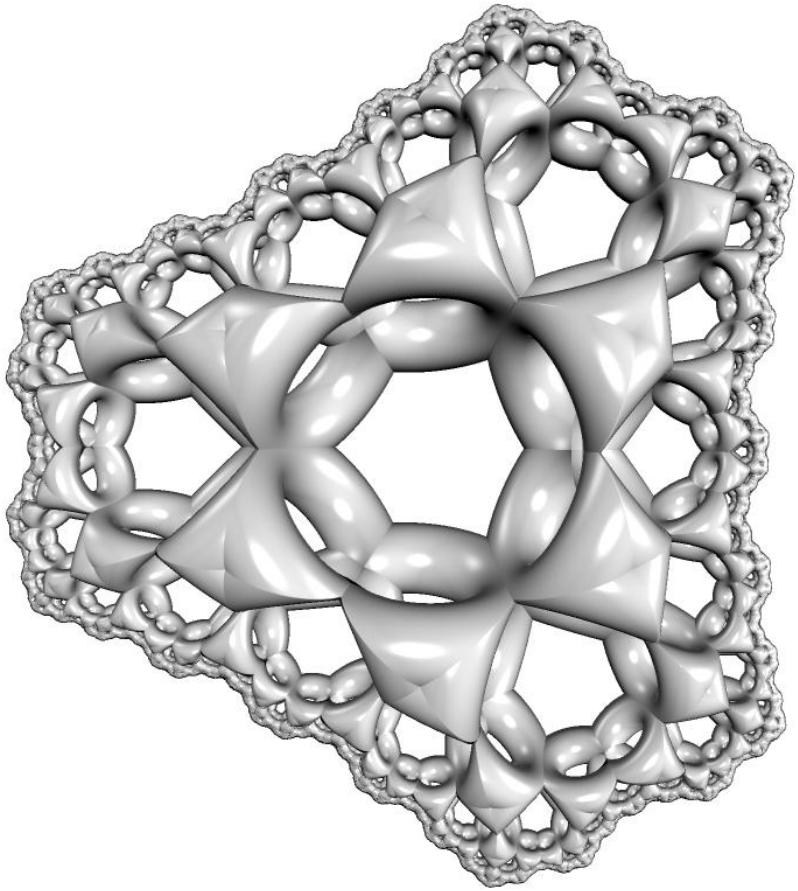

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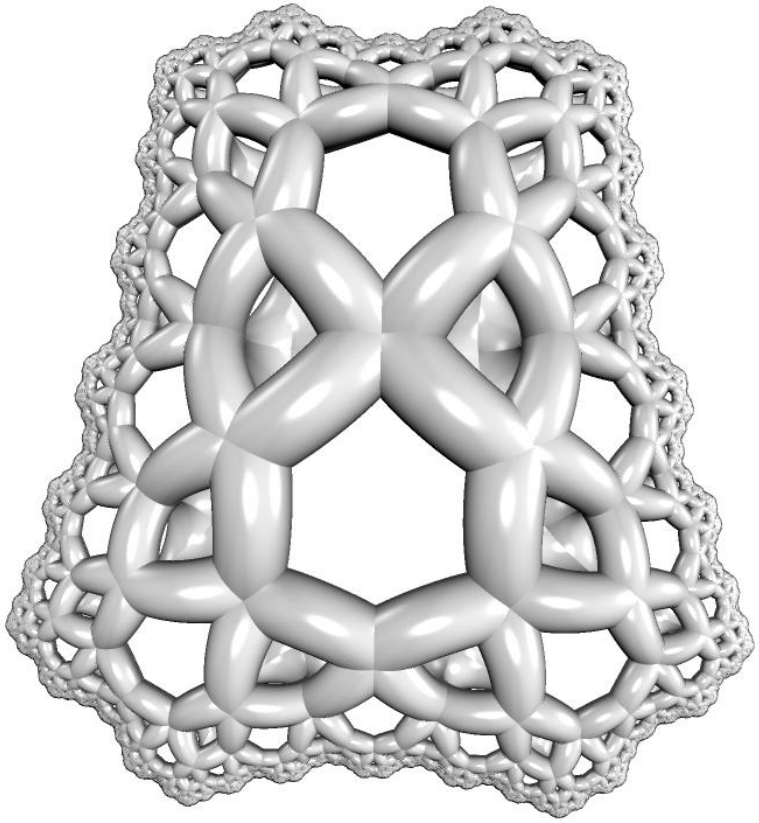

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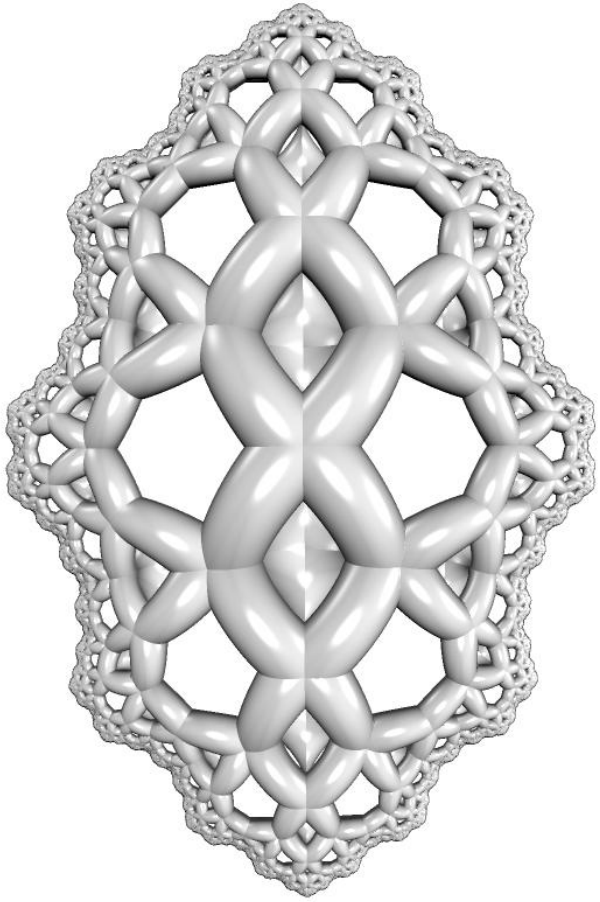
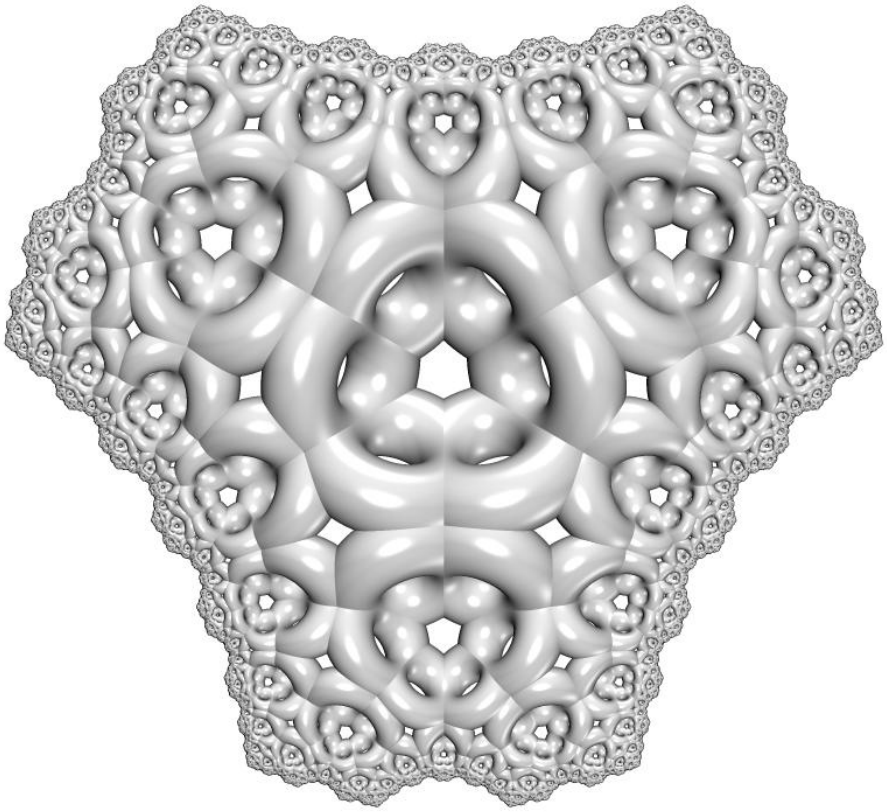
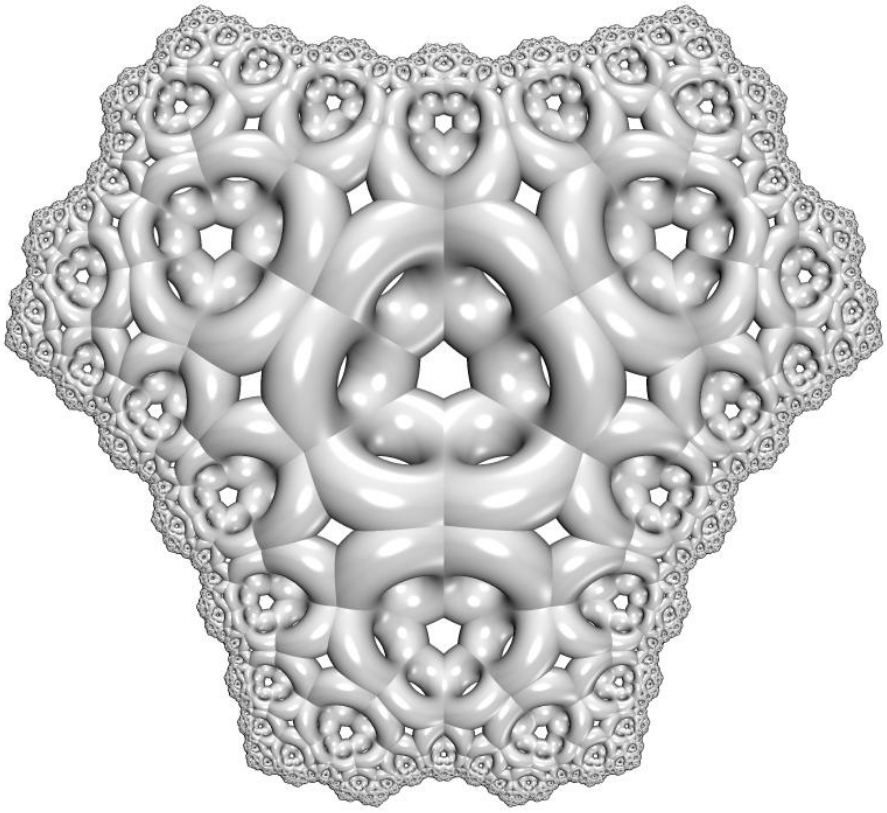


Final choice for pendant



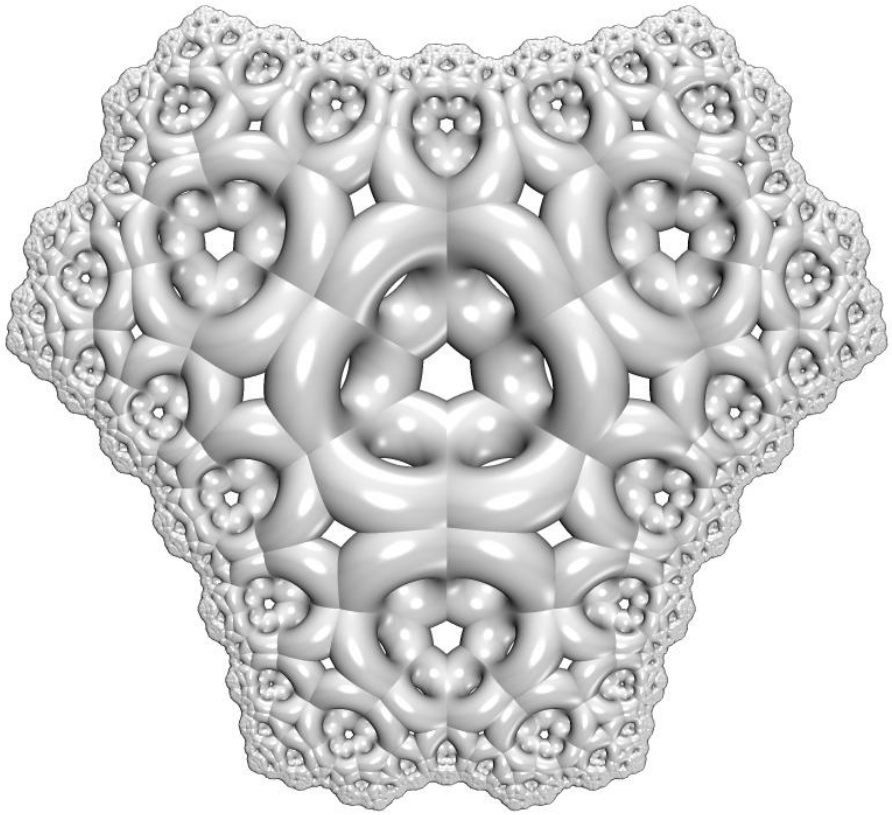
Geometry of pendant



Fractal boundary is too thin to print

It needs to be "thickened"

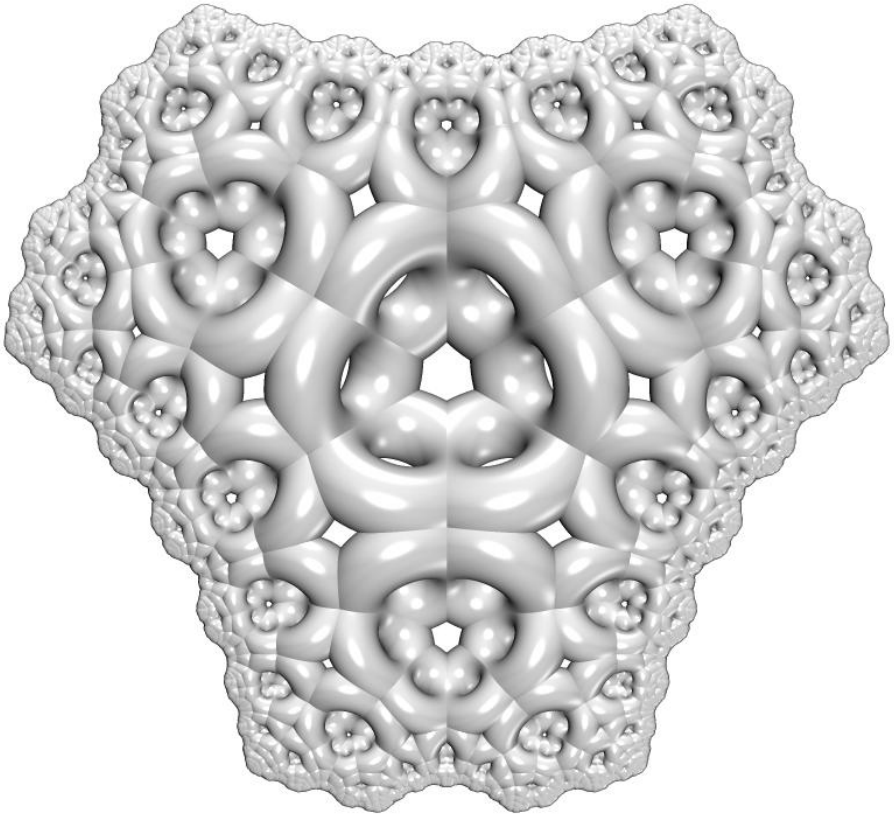
Thickening of boundary



Fractal boundary is too thin to print

It needs to be "thickened"

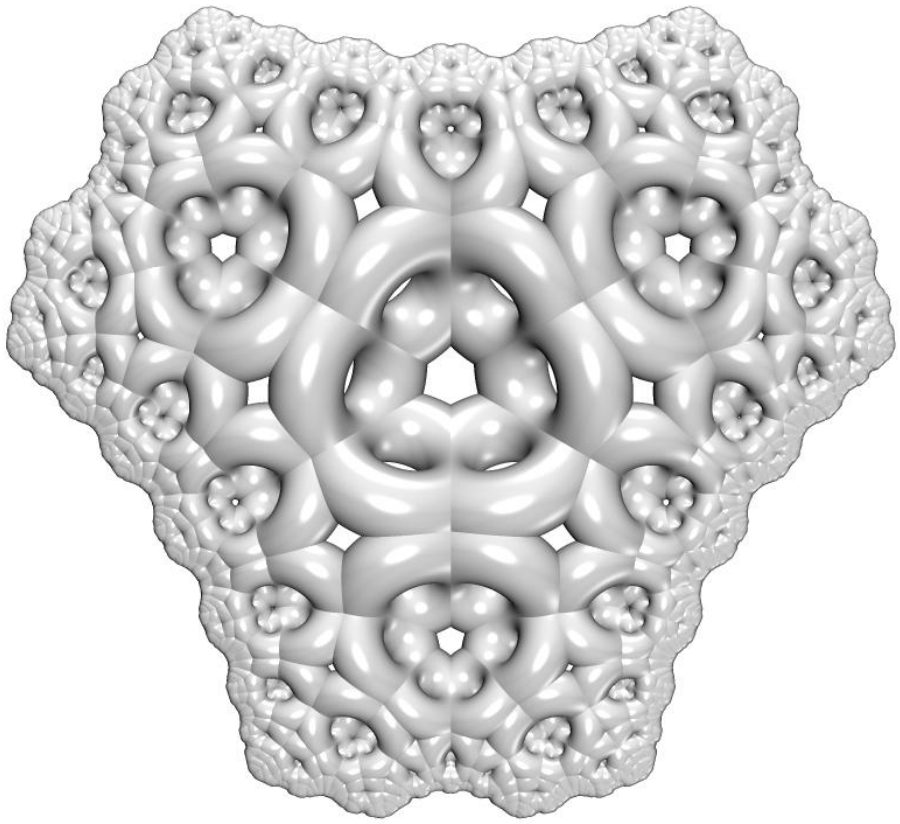
Thickening of boundary



Fractal boundary is too thin to print

It needs to be "thickened"

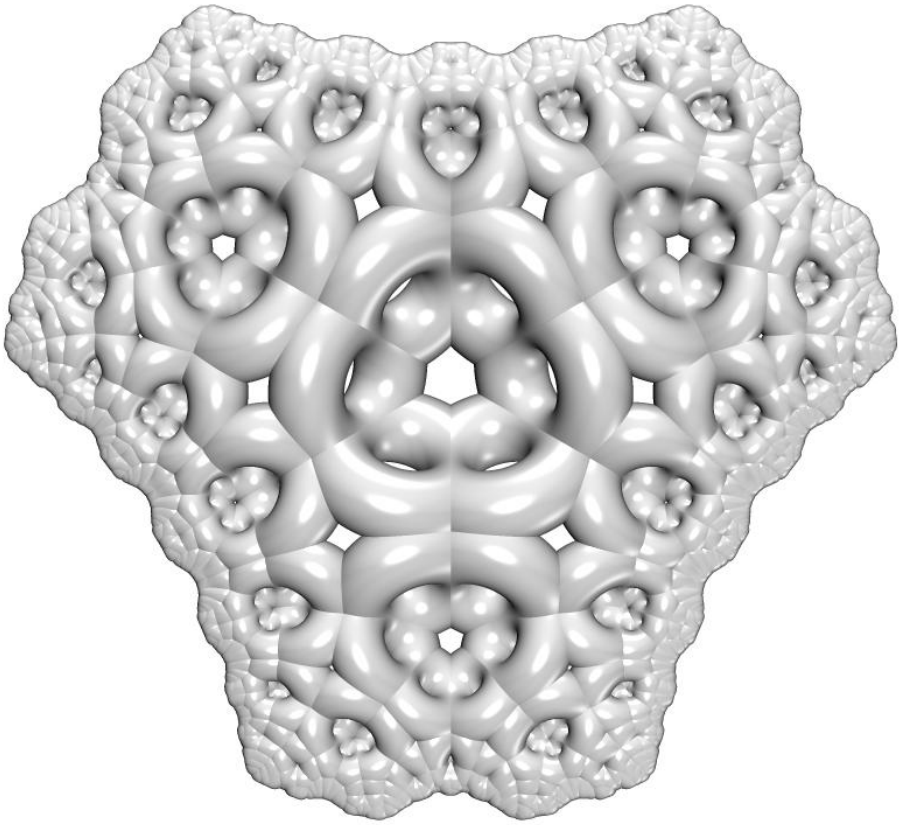
Thickening of boundary



Fractal boundary is too thin to print

It needs to be "thickened"

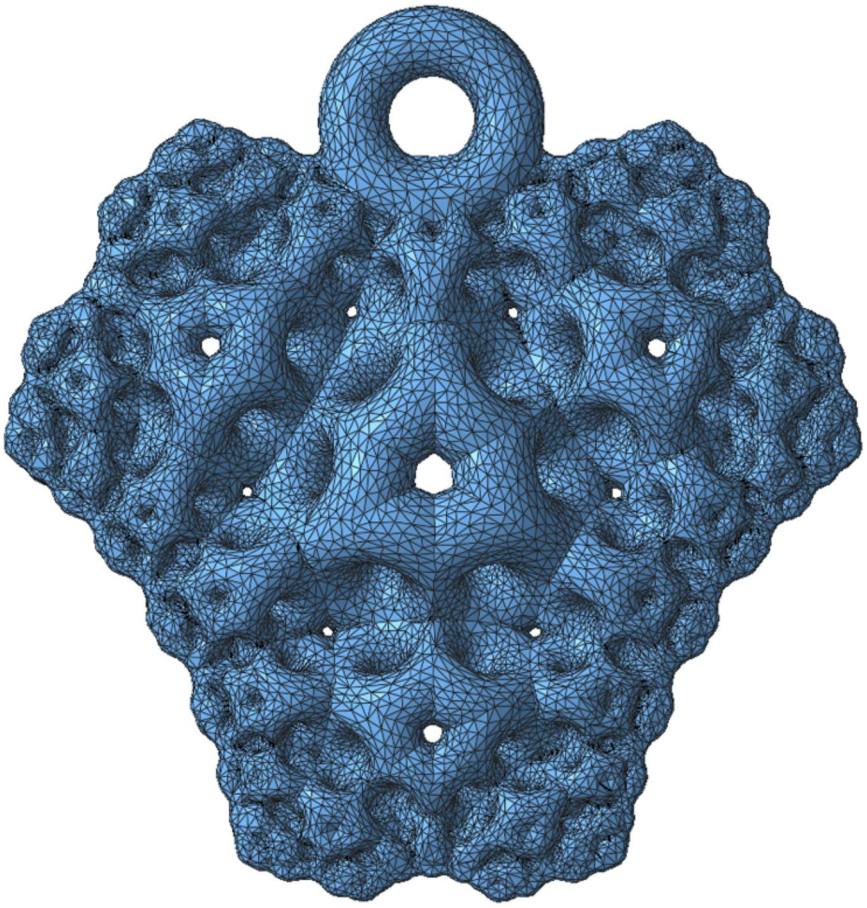
Thickening of boundary



Fractal boundary is too thin to print

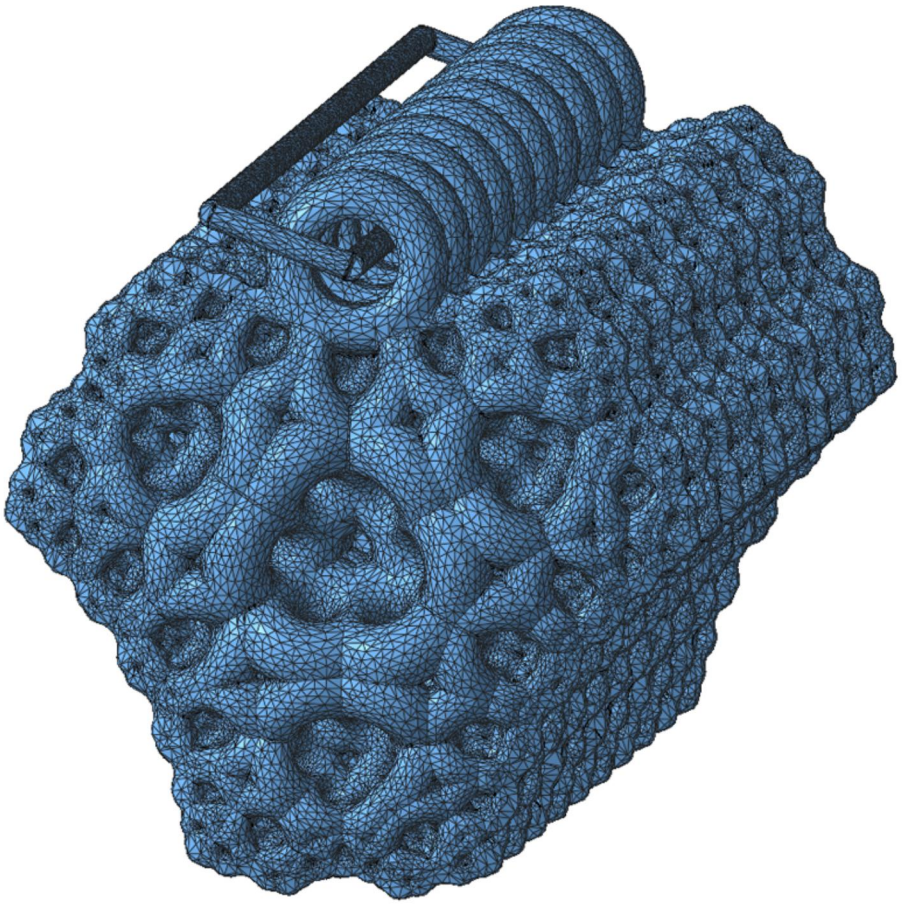
It needs to be "thickened"

Conversion into Mesh



3D print needs 3D mesh file

Maling a Bundle



Bundling 10 pendants in group reduces maniufacturing cost

ShapeJS summary

- simple to code (javascript)
- volumetric modeling via signed distance function
- real time server side 3D rendering
- compatible with any device which can run web browser
- 3D print compatible models
- easy model sharing
- intellectual property protection

We are actively extending the system by adding new capabilities.

Suggestions are very welcome!