Projecting the Uncanny:
The Intersection of Visuality and Architecture

by Karen Kitayama

Bachelor of Arts in Architectural Studies & Art History
University of California, Los Angeles (2012)

Submitted to the Department of Architecture in Partial Fulfillment of the Requirements for the Degree of Master of Architecture at the Massachusetts Institute of Technology, February 2016

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Abstract

This thesis explores architectural drawings and representations appropriate to describe forms and spaces in zero and artificial gravity. Its focus is on the physical forces associated with life and motion in a rotating environment and the formal and geometric architectural response to those forces.

Orthographic drawing relies on a flat plane onto which lines are statically inscribed. This project hopes to speculate on an alternative drawing that can help to describe habitation and the uncanny experience of life in space. Without the constraints of gravity, architecture is no longer forced to have plumb walls, that floors, or ramps with specific ratios. Zero gravity presents itself with its own challenges of disorientation and visual confusion. This project will juxtapose the effects of zero gravity with the spaces imbued with artificial gravity generated by centripetal force.

Human experience in outer space is tied to feelings of disorientation and distortion. This project seeks to understand these perceptual changes in order to adapt the human body to a new way of seeing. The visualization of movement through the presence of the human body and its role in orientation and perception will set the parameters for an experiential representation of life in space.

Thesis Supervisor: Joel Lamere
Title: Assistant Professor of Architecture

Acknowledgments

Thank you Joel, for all of your guidance and encouragement throughout the semester. Without your help, I would not have been able to communicate my ideas. Your sharp critique and suggestions pushed me to consider different facets of representation. I really appreciate all of the thoughtful comments you made during each of our meetings.

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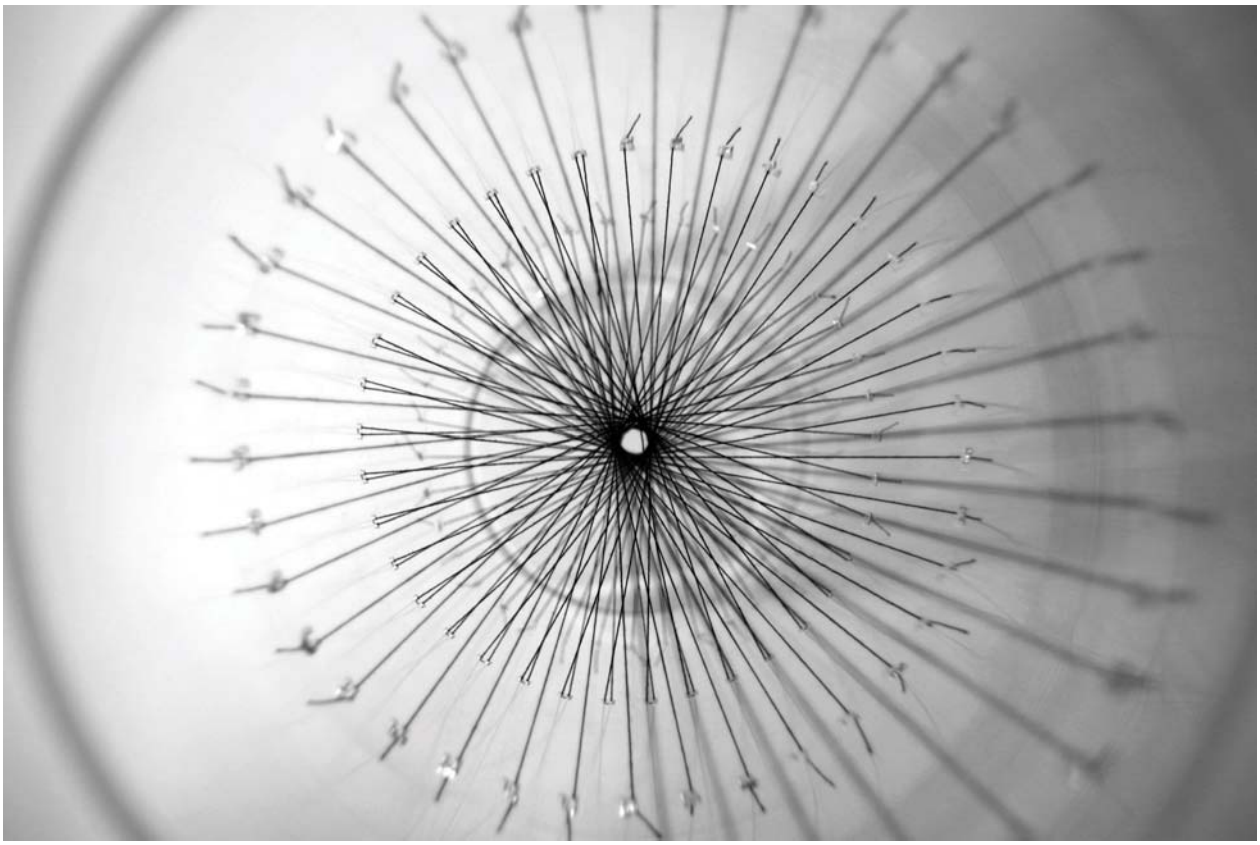
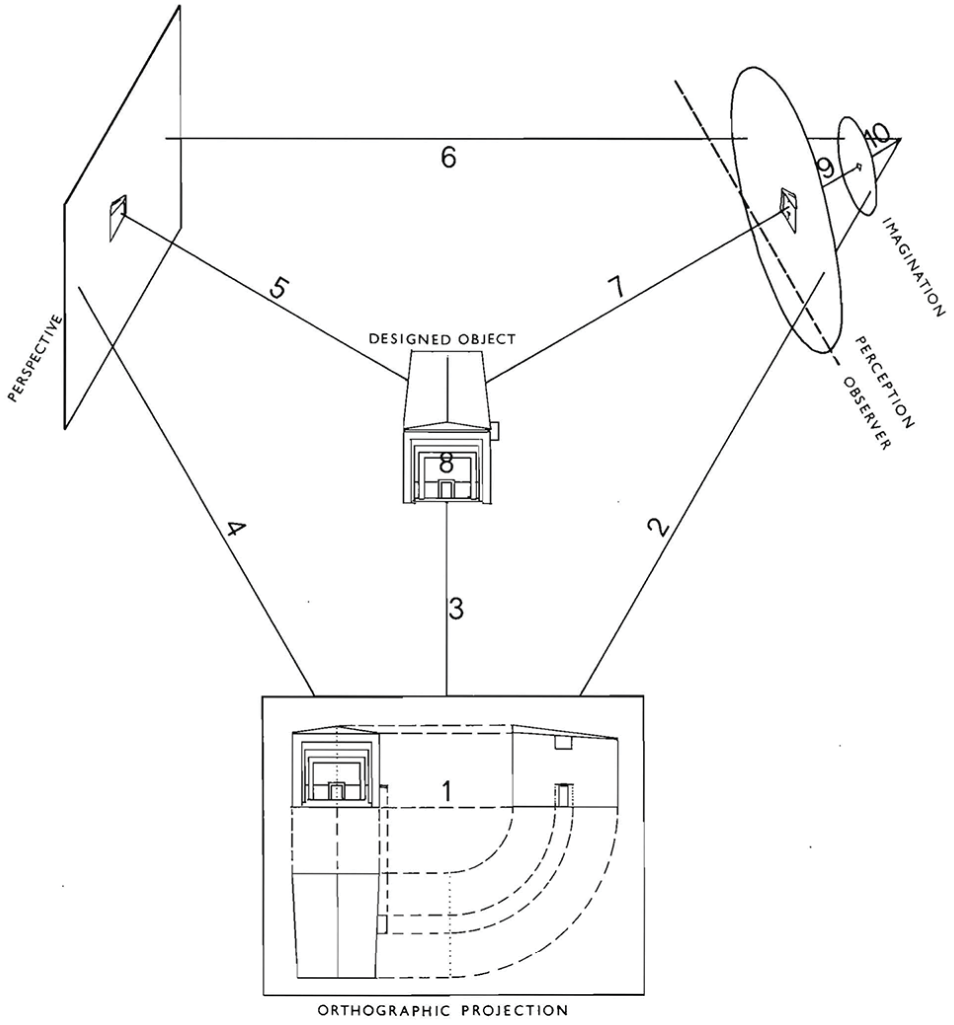
To Sixto, for your incredible patience, support, and compassion. Thank you for always believing in me.

Lastly, to my parents and Ken, thank you for your unending support.



Contents



Robin Evans, Projection and its analogues: The Arrested Image

The Act of Architectural Drawing

The initial drive of this thesis was to explore different architectural drawing techniques and the construction of distinct visual constructs in order to research the relationship between optical and representational operations and their impact on form. What is the intersection between visuality and architecture? How do composite and synthetic drawings produce specific ways of seeing and different interpretations of space? How can drawings influence the everyday experience and create aesthetic experiences of space?

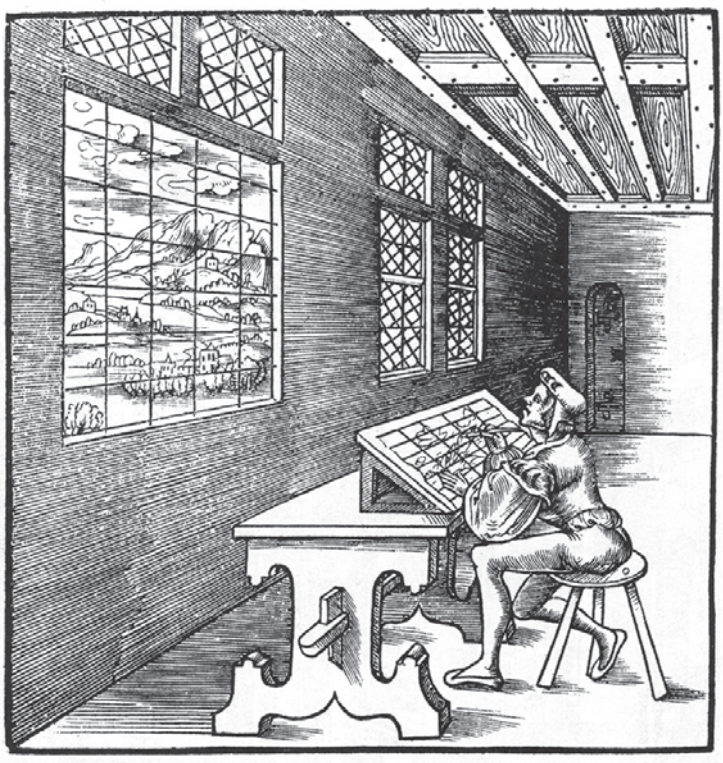
In his book, Translations from Drawing to Building, Robin Evans wrote, "The imagination works with eyes open. It alters and is altered by what is seen. The problem is that if we admit this, then the relation between ideas the things turns mutable and inconstant. Such destabilization is bound to affect our understanding of architectural drawing, which occupies the most uncertain, negotiable position of all, along the main thoroughfare between ideas and things. For this same reason, drawing may be proposed as the principal locus of conjecture in architecture."[1]

The act of architectural drawing is not merely a rote mechanical activity, neither is its aim to simply reproduce static representation. On the contrary, its capabilities stem from its dynamic abilities as a medium and practice that is able to provoke and underwrite disciplinary design intellection and speculation. The gap between drawing and building is essential; this blind spot creates generative anxiety in the process of architectural design.

Furthermore, in his book, The Quadruple Object, philosopher Graham Harman wrote, "An object is not a bundle of qualities, and for this reason a thing cannot be reproduced simply by duplicating all of its qualities and bundling them together. At most this would give us an externally convincing simulacrum of the thing, not the thing itself. This is why nothing can be modeled adequately by any form of knowledge, or by any sort of translation at all. In its primary sense, an object is not used or known, but simply is what it is. No reconstruction of that object can step in for it in the cosmos."[2]

An object cannot be exhausted by its qualities. A dark nucleus is what philosopher Graham Harman uses to describe what all real objects contain. The dark speaks of that which is unclear and uncertain, existing beyond experience and likewise beyond our capabilities to sense. The nucleus is that which exists to be an object and that which individualizes these objects.

1 Robin Evans, *Translations from Drawing to Building*, (Cambridge, MIT Press, 1997).
2 Graham Harman, *The Quadruple Object, (Lanham: O Books, 2011).*



Alberti's Window
Image obtained from:
http://www.justinlogue.co.uk/madigitalarts/wp-content/uploads/2012/11/Woodcut.jpg

This thesis attempts to engage in discourse that questions the role of architectural drawing in contemporary practice. By aligning the project with contemporary supporters who critically believe in the project of the drawing as a productive force in the discipline, this thesis tries to demonstrate how new drawing techniques could help to further this discussion. In a lecture describing his office's current work and preoccupations, Andrew Atwood argued, "The object is at the center of architecture, and drawing is the primary medium of architecture."[3] By adopting this viewpoint, this project analyzes the limitations of orthographic projections to adequately describe objects, and adopts different drawing techniques in order to describe a new multiplicity of multi-directionality that can help to describe novel experiences. How can one design projections that resist singularity and fixed views and instead, provide a multiplicity of visual readings and intellectual interpretations? The goal is to create a productive reciprocity between experience and drawing.

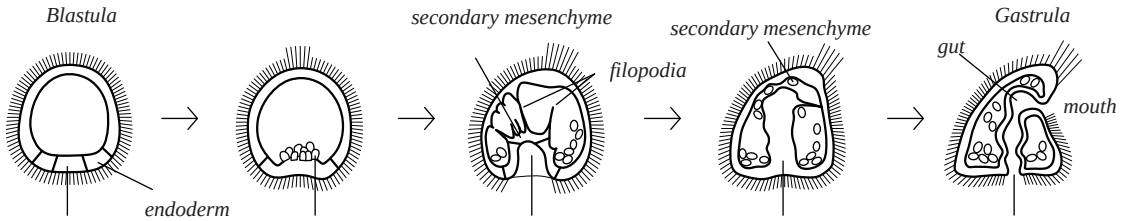
New gravity-less possibilities of unfixed directionality, anti-singularity, and constant rotation were chosen as characteristics to speculate on drawings that would be tested as descriptive, perceptual, aesthetic, conceptual, and generative devices.

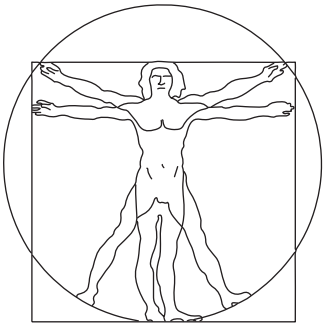
3 Andrew Atwood, "Current Work," (Lecture given at Sci-Arc, Los Angeles, California, March 30, 2012).

On Gravity and Flatness

We start on the Earth. Gravity has imbued our world with an inherent structure linked to the principal directions.

Man's cosmology of the world is tied to notions of flatness and planarity. This worldview can be understood through the lens of the human body and its inherent directionality. In early developmental biology, the transformation of a simple spherical ball of cells, the blastula, into a multi-layered organism begins to show the formation of a fixed top and bottom. This inherent sense of up and down, already demonstrates how the world has been organized in terms of a vertical sense of gravitational force.


Blastula
endoderm
mesoderm
primary mesenchyme
secondary mesenchyme
filopodia
invagination of endoderm
secondary mesenchyme
archentron
Gastrula
gut
mouth
anus



Earth View from Near Space
Image obtained from:
http://digitalhint.net/wp-content/uploads/2015/02/Earth-view-from-near-space-wallpaper.jpg

A New Way of Seeing: Life in Outer Space

The identification of these directions has, until now, been taken as a universal constant in architectural design. Our understanding of space depends on six directions on three axes; up-down or height, left-right or breadth, and front-back or depth. In architecture, the plumb line, or the up-down axis, is tied to the force of gravity. The other axes are free to rotate around it. Space on Earth has an anisotropic character. That is to say, it is directionally dependent, as opposed to isotropy, which implies identical properties in all directions. Up and down are distinct and irreversible poles, while left, right, front and back are interchangeable by turning around. Based on gravity, there are three principal directions - up, down, and horizontal. These are tied to basic architectural elements: the ceiling, the floor, and the wall. Walls are not inherently distinct. The floor and the ceiling, on the other hand, are not interchangeable. Architecture can isolate its inhabitants from the cues of the cardinal directions, but architecture cannot divorce itself from the effects of gravity.

Architecture will be freed from the constant pressures of gravity in the eventual migration into outer space.

This project explores the architectural drawings appropriate to describe forms and spaces in zero and artificial gravity. Its focus is on the physical forces associated with life and motion in a rotating environment, and the formal and geometric architectural response to those forces.

Orthographic drawing relies on a flat plane onto which lines are statically inscribed. This project speculates on an alternative drawing that can help to describe habitation and the uncanny experience of life in space. Without the constraints of gravity, we are no longer forced to have plumb walls, flat floors, and even ramps in very specific ratios. Zero gravity presents itself with its own challenges of disorientation and visual confusion. This project juxtaposes the effects of zero gravity with the spaces imbued with artificial gravity generated by centripetal force. Rotation is the only viable means of providing artificial gravity, yet it also has its own effects, such as the Coriolois effect, which causes dizziness when a person walks towards or away from the axis of rotation.

Man's experience in outer space is tied to feelings of disorientation and distortion. This project seeks to understand these perceptual changes in order to adapt the human body to a new way of seeing. One such example was that of Buzz Aldrin and his experience on the moon. Because the moon is only 1/4th the size of the Earth, the horizon was much closer, which caused him to feel disoriented.

Understanding Zero Gravity and Artificial Gravity

Newton's Laws

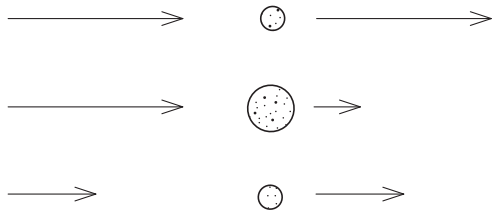
The First Law of Motion: A body at rest will remain at rest, and a body in motion will continue in motion with constant velocity, unless it is compelled to change by forces acting upon it.

The Second Law of Motion: The net force acting upon a body is equal to the product of its mass and acceleration; the direction of the force is the same as that of the acceleration. In equation form:

$$F = m\ddot{R}$$

where:

F is the net force acting upon the body.
m is the mass of the body
$\ddot{R}$ is the acceleration of the body in inertial space.



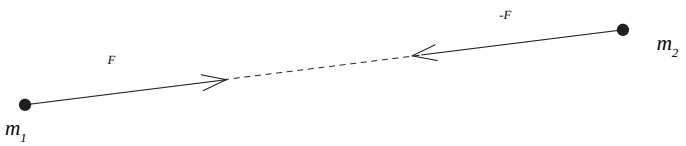
The Third Law of Motion: The mutual actions of two bodies upon each other are always equal and opposite.

The Law of Gravitation: Every body in the universe is attracted to every other body with a force that is directly proportional to the product of the bodies' masses and inversely proportional to the square of the bodies' separation. In terms of mathematical relationships, Newton's Law of Gravitation states that the force of gravity, F_g , between to particles of mass m_1 and m_2 has a magnitude of :

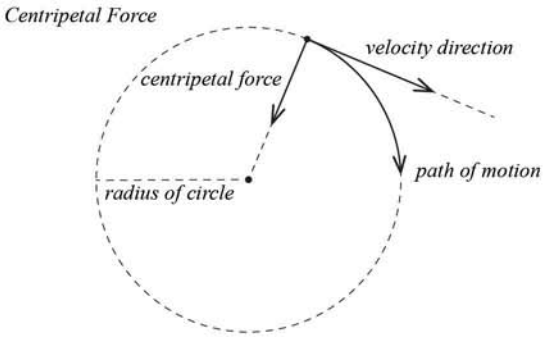
$$F_g = G \frac{m_1 m_2}{r^2}$$

where:

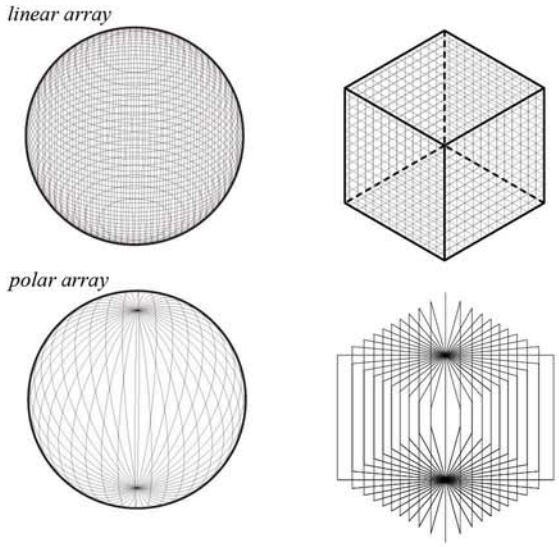
r is the distance between the center of the two masses
G is the gravitational constant



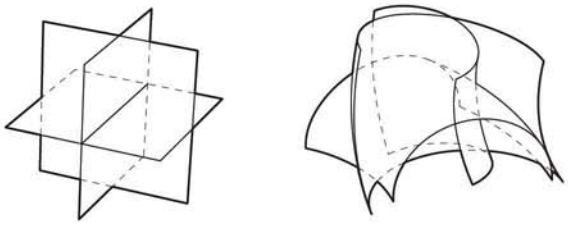
Centripetal Force and Rotation



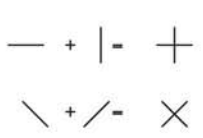
Any motion in a curved path represents accelerated motion, and requires a force directed toward the center of curvature of the path. This force is called the centripetal force which means "center seeking" force.

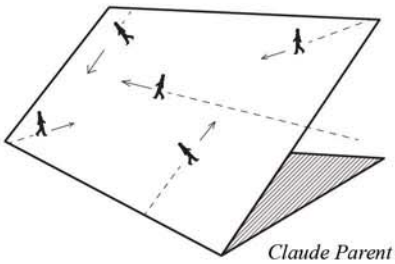


The cartesian grid describes space linearly while a polar array describes space rotationally.



if,

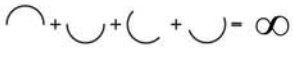


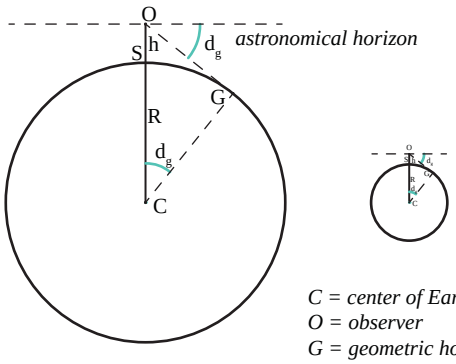


Claude Parent and Paul Virilio

Architects Paul Virilio and Claude Parent began to question our deep insistence on horizontal and vertical surfaces by arguing the merits of the oblique. Diagonal surfaces allow for a multiplicity of inhabitation and a new way of seeing the world.

then:





C = center of Earth
O = observer
G = geometric horizon
OG = observer's apparent horizon
R = radius of the Earth
S = point on the surface
h = observer's height

Distance to the Horizon and Visual Disorientations

"On Earth, we have no awareness of the horizon's curvature. But the moon is only 1/4th the size of the Earth. The horizon was much closer than I was used to, and I even felt a bit disoriented." - Buzz Aldrin

The horizon is the apparent line that separates earth from sky. It is the line that divides all visible directions into two categories: lines that intersect the Earth's surface, and those lines that do not. The word horizon derives from the Greek "ὁρίζων κύκλος" horizōn kyklos, "separating circle", from the verb ὁρίζω horizō, "to divide", "to separate", and that from "ὅρος" (oros), "boundary, landmark".

The diagram above shows a vertical plane through the center of the Earth (at C) and the observer (at O). The radius of the Earth is R, and the observer's eye is a height h above the point S on the surface. (It should be noted that the height of the eye, and consequently the distance to the horizon, is greatly exaggerated in this diagram). The observer's astronomical horizon is the dashed line through O, perpendicular to the Earth's radius OC, whihe observer's apparent horizon is the dashed line OG, tangent to the surface of the Earth. The point G is the geometric horizon.

Elementary geometry tells us that, because the angle between the dashed lines at G is a right angle, the distance OG from the observer (O) to the horizon (G) is related to the radius R and the observer's height h by the Pythagorean Theorem:

$$(R + h)^2 = R^2 + OG^2$$

or

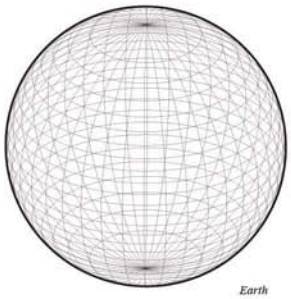
$$OG^2 = (R + h)^2 - R^2 .$$

But if we expand the term $(R + h)^2 = R^2 + 2 R h + h^2$, the R2 terms cancel, and we find

$$OG = \sqrt{(2 R h + h^2)} .$$

It's customary to use the fact that $h << R$ at this point, so that we can neglect the second term. Then

$$OG \approx \sqrt{(2 R h)}$$



Earth

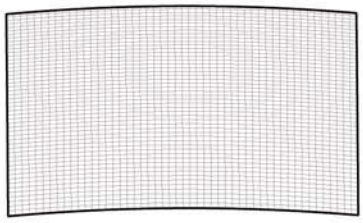
d = 7917.5 miles

R = 3,958.75 miles

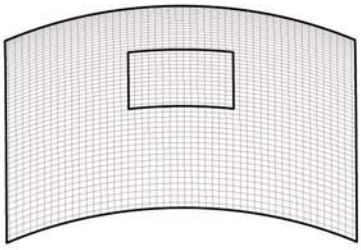
Moon

d = 2,159 miles

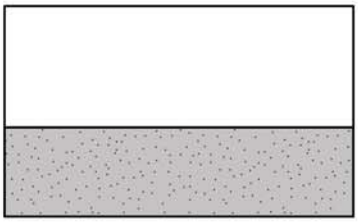
R = 1079.5 miles

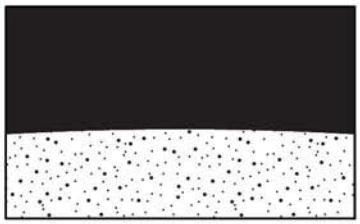


For an observer on the ground with eye level at h = 5 ft 7 in, the horizon is at a distance of 2.9 miles. The curvature of the earth is not apparent.



For an observer on the ground with eye level at h = 5 ft 7 in, the horizon is at a distance of 1.51 miles. The curvature of the earth is not apparent.





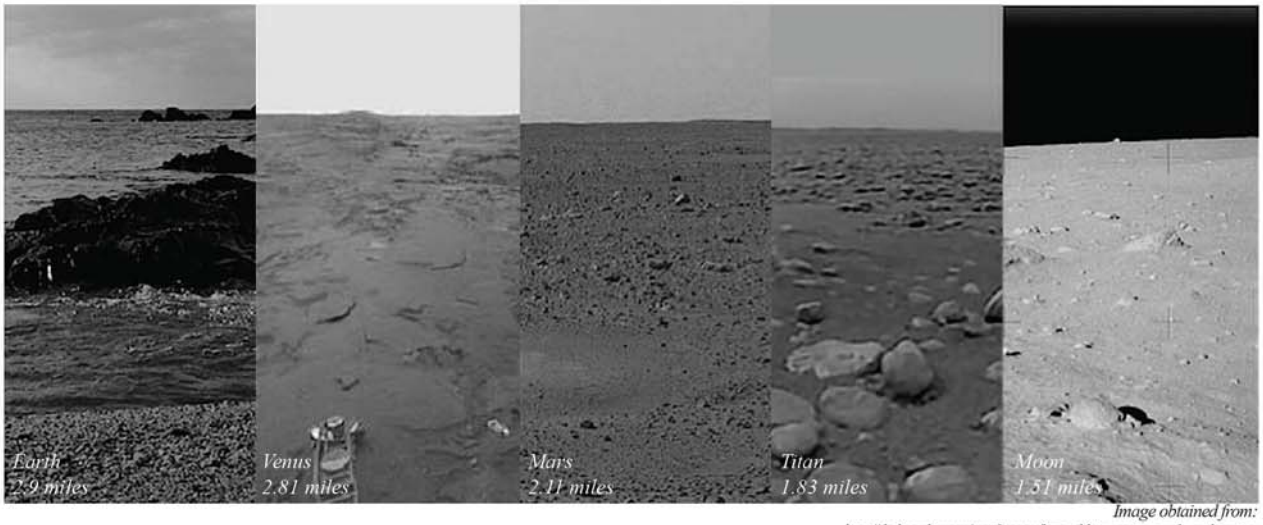
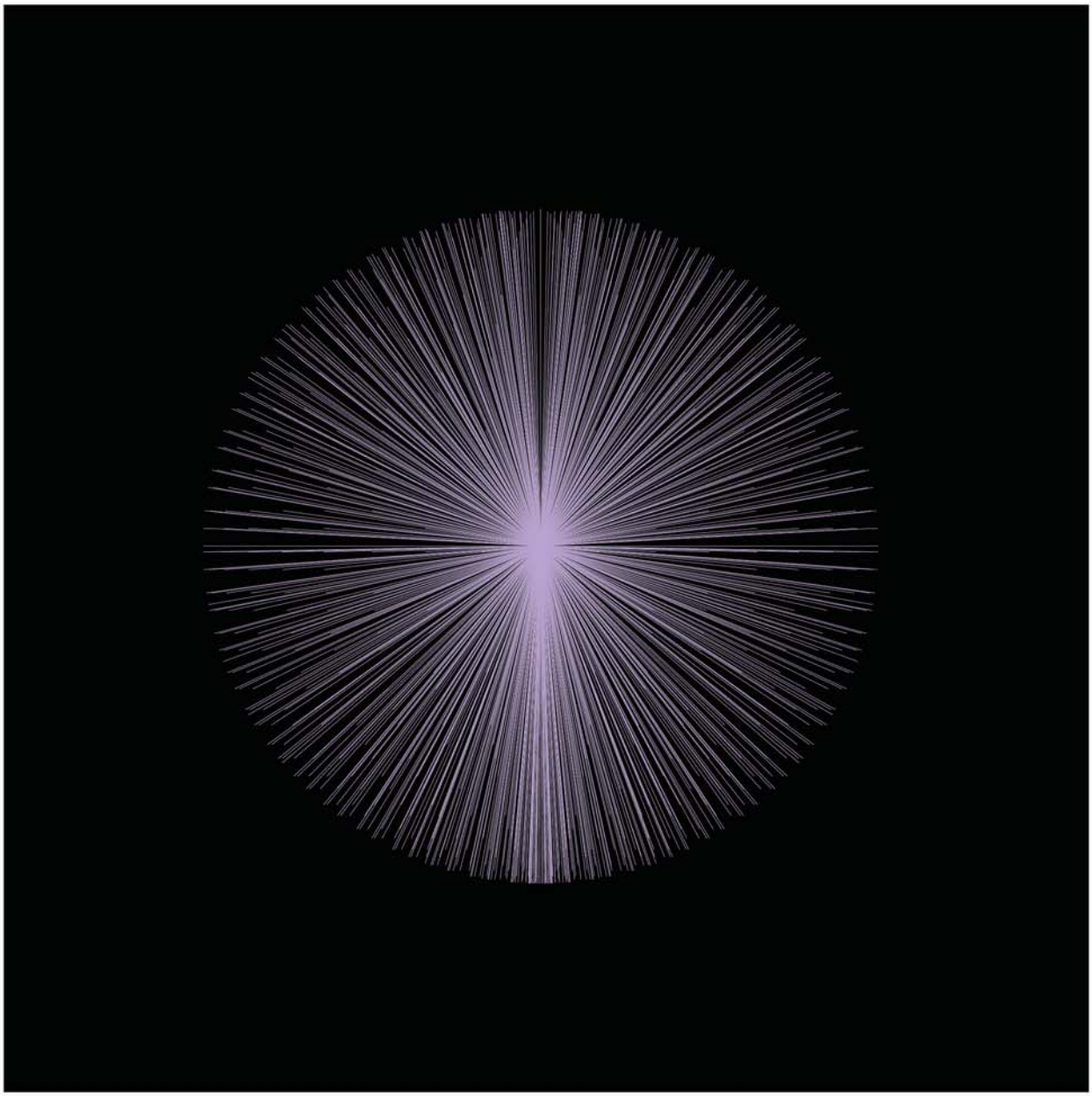


Image obtained from:
http://dailygarlic.com/userImages/buzz-aldrin-quoton-earth-we-have.jpg

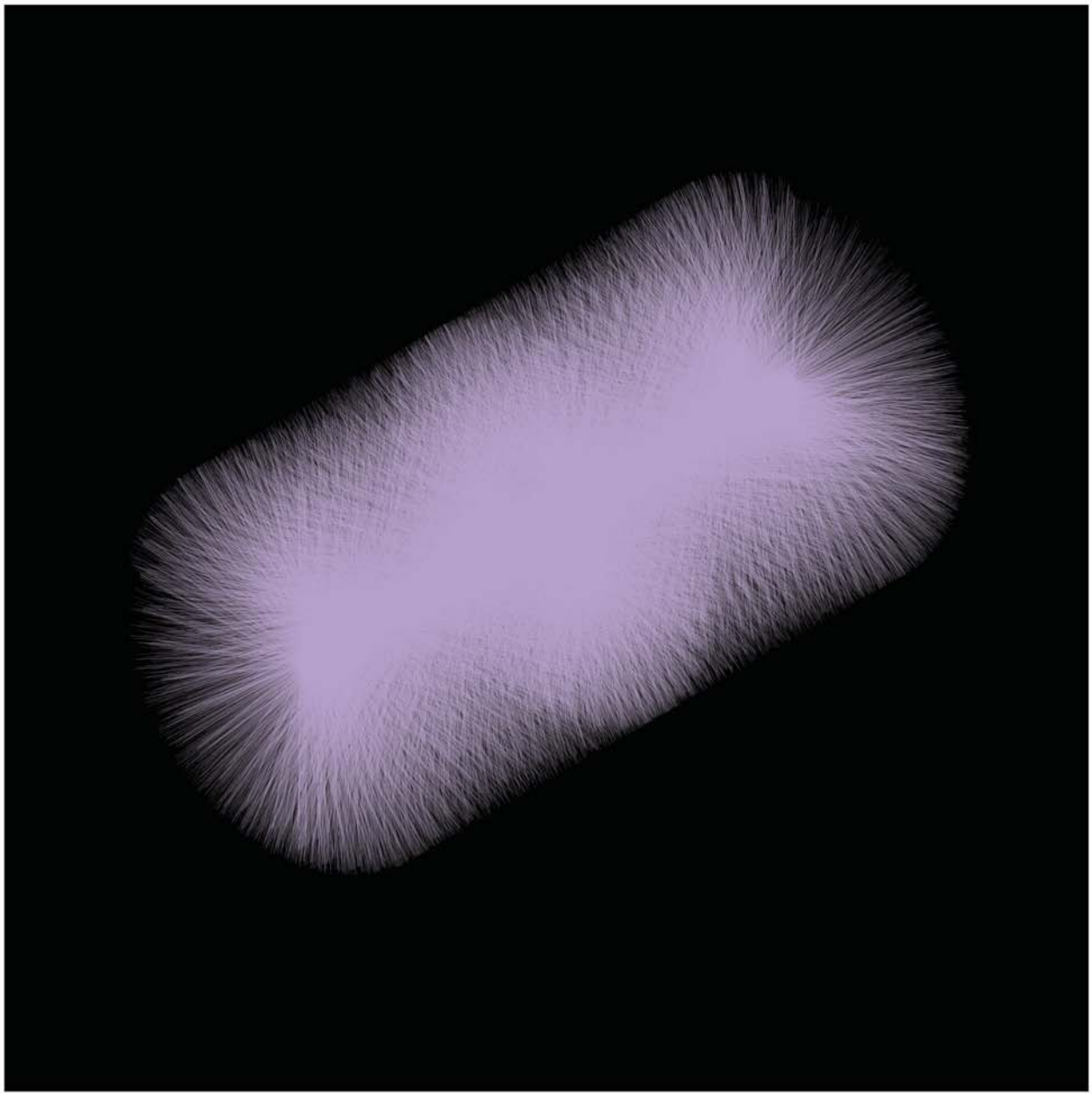
Initial Genealogy of Rotational Space Generators

My initial genealogy of rotational space generators started with a point, a line and lastly, a thickened sphere.



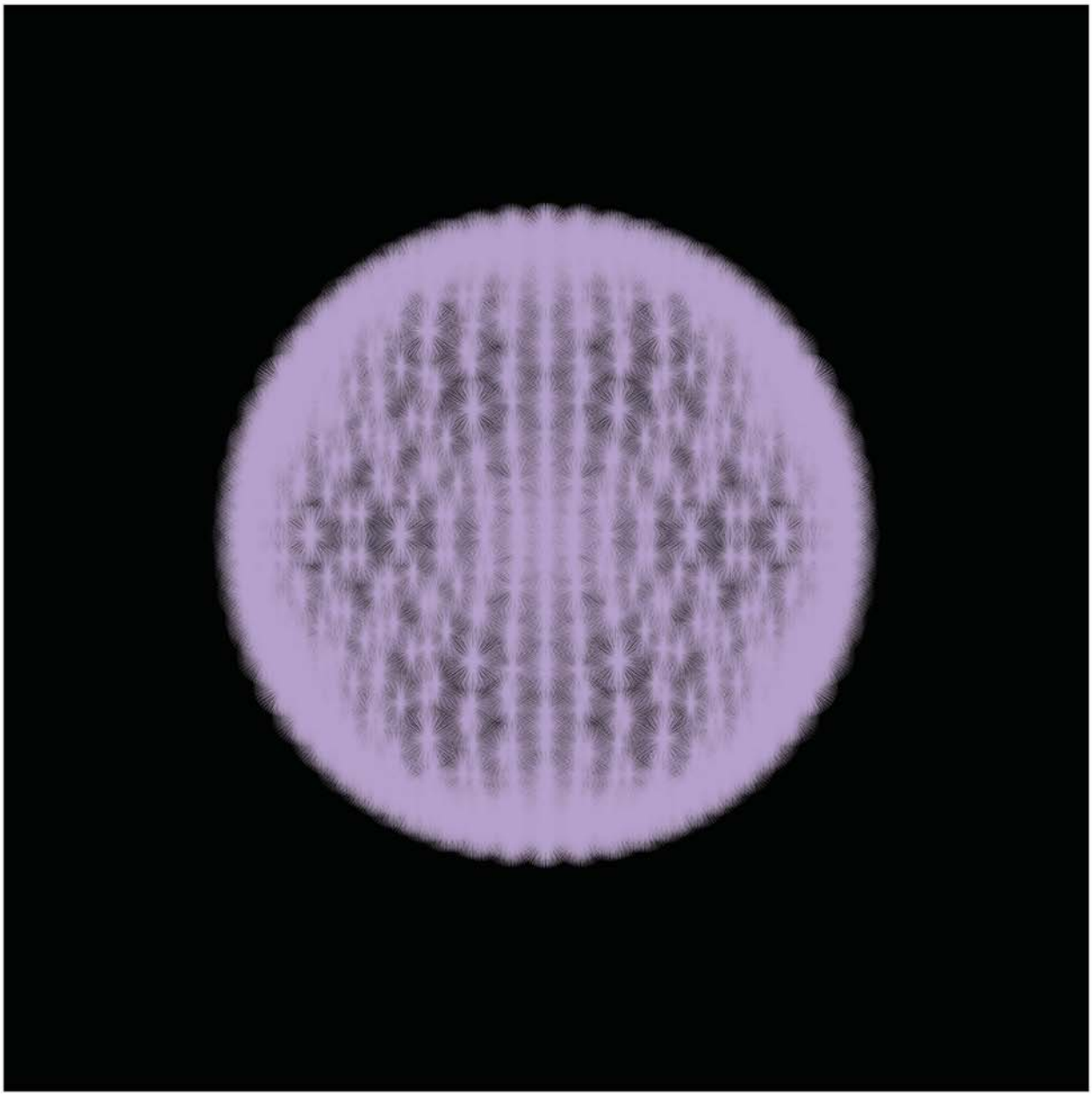
Point

A point marks a position in space. In a system of rotation, a point can be thought of as a static marker that remains stable and fixed. Lines could extend radially from the point, but its connection to a center could always be read. Stability versus instability, fixed versus constantly changing, static versus variable. These are all relationships that can be established by a point.



Line

Next, a line. A line can act as a path of a moving point. In rotation, it can generate a curving path that undulates up and down. No longer tied to the laws of gravity, this path could create topological space with the potential of creating new experiences in zero gravity. On the other hand, these lines are also crucial in designing the framework needed to create centripetal force.

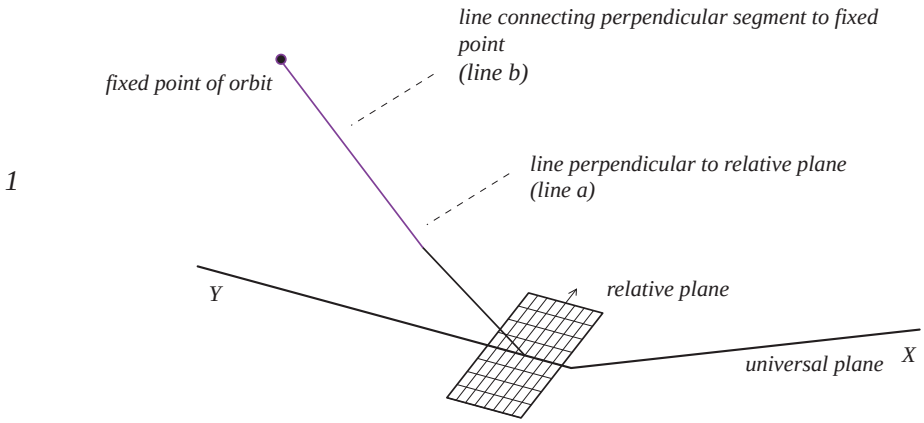


Thickened Sphere

Lastly, the thickened sphere was used as a spatial diagram to visualize the positive or negative space that can result from lines radiating out from a point. One can begin to imagine these rotating shapes as inhabitable spaces.

Rotation Diagrams and Degrees of Freedom

The initial genealogy of rotational space generators led me to the construction of line drawings with an embedded logic of rotation. Several degrees of freedom were at play in these rotations, in hopes of representing a technique that moved away from the flat planes associated with gravity.



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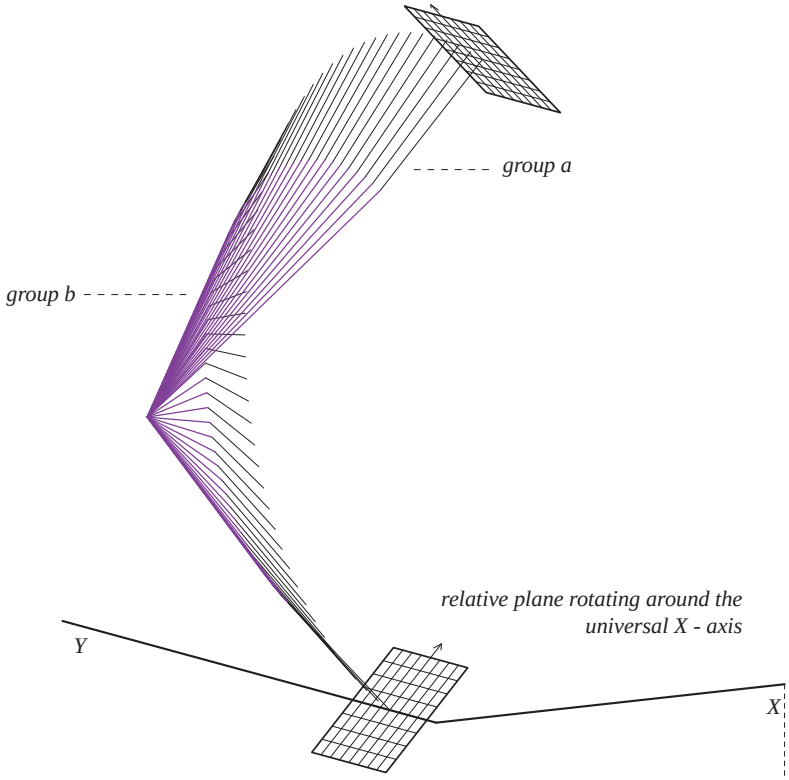
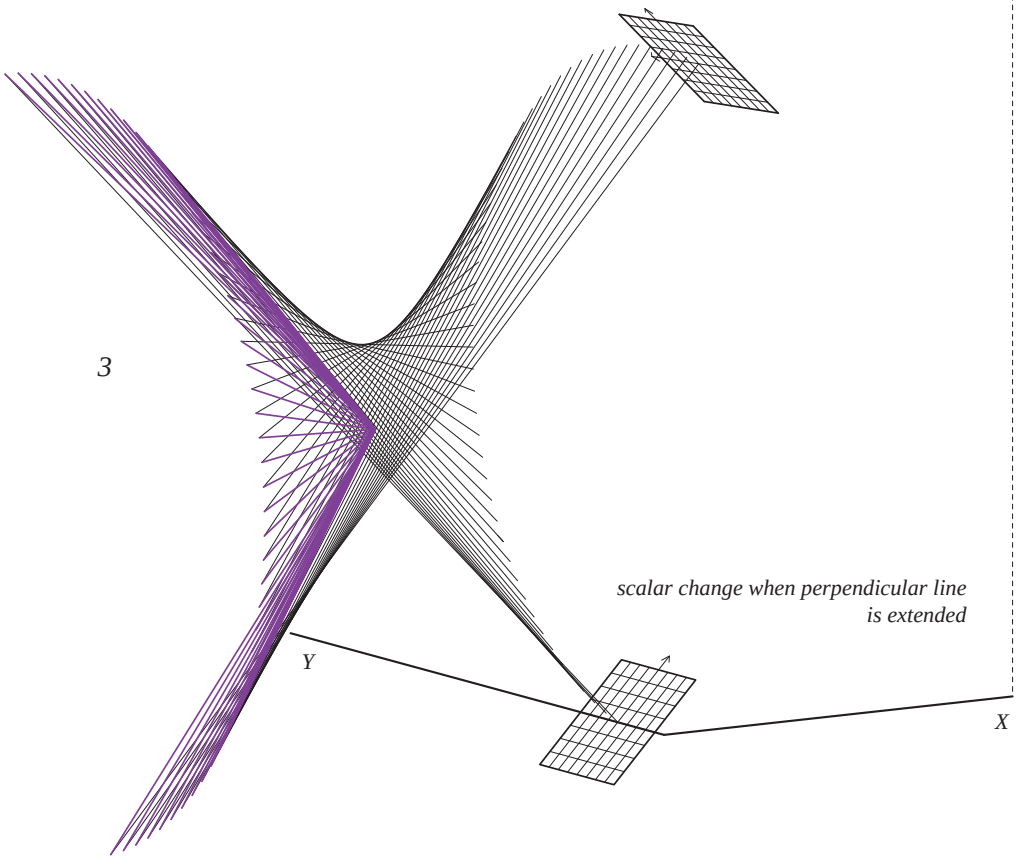
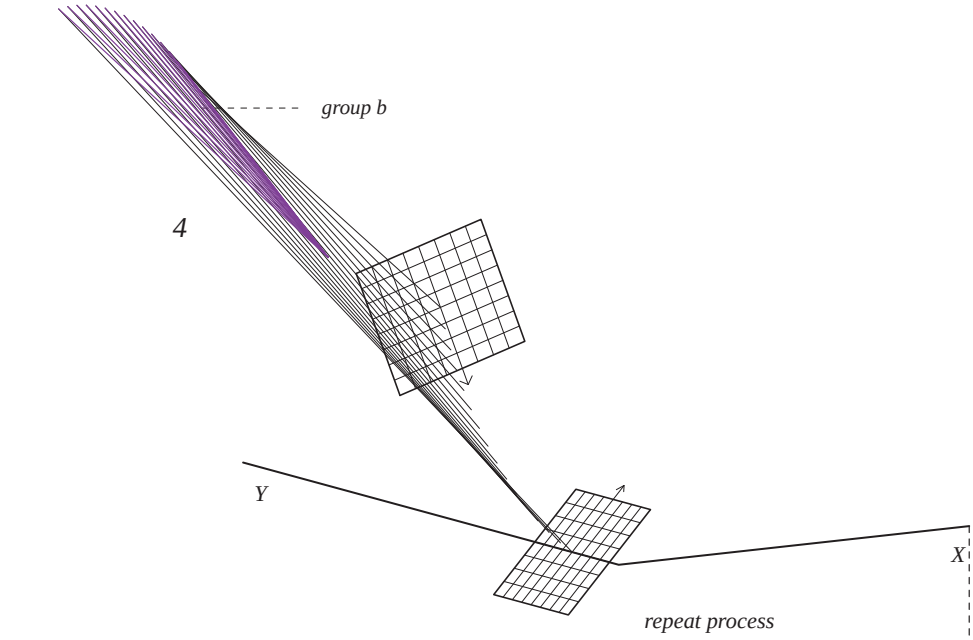
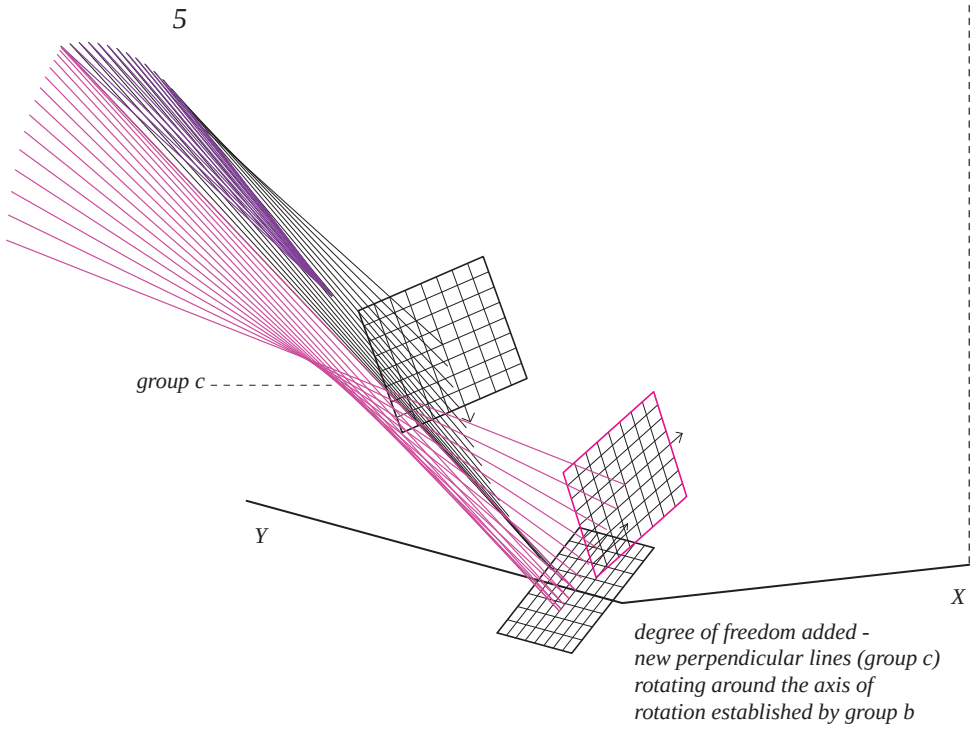
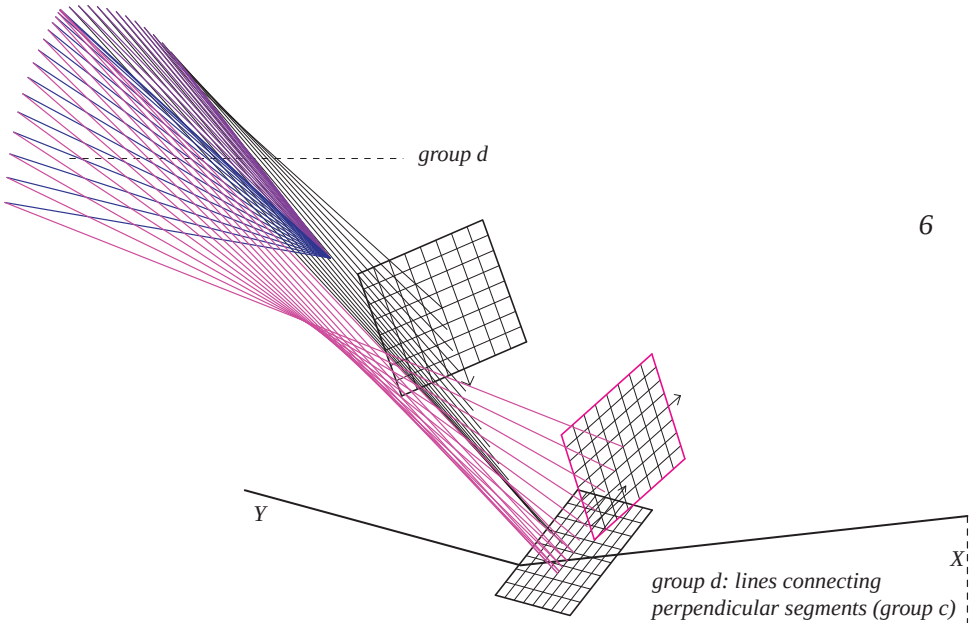

group a
group b
relative plane rotating around the
universal X - axis
Y
X

3


scalar change when perpendicular line
is extended
Y
X

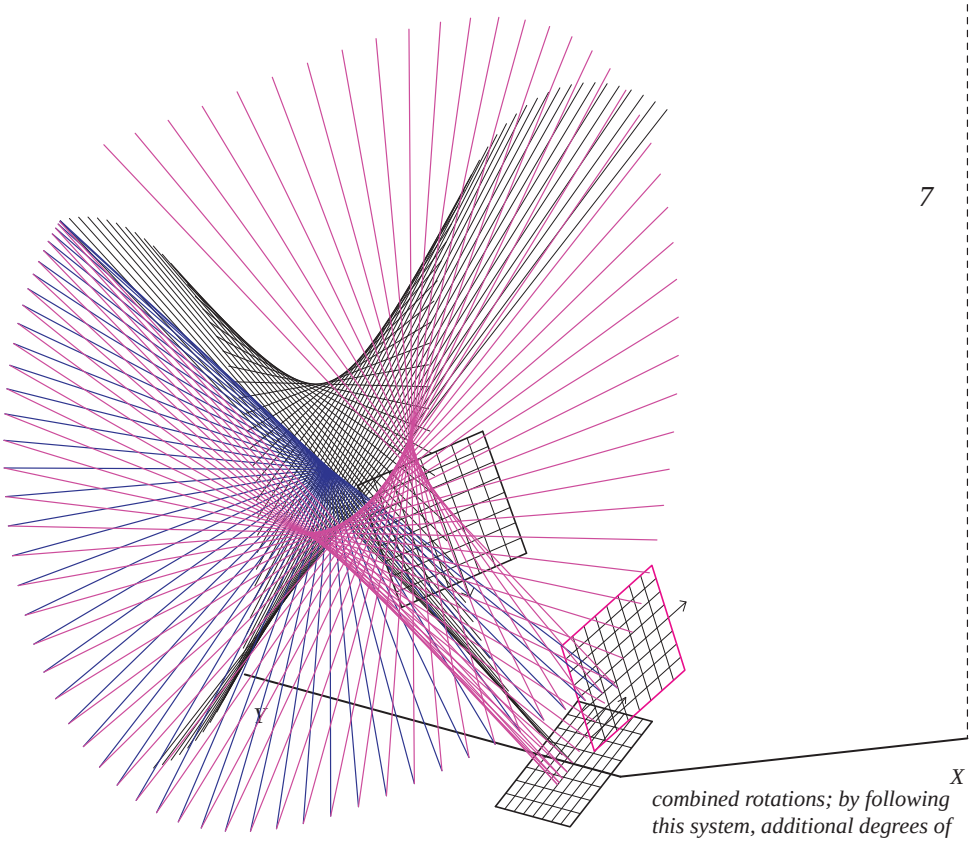

group b
4
Y
X
repeat process


5
group c
Y
X
degree of freedom added -
new perpendicular lines (group c)
rotating around the axis of
rotation established by group b



6

group d: lines connecting perpendicular segments (group c) to fixed point

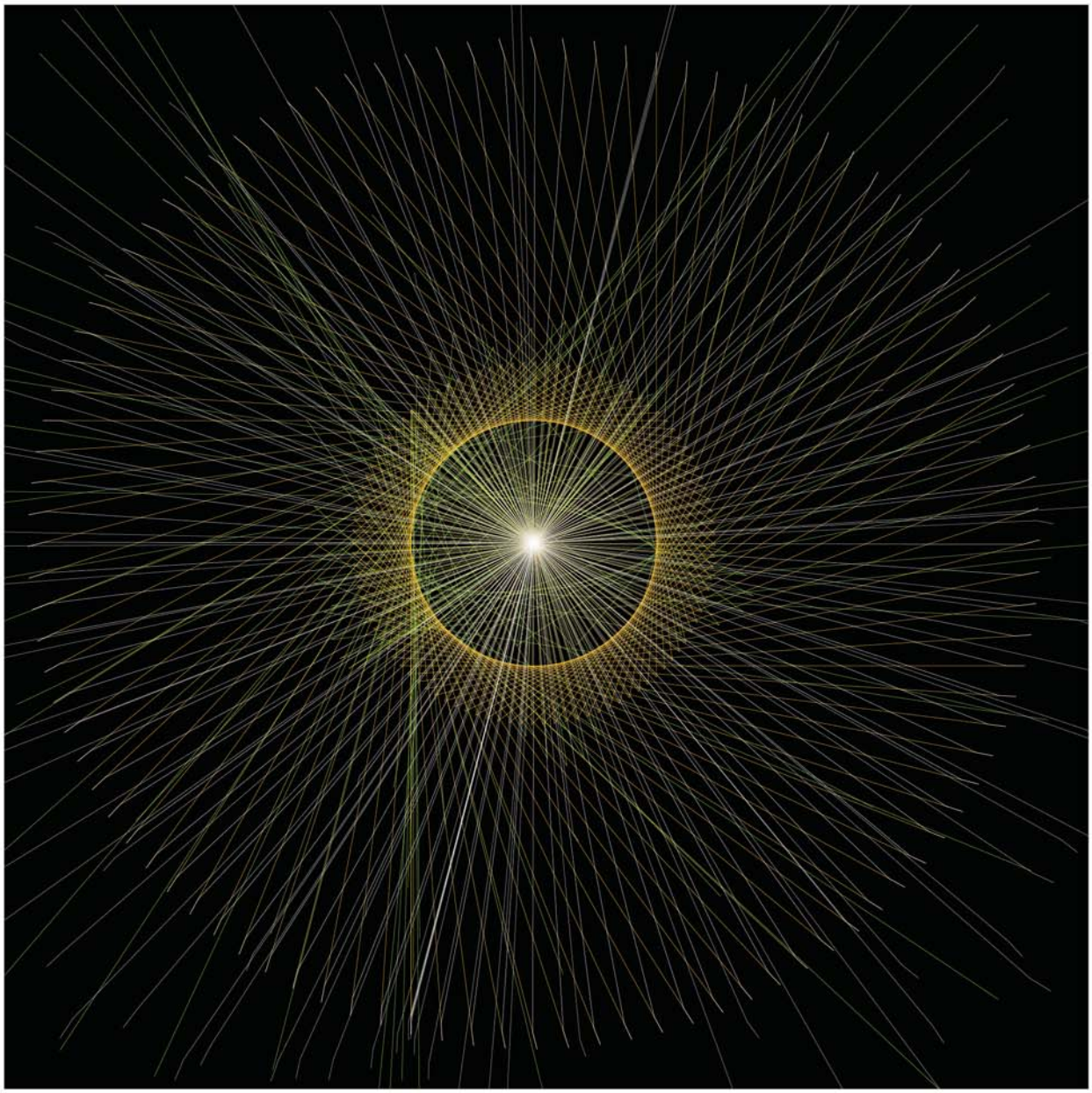


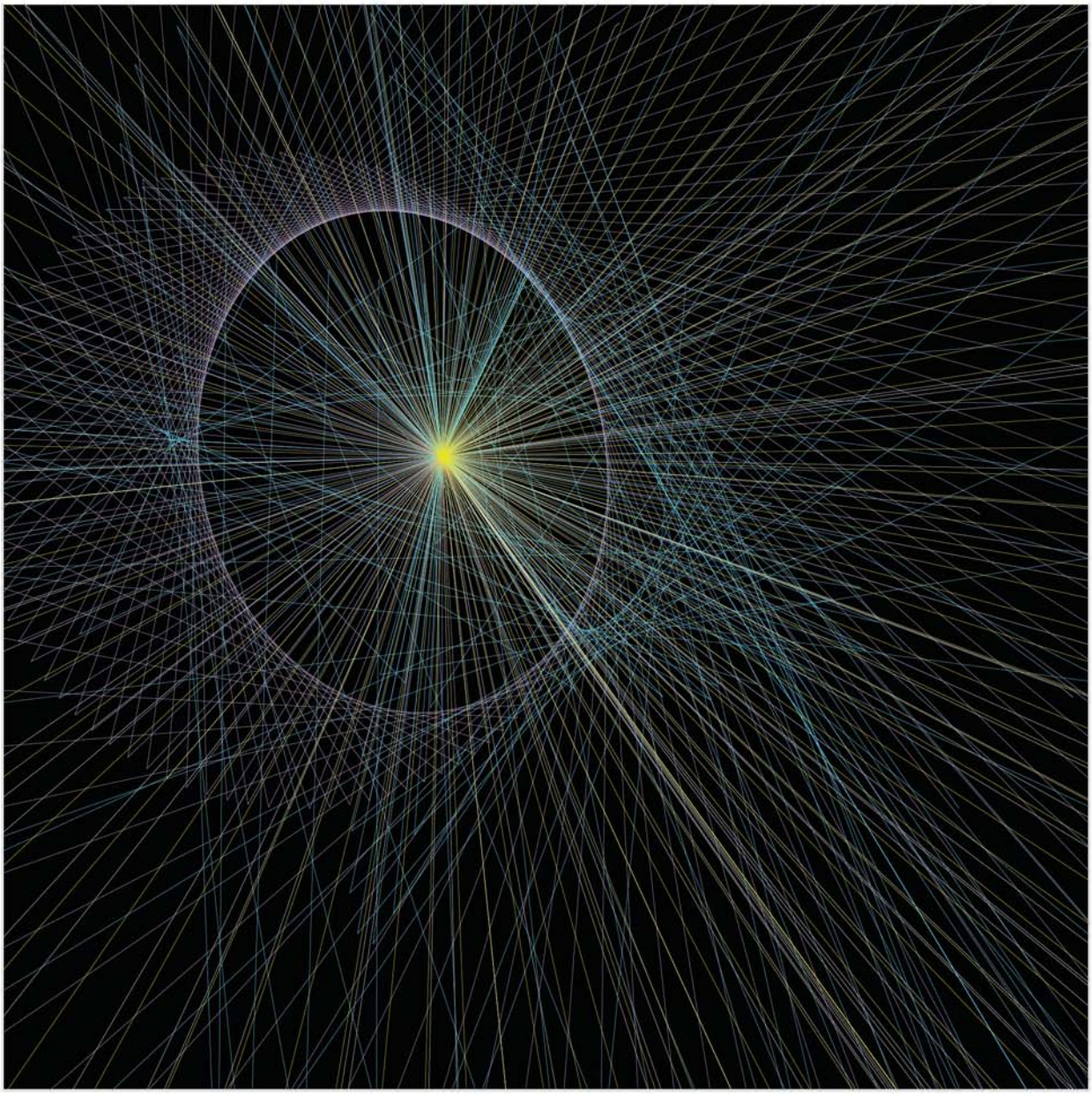
7

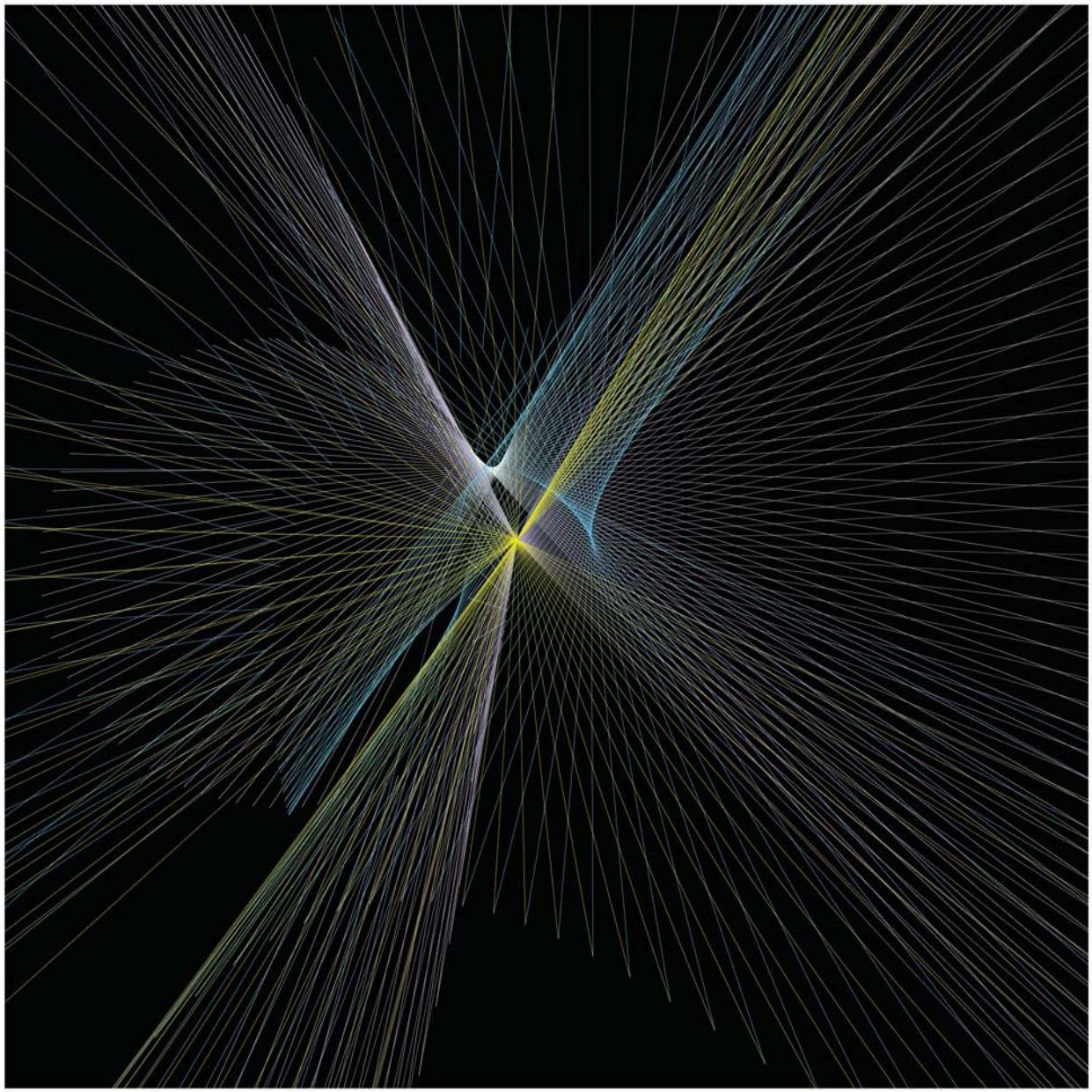
combined rotations; by following this system, additional degrees of freedom could be added infinitely

The Visualization of Rotation

The following three drawings attempt to visualize rotational space according to the logic established by the system outlined in the previous diagrams. Several degrees of freedom have been applied to the logic of the generation of each line, and the rotation of each axis depends on the rotation of the previous axis. These drawings are visualizations of rotational movement established by new relative planes and their relationship to a point. Rotations have been compounded, and additional degrees of freedom could be added infinitely.







Rotational Axes and Degrees of Freedom

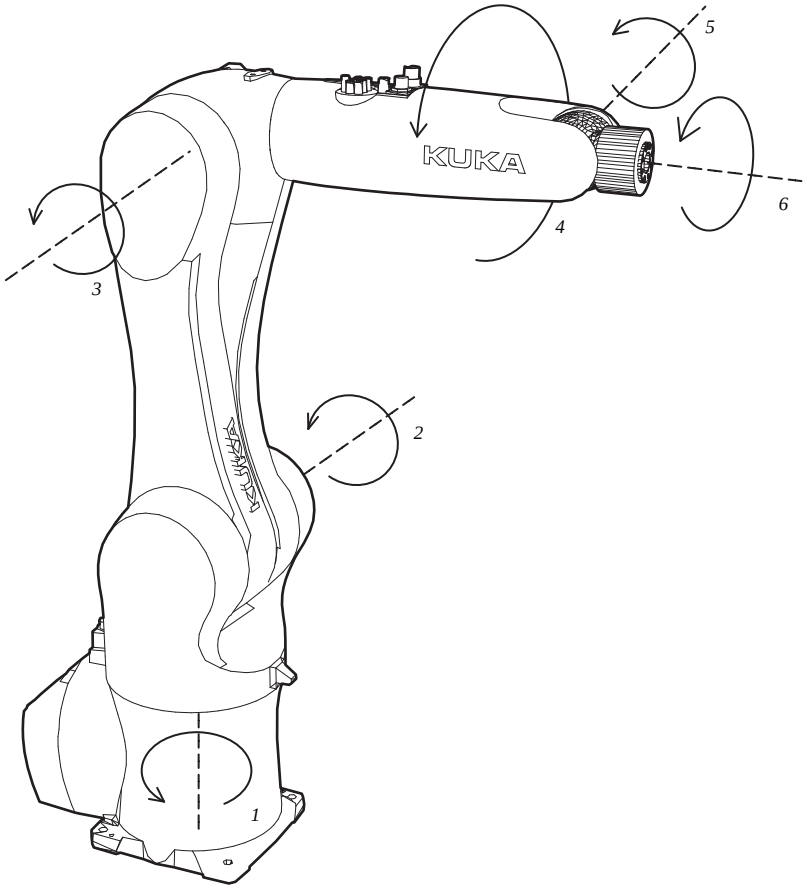
Contemporary architects design on the computer within a 2D interface designing three dimensional spaces. Drawings persist on a two dimensional plane. These light drawings avoid a flattening of space by keeping the three dimensionality of the project. Speculating on the future, drawings may no longer be thought of as static, flat artifacts, but instead, dynamic visualizations that lift up and free themselves from the drafting board or computer screen.

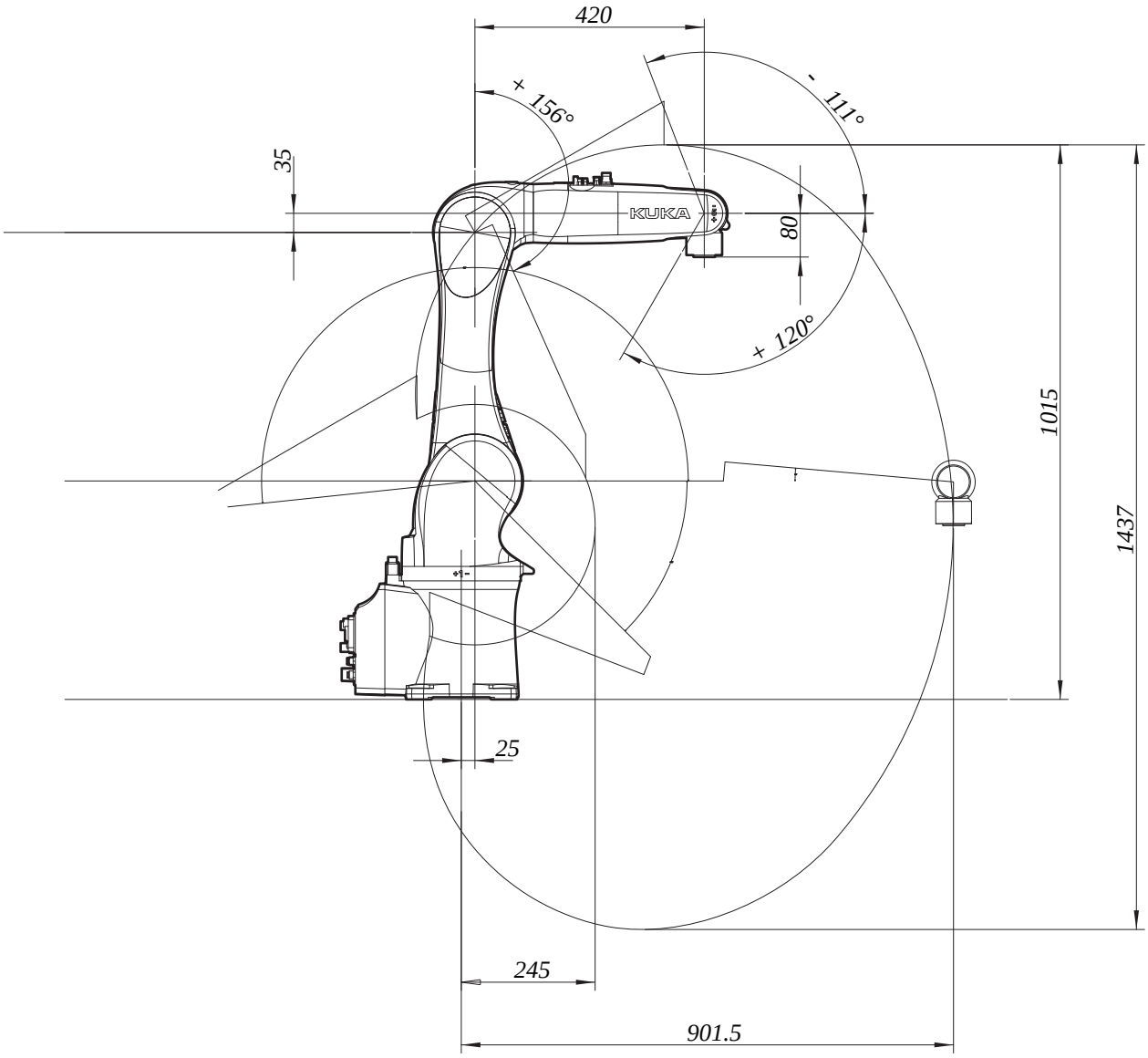
By focusing on contemporary architectural drawing, this project seeks to explore the future of drawing in an age where orthographic architectural drawing has disappeared. In his essay, "New Massings for New Masses: Collectivity After Orthography," John May stated, "We once imagined architectural possibilities by pushing ink and graphite across mechanical surfaces. We called that process "orthographic drawing." We now push buttons and keys on electronic surfaces to produce "models." These models do not contain drawings, but rather simulations of all possible drawings, because "cutting" through an electro-topological model- "making 2d"- bears no relation to the task of hand-mechanically drawing an orthographic plan. The pushing of buttons is neither better nor worse than orthographic drawing, but despite all visual similarities the two are separated by a techno-epistemic chasm that cannot be crossed."[4]

What does it mean to construct drawings in the digital realm, and how do these tools affect the construction of narratives? Unlike construction drawings, the aspiration of architectural drawings is to not only describe a project formally and according to its appearance, but to also inscribe some type of meaning into each line and figure, to express an intrinsic need to unpack and to illustrate an internal logic and statement about the order of things.

By analyzing the intimate relationship between drawings and objects, this project seeks to question and understand the structure and execution of visual constructs in hopes of realizing a generative methodology. The juxtaposition of orthographic drawings to new techniques that will speculate on notions of unfixed directionality, anti-singularity, and an overall multiplicity of views will be explored in order to question architecture's relationship to its own history and test whether these new methodologies could elucidate novel interpretations and meaning in the description of spaces.

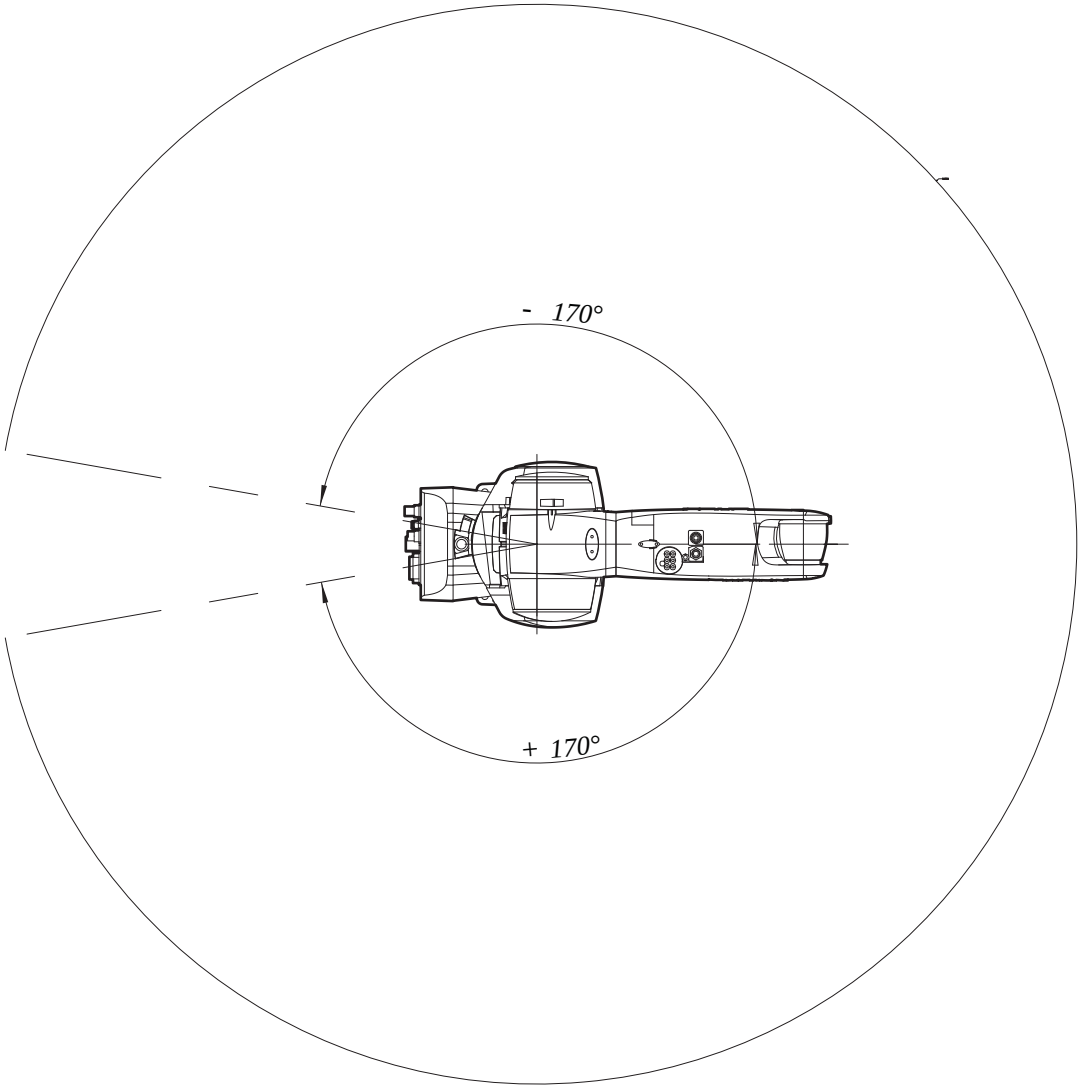
4 John May, "New Massings for New Masses: Collectivity After Orthography," (Cambridge, MIT Press, 2014).


KUKA
1
2
3
4
5
6

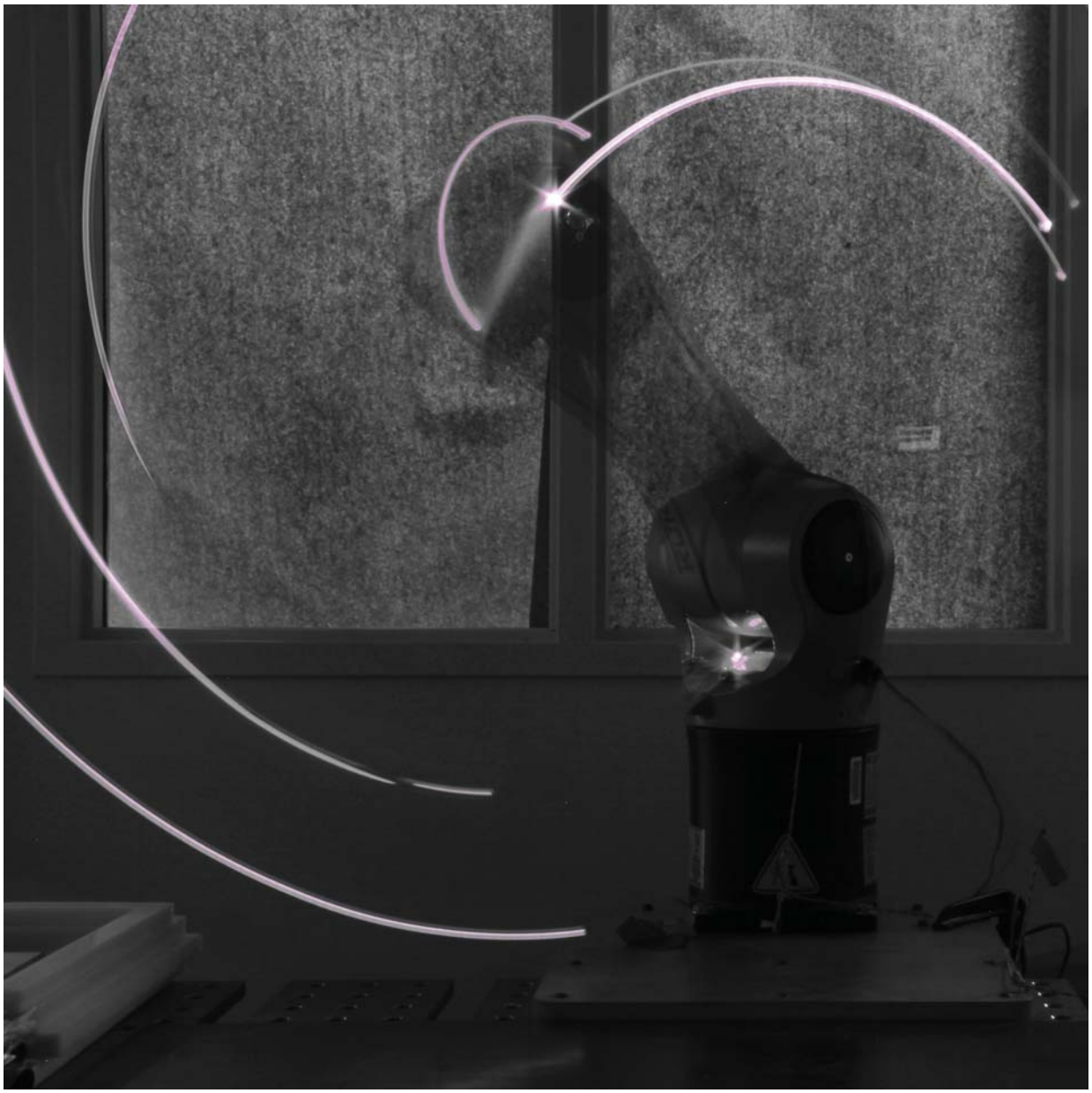


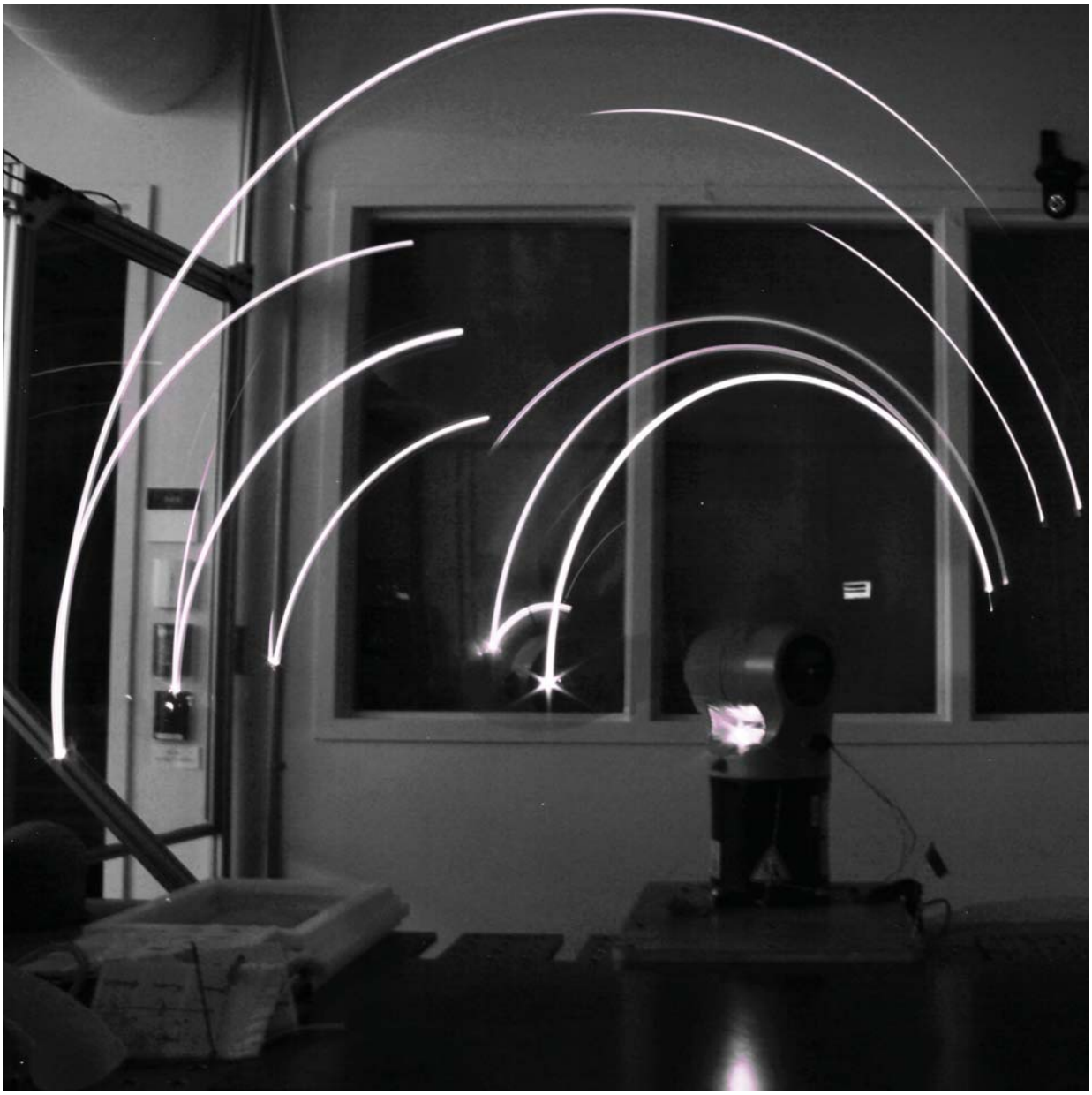
Speculative Light Drawings

The internalized logic of increasing degrees of freedom and cumulative intelligence led to explorations with the Kuka robotic arm. Orthographic drawing relies on a flat plane onto which lines are statically inscribed. The Kuka robotic arm allows for the measured and controlled movement of six rotating axes. This exploration projects a new type of drawing that will be needed to describe spaces that are no longer composed of flat planes governed by gravity. The “light drawings” are inscriptions that describe spaces generated by centripetal forces. The movements of the robot arm trace the movement of lines generated by a rotational logic.


- 170°
+ 170°

Speculative Light Drawings





A Viewing Apparatus

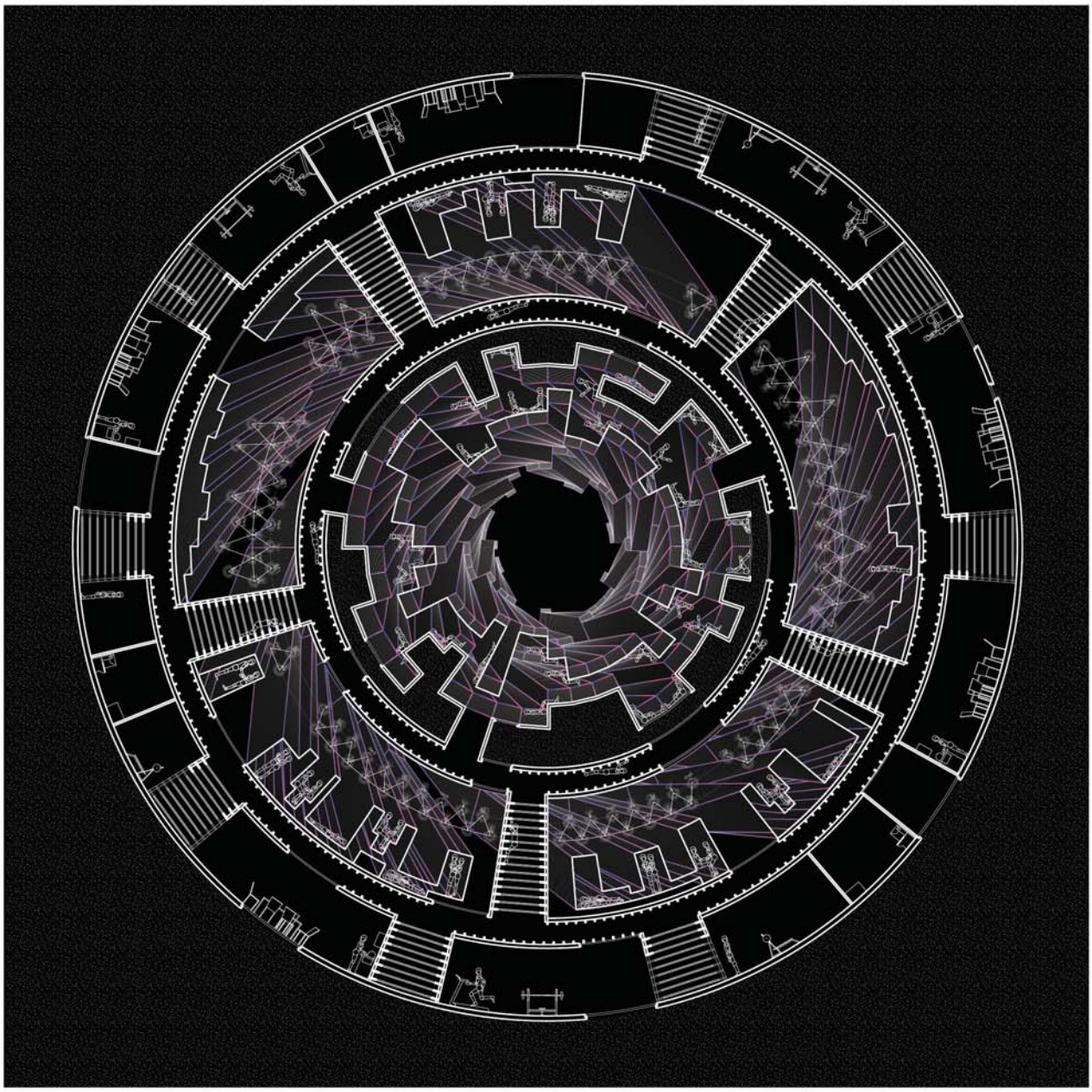
The space capsule is a viewing apparatus that tries to confront the issues of perception that are inherently extraterrestrial. In outer space, rotations affect the ways that we perceive our own bodies in terms of their relationship to a ground. In the space capsule, the artificial ground is created by artificial gravity. The centripetal force generated to simulate gravity is a spinning apparatus. This is in fact another degree of freedom added to a celestial system of orbit.

This project seeks to understand the perceptual changes that occur in rotational space in order to adapt the human body to a new way of seeing. The visualization of movement through the presence of the human body and its role in orientation and perception set the parameters for an experiential representation of life in space.

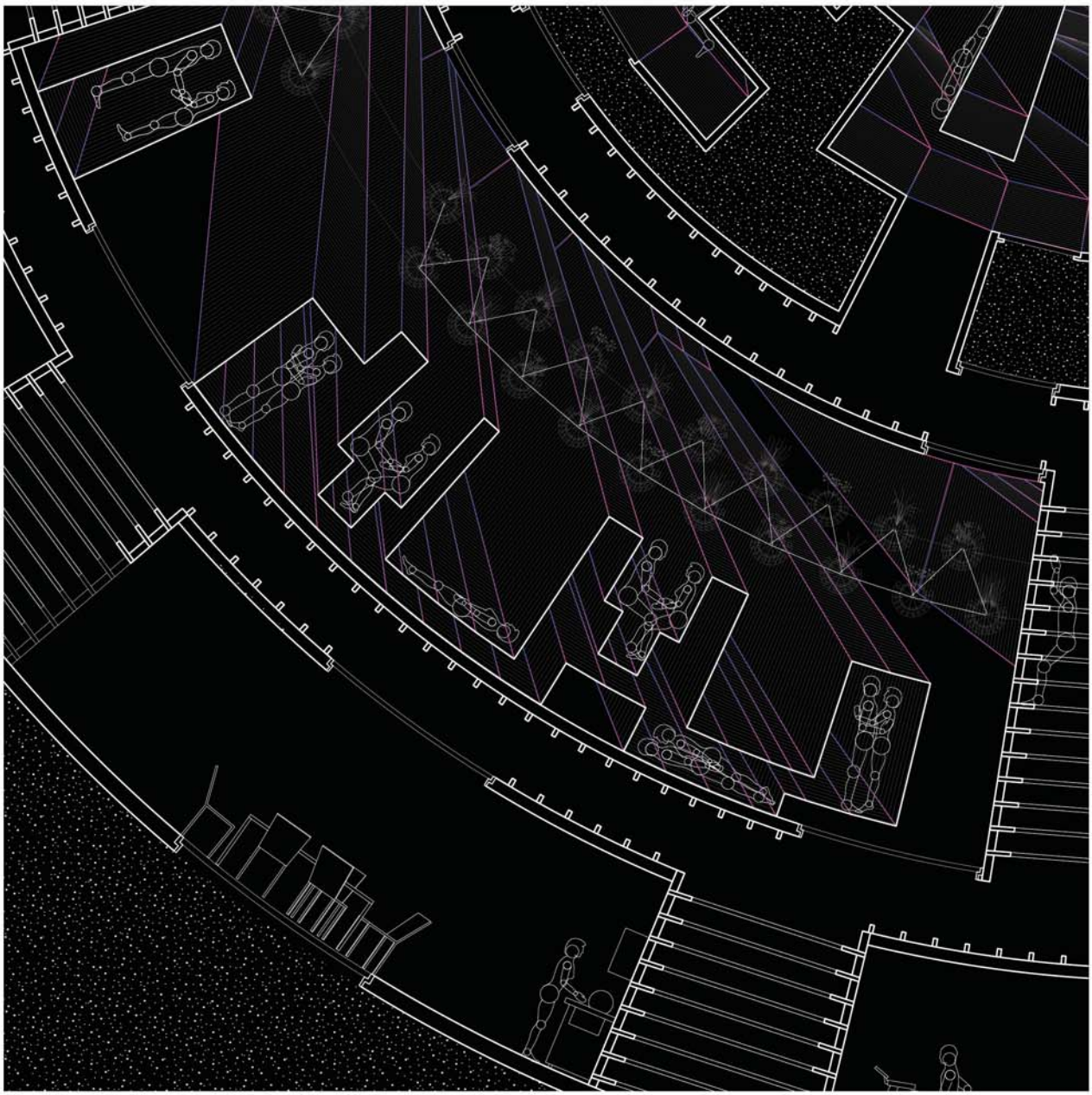
The space capsule is organized into three rings, each rotating at a different rate, connected by double sided corridors. Conceptualized as a domestic space for ten families, the program has been divided into three rings according to varying levels of artificial gravity. The outer ring simulates the gravity experienced on Earth. The kitchen, dining space, and physical activity facilities are all housed in the outermost area of the capsule. This section of the capsule is eerily familiar. The domestic space is governed by the same physical laws as on Earth, and the only visual cues that signal to something different is the slight curvature of the ground and the ceiling.

The intermediate ring supports life in half-gravity. More private quarters are located in this space, along with the storage space and greenhouse. In half-gravity, humans are able to lift heavy objects with less exertion, and jump to greater heights, and plants are able to grow in this environment.

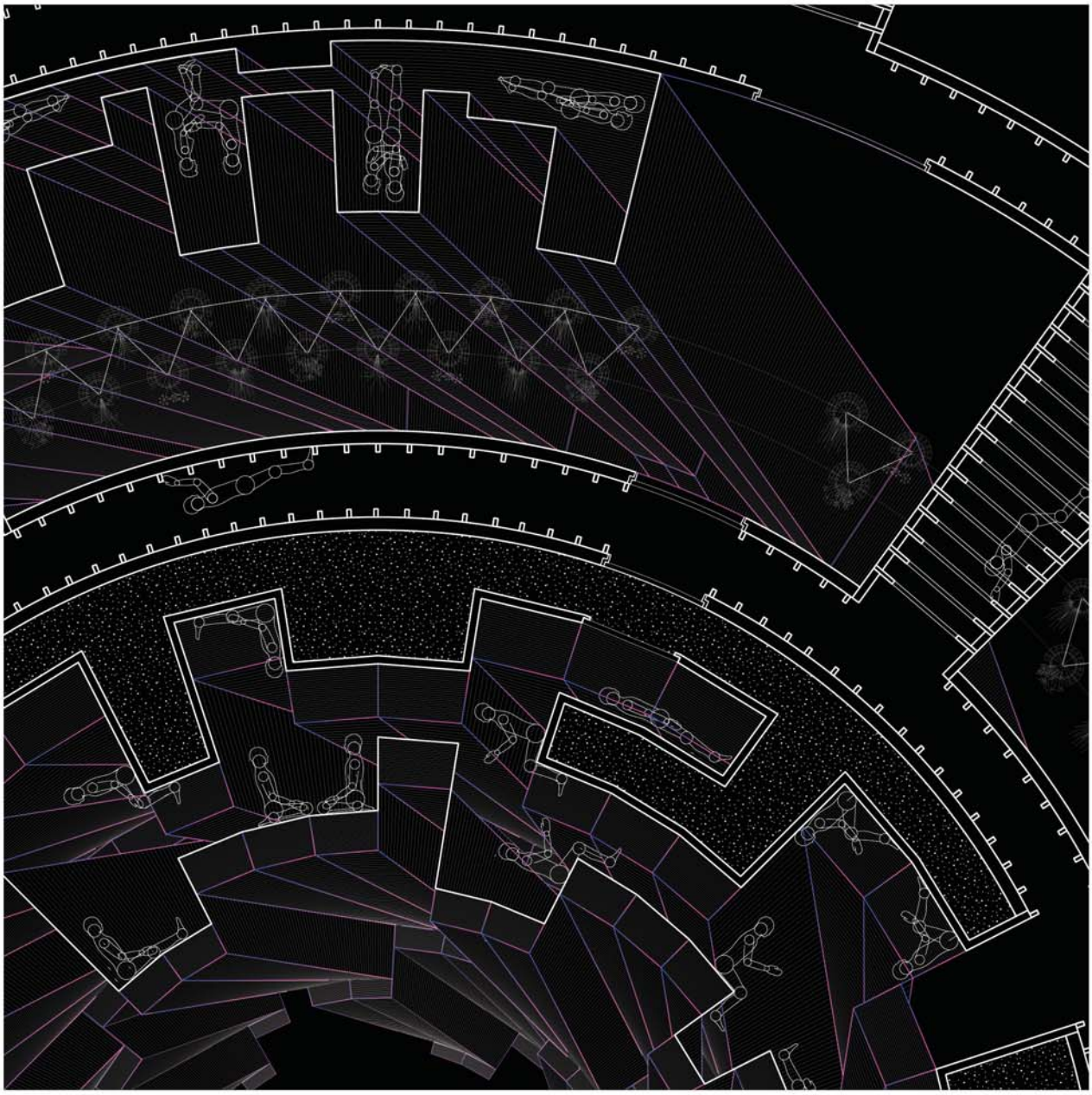
Lastly, the inner ring has zero gravity, and has been conceptualized as the communal living space where all of the inhabitants could come together. The communal lounge-scape has been designed to fit the human body in different orientations for comfortable socializing.



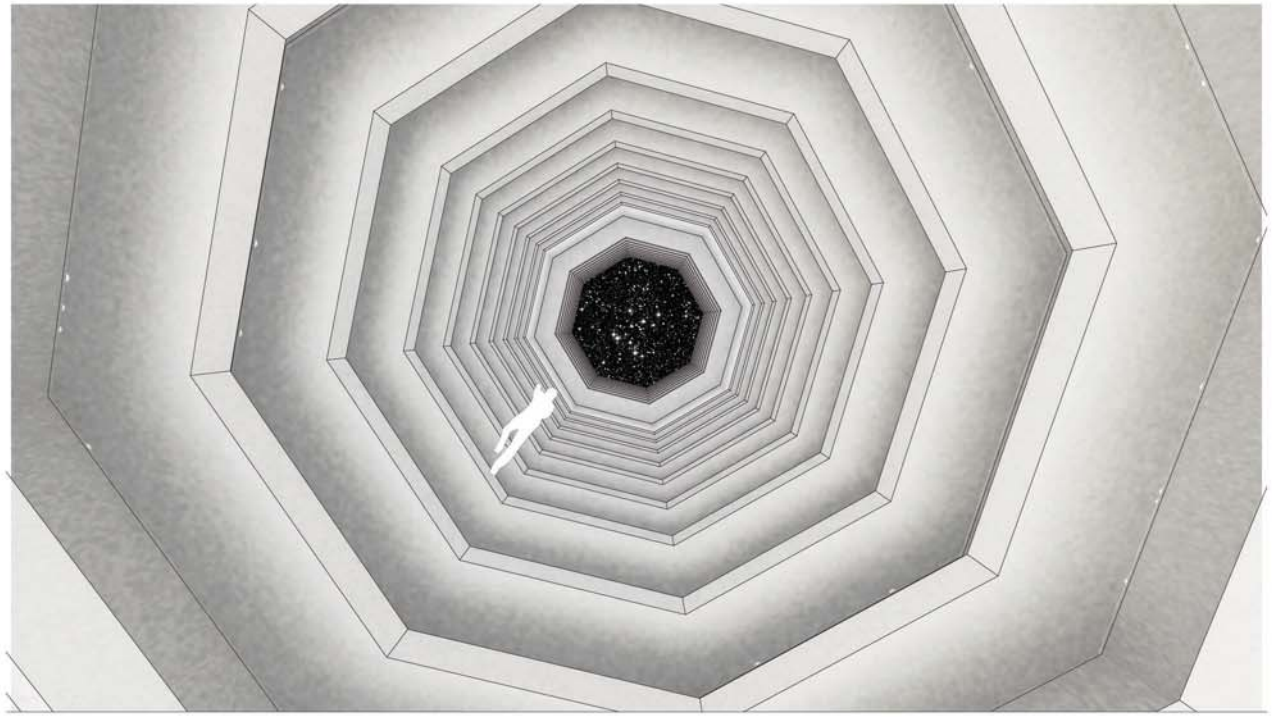
section of space capsule



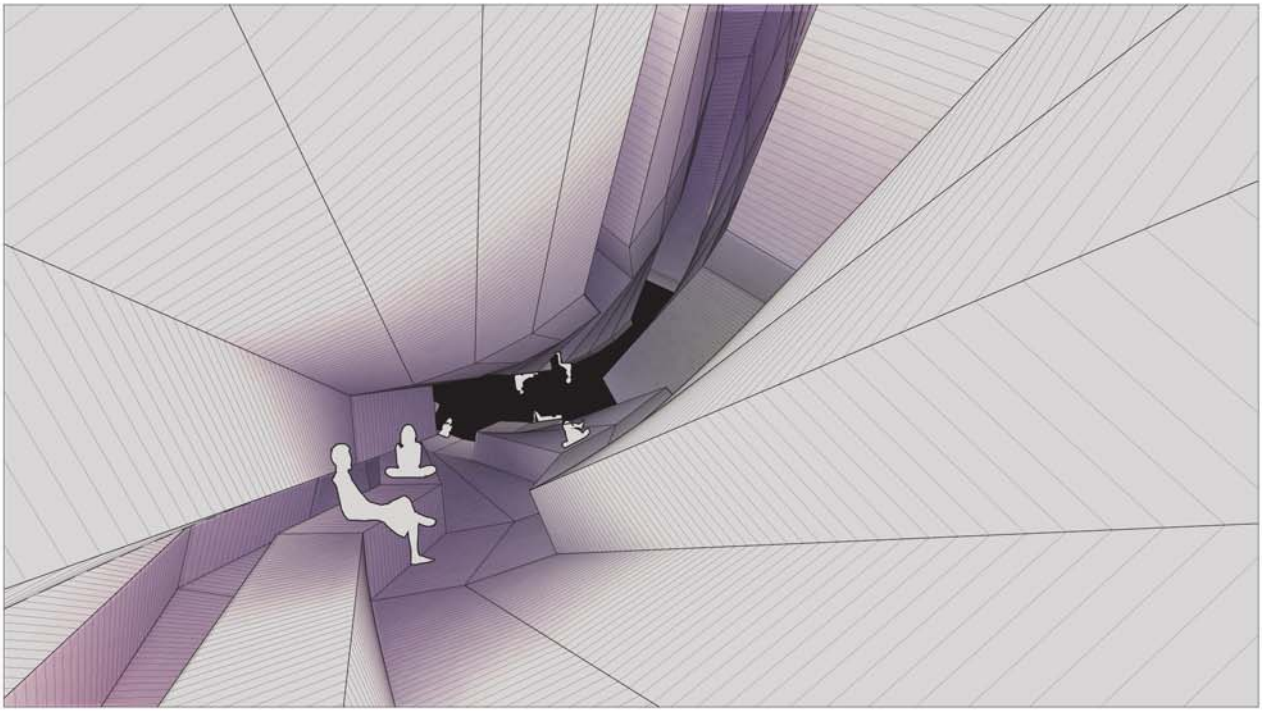
close-up of outer ring and intermediate ring



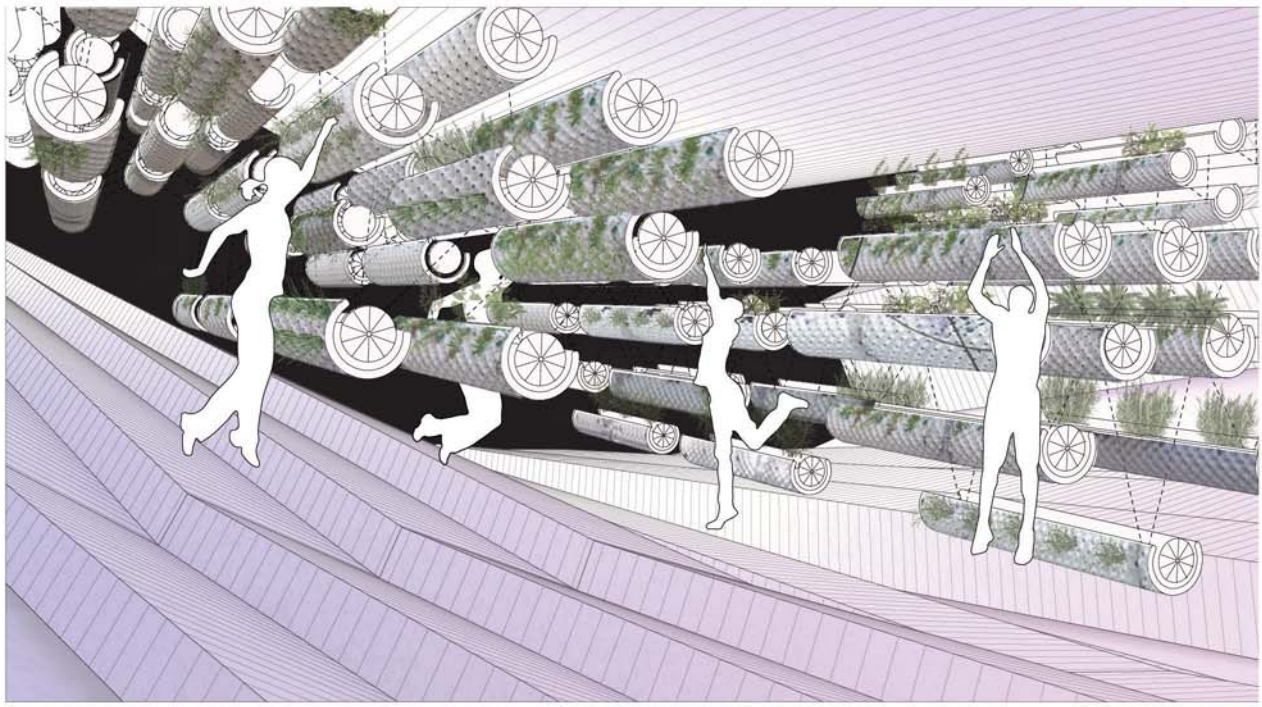
close-up of intermediate ring and inner ring



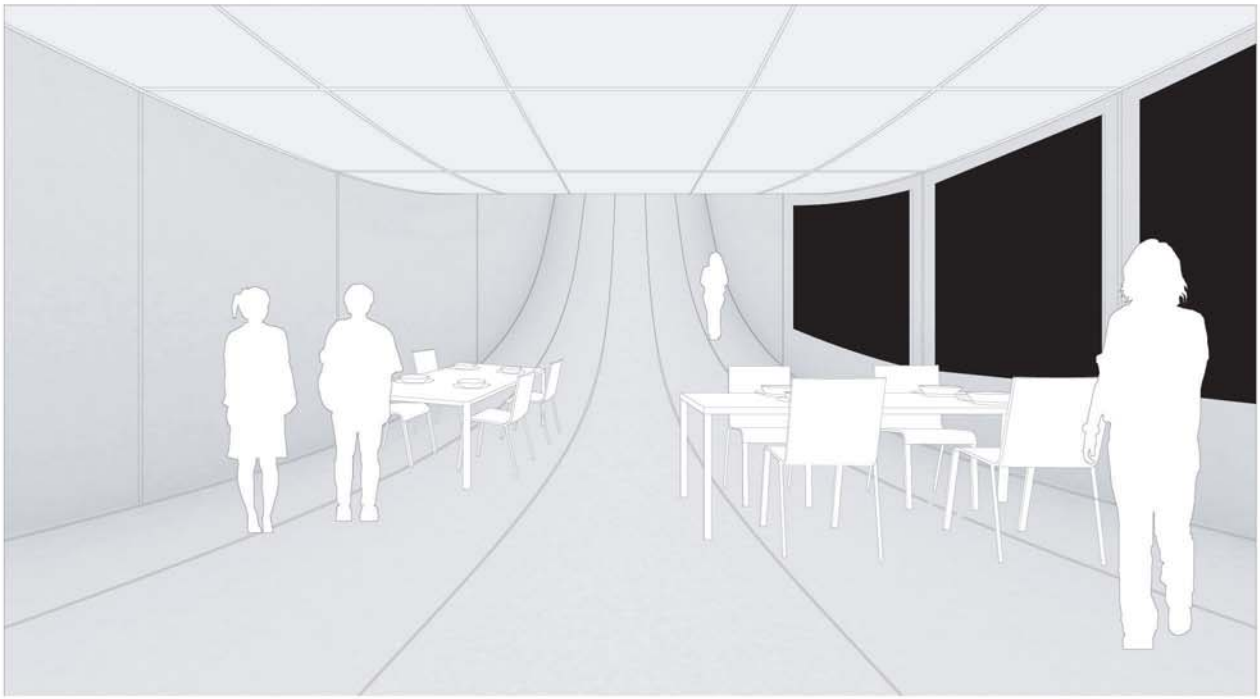
This image illustrates a moment where the circulation tunnels all line up, and a clear view to outer space is achieved.



zero gravity communal living space

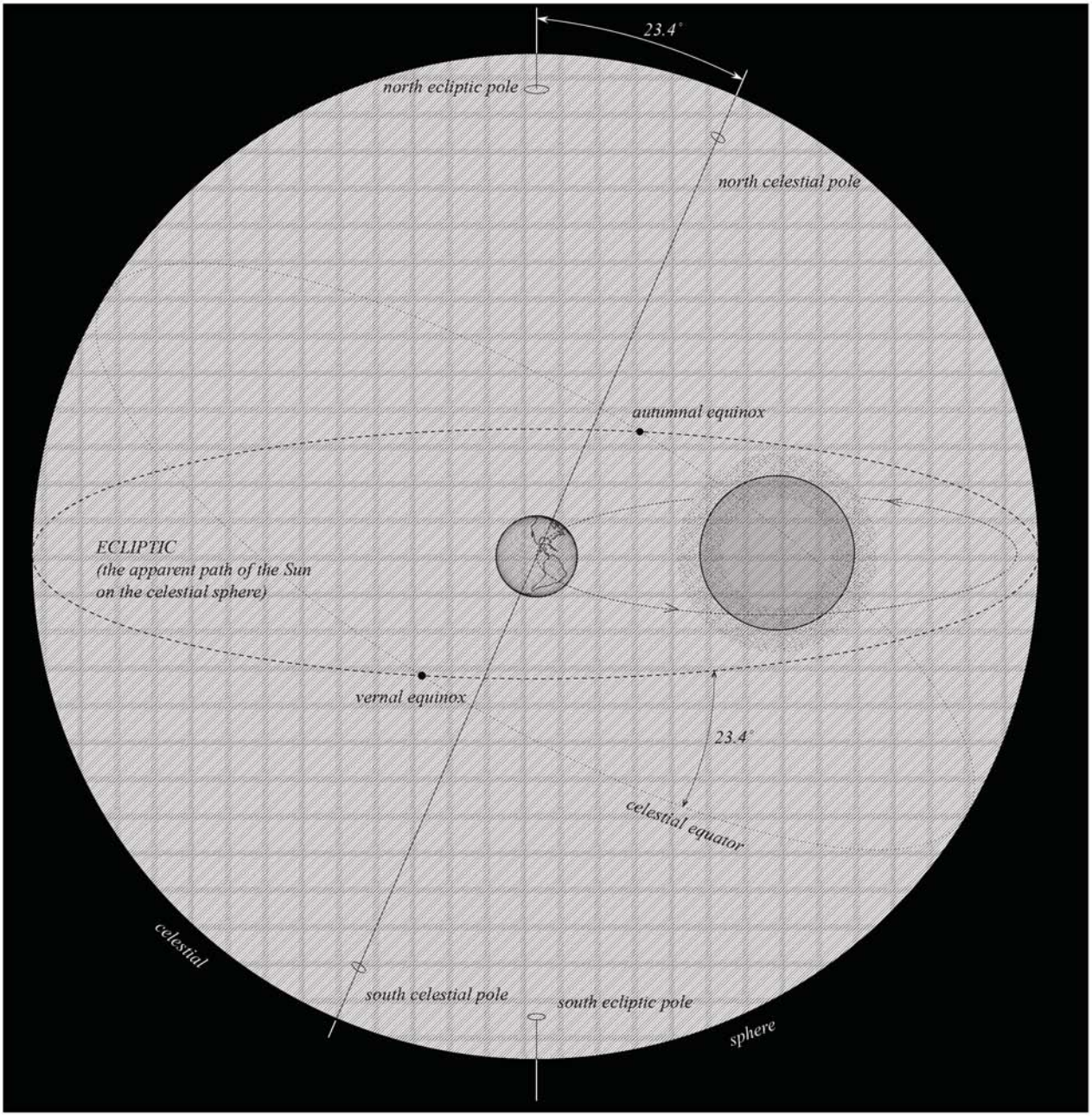


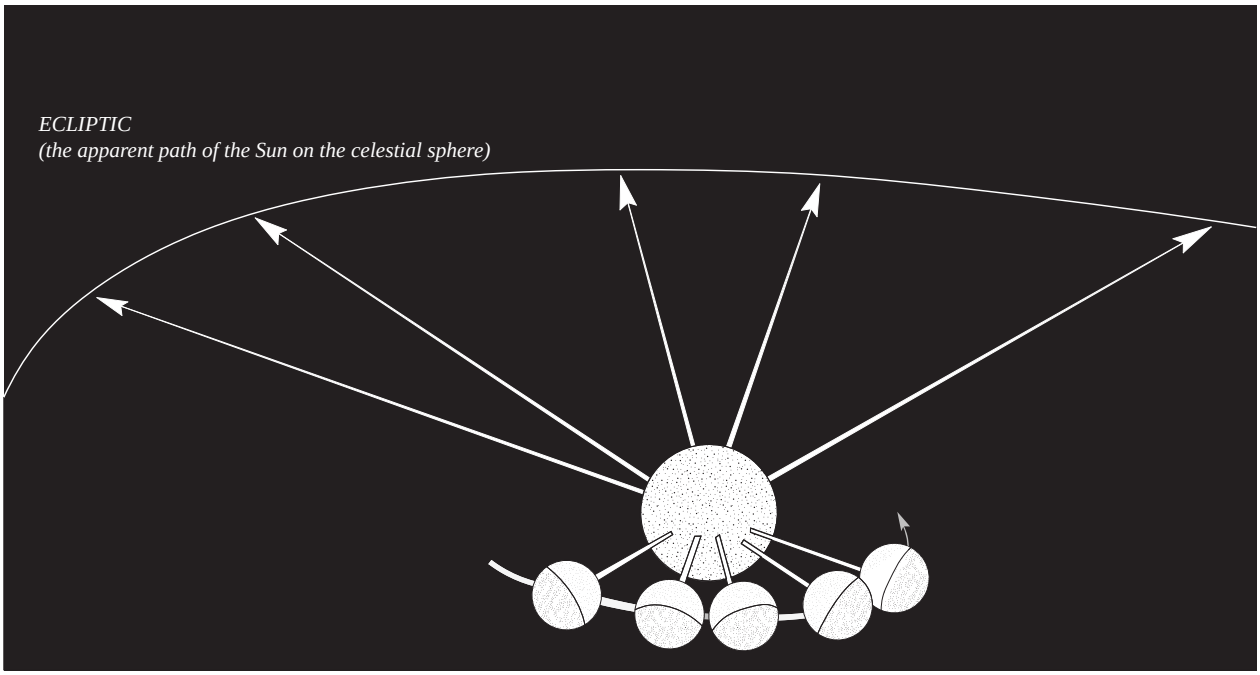
half-gravity greenhouse



The outer ring simulates the gravity experienced on Earth.

Celestial System of Orbit

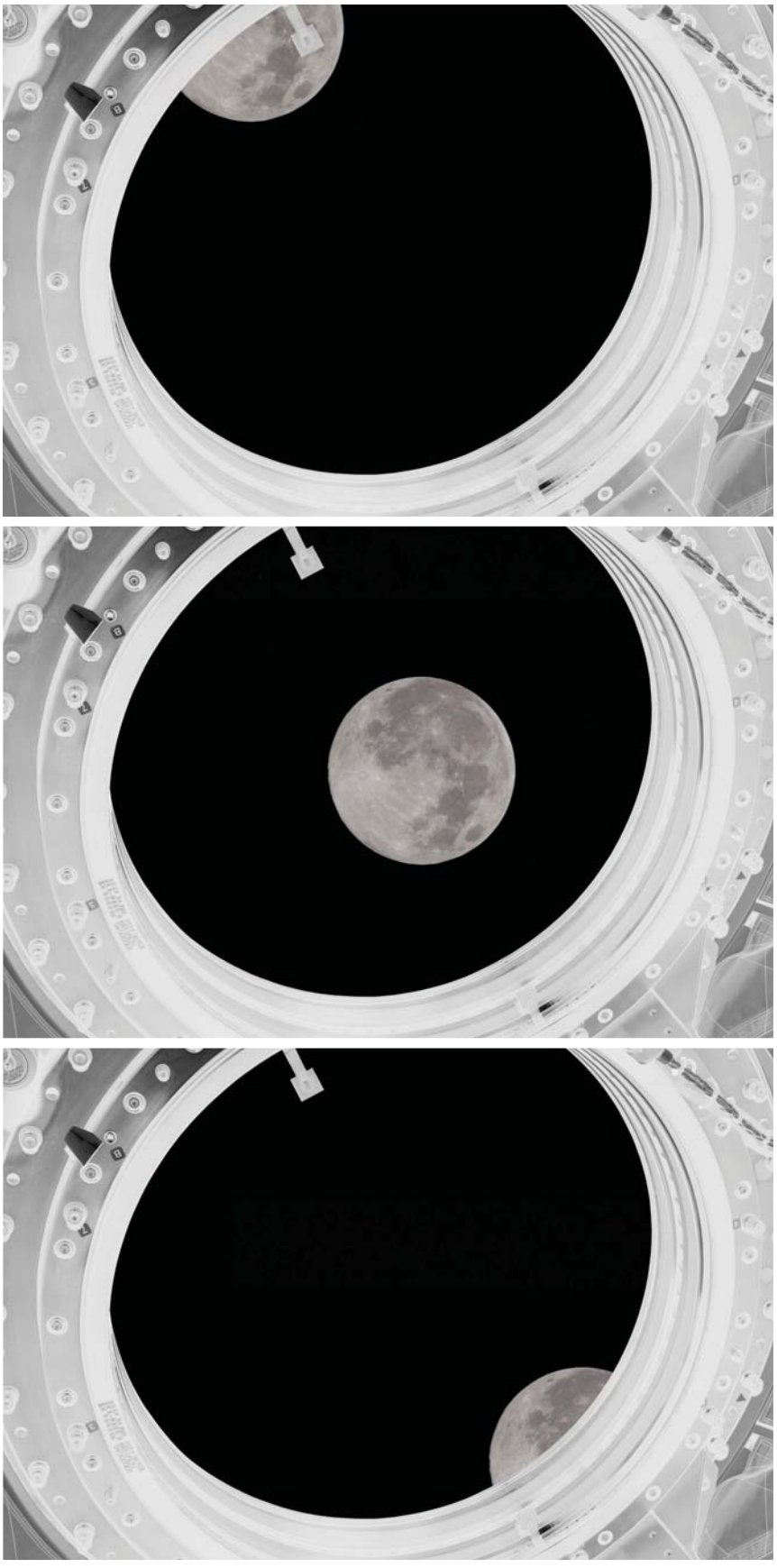

23.4°
north ecliptic pole
north celestial pole
autumnal equinox
ECLIPTIC
(the apparent path of the Sun
on the celestial sphere)
vernal equinox
23.4°
celestial equator
celestial
sphere
south celestial pole
south ecliptic pole



The Ecliptic

The concept of the ecliptic explains the apparent path of the sun in the celestial sphere. Perceptually, it was once believed that the sun revolved around the Earth because of its apparent motion.

From the outer ring of the space capsule, windows to the exterior expose views of the moon. Perceptually, it appears as if the moon is rotating around the capsule, when in fact, the capsule itself is spinning.



Rotational Relationships

Sight lines and visual connections to each rotating ring and outer space were motivating factors to the design of the space capsule. Each ring rotates at a different speed, but there are moments where the circulation tunnels all line up, and a clear view to outer space is achieved. Interstitial space also allows for views of outer space from within the interior rings. Windows have also been designed to allow for views between rotating rings.

In a lecture given by the German philosopher Peter Sloterdijk, he stated,

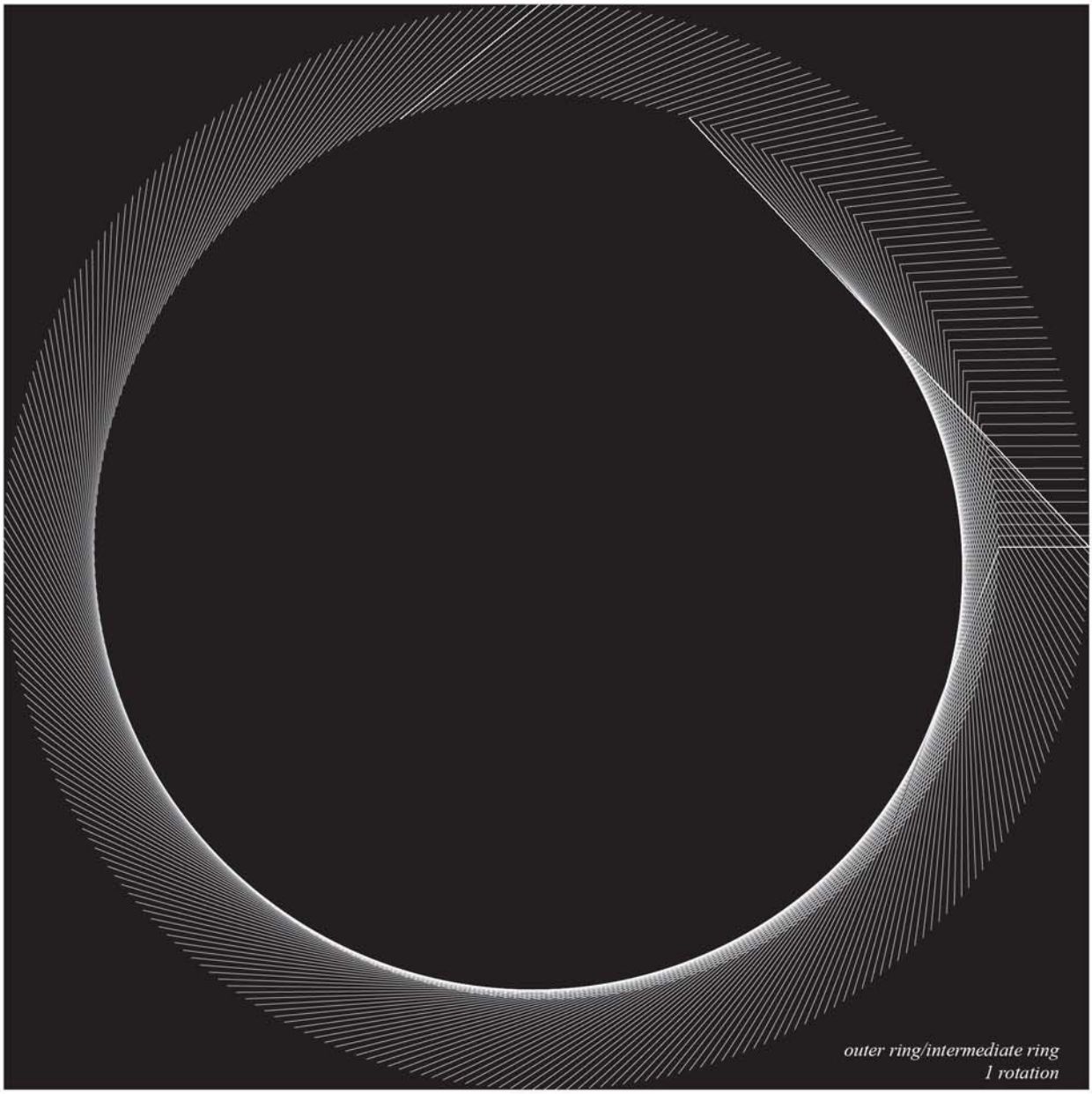
Our brain has an innate concept of a stable horizon. All of you have had this strange experience, this famous train station experiment that our life provides us with almost daily. You're sitting in your compartment in the train station and suddenly you have the feeling that your train is set in motion, you look outside the window and you're still on the right side, and suddenly you see that it is not you but the train on the other track that has departed. What happened? Your brain provides you automatically with the information that you move, because the horizon cannot move. As soon as you see that the other train is leaving your brain is obliged to convert this information into the opposite information: you move, and the horizon is still stable, because a moving horizon: this is a horror, this is the vertigo, and in order to stabilize you're being there, in a given world: a horizon is never allowed to move.[5]

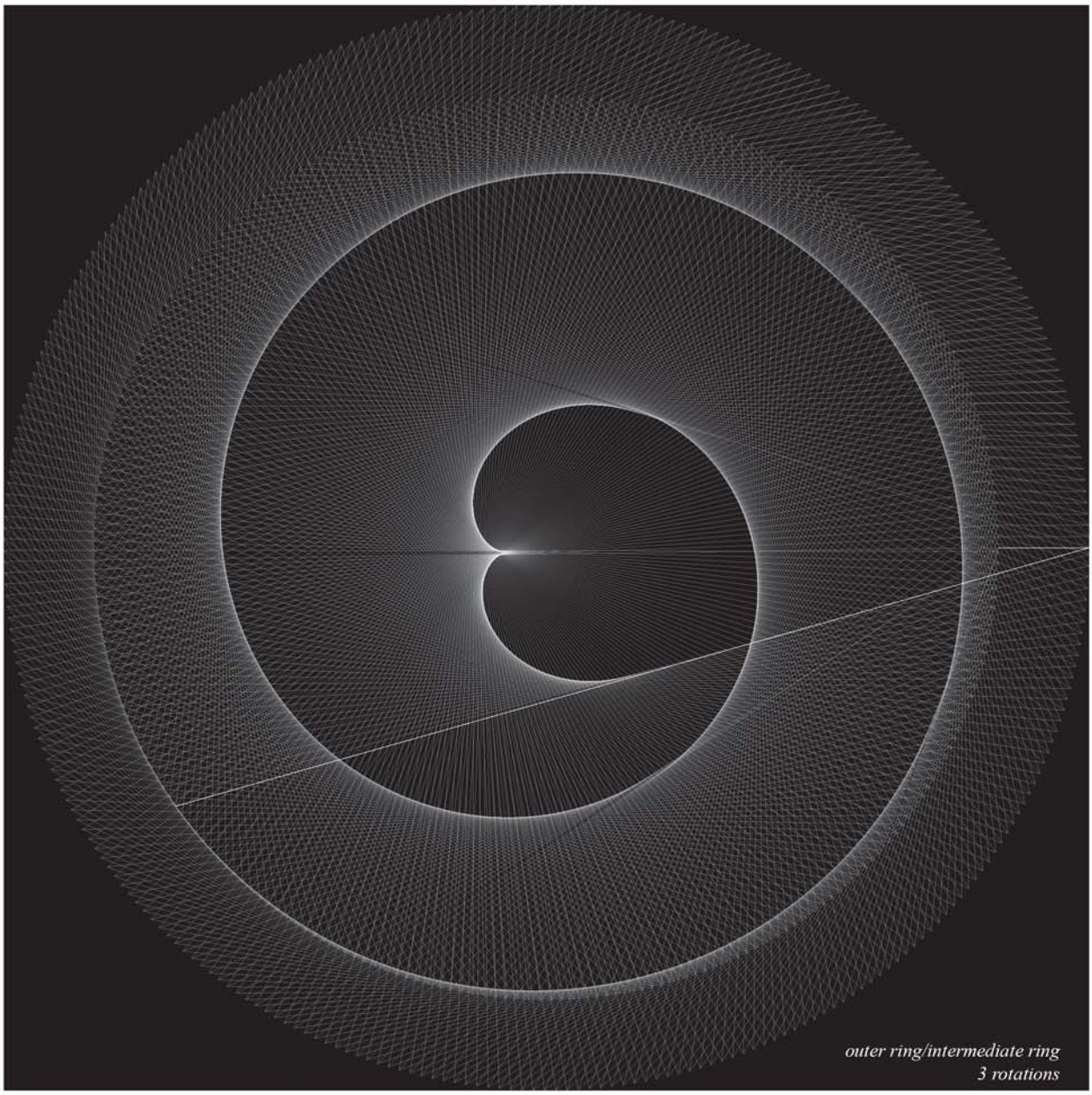
What happens when your horizon is no longer fixed and stable? This project questions fixed notions of perception and visual experience. Windows with views to other rotating rings help inhabitants realize they are in fact rotating, and help to destabilize an understanding of space that was once believed to be fixed and unchanging.

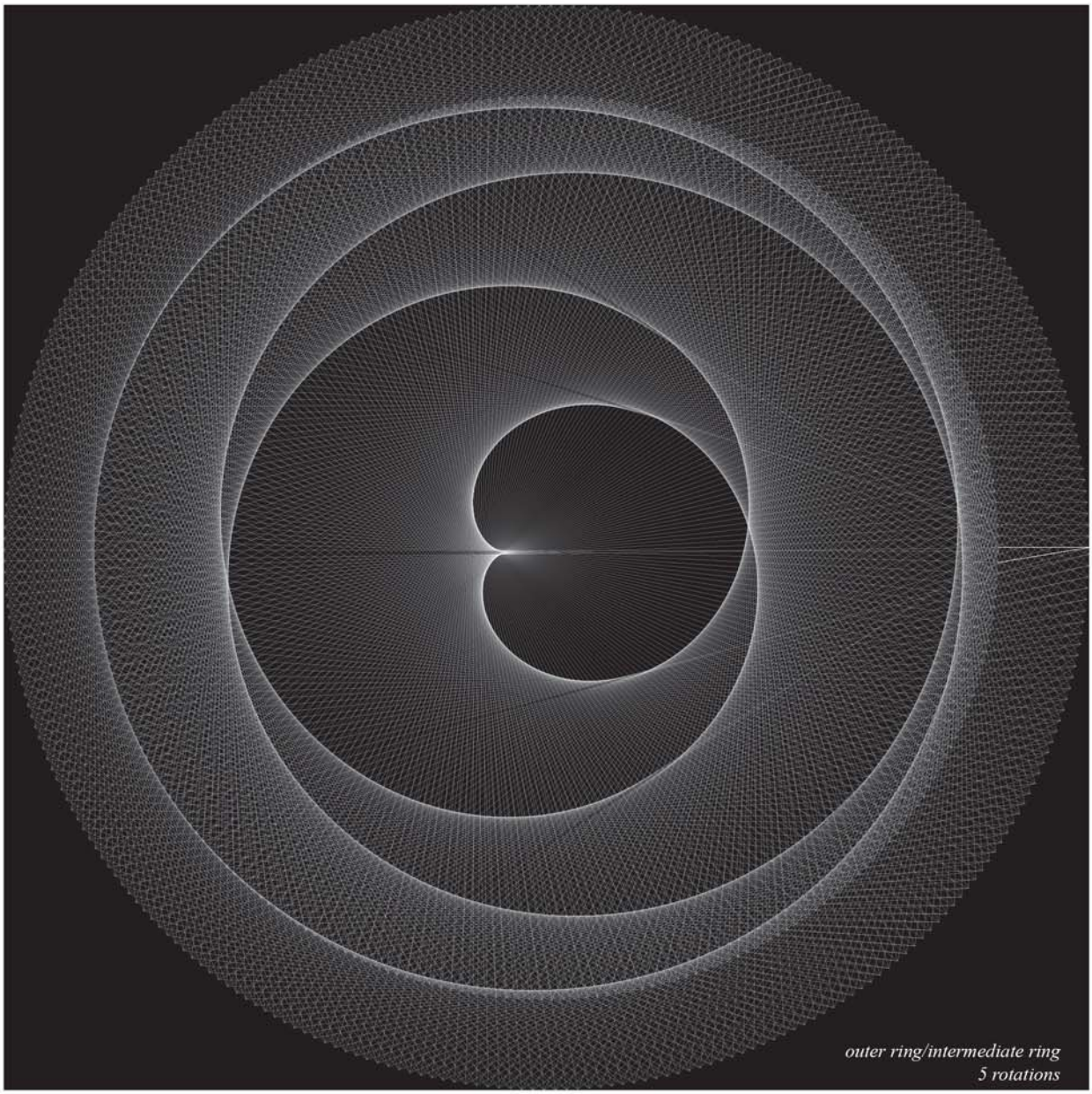
The following set of drawings illustrates the visual relationships between bodies in different rings within the space capsule. The lines trace the motion of these bodies and their relationship to each other according to a set number of rotations. Each ring rotates at a different rate, and each line helps to establish a visual connection.

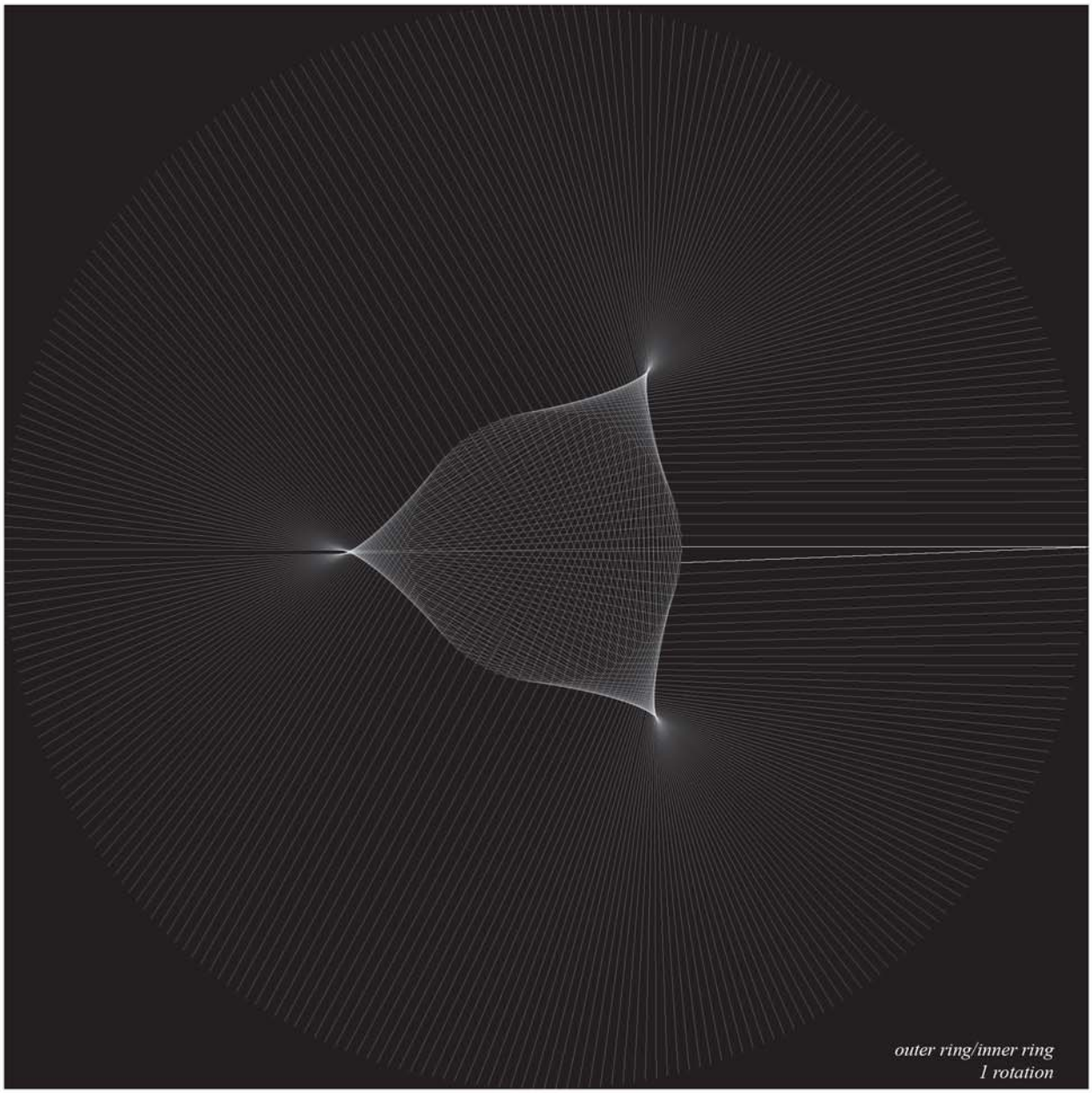
Compounded together, the lines trace the visual relationships and the complexities of constant motion and rotation.

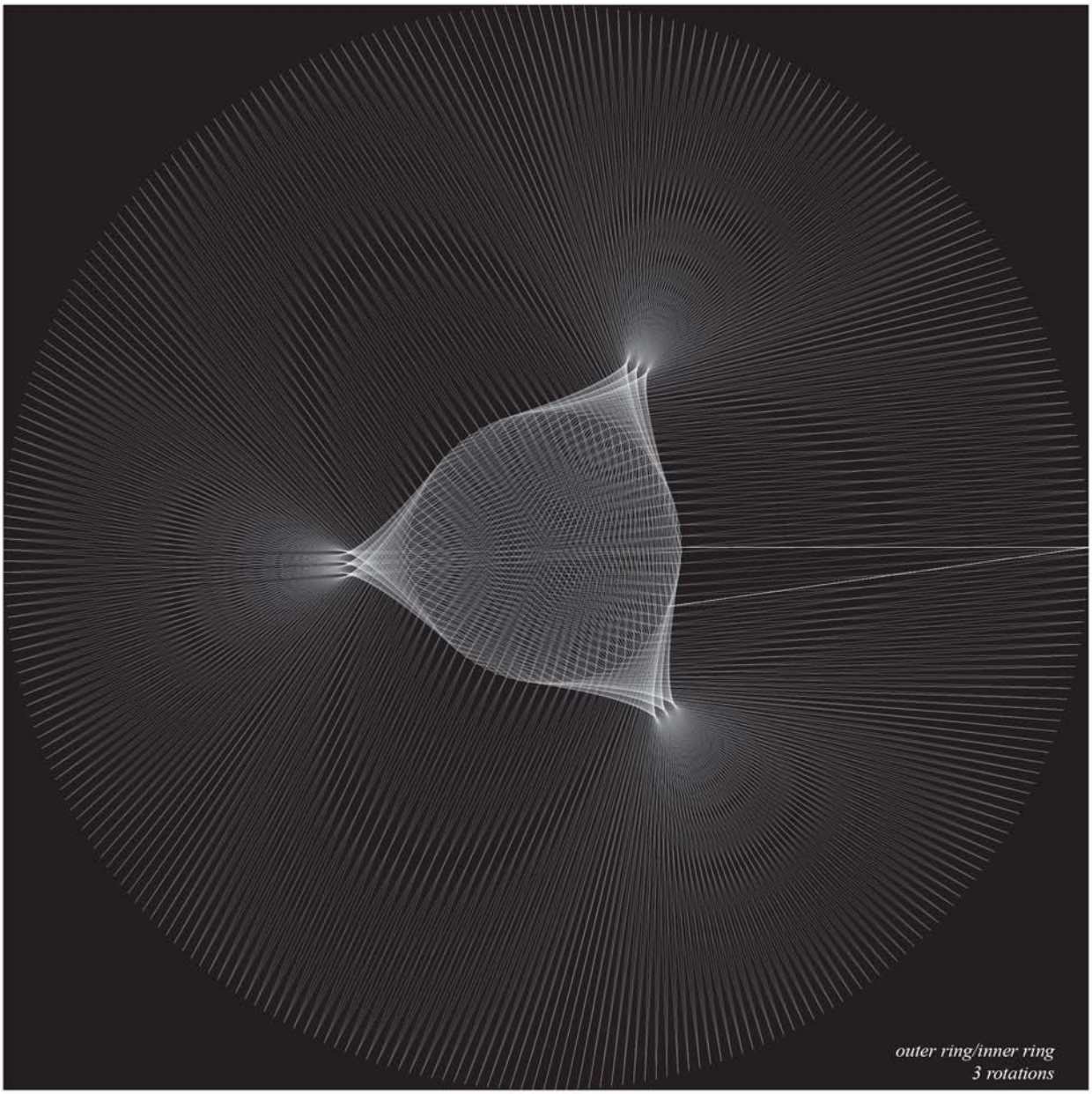
5 Peter Sloterdijk, "Inspiration," (Lecture given at the Jan van Eyck Academy, Maastricht, The Netherlands, May 31, 2005).

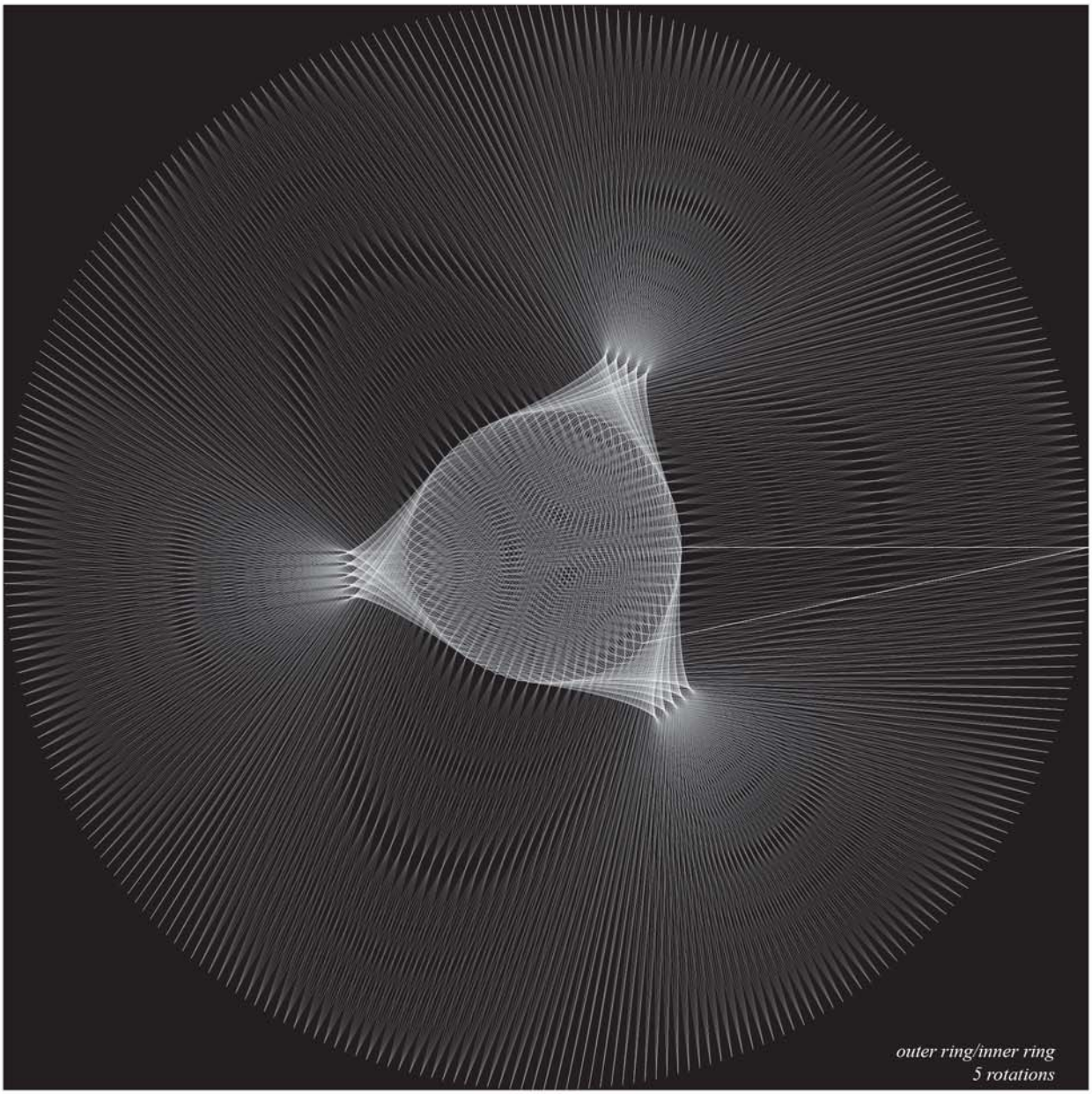

outer ring/intermediate ring
1 rotation

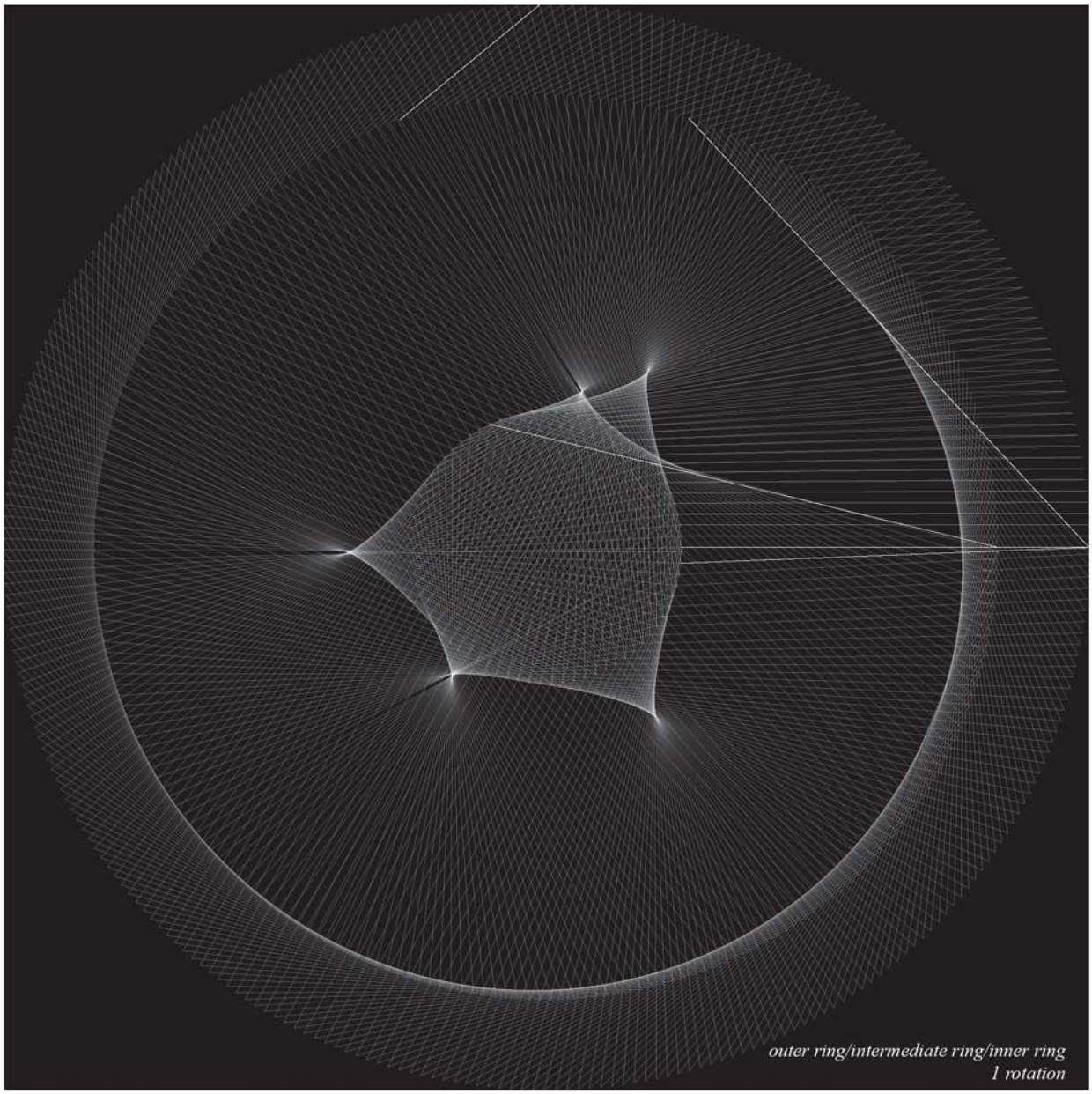

outer ring/intermediate ring
3 rotations

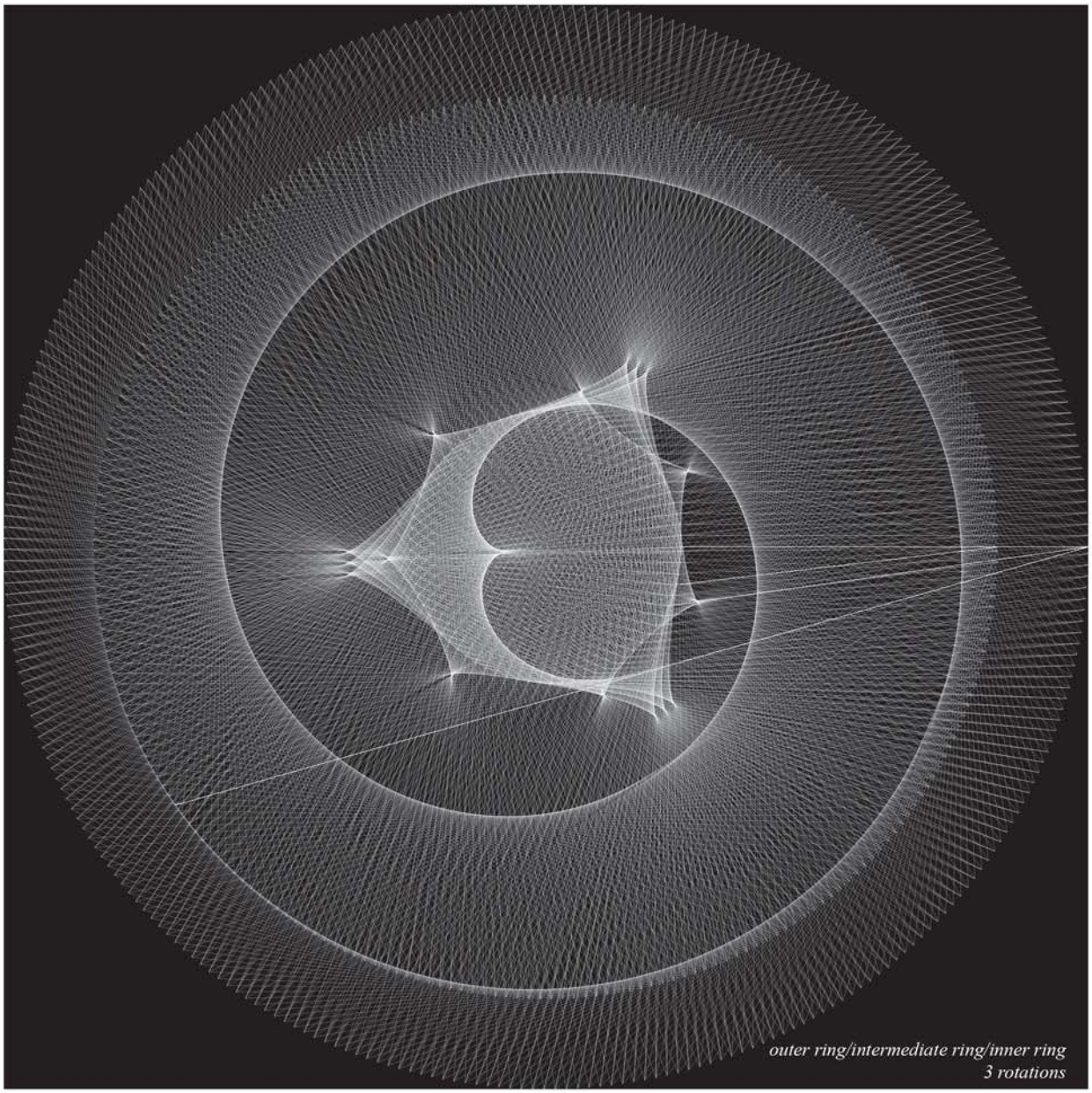

outer ring/intermediate ring
5 rotations

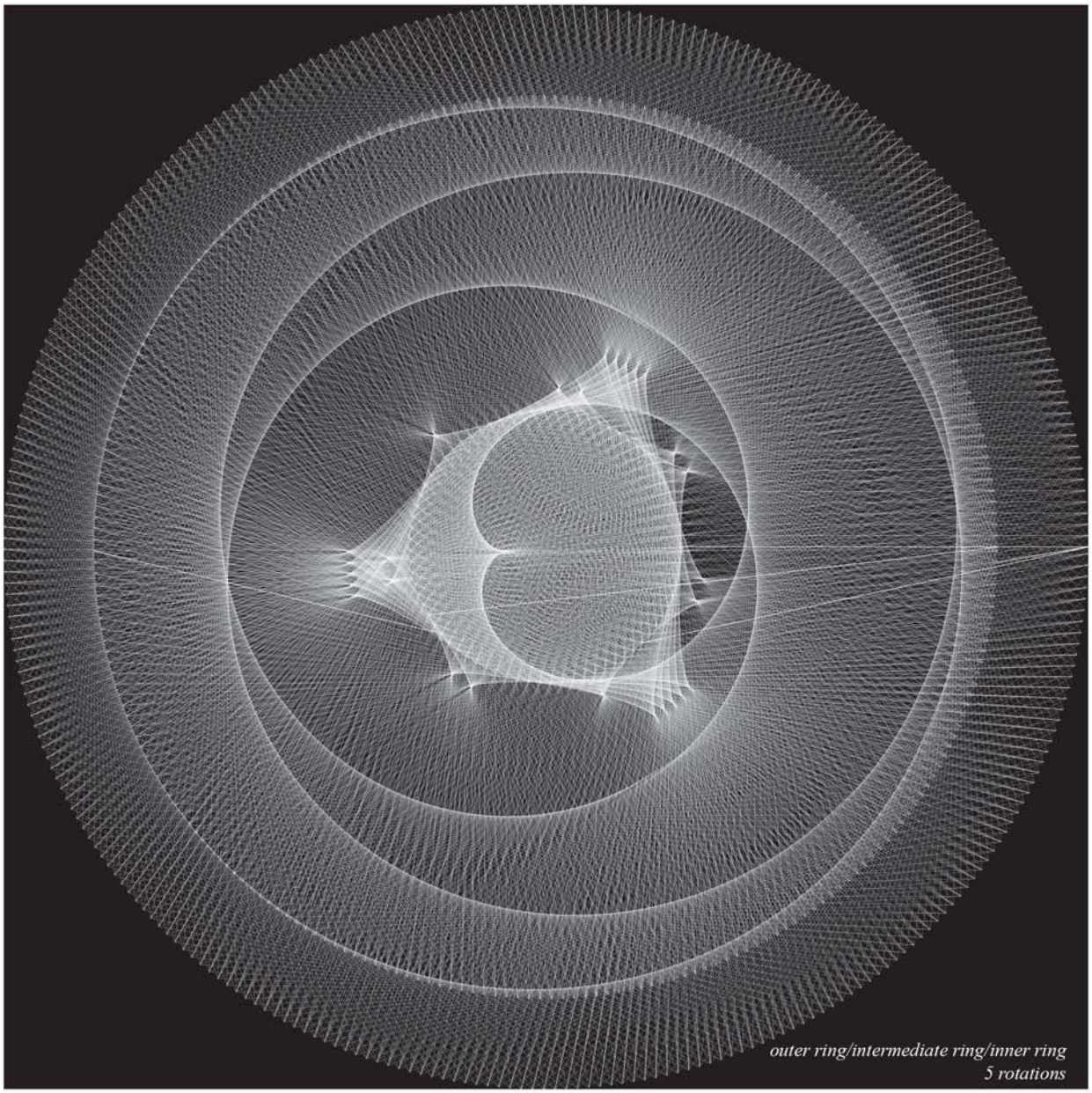

outer ring/inner ring
1 rotation


outer ring/inner ring
3 rotations

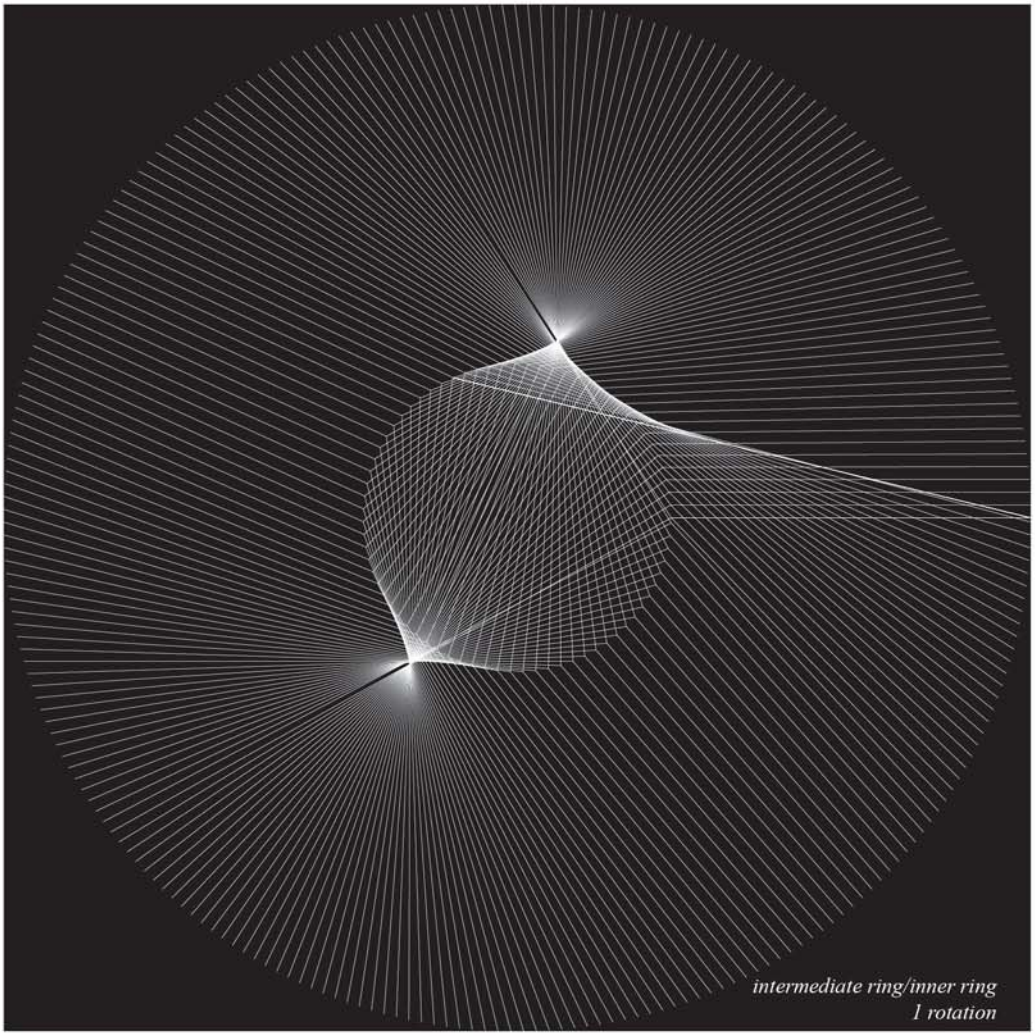

outer ring/inner ring
5 rotations

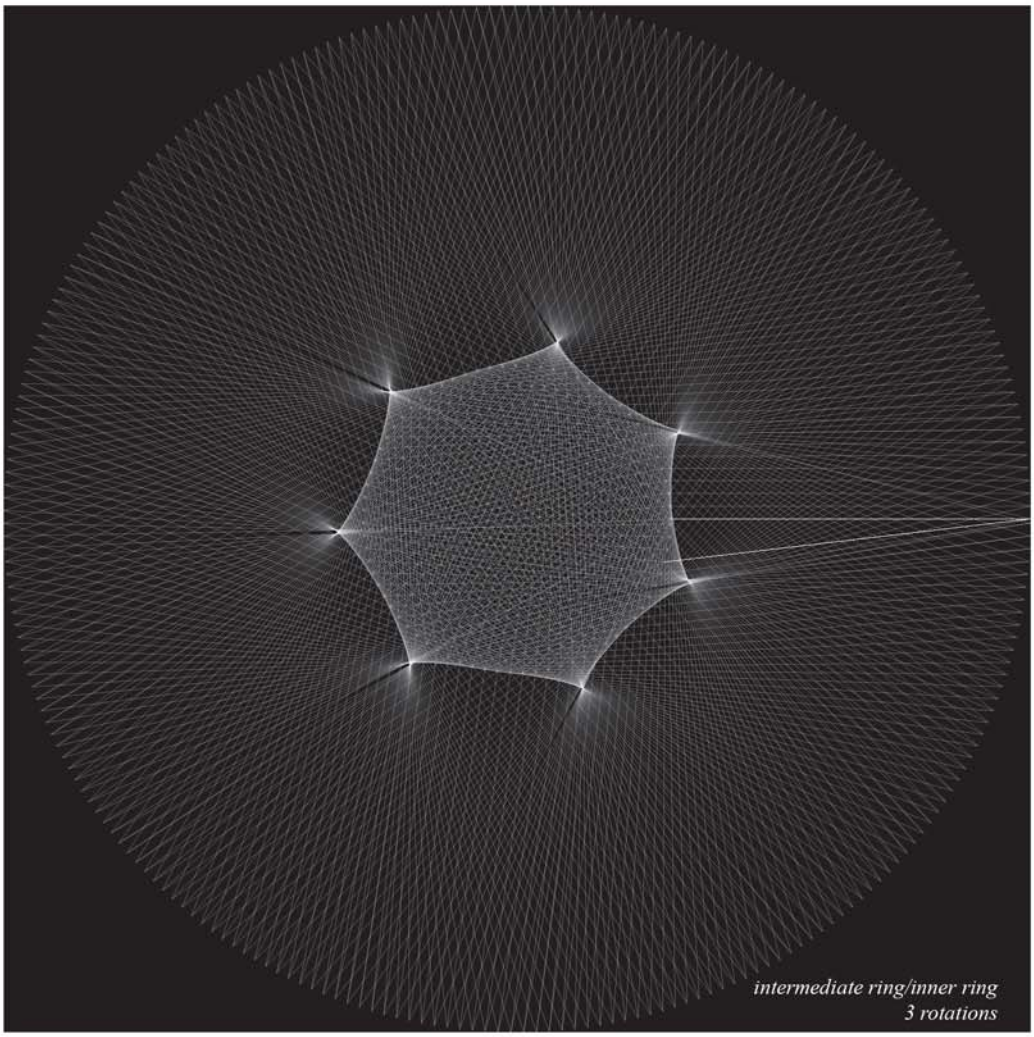

outer ring/intermediate ring/inner ring
1 rotation

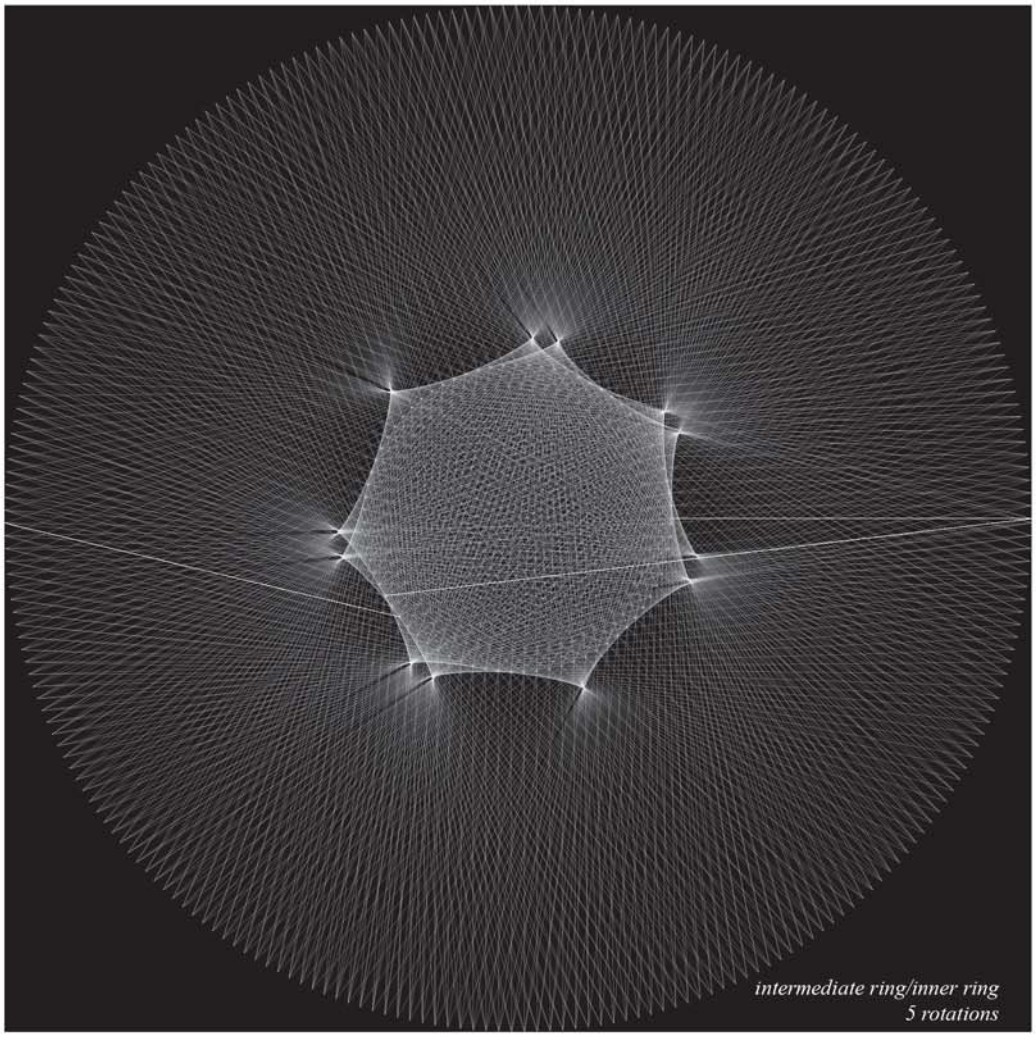

outer ring/intermediate ring/inner ring
3 rotations

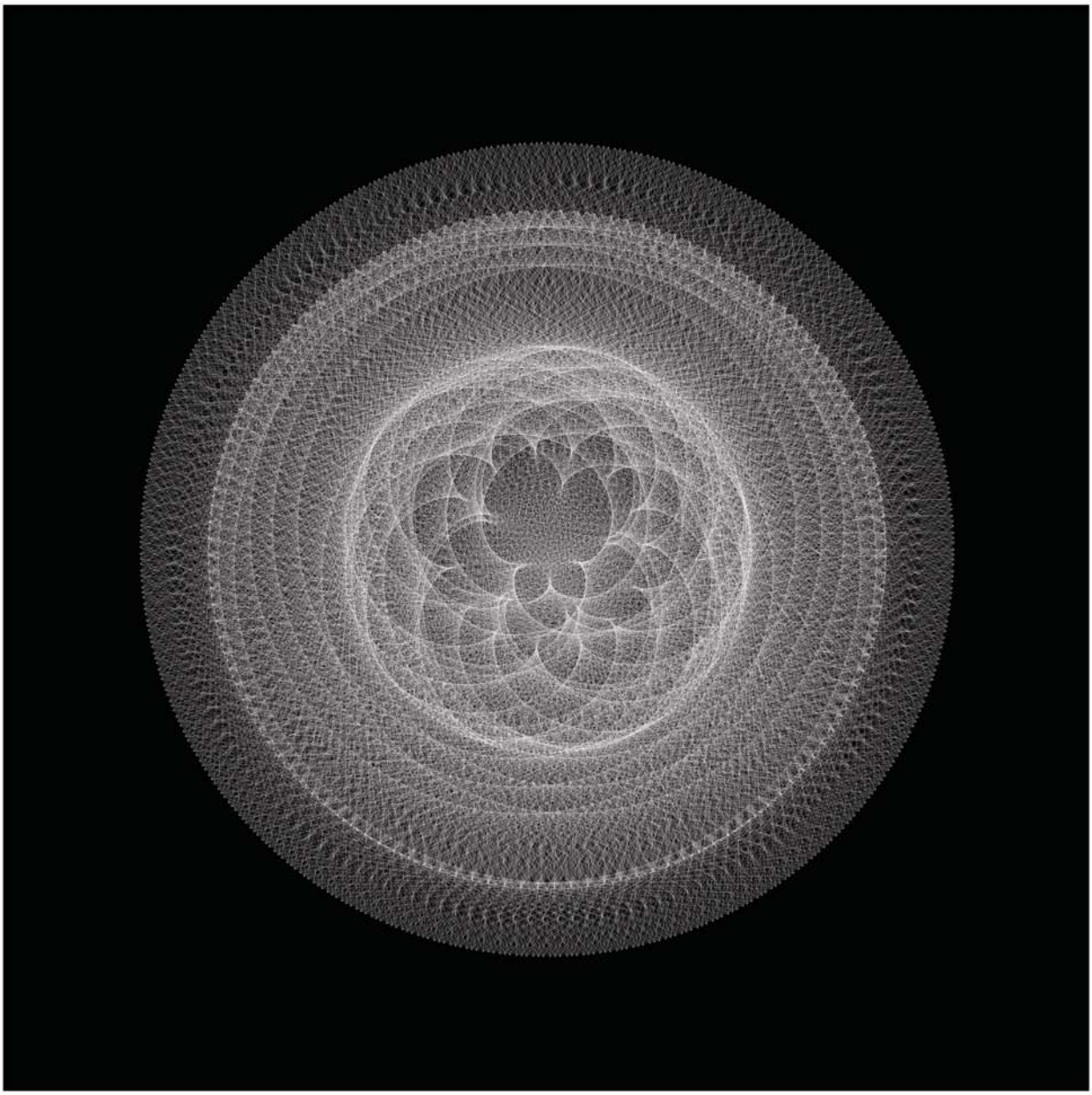


outer ring/intermediate ring/inner ring
5 rotations

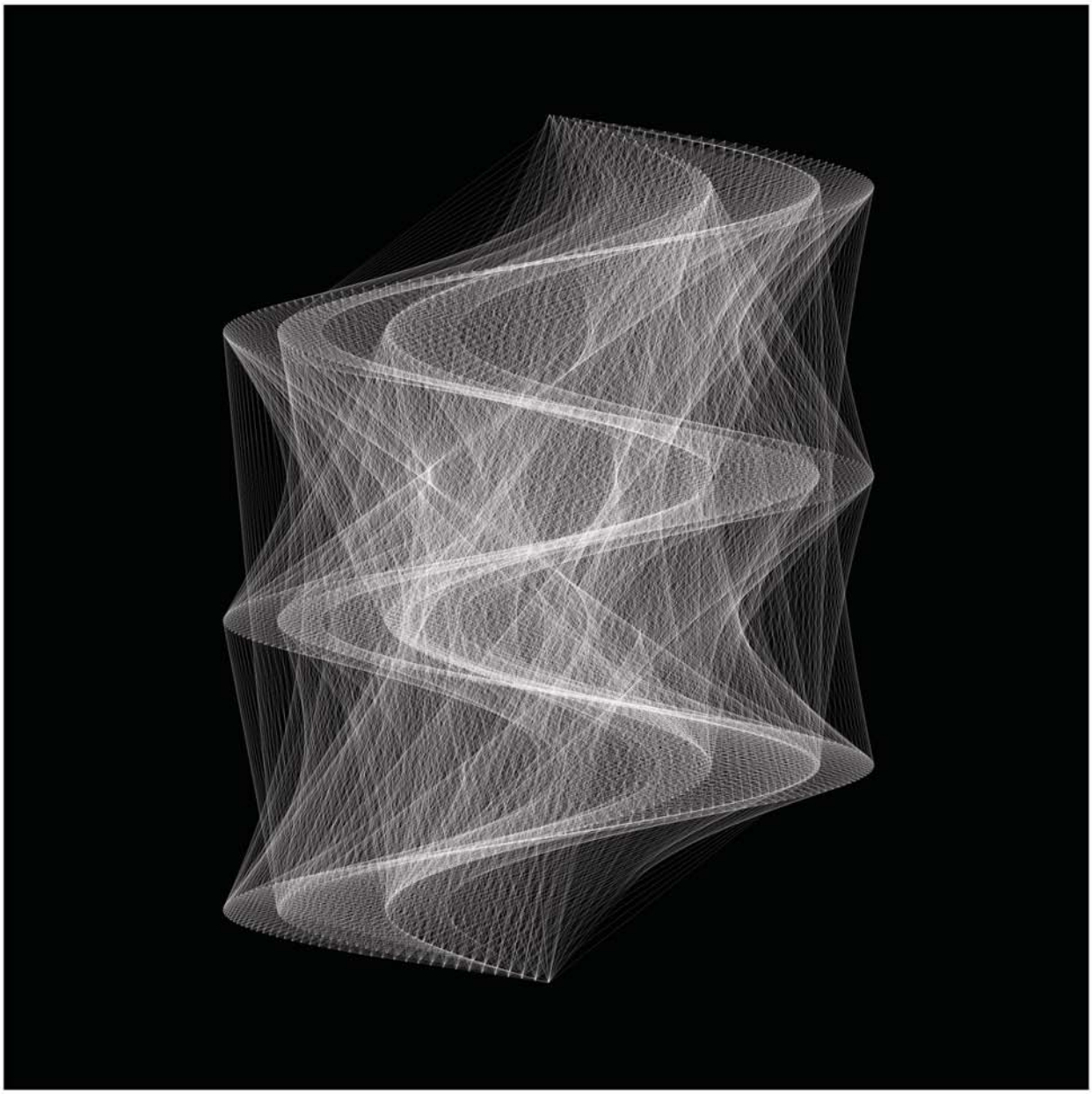

intermediate ring/inner ring
1 rotation

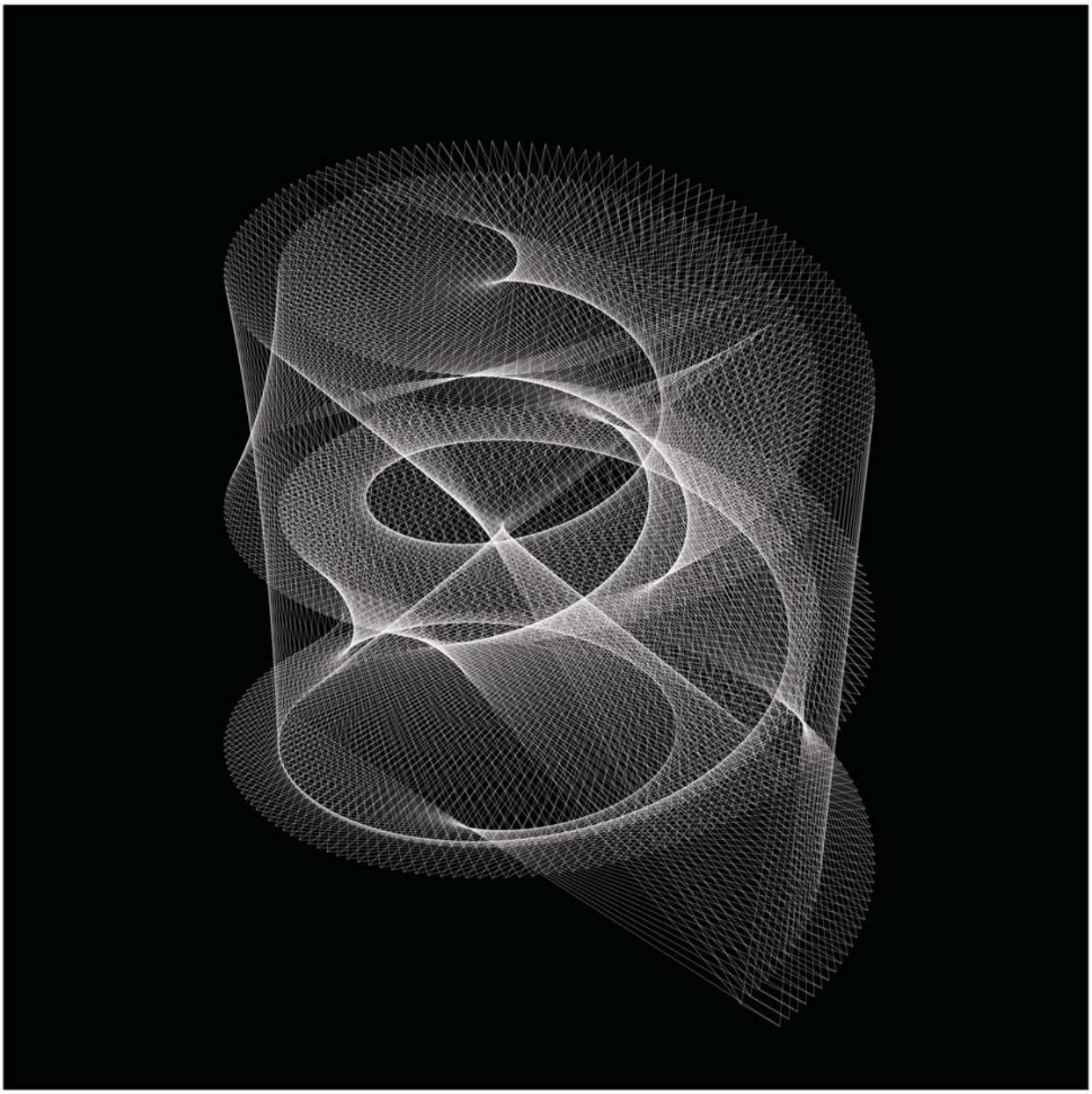

intermediate ring/inner ring
3 rotations


intermediate ring/inner ring
5 rotations



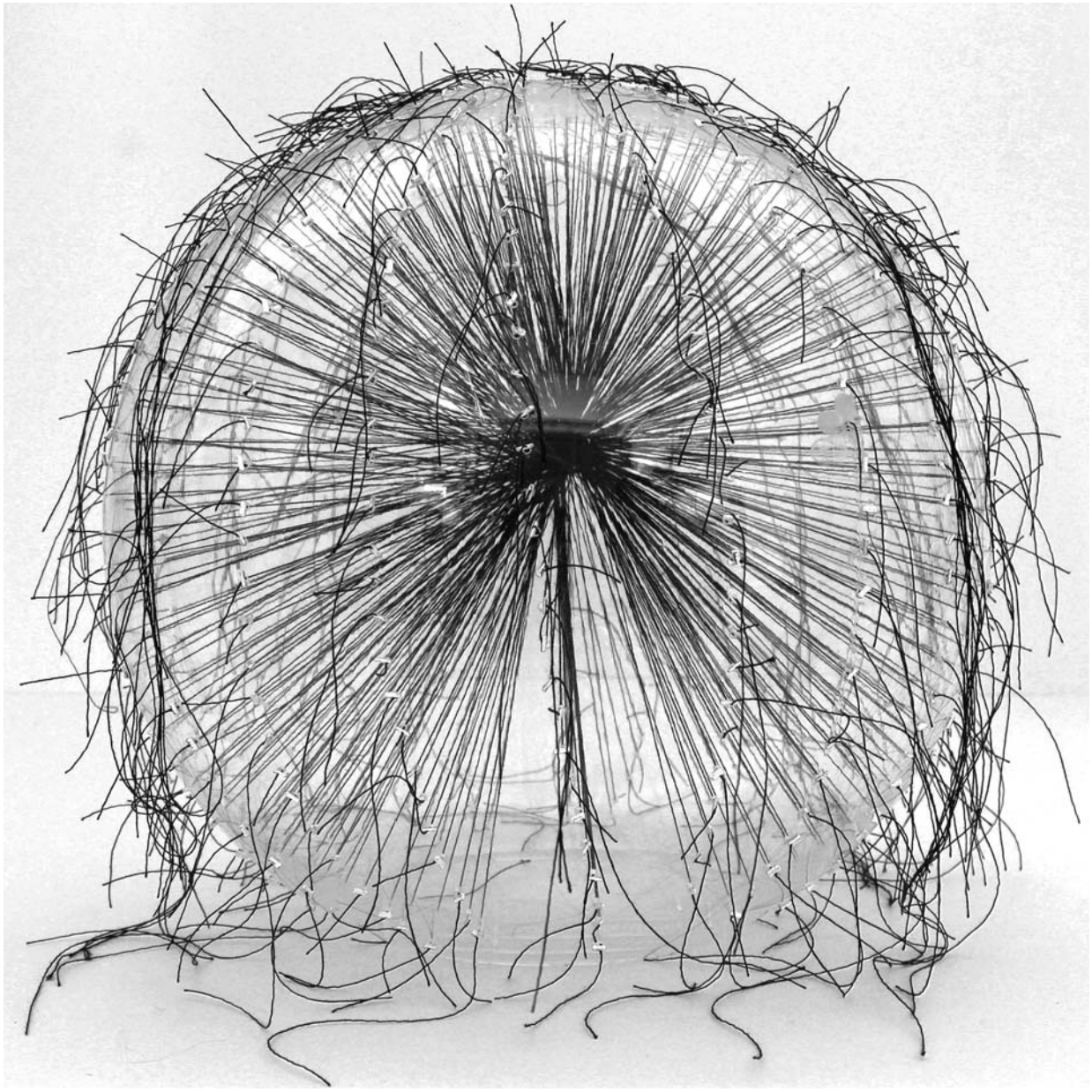
compounded rotations



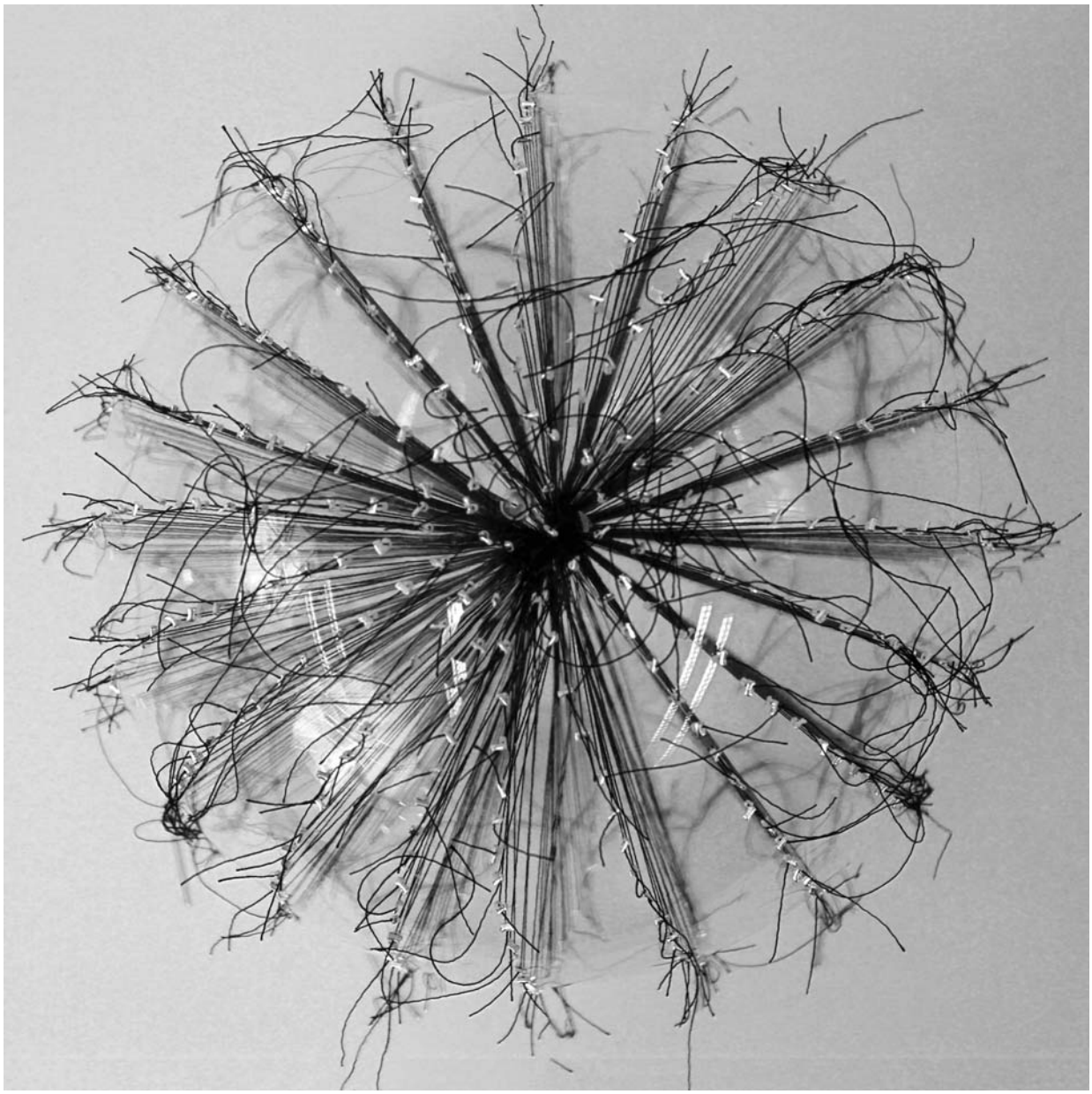


Physical Models

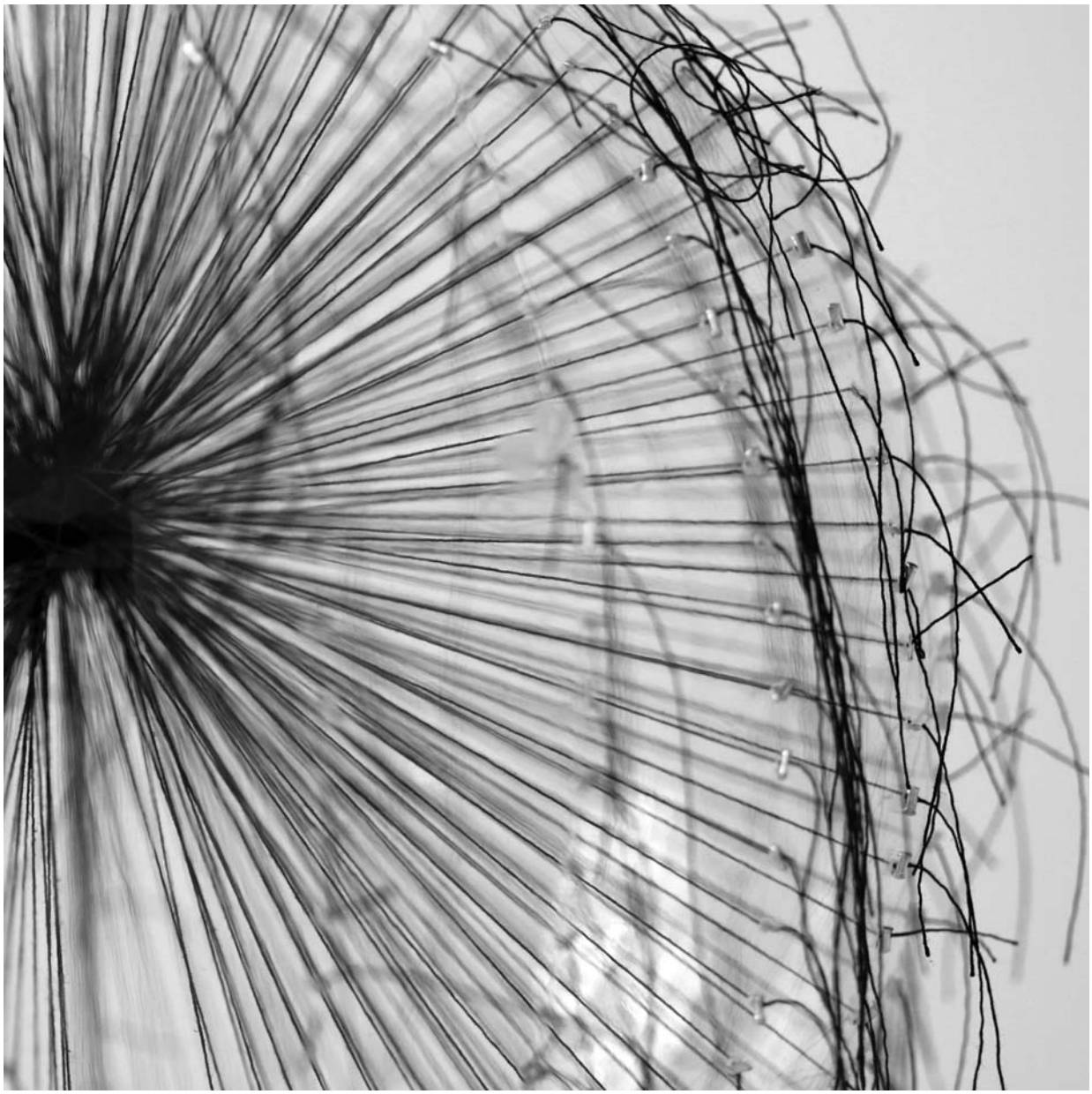
Models as three-dimensional visualizations
of the drawings.



Point



Point



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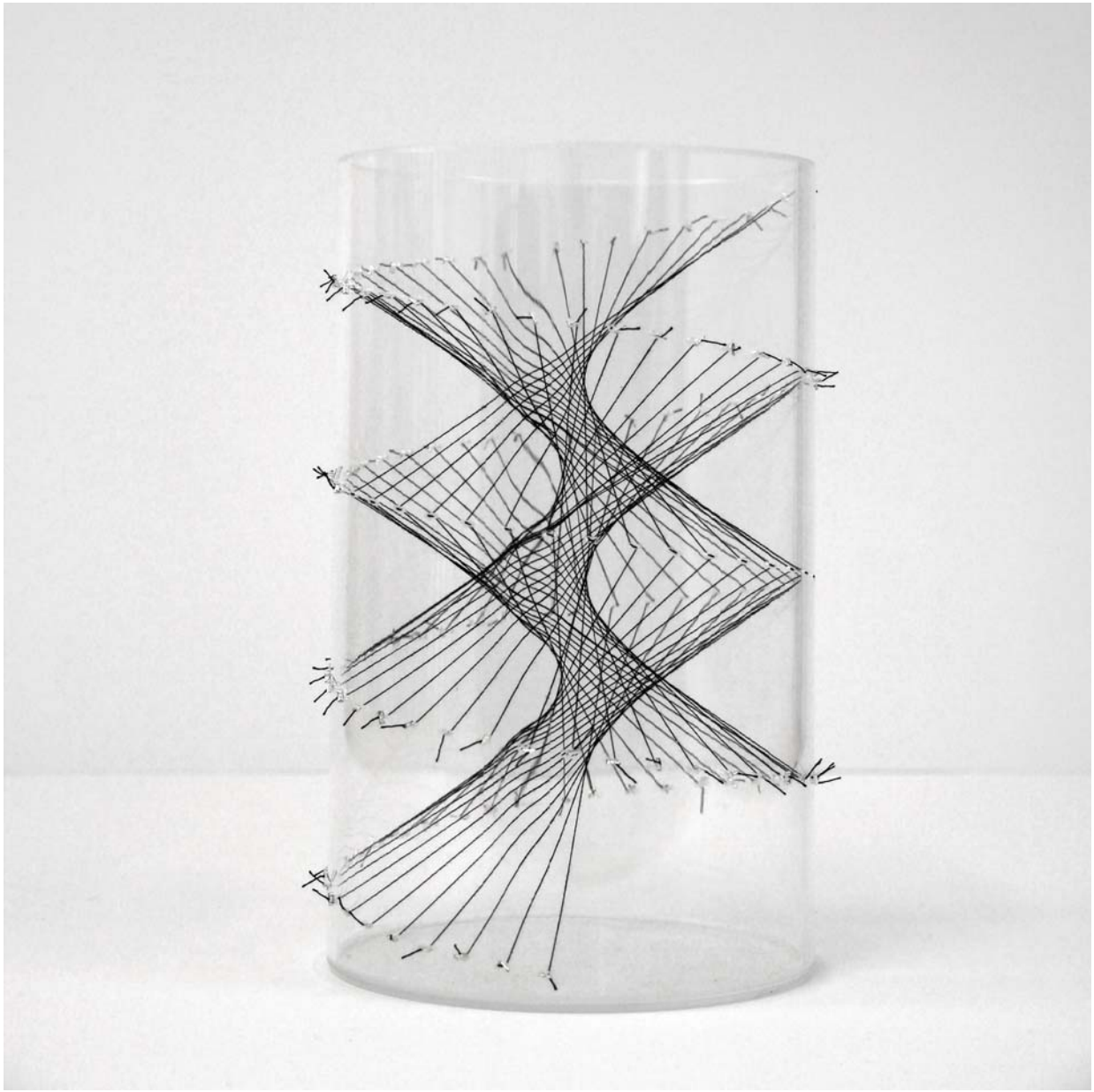
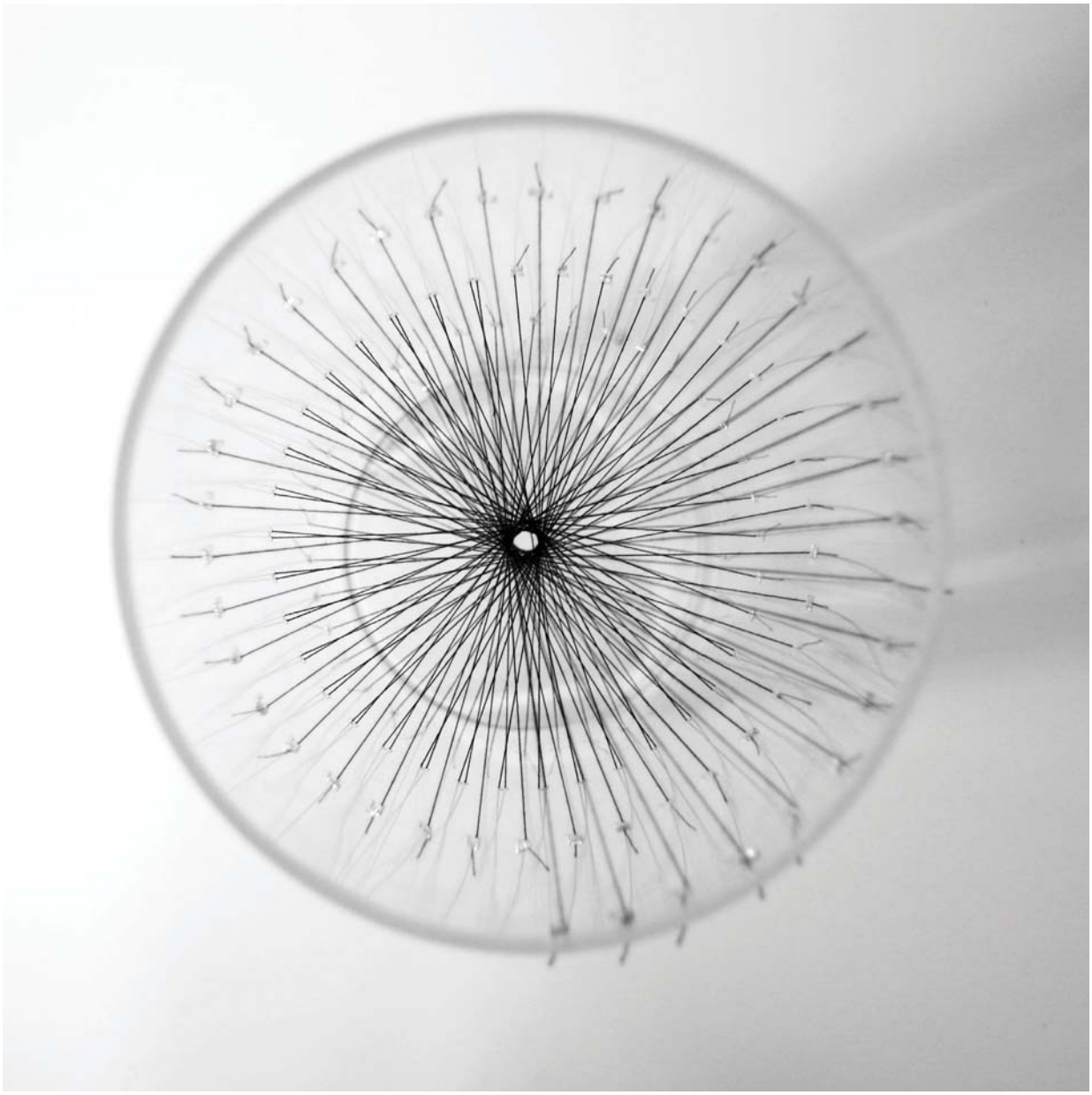
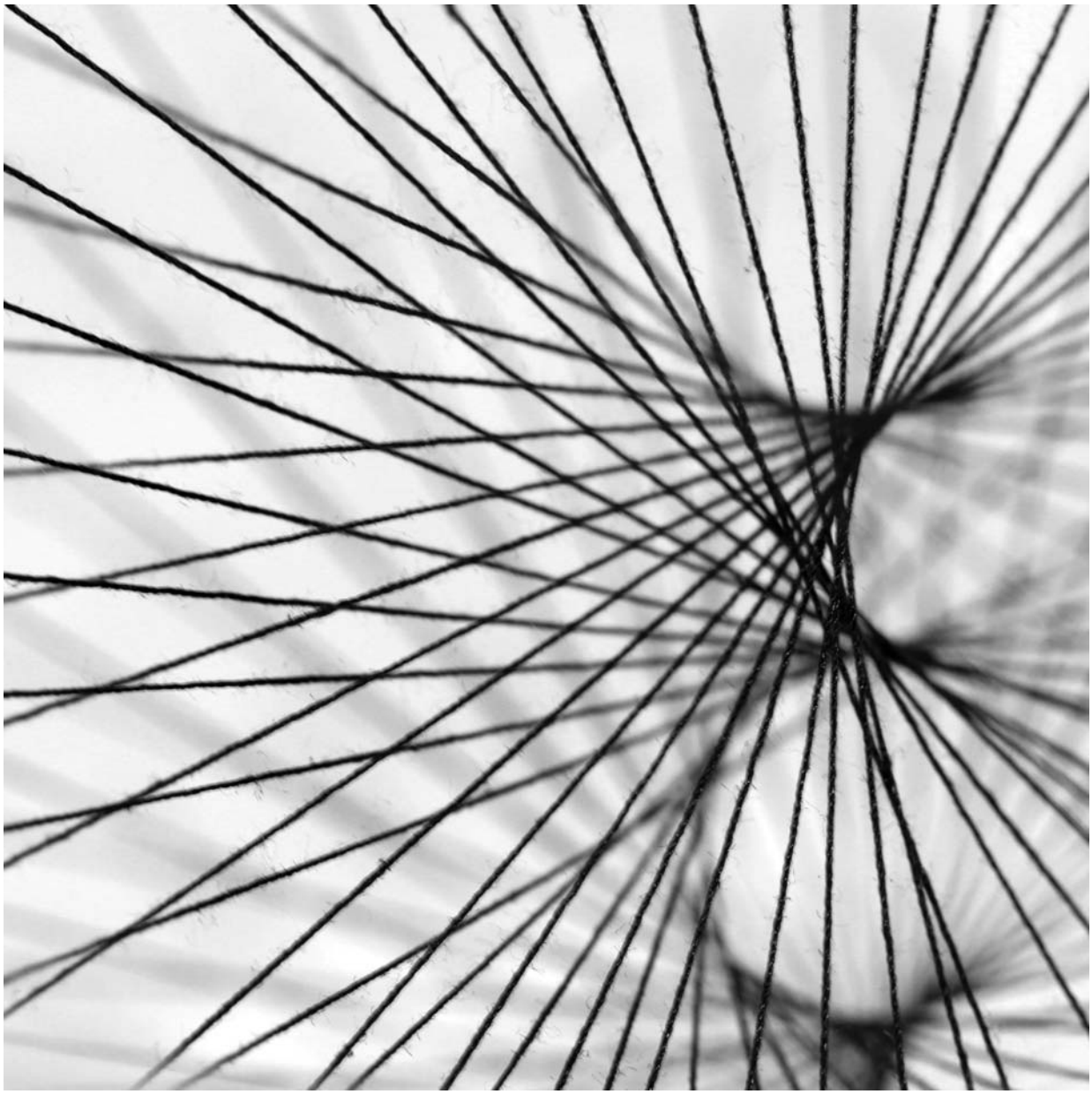


Line

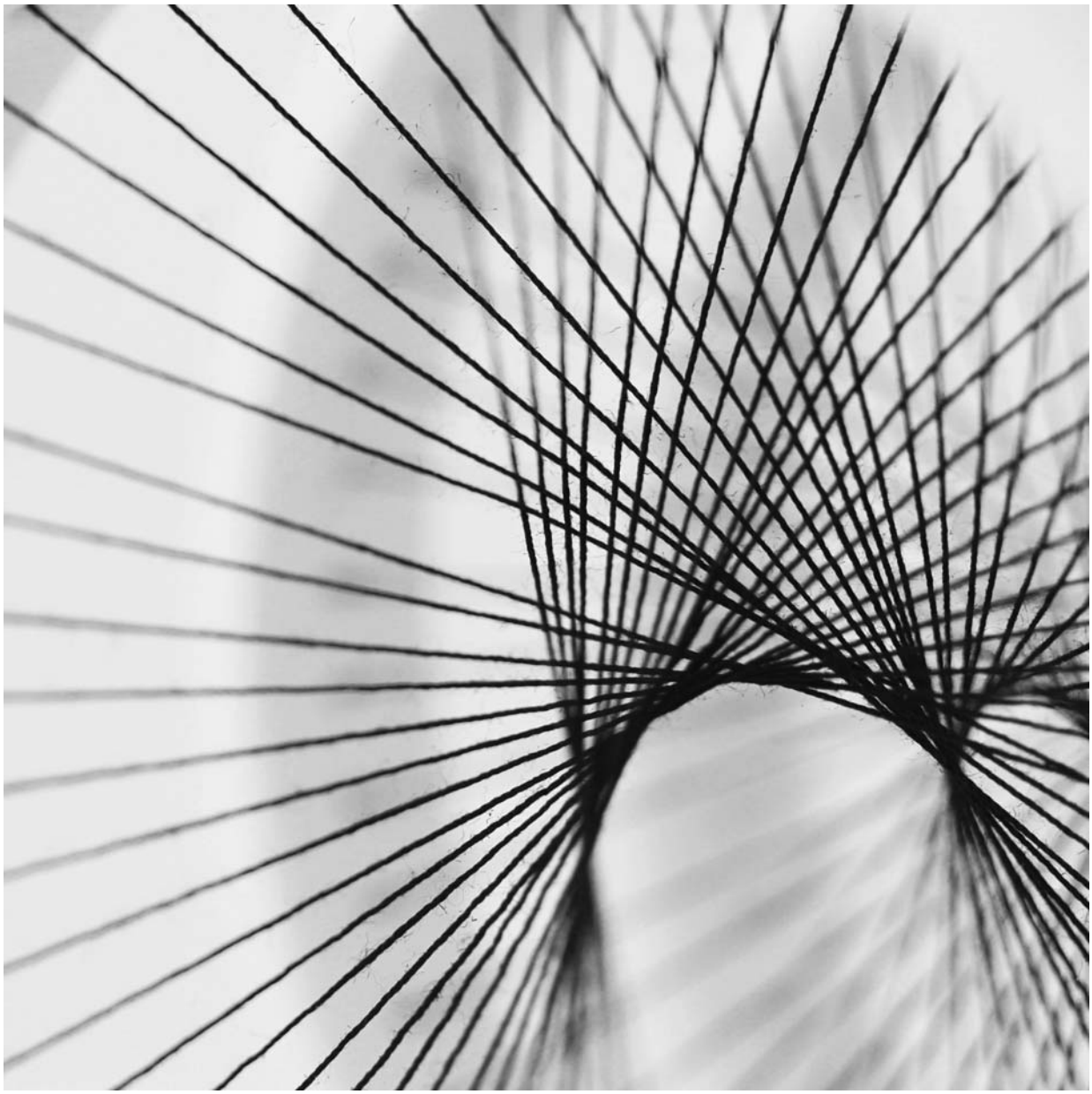


Line



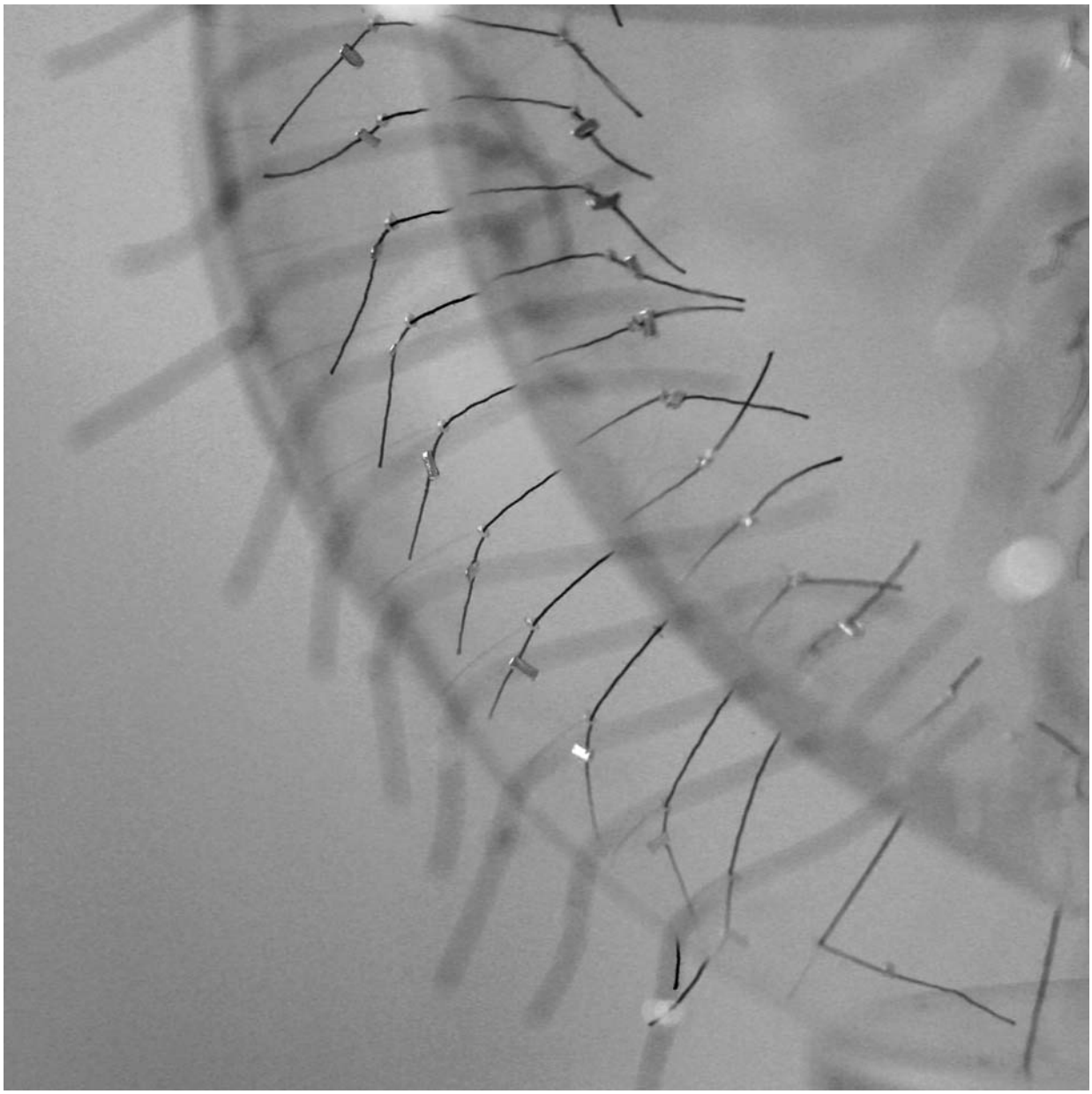
Line

Line

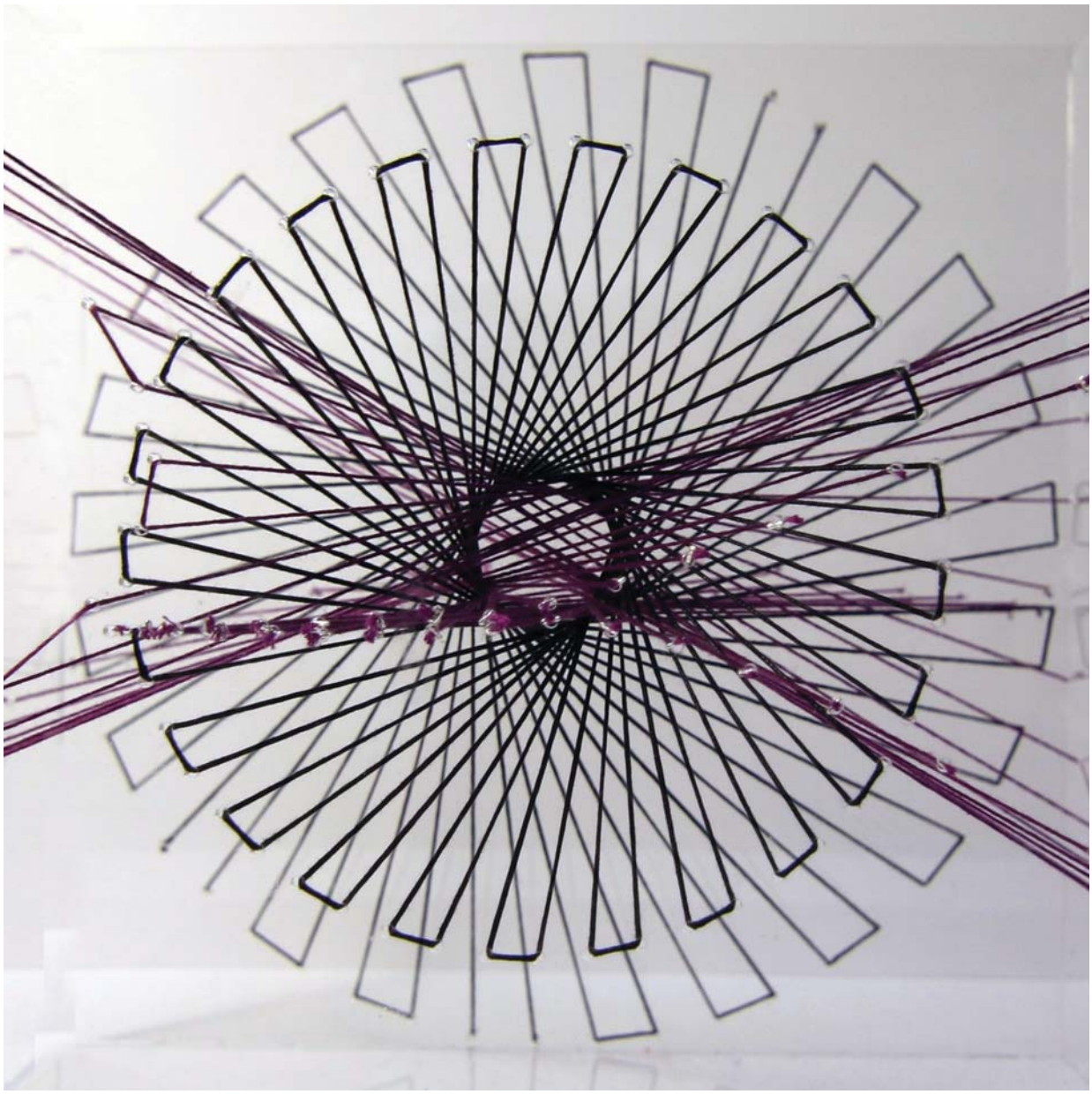


Line

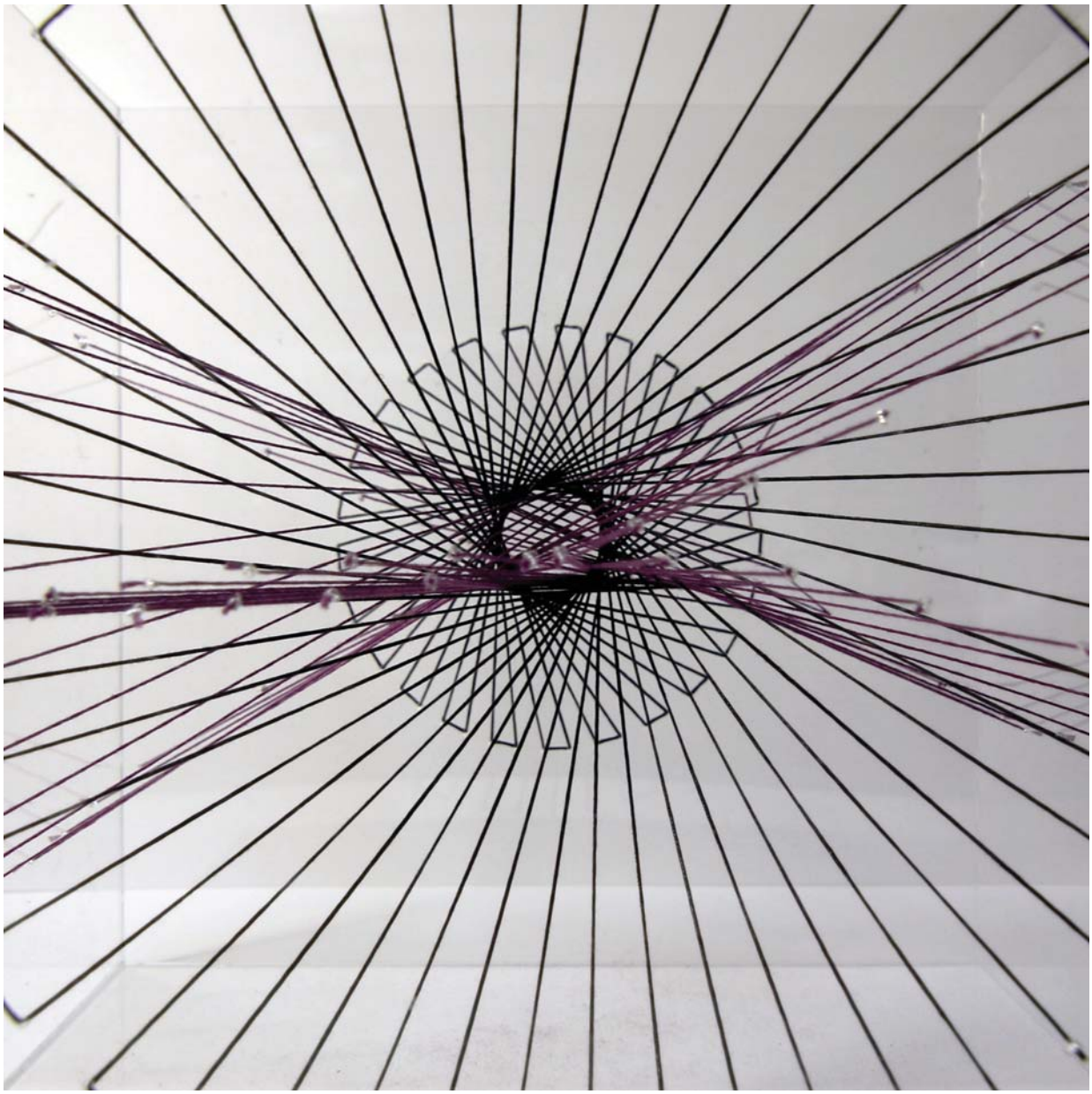
Line



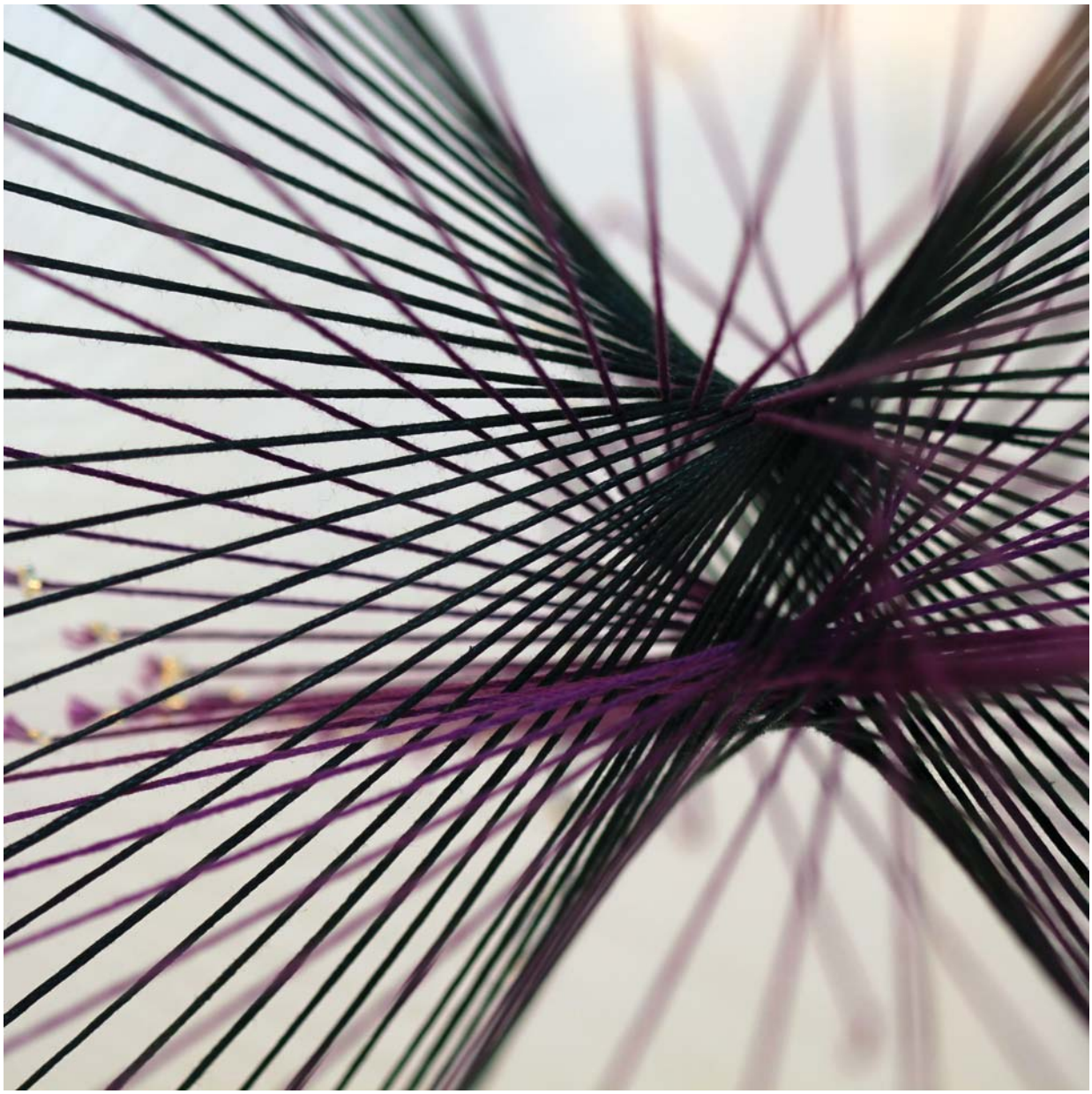
Thickened Sphere



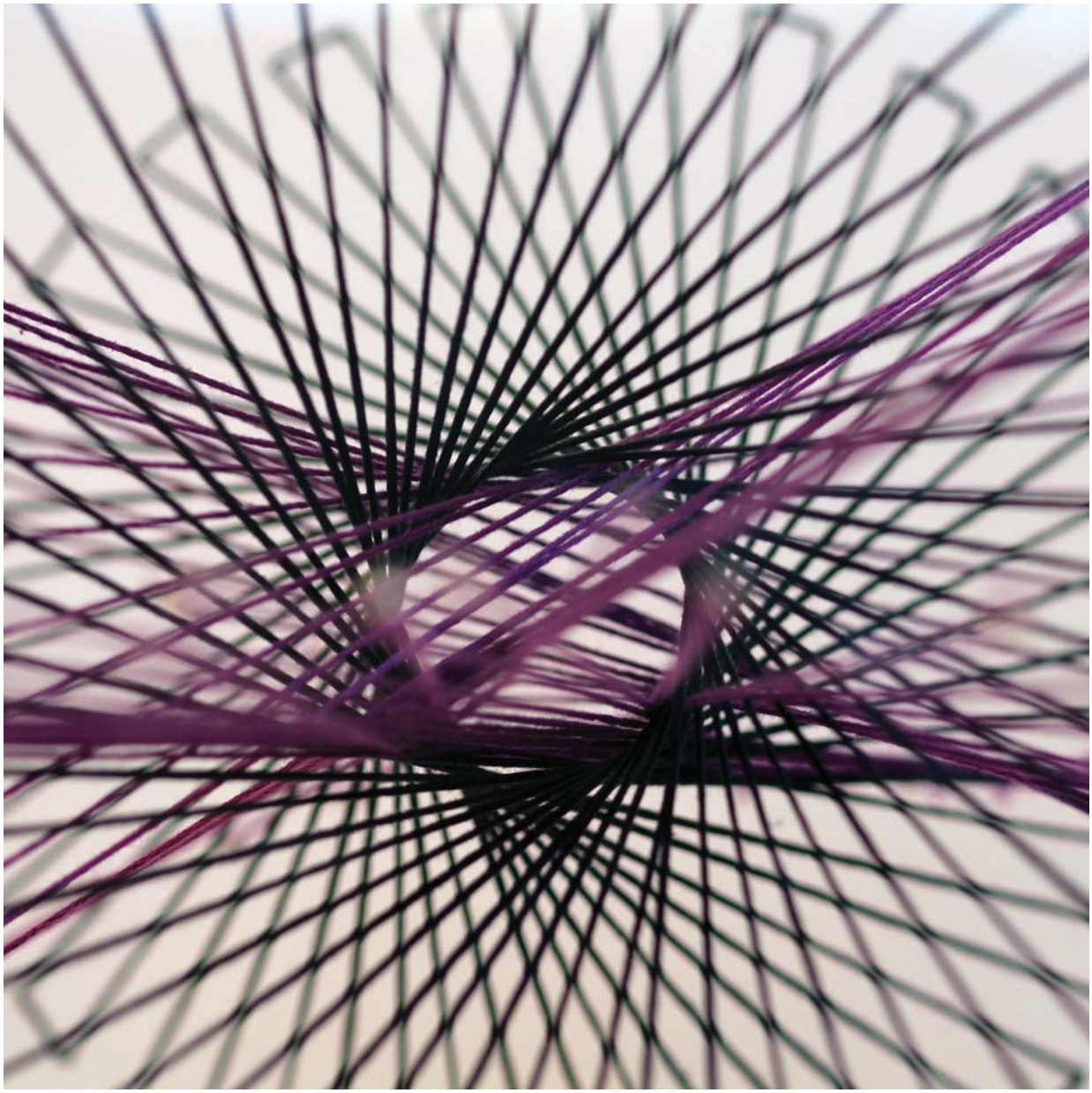
Visualization of Rotational Motion



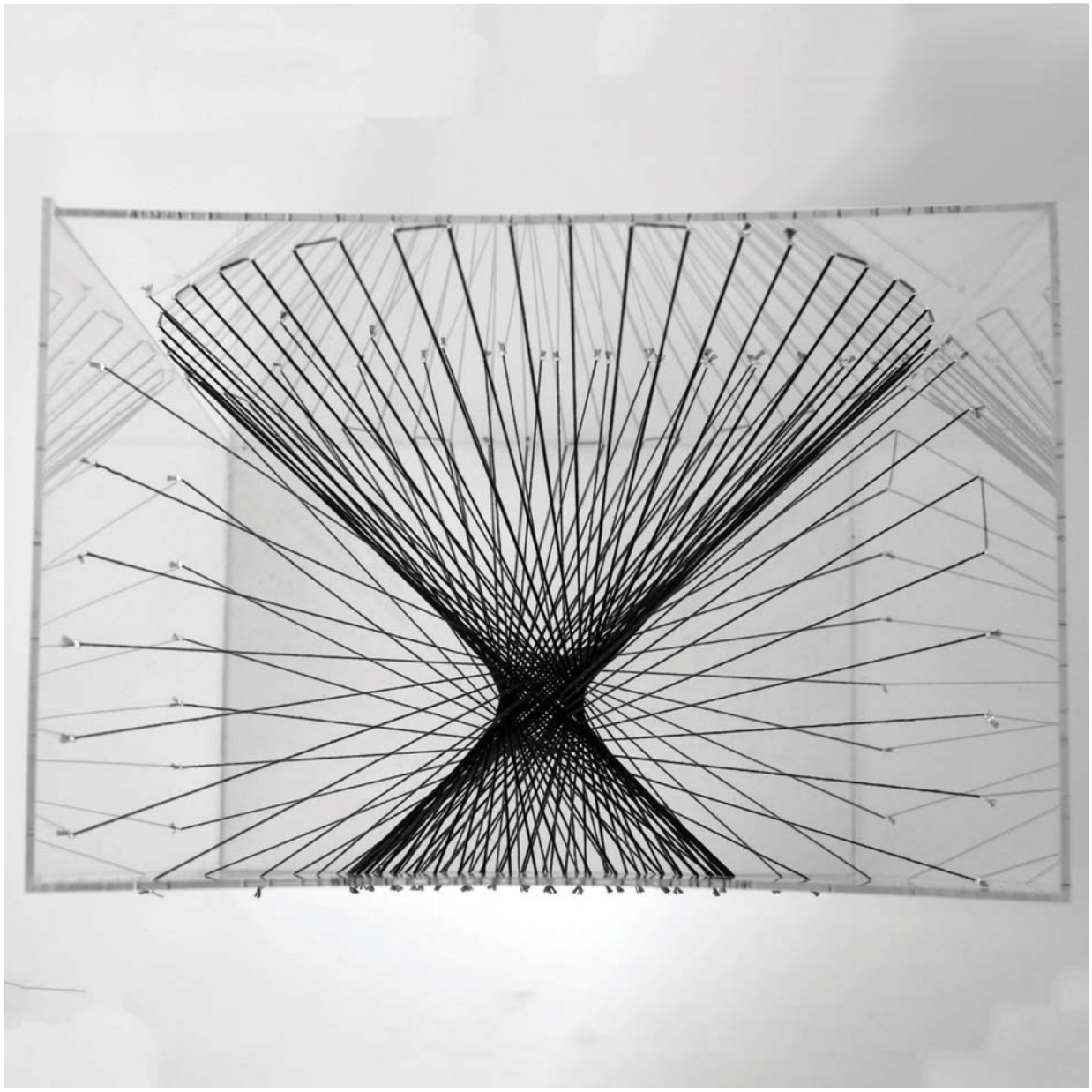
Visualization of Rotational Motion



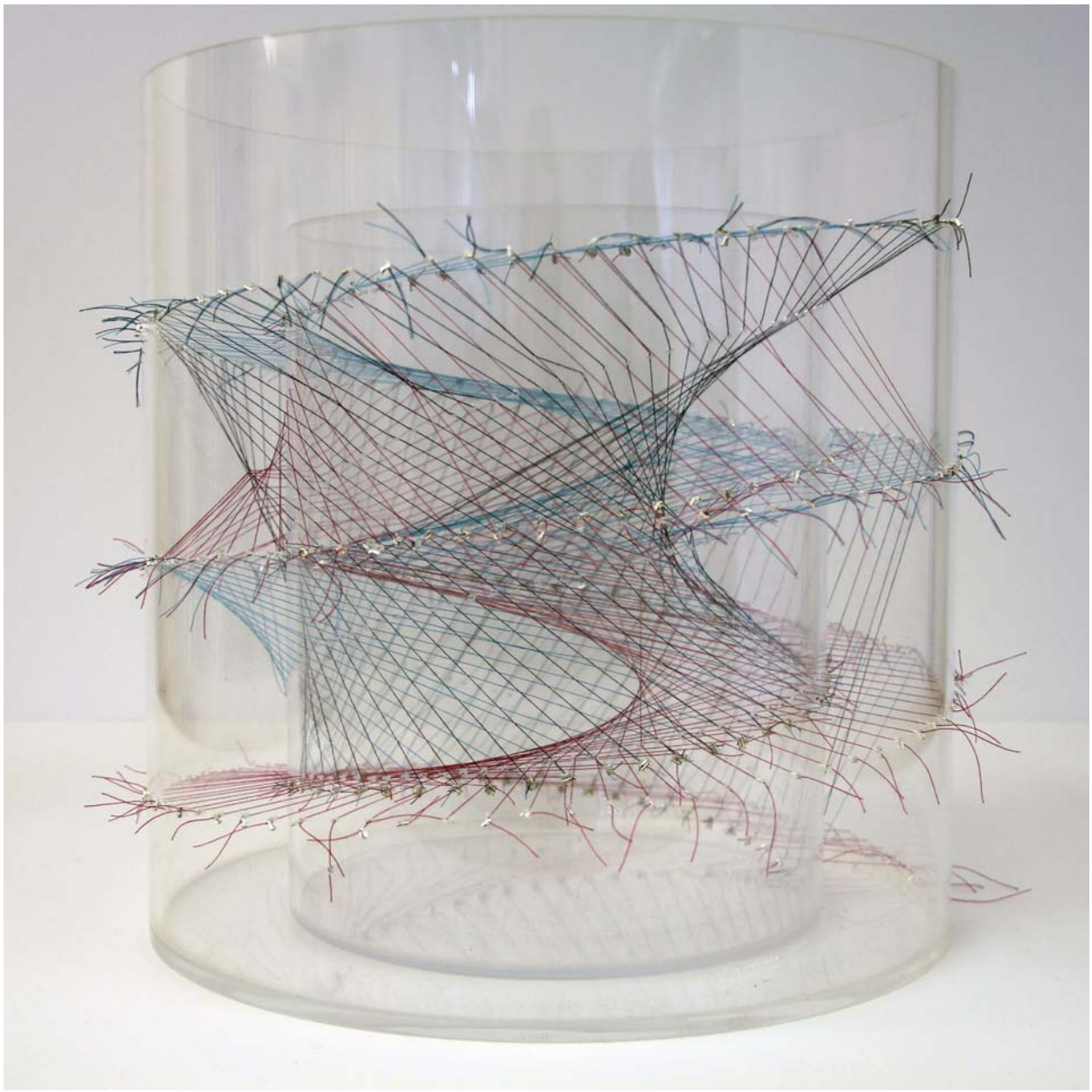
Visualization of Rotational Motion



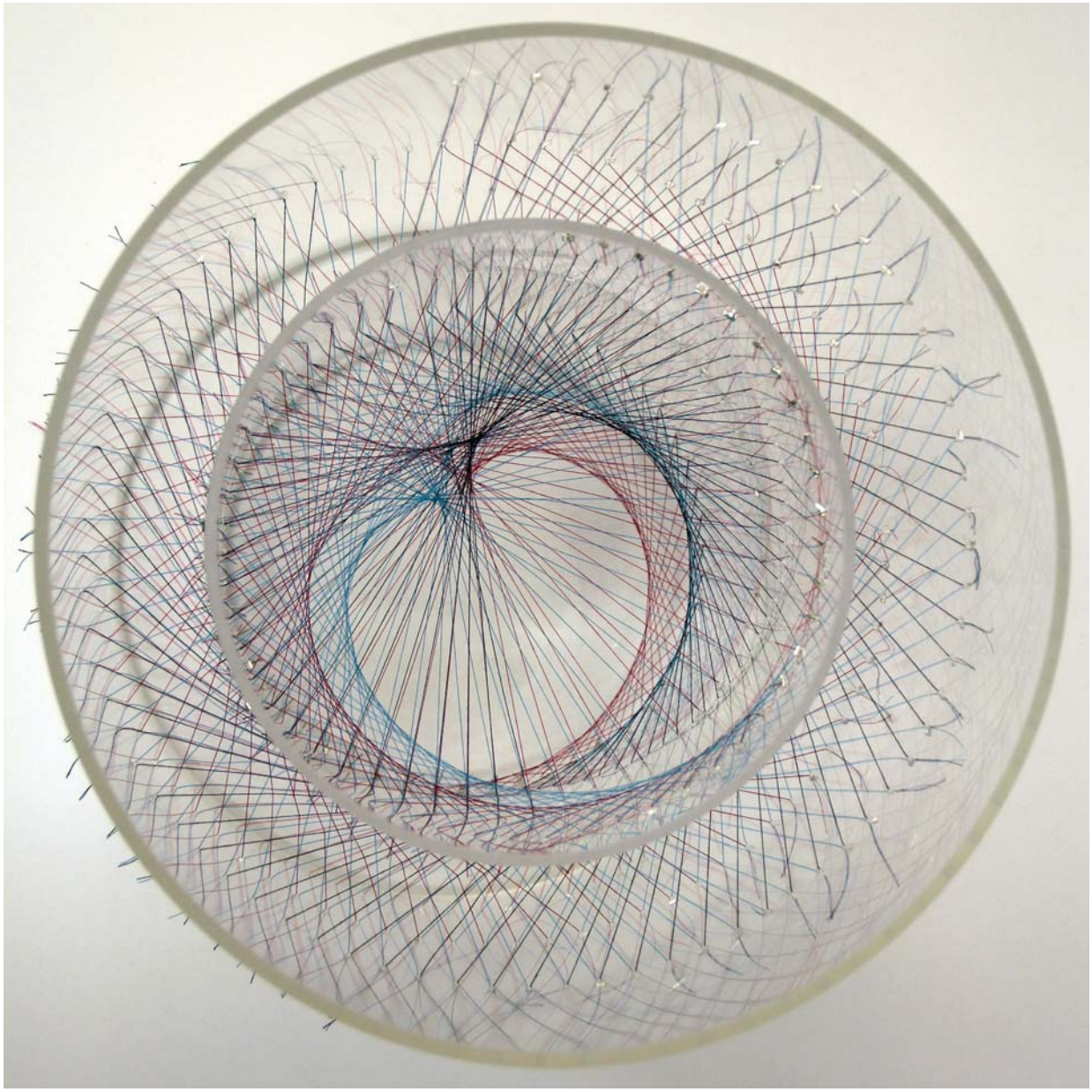
Visualization of Rotational Motion



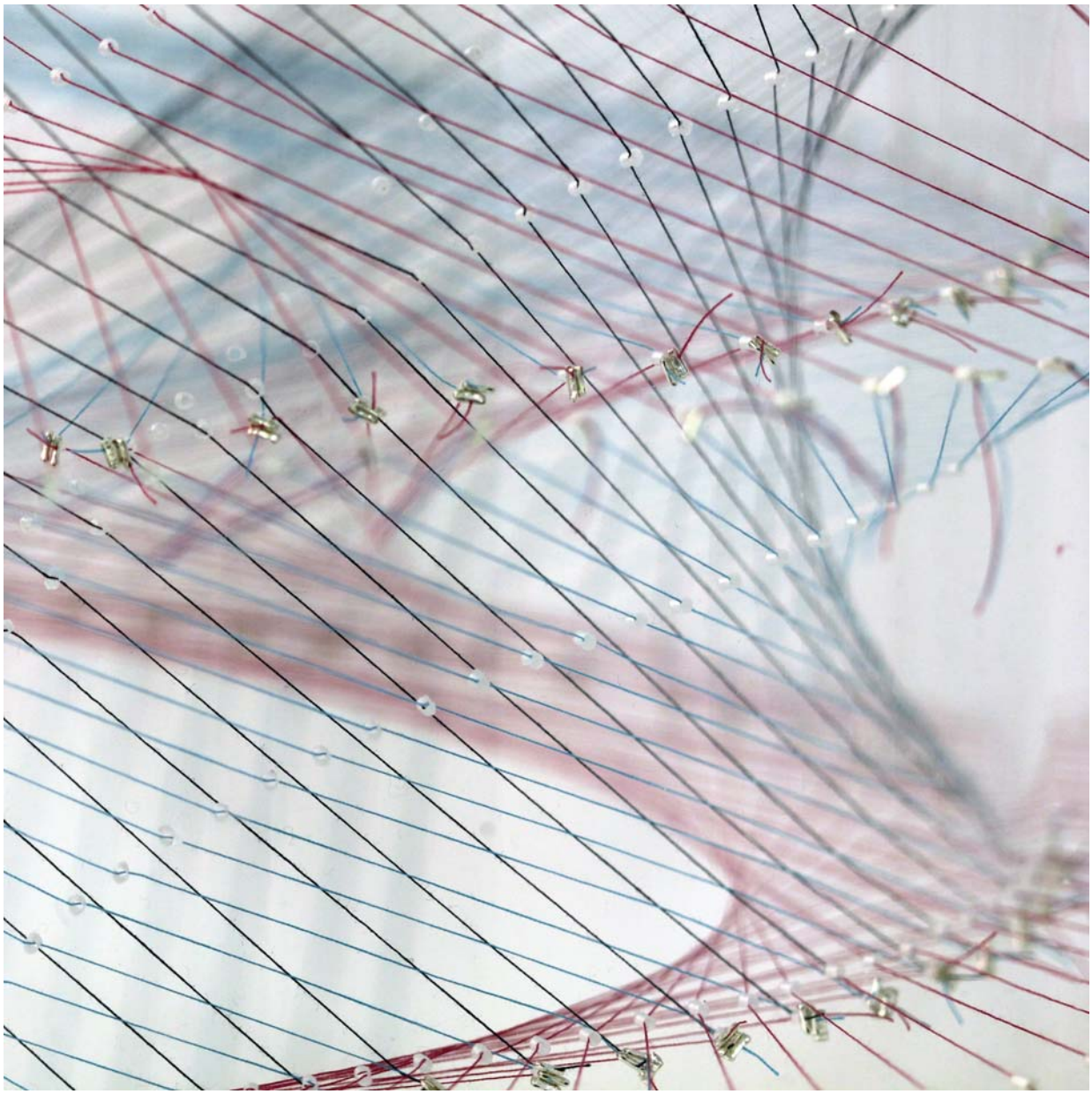
Visualization of Rotational Motion



Rotational Relationships



Rotational Relationships



Rotational Relationships

Thesis Defense


KUKA

Endnotes

1 Robin Evans, *Translations from Drawing to Building*, (Cambridge, MIT Press, 1997).
2 Graham Harman, *The Quadruple Object*, (Lanham: O Books, 2011).
3 Andrew Atwood, “Current Work,” (Lecture given at Sci-Arc, Los Angeles, California, March 30, 2012).
4 John May, “New Massings for New Masses: Collectivity After Orthography,” (Cambridge, MIT Press, 2014).
5 Peter Sloterdijk, “Inspiration,” (Lecture given at the Jan van Eyck Academy, Maastricht, The Netherlands, May 31, 2005).

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