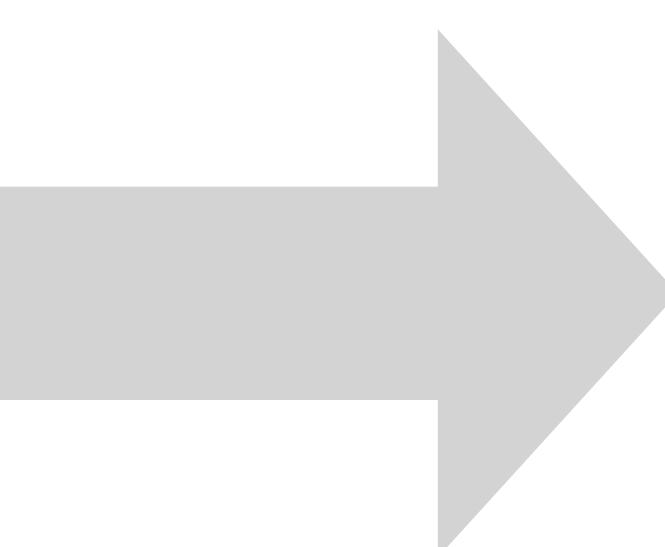
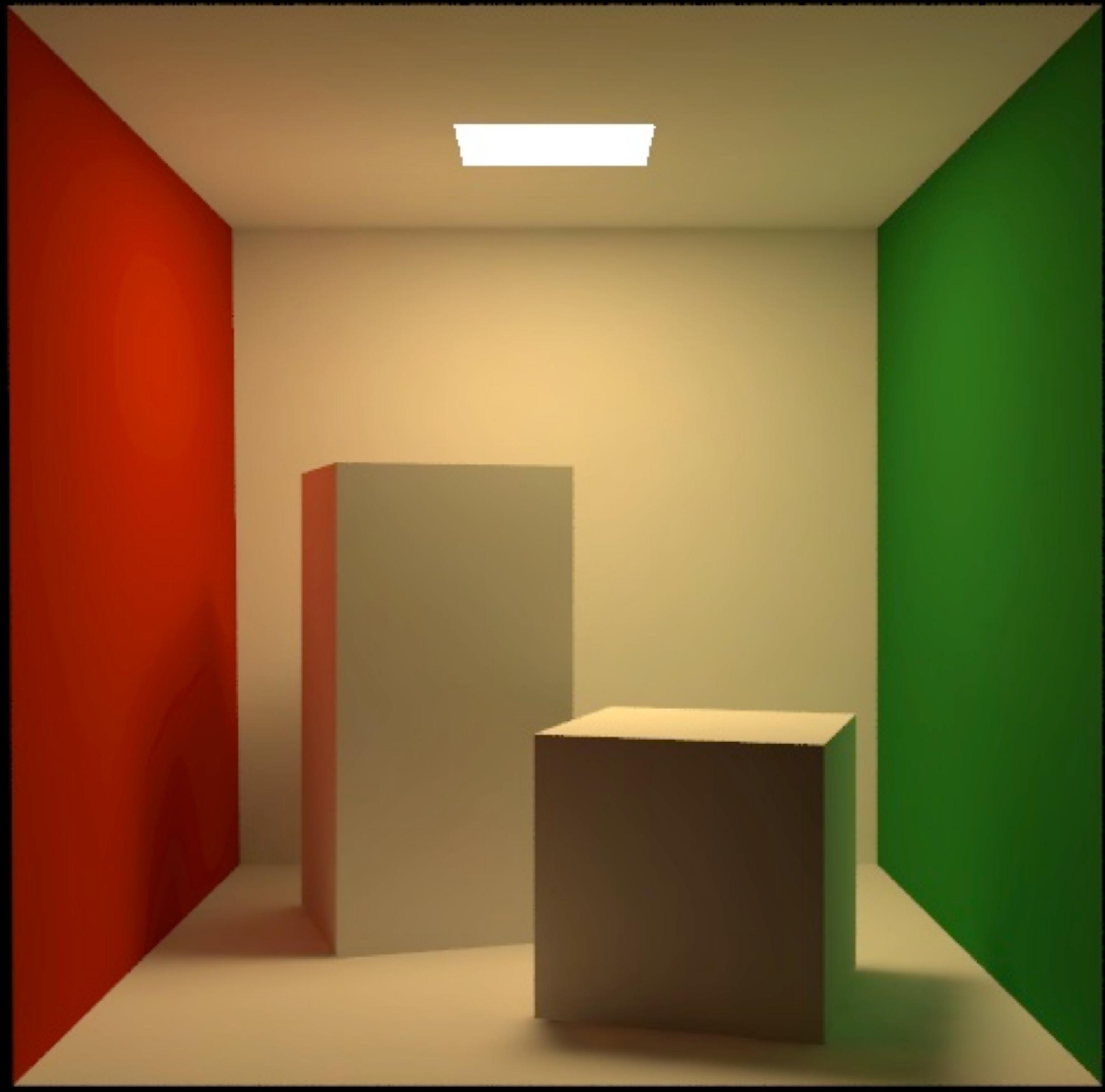


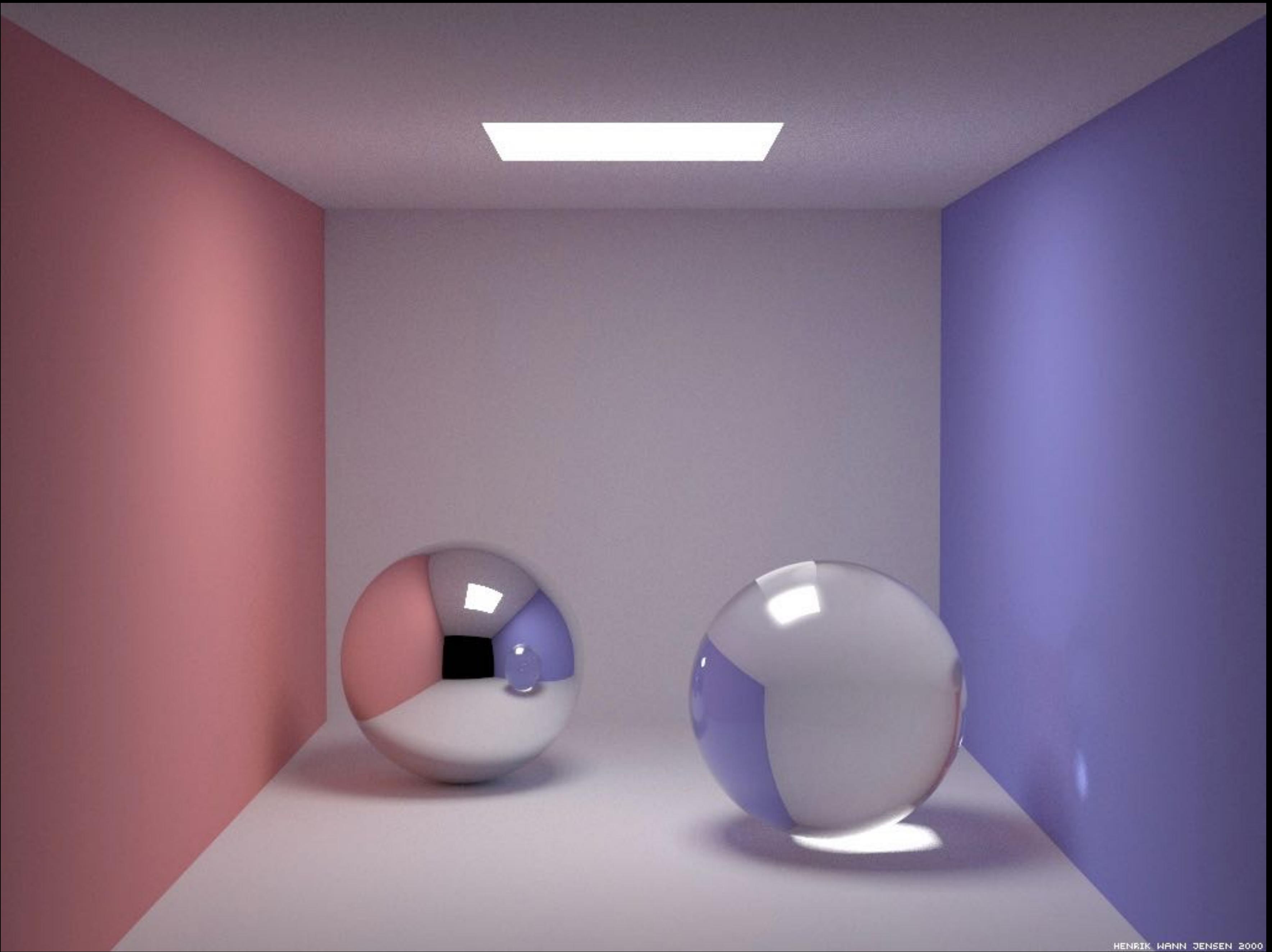
Wrap-up

CS4620 Lecture 27

CS4620	Home	Staff	Schedule	Assignments	Exams	About	Office Hours	Books	Piazza
date	topic		reading		assignments				
25 Jan	Introduction slides								
27 Jan	Triangle meshes slides					Meshes out			
30 Jan	Triangle meshes .obj files demo meshes								
1 Feb	Triangle meshes 2 slides		Sec. 12.1						
3 Feb	Ray tracing intersection slides		Chap. 4, Sec. 2.7						
6 Feb	Ray tracing shading slides								
8 Feb	Ray tracing textures slides		Sec 11.1-2 except 11.2.4			Meshes due			
10 Feb	Ray tracing interpolation slides					Ray 1 out			
13 Feb	Perspective slides								
15 Feb	Transformations slides		Chap. 6, Review 5.1-5.0						
17 Feb	Transformations					Ray 1 due			
20 Feb	—February Break—								
22 Feb	History of CG								
24 Feb	Viewing: Orthographic slides		Sec. 7.0-7.1			Scenes out			
27 Feb	Viewing: Perspective demo		Sec. 7.2-7.5						
1 Mar	Hierarchies and scene graphs slides		Sec. 12.2						
3 Mar	Rasterization slides		Sec. 8-8.1						
6 Mar	Rasterization Graphics Pipeline slides		Chap. 8			Shaders out			
8 Mar	Graphics pipeline								
10 Mar	OpenGL and GLSL demo slides		Chap. 17			Scene due			
13 Mar	Games with textures slides								
15 Mar	—Snow Day—								
17 Mar	Games with textures demo								
20 Mar	Textures Splines slides		Sec. 15.0-15.3						
21 Mar	Midterm: 7:30pm, Olin Hall 155								
22 Mar	Splines		Sec. 15.4-15.6			Splines out			
24 Mar	Splines					Shaders due			
27 Mar	Subdivision surfaces slides								
29 Mar	Animation slides		Sec. 16.0-2						
31 Mar	Animation and 3D Rotations		Sec. 16.3-7 (just for interest)			Splines due			
3 Apr	—Spring Break—								
5 Apr	—Spring Break—								
7 Apr	—Spring Break—								
10 Apr	Ray Tracing acceleration slides		Sec. 12.3			Animation out			
12 Apr	Physics-based animation slides								
14 Apr	Reflection and illumination slides								
17 Apr	Monte Carlo illumination slides								
19 Apr	Monte Carlo illumination					Animation due			
21 Apr	Advanced ray tracing slides		Chap. 13			Ray 2 out			
24 Apr	Advanced ray tracing								
26 Apr	Advanced ray tracing								
20 Apr	Images and Displays slides		Chap. 3						
1 May	Antialiasing and compositing slides		Sec. 3.4, 11.4						
3 May	Antialiasing and compositing								
5 May	Color science		Chap. 19			Ray 2 due			
8 May	Color science								
10 May	Wrap-up								
12 May	Final Exam: 1pm, Olin Hall 155								





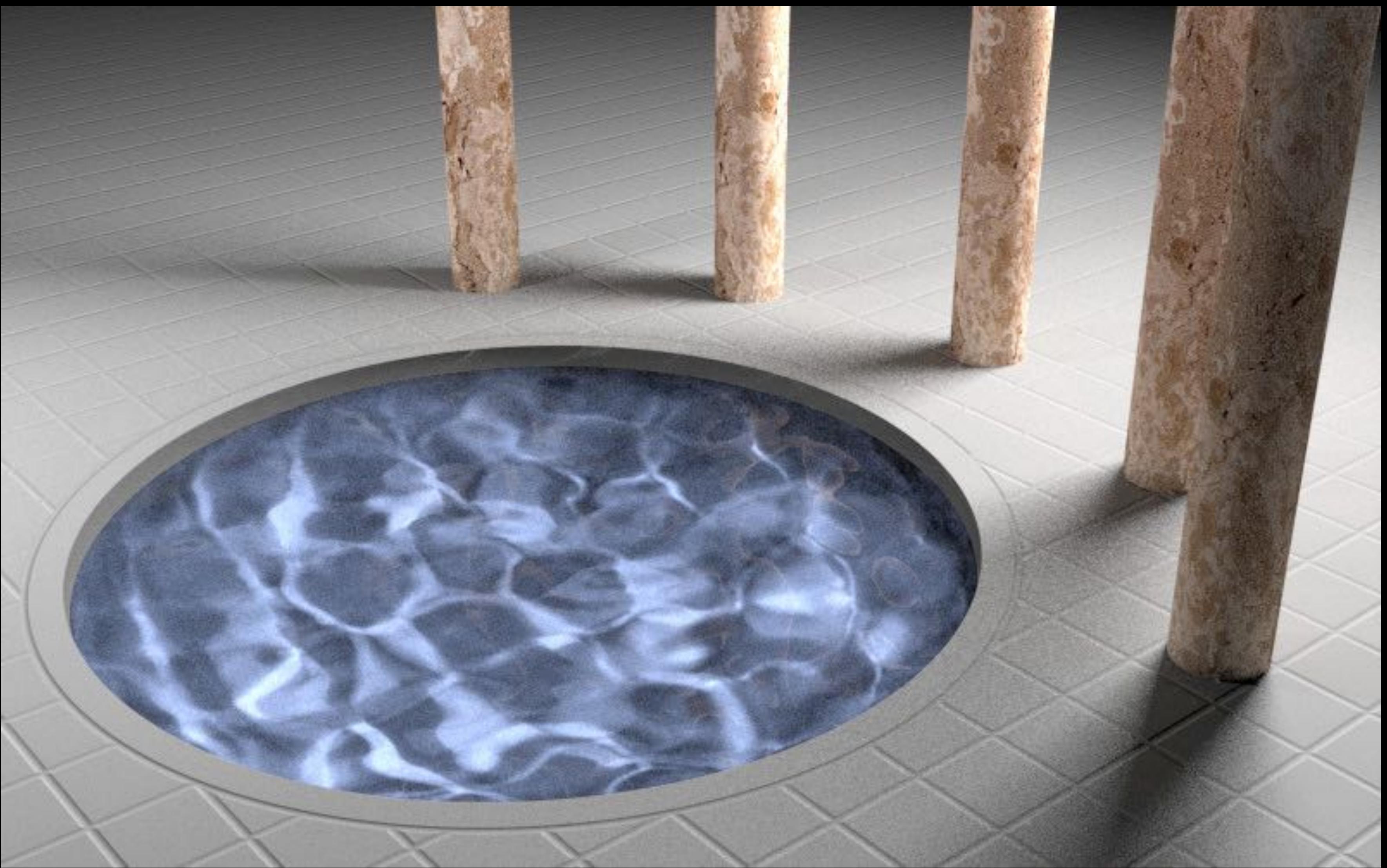


HENRIK WANN JENSEN 2000



Henrik Wann Jensen

RENDERED USING DALI - HENRIK WANN JENSEN 2000

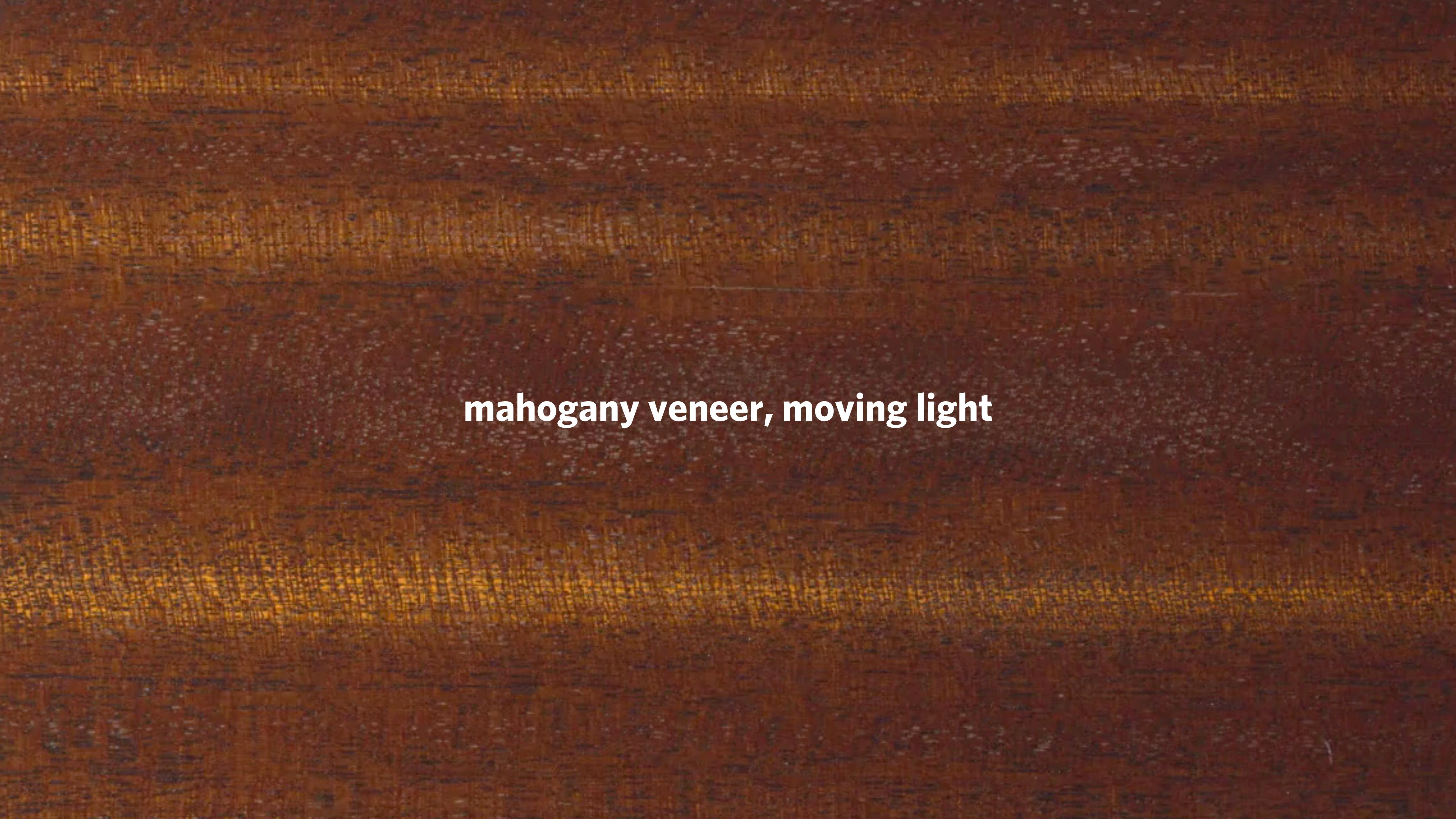




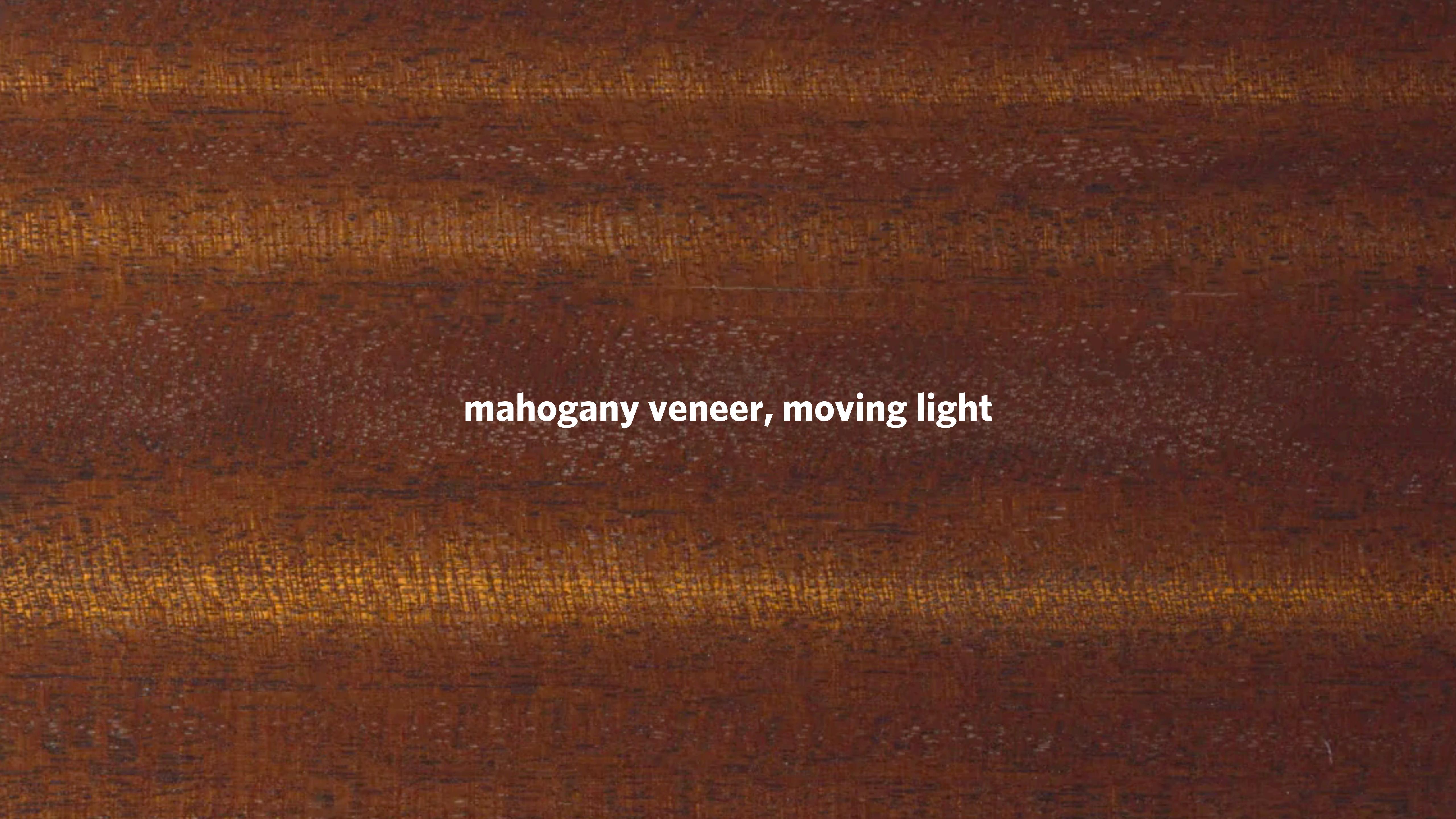
[Jakob et al. SIGGRAPH 2014]





A close-up photograph of a dark wood surface, likely mahogany veneer. The wood grain is clearly visible, running horizontally across the frame. The color is a rich, dark brown with some lighter, golden-yellow highlights where the light hits the grain. There are also a few small, white, irregular spots scattered across the surface.

mahogany veneer, moving light

A close-up photograph of a dark wood surface, likely mahogany veneer. The wood grain is clearly visible, running horizontally across the frame. The color is a rich, dark brown with some lighter, golden-brown highlights where the light hits the grain. There are a few small, white, irregular spots scattered across the surface.

mahogany veneer, moving light



Valdese Weavers



volume optics

light reflection from translucent materials

volume optics

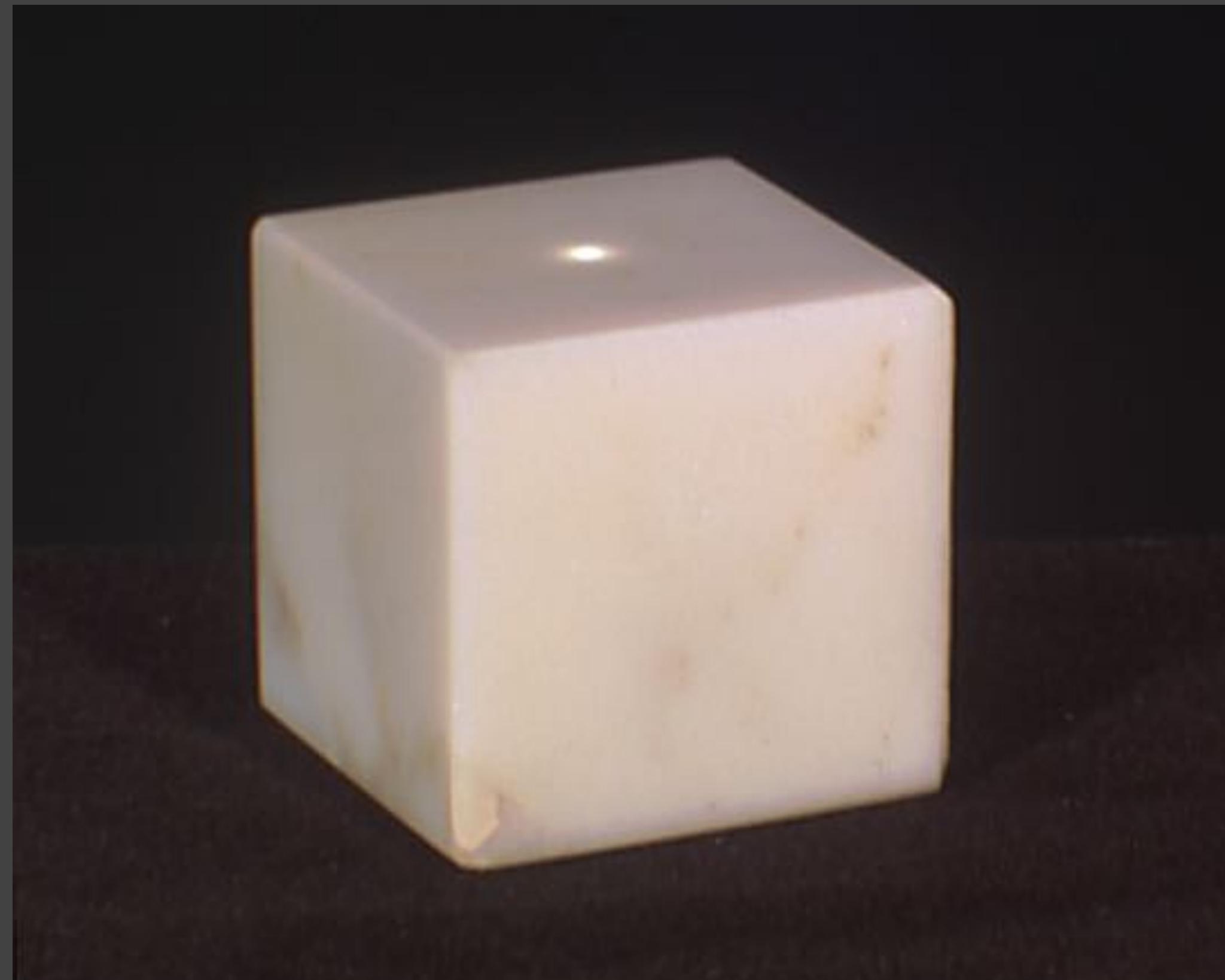
light reflection from translucent materials

Henrik Wann Jensen, Stephen R. Marschner, Marc Levoy, and Pat Hanrahan.
“A Practical Model for Subsurface Light Transport.” SIGGRAPH 2001.

Why do these look wrong?



Marble sample



40mm cube of statuary marble

HDR photograph



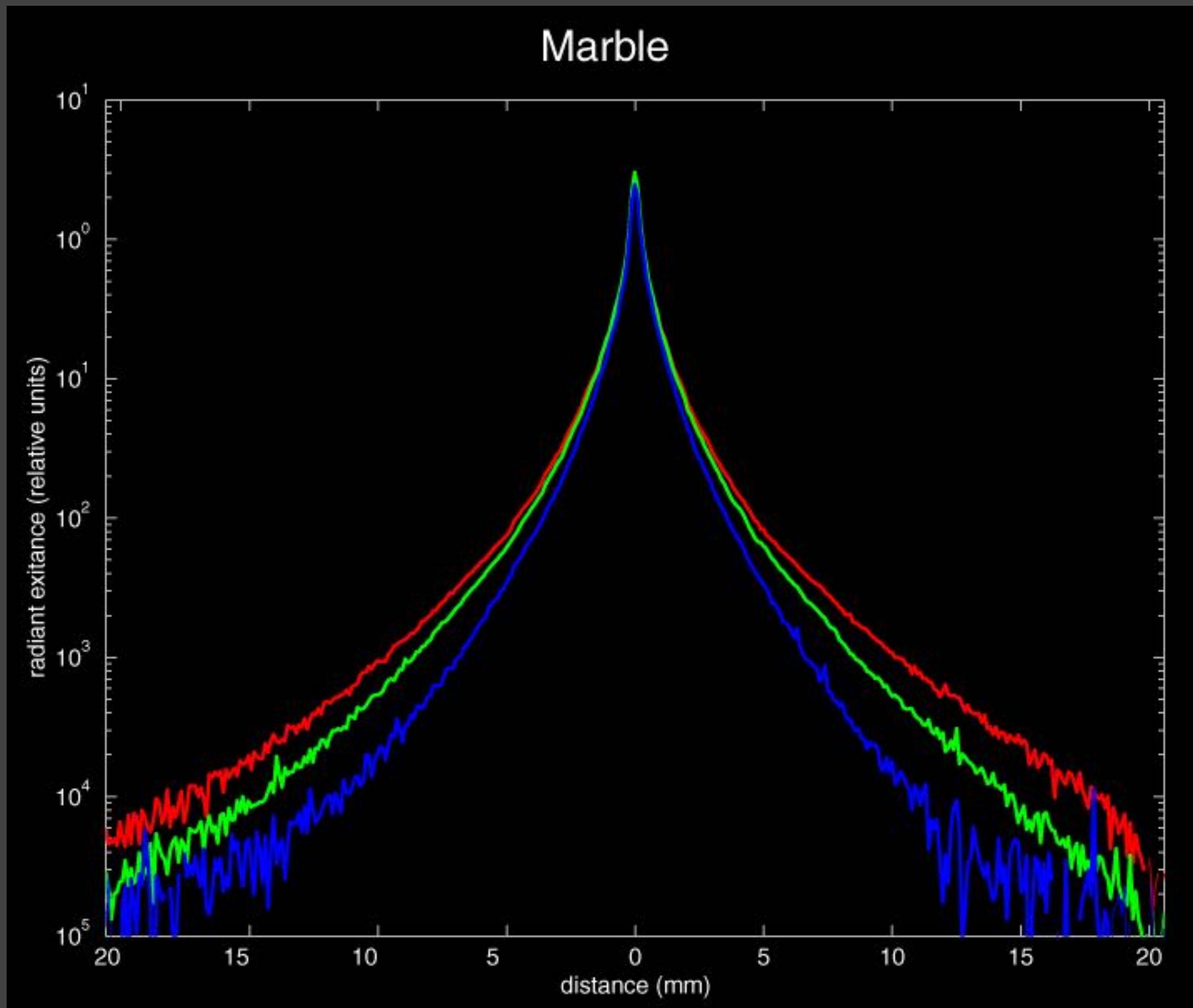
(log scaled image)

HDR photograph

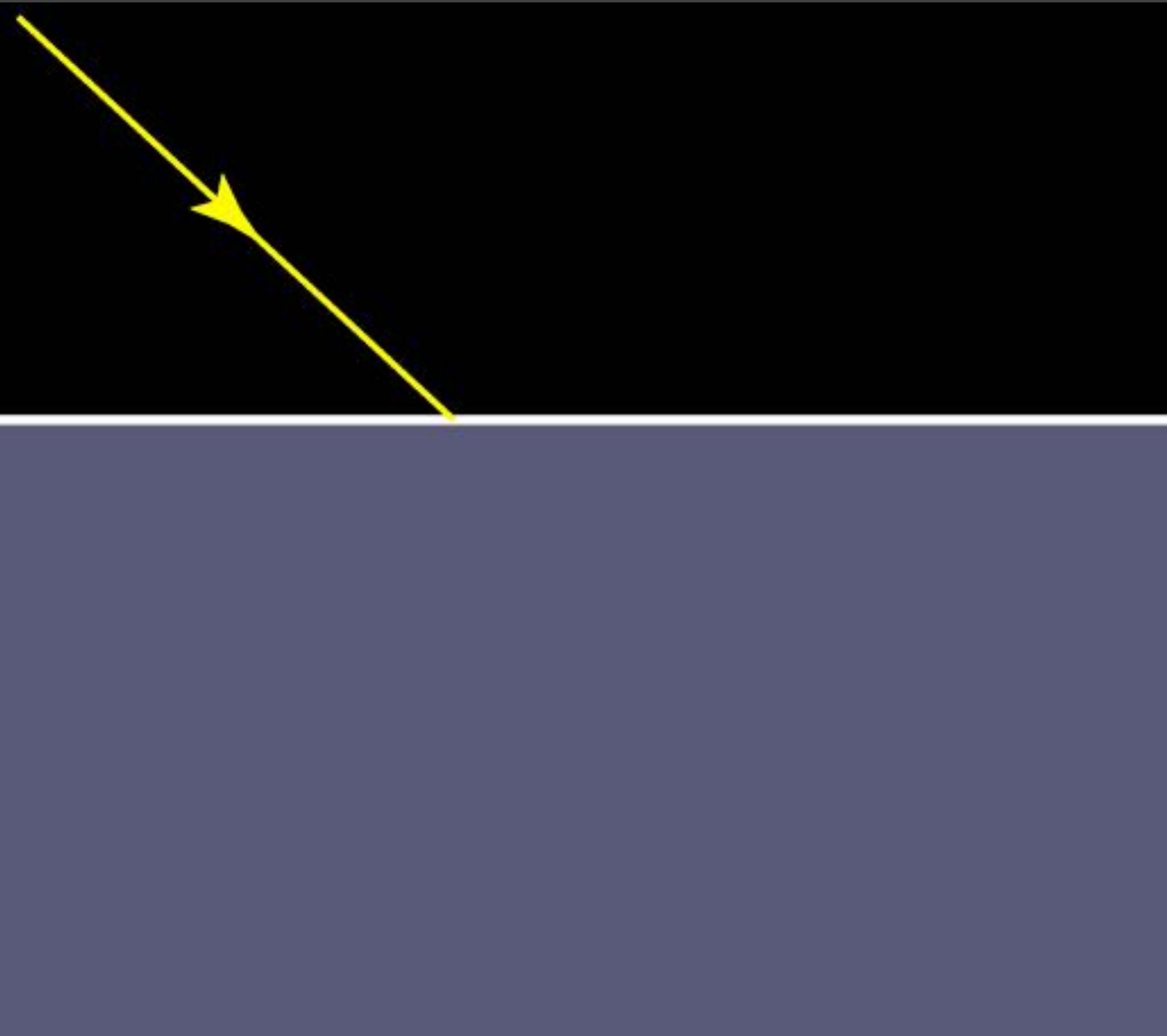


(log scaled image)

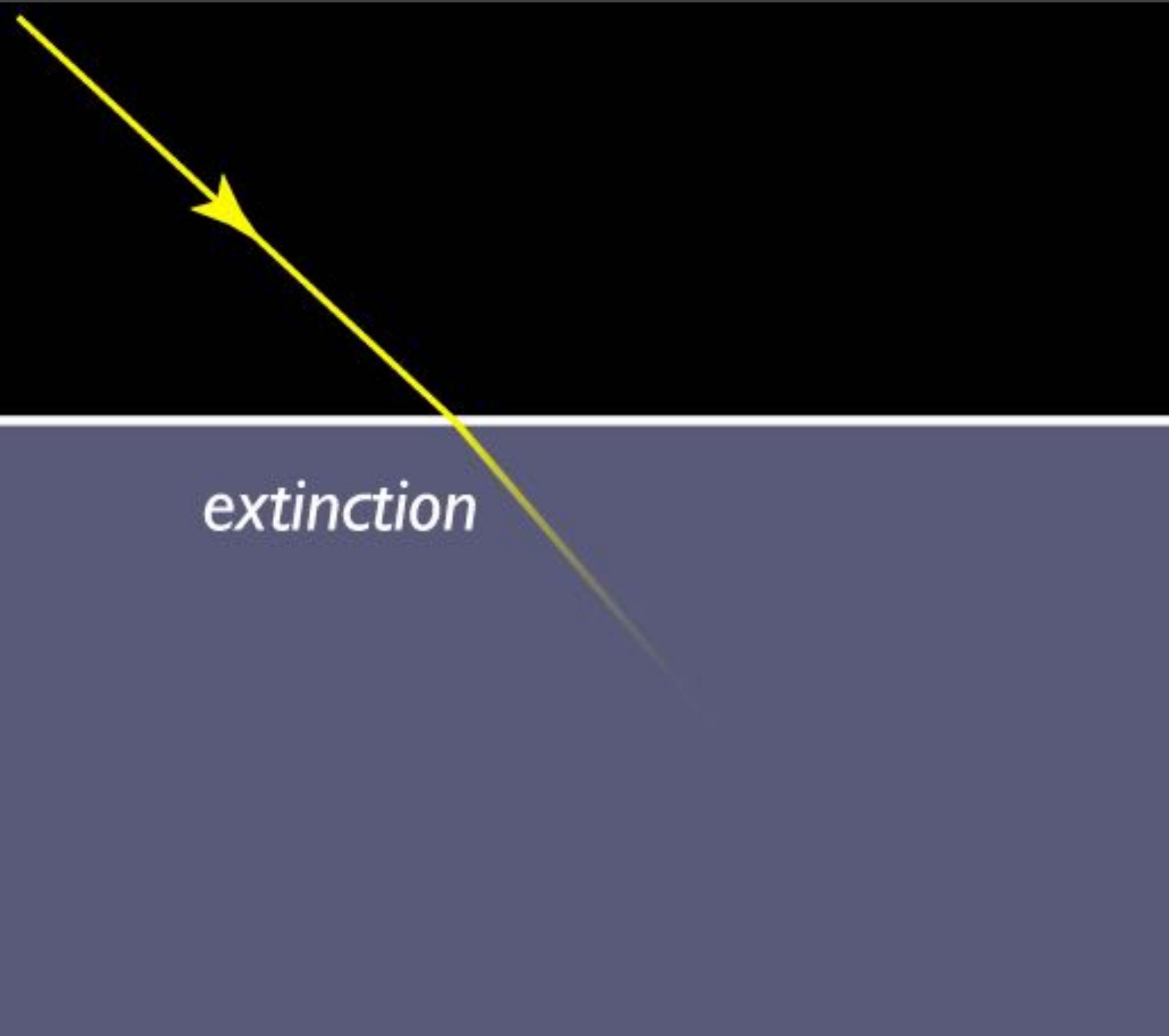
Marble



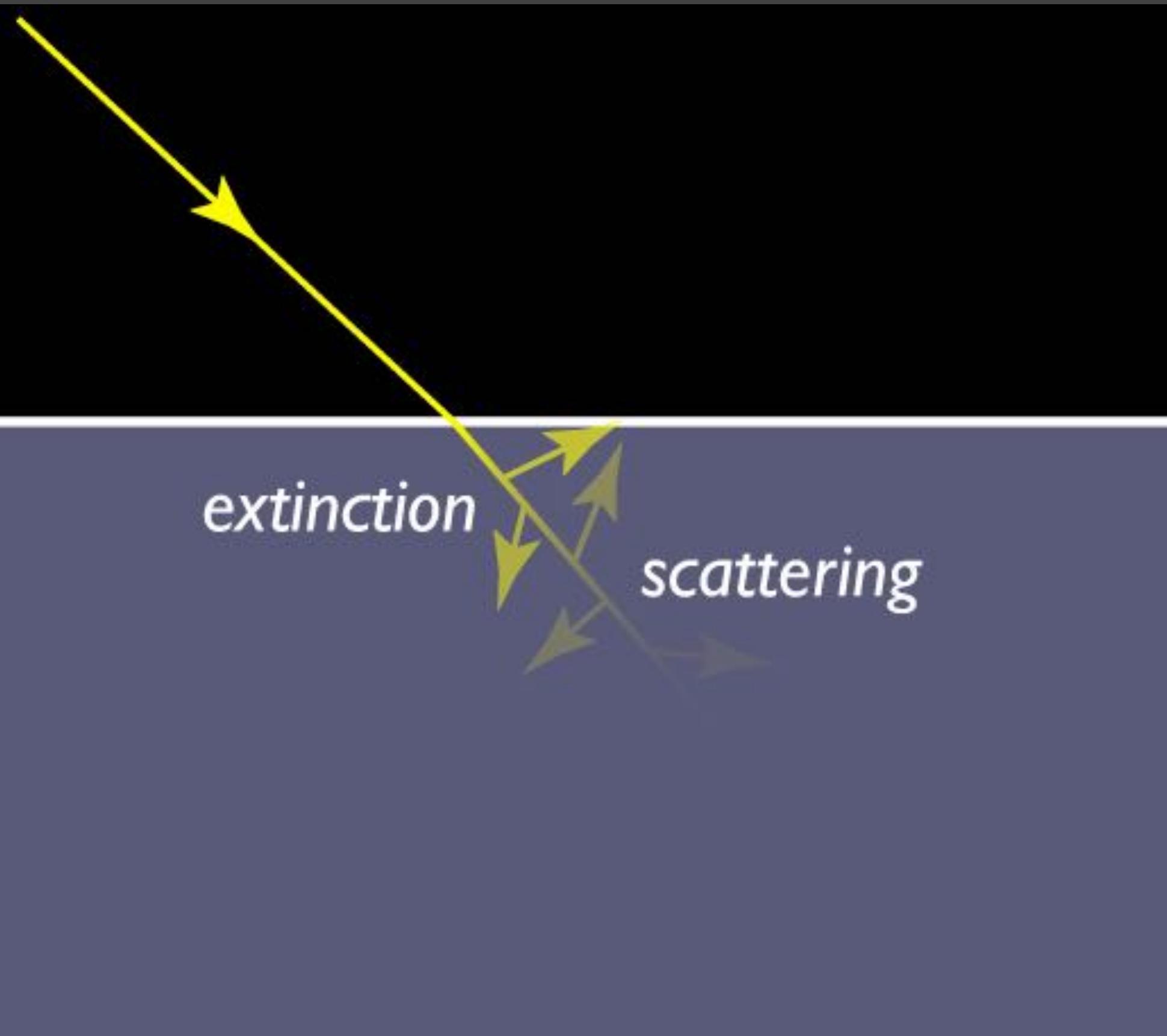
Subsurface volume scattering



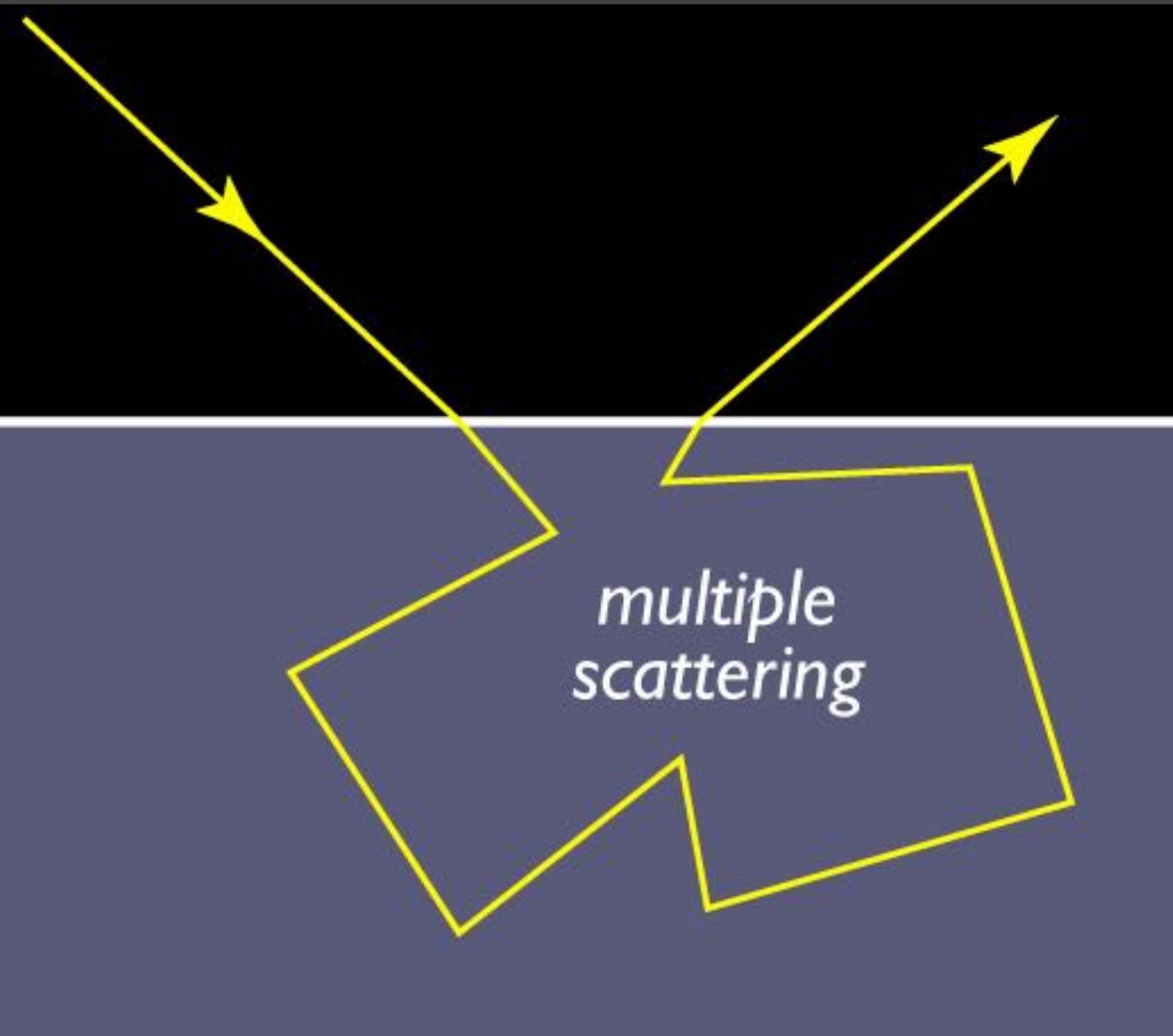
Subsurface volume scattering



Subsurface volume scattering



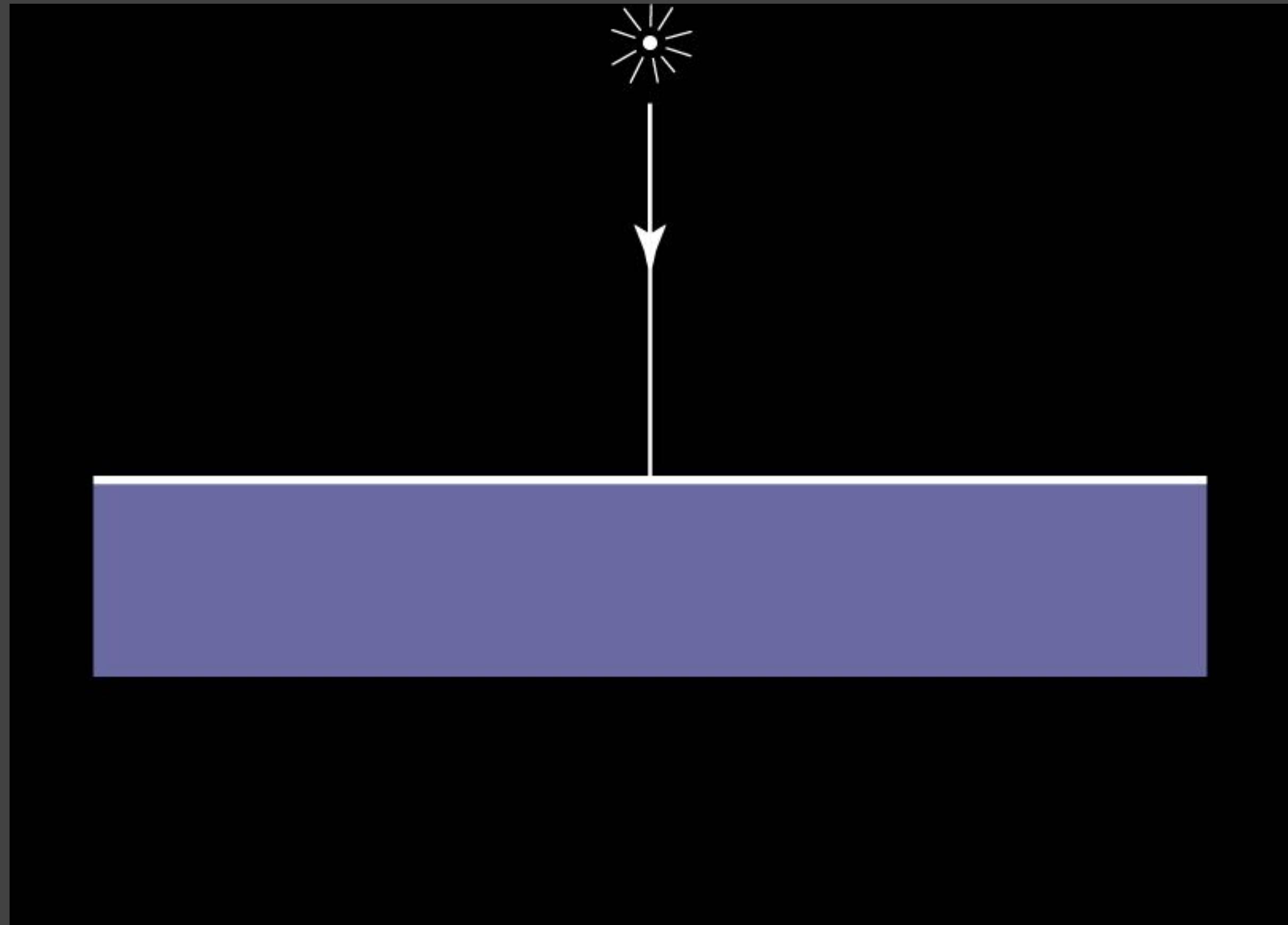
Subsurface volume scattering



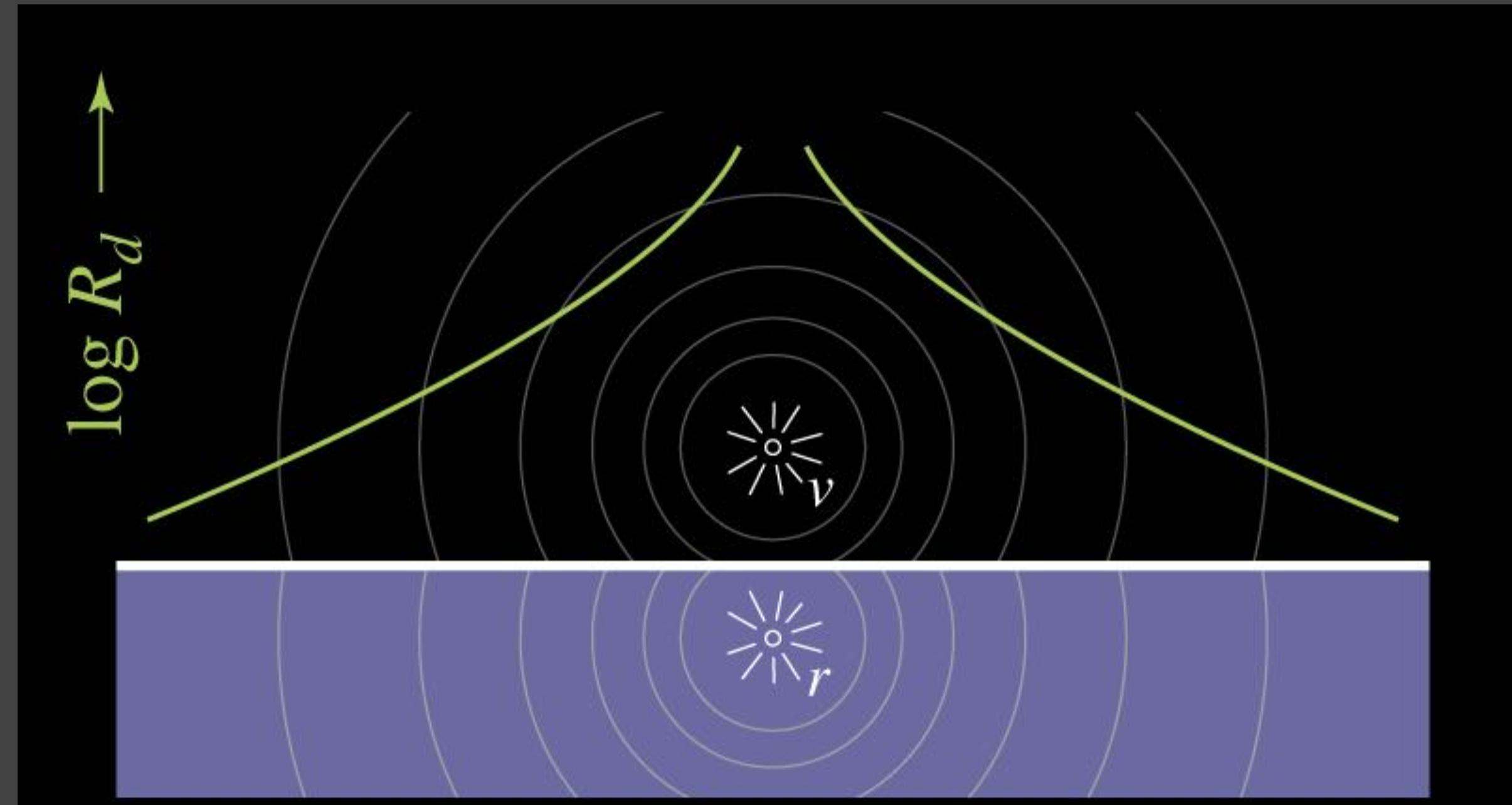
Light diffusion

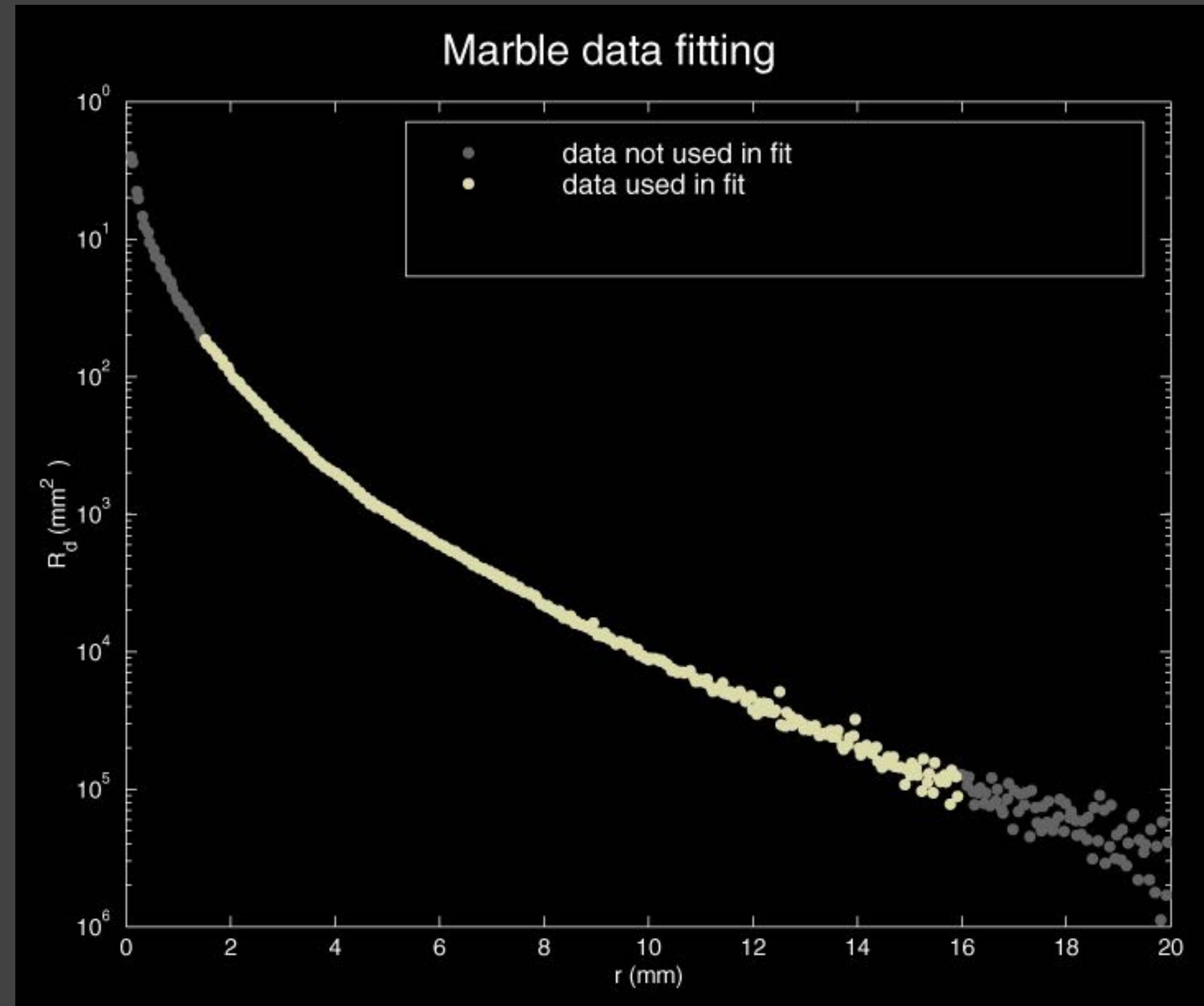


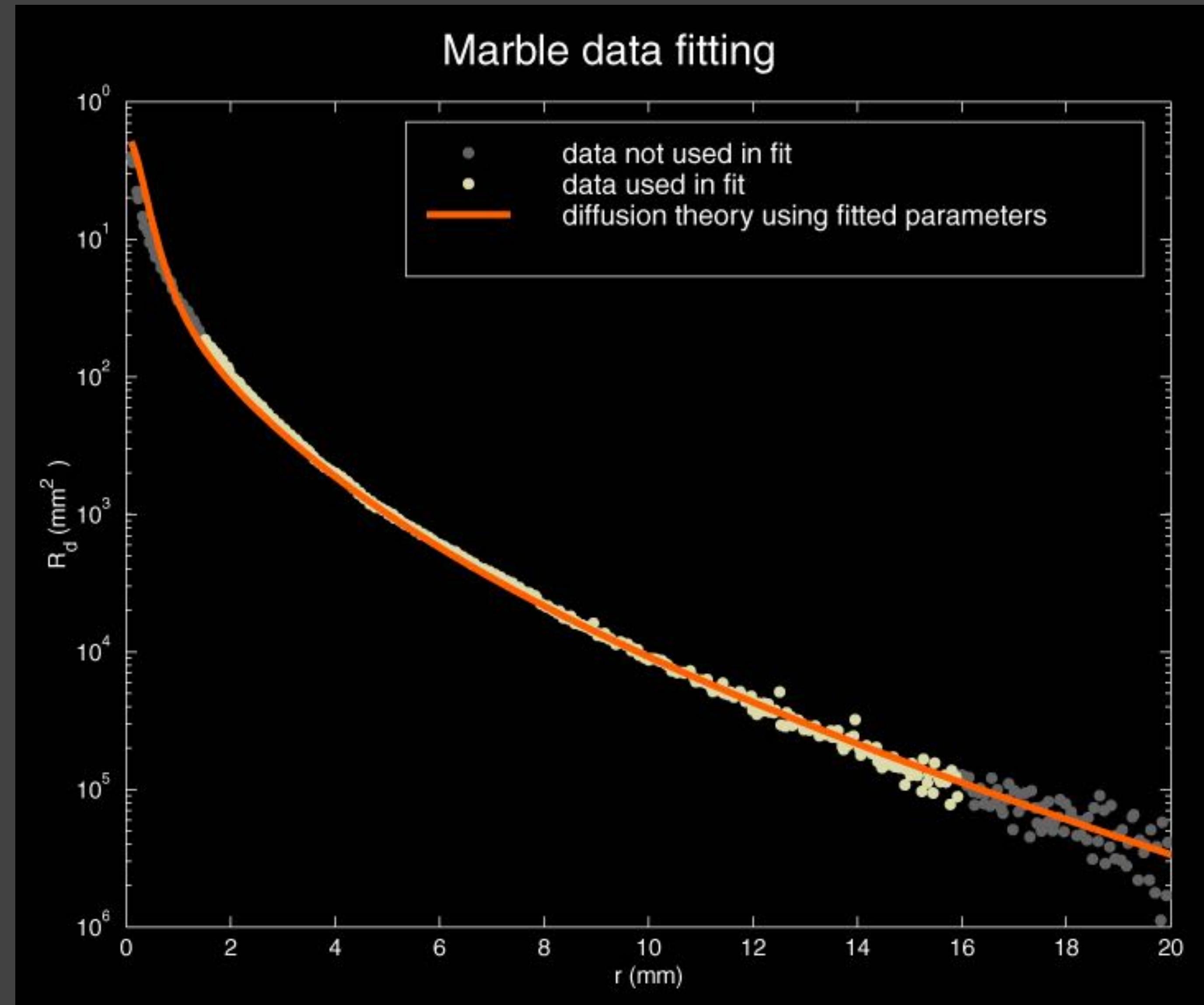
Diffusion approximation



Diffusion approximation







Results: milk



Diffuse “milk”

Results: milk



Diffuse “milk”



Skim milk

Results: milk



Diffuse “milk”

Skim milk

Whole milk

Results: skin



opaque skin



translucent skin

The Two Towers (2002)



hair optics

scattering from human hair fibers

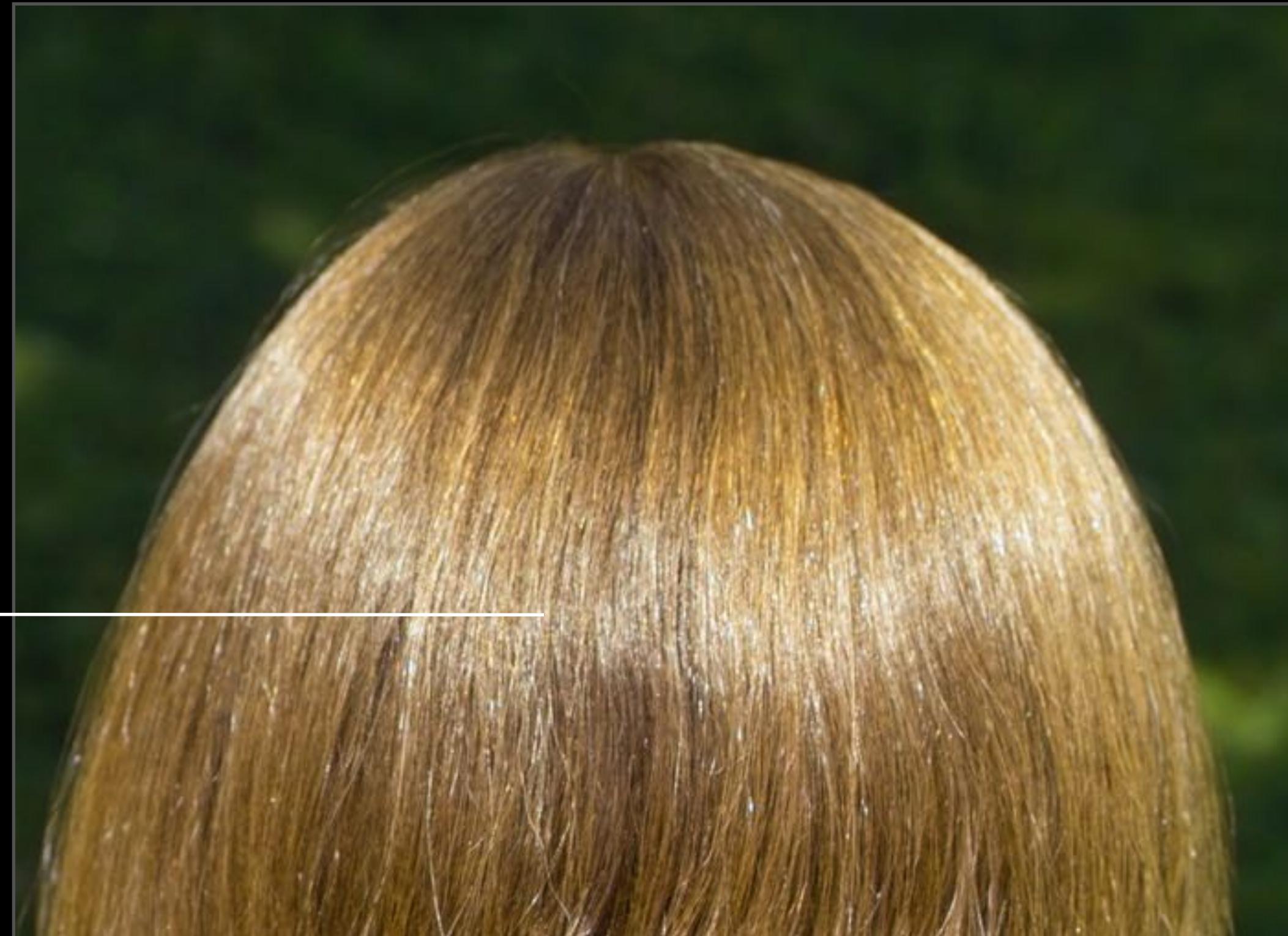
hair optics

scattering from human hair fibers

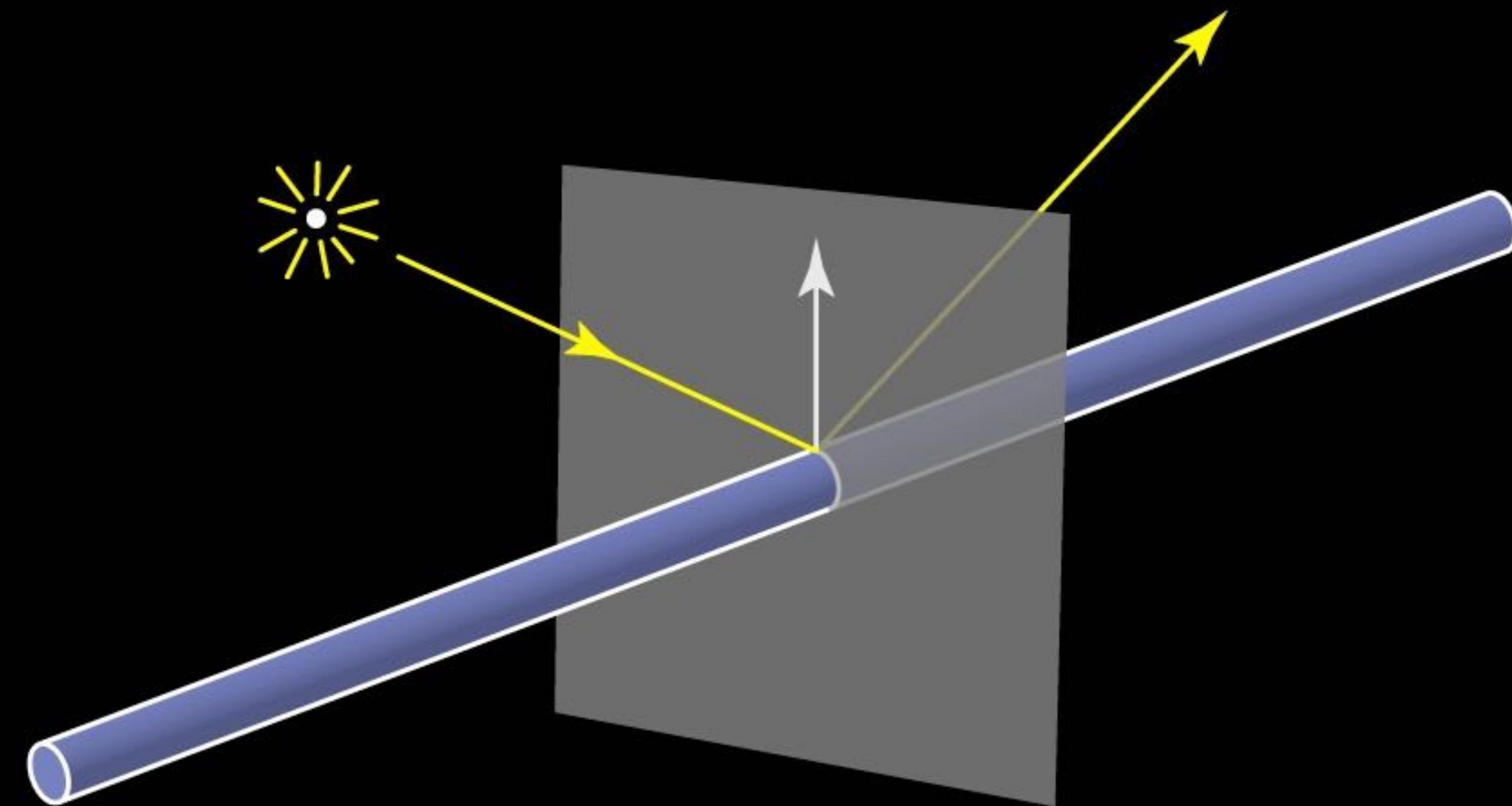
Stephen R. Marschner, Henrik Wann Jensen, Mike Cammarano, Steve Worley, and Pat Hanrahan. "Light Scattering from Human Hair Fibers." SIGGRAPH 2003.

Hair appearance

highlight

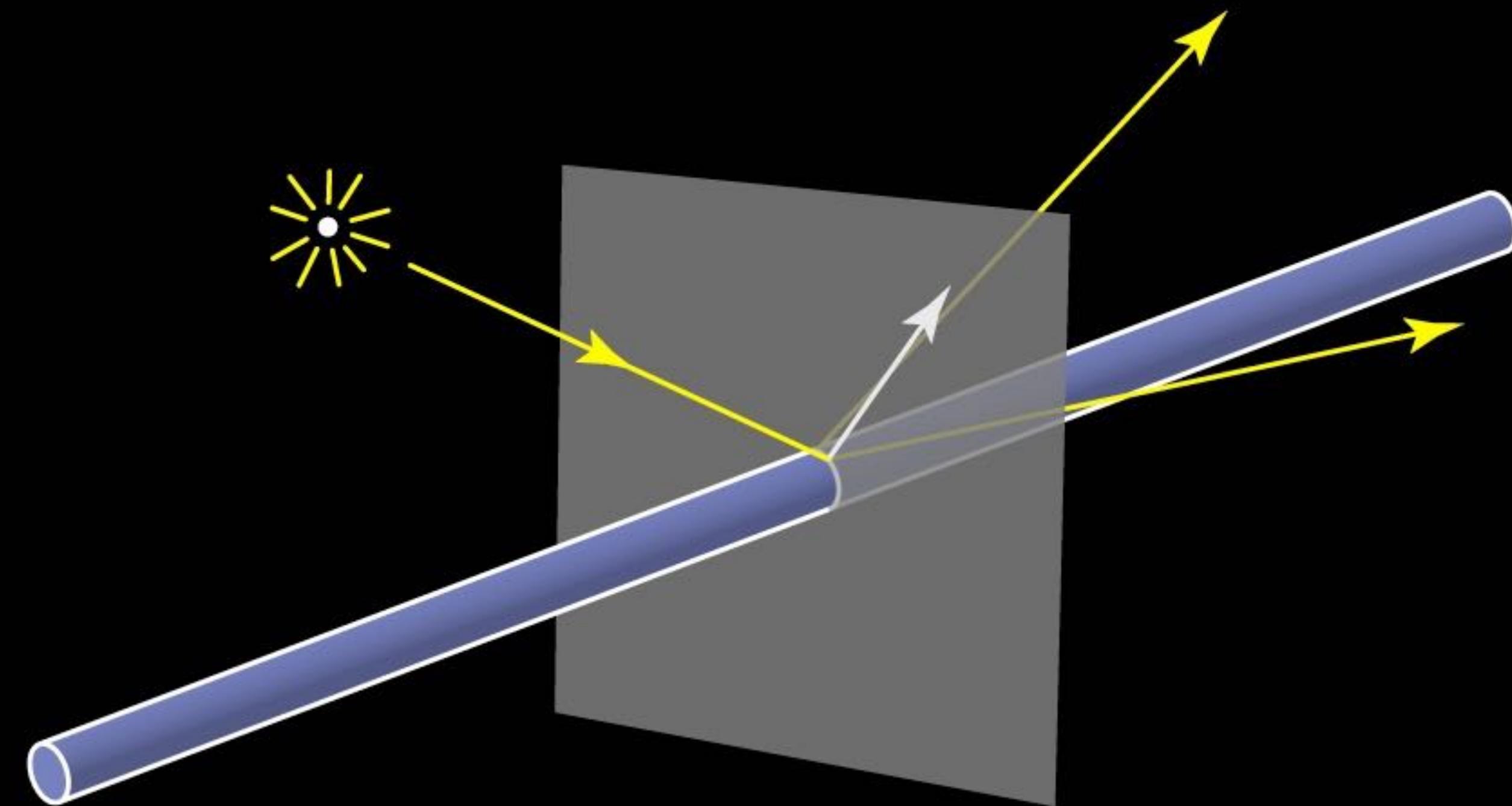


Classic hair reflection model



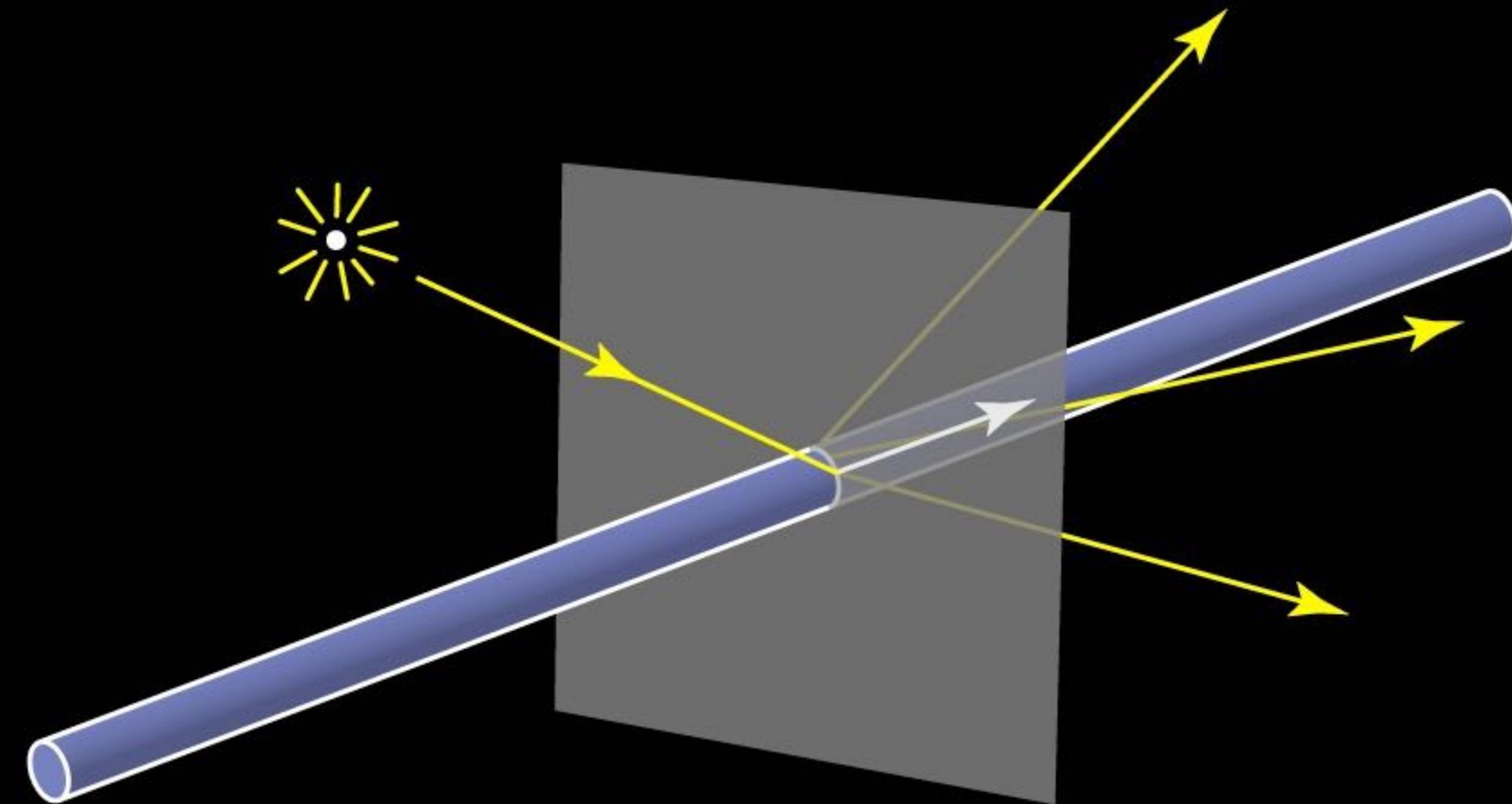
predicts a single, white highlight

Classic hair reflection model



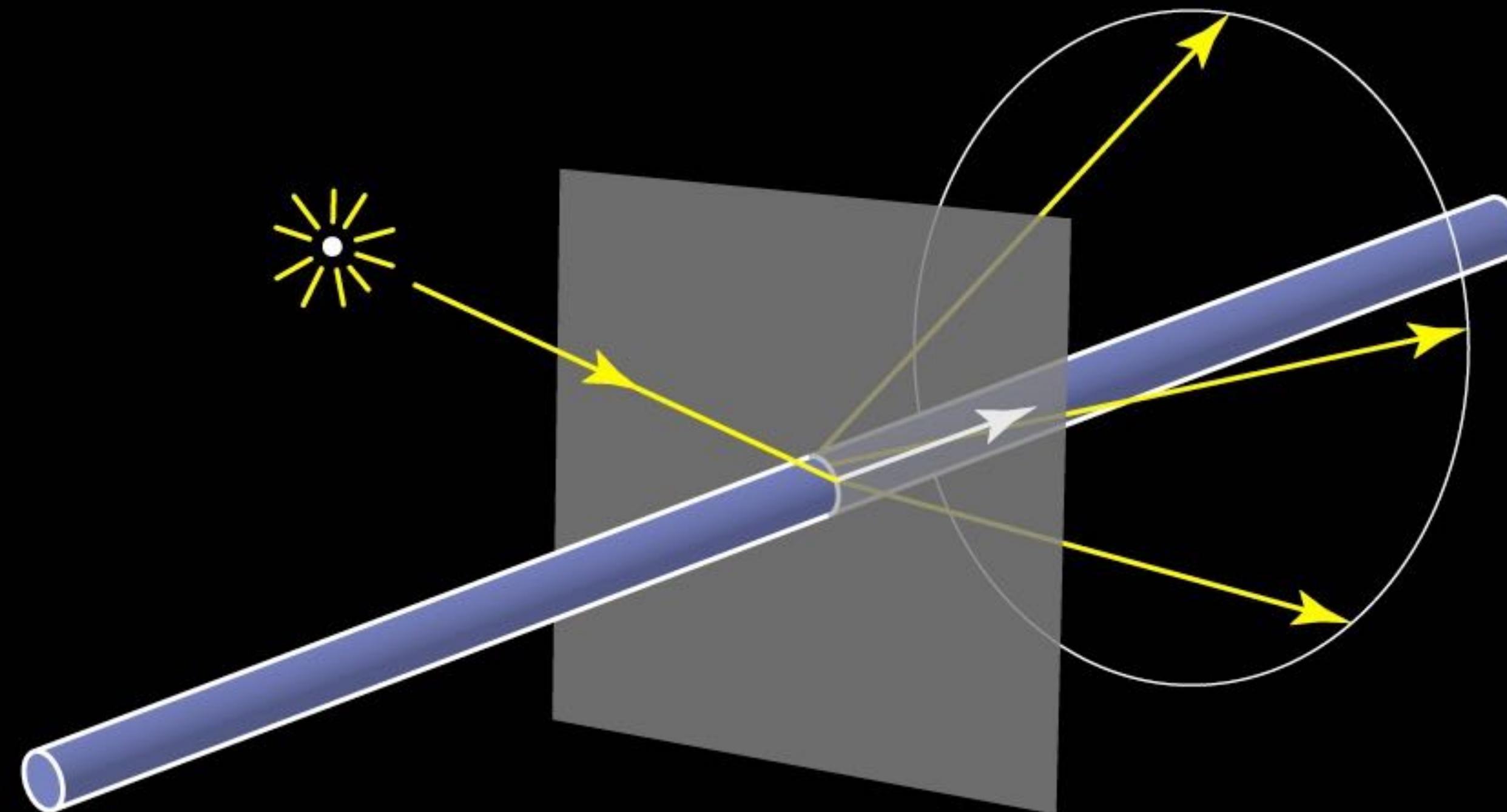
predicts a single, white highlight

Classic hair reflection model



predicts a single, white highlight

Classic hair reflection model

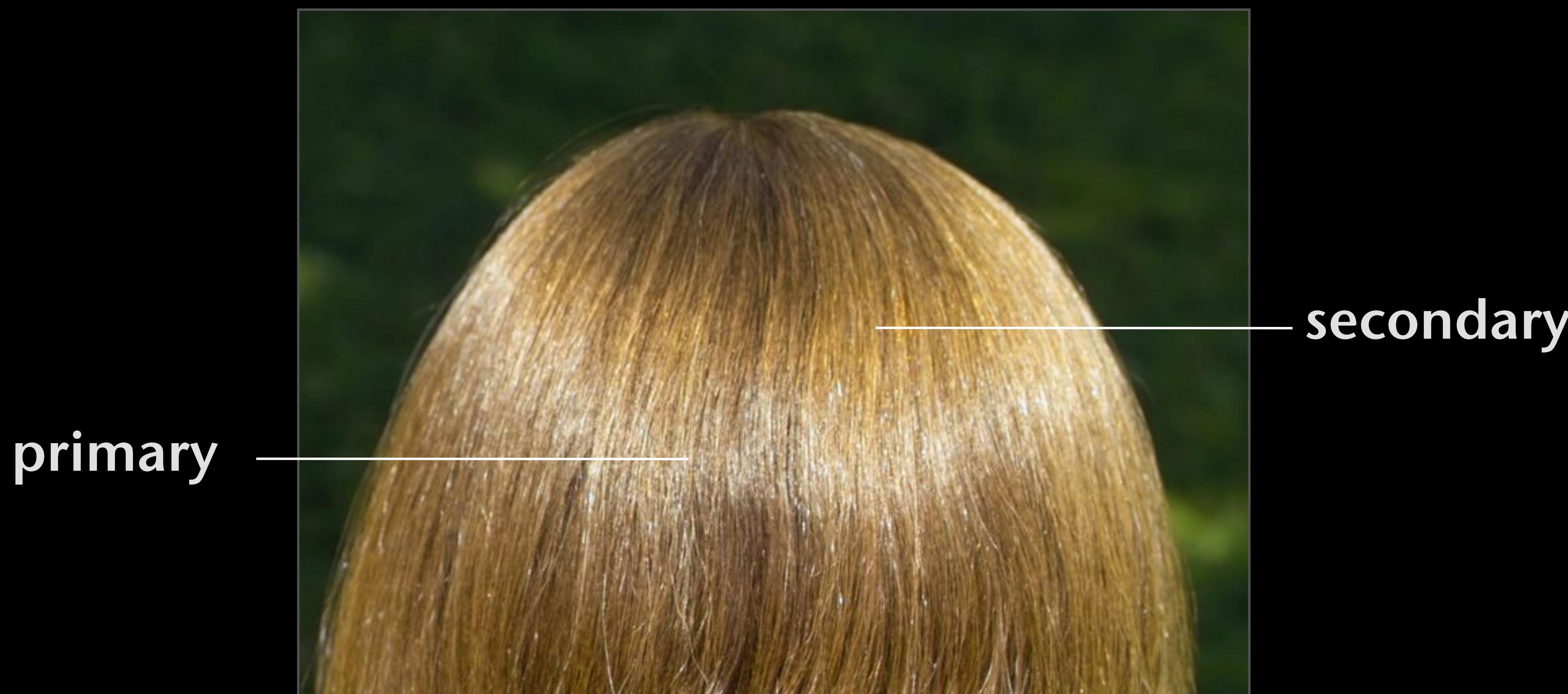


predicts a single, white highlight

Hair appearance

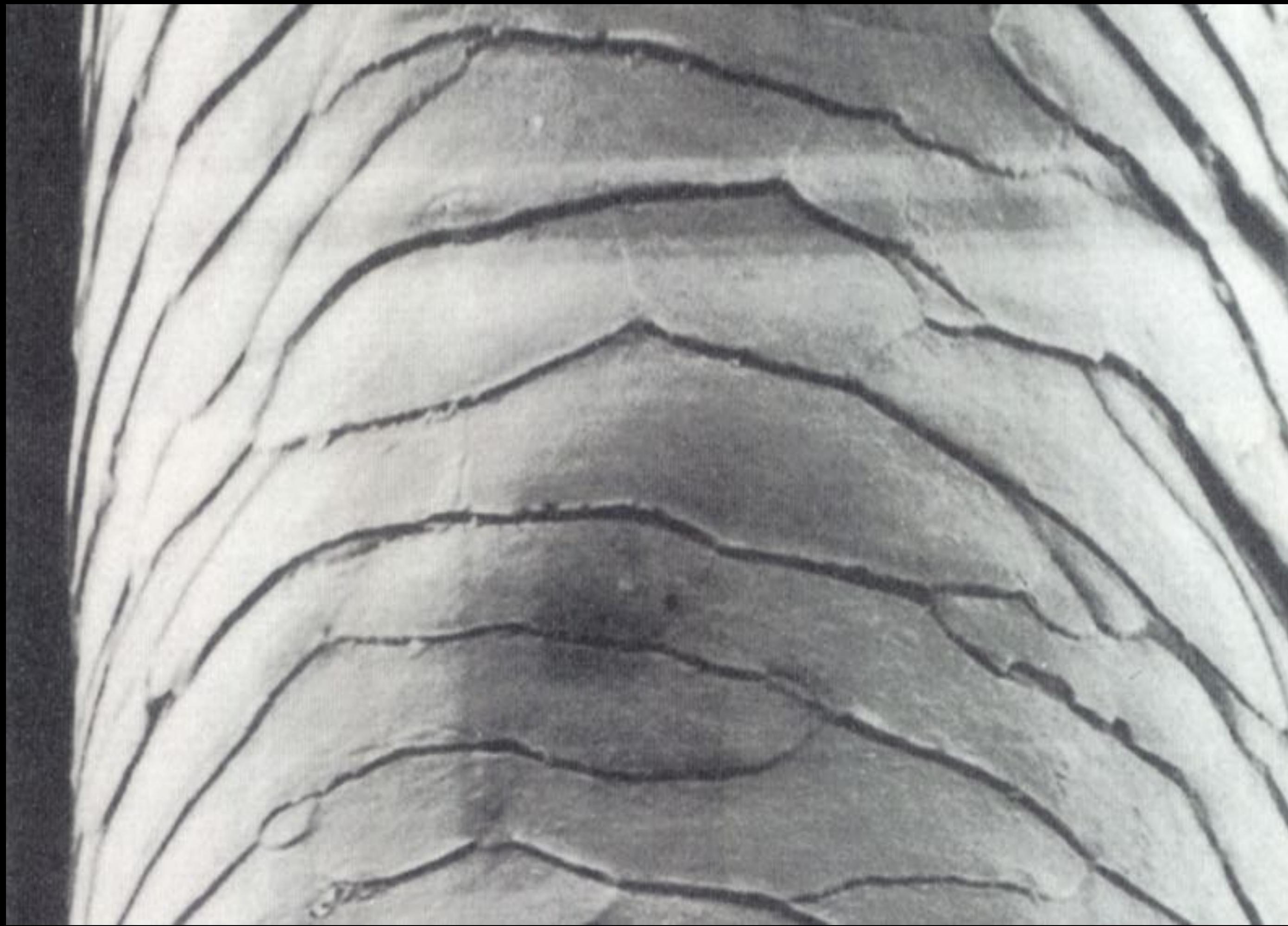


Hair appearance

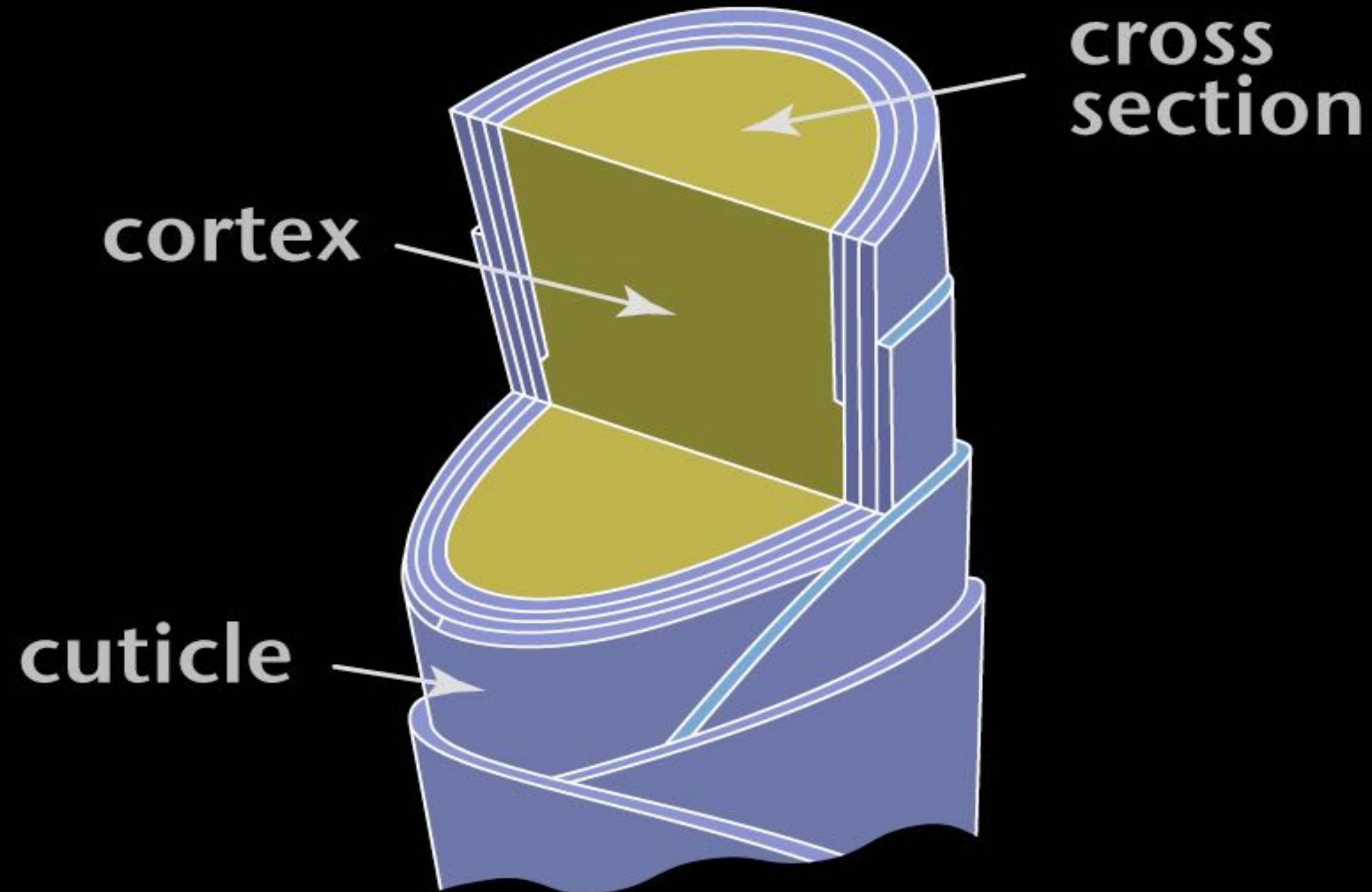


Hair appearance

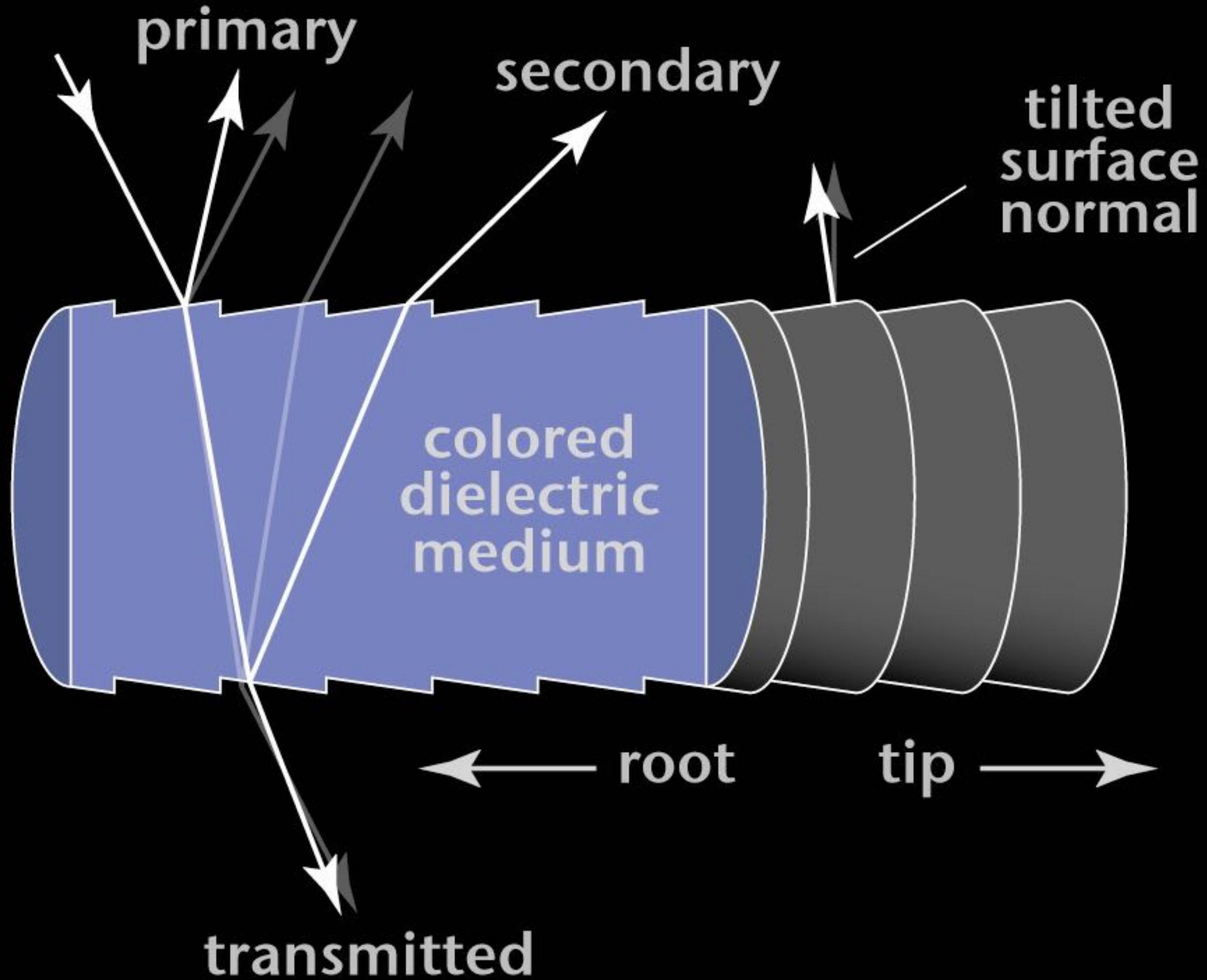




[Robbins 1994]



(after [Robbins 1994])



secondary



primary

secondary



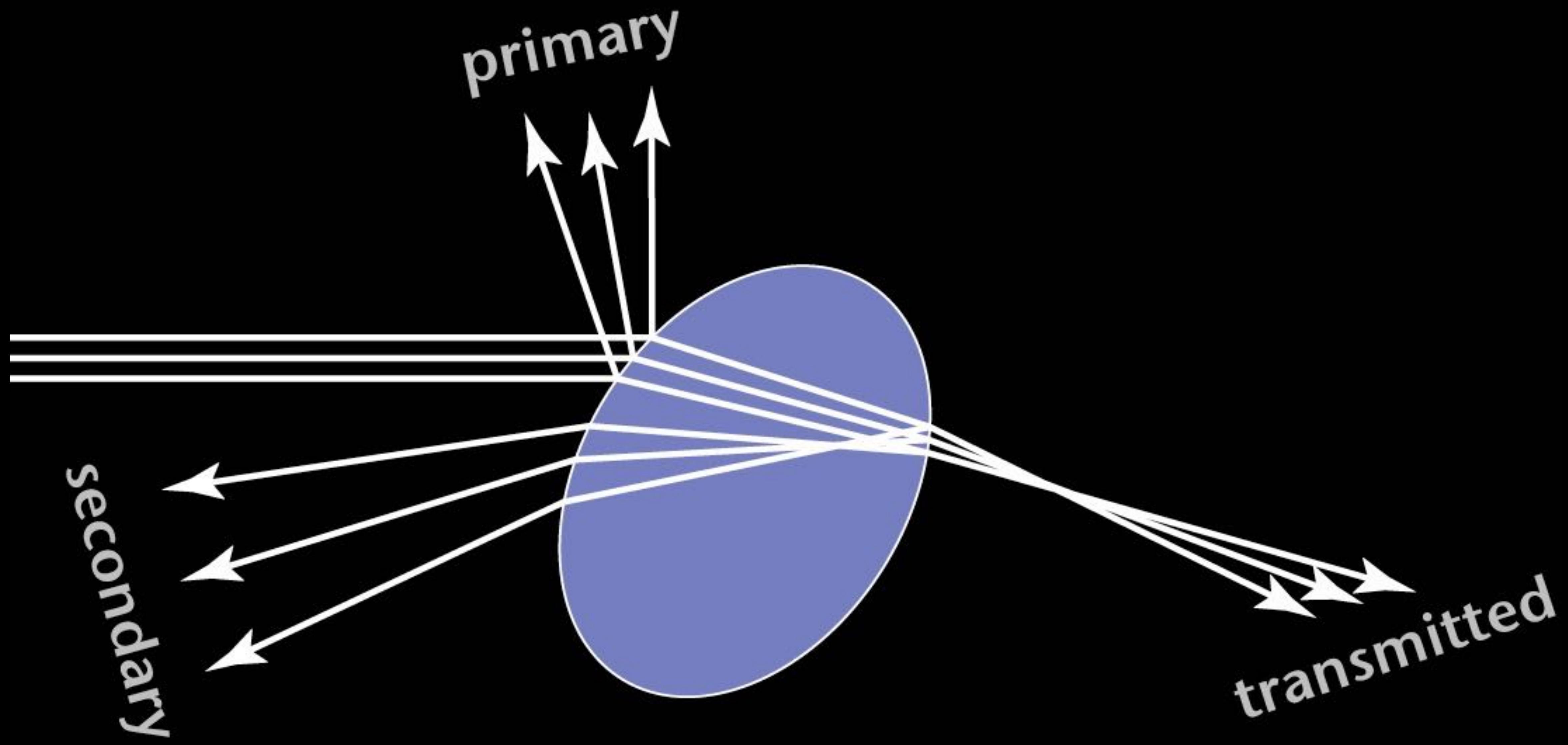
primary

**glints
(secondary)**











King Kong (2005) | visual effects: Weta Digital





A Practical and Controllable Hair and Fur Model for Production Path Tracing
Matt Jen-Yuan Chiang, Benedikt Bitterli, Chuck Tappan, Brent Burley
Eurographics Symposium on Rendering, 2016

wood optics

reflection from finished wood surfaces

wood optics

reflection from finished wood surfaces

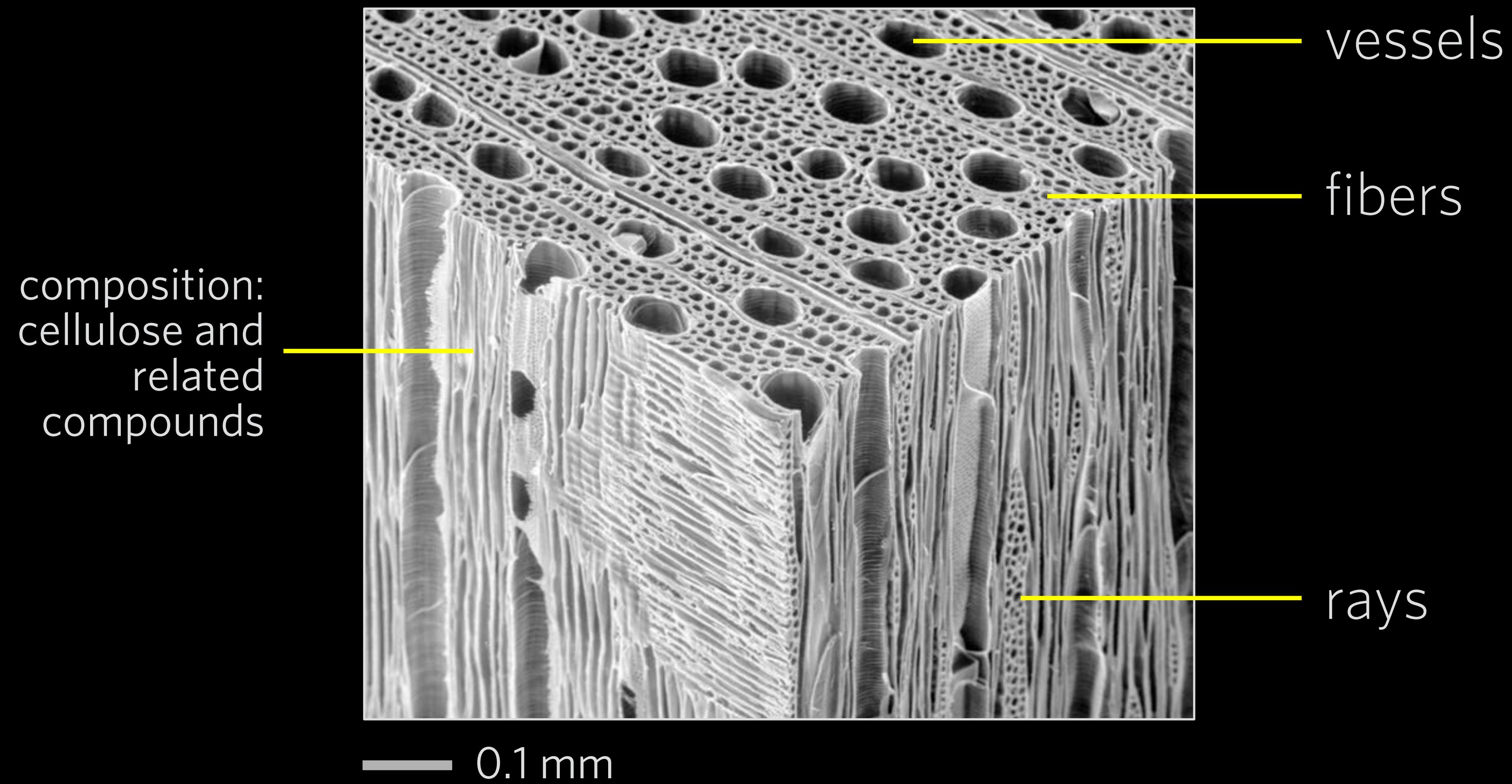
Stephen R. Marschner, Stephen H. Westin, Adam Arbree, and Jonathan T. Moon.
“Measuring and Modeling the Appearance of Finished Wood.” SIGGRAPH 2005.



**What causes the distinctive “depth”
of finished wood?**

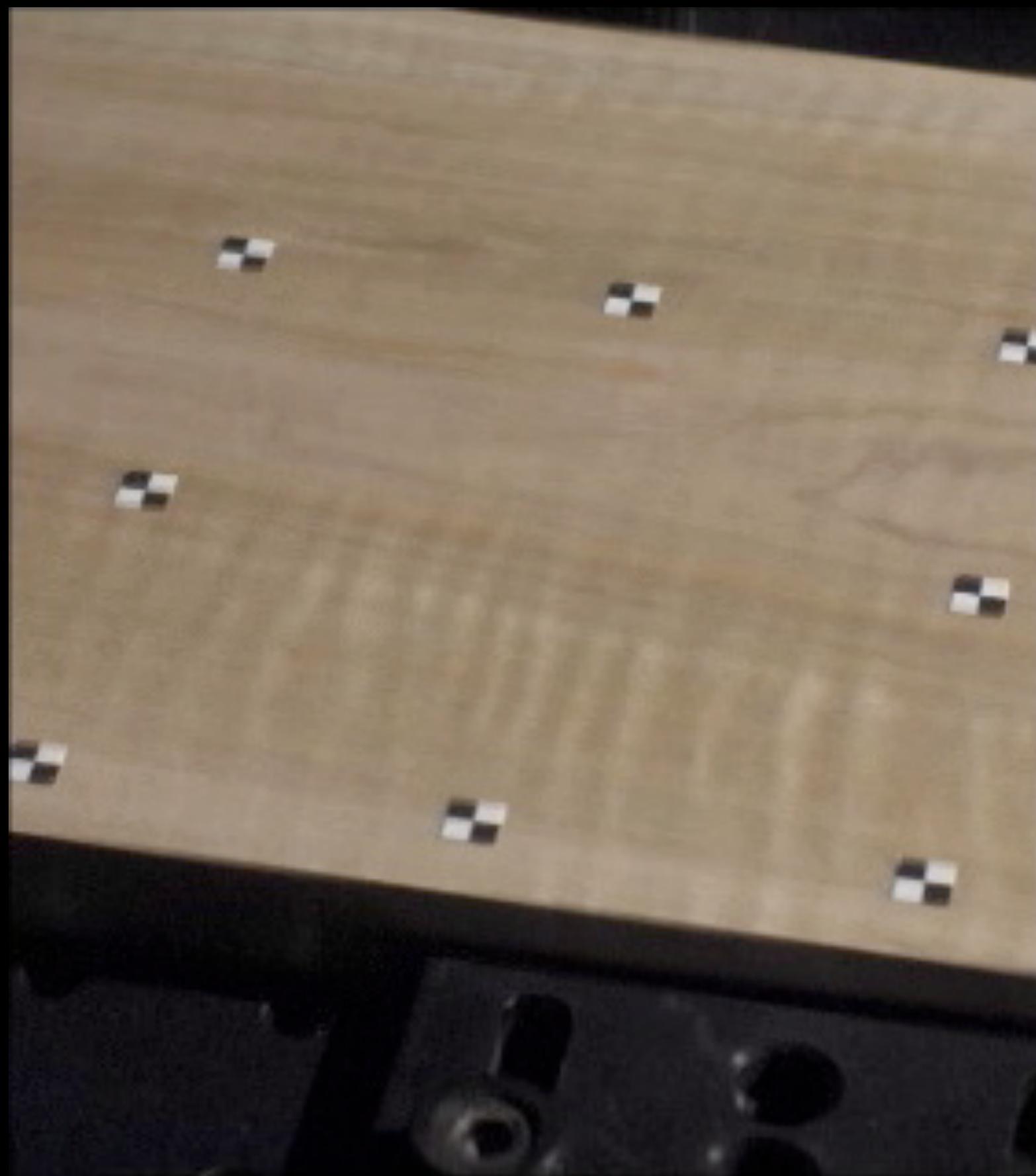


**What causes the distinctive “depth”
of finished wood?**



Optically: parallel air tubes in dielectric

curly maple



video



rendering

curly maple

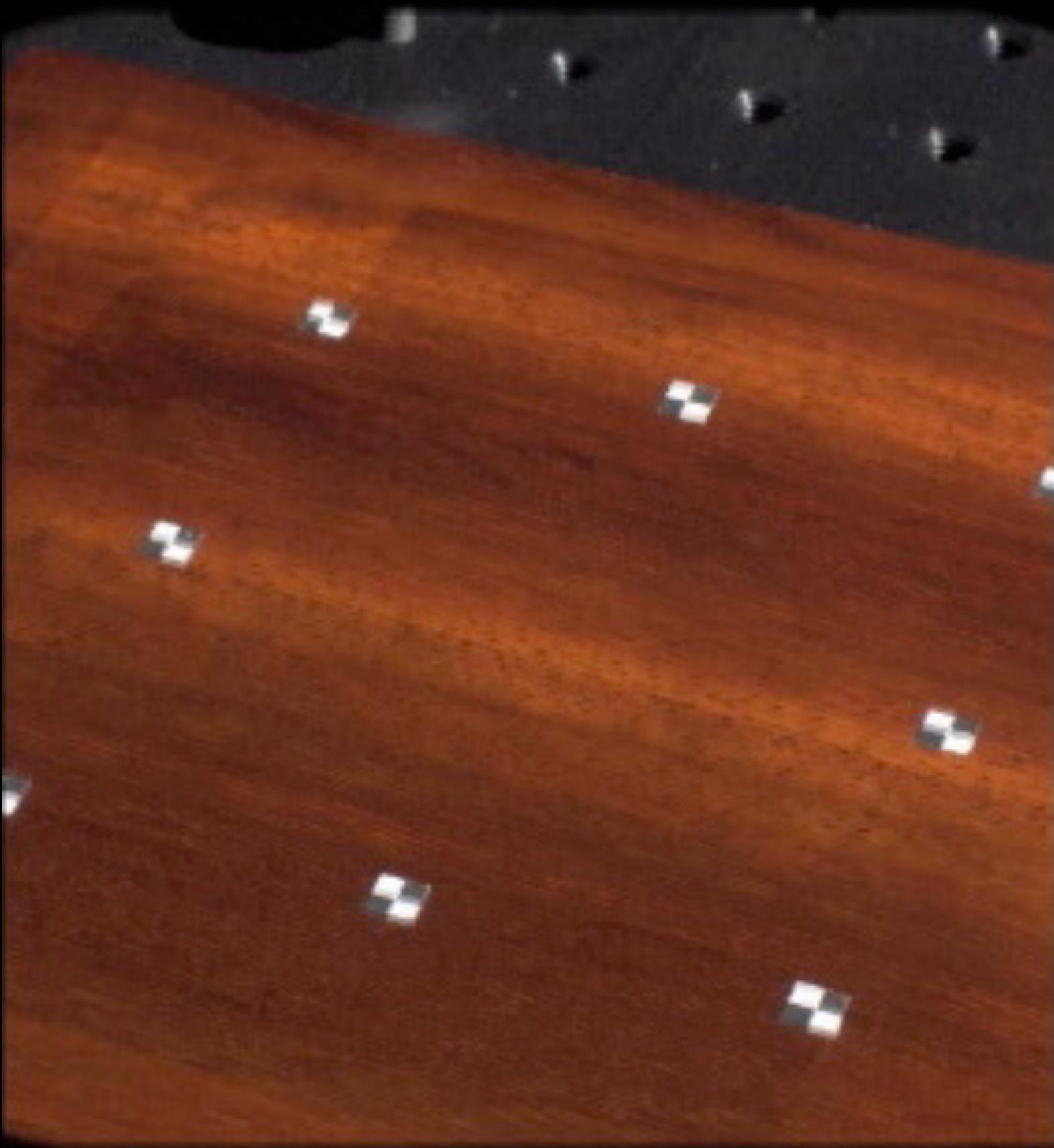


video

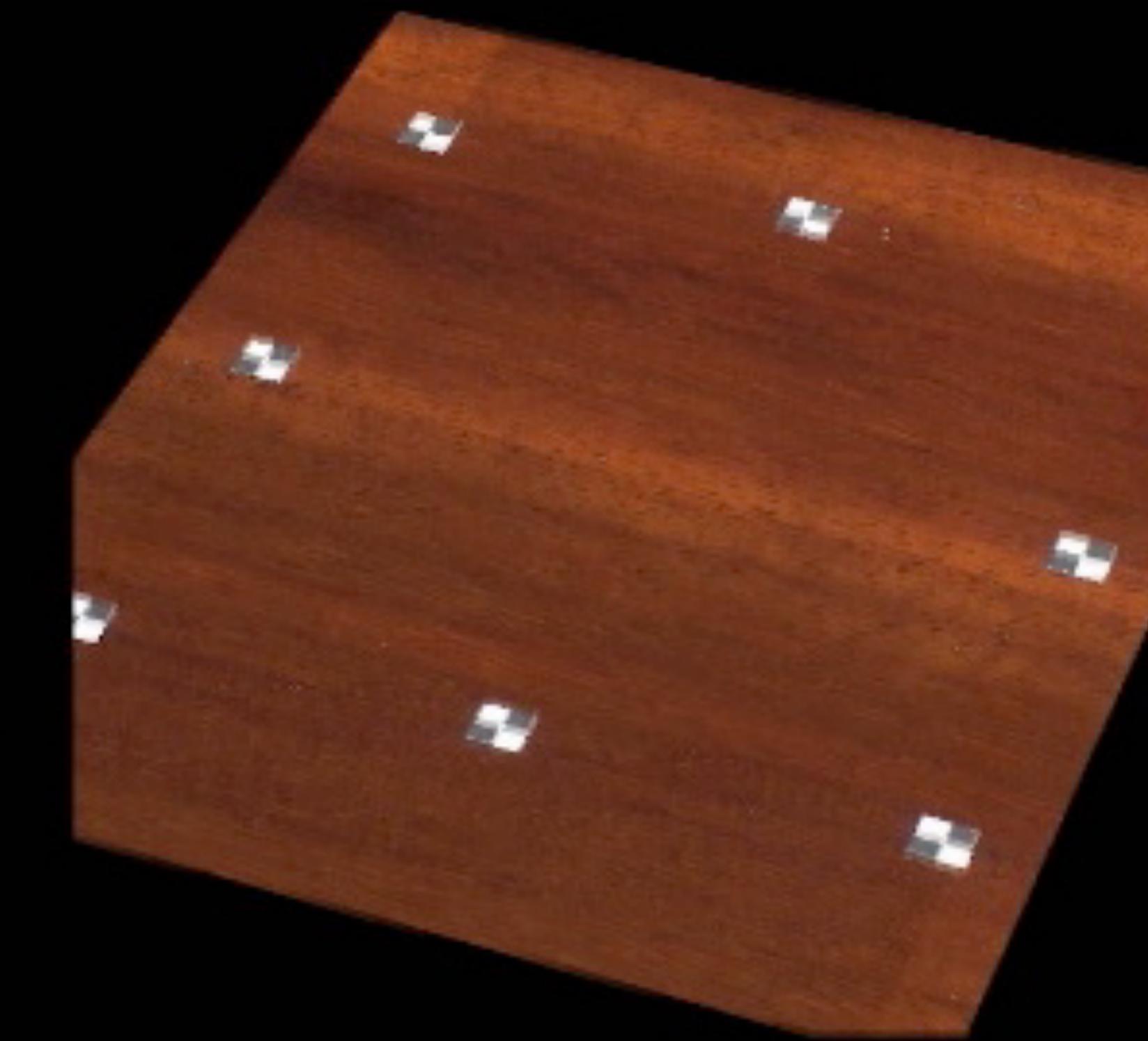


rendering

padauk

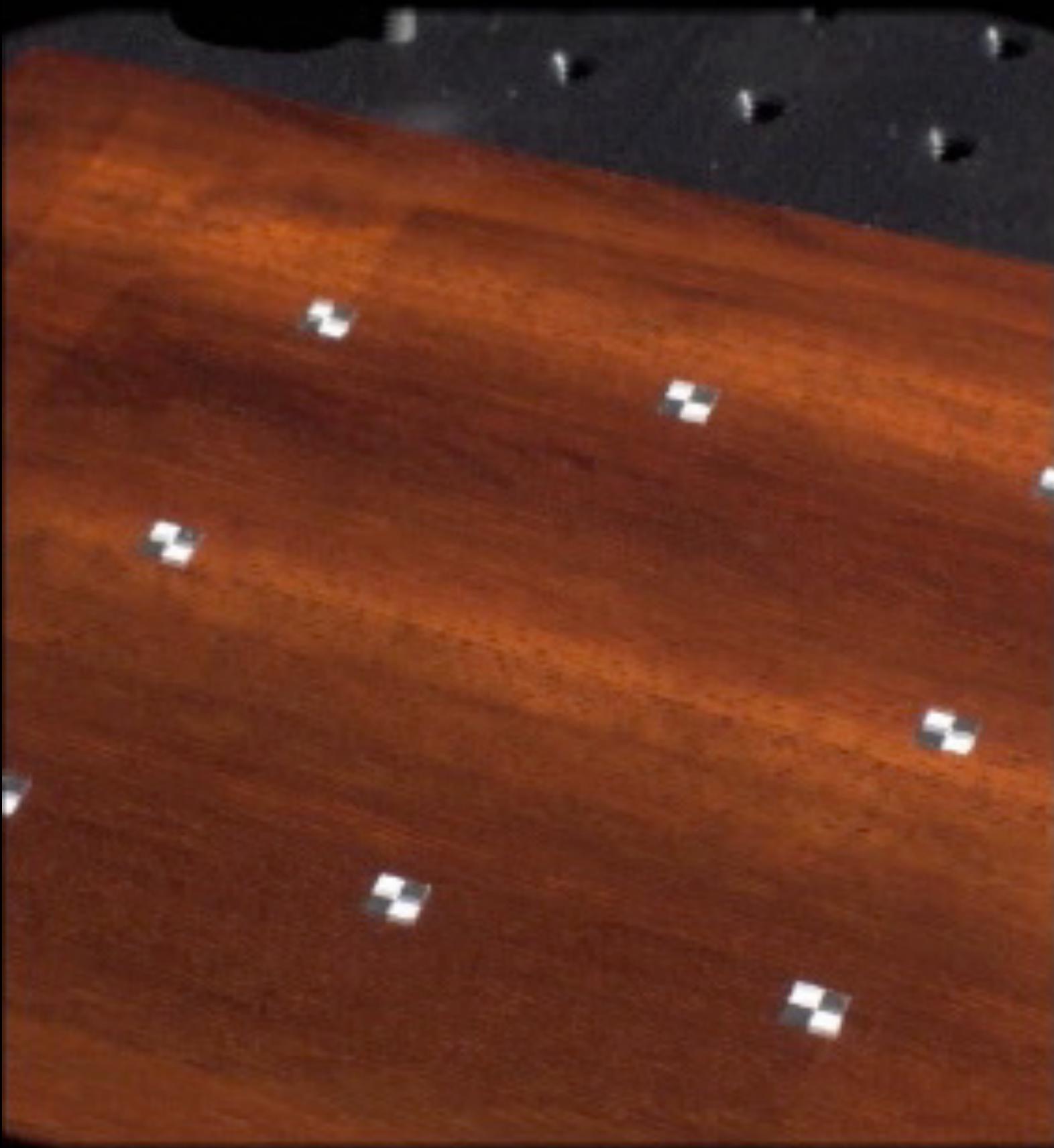


video

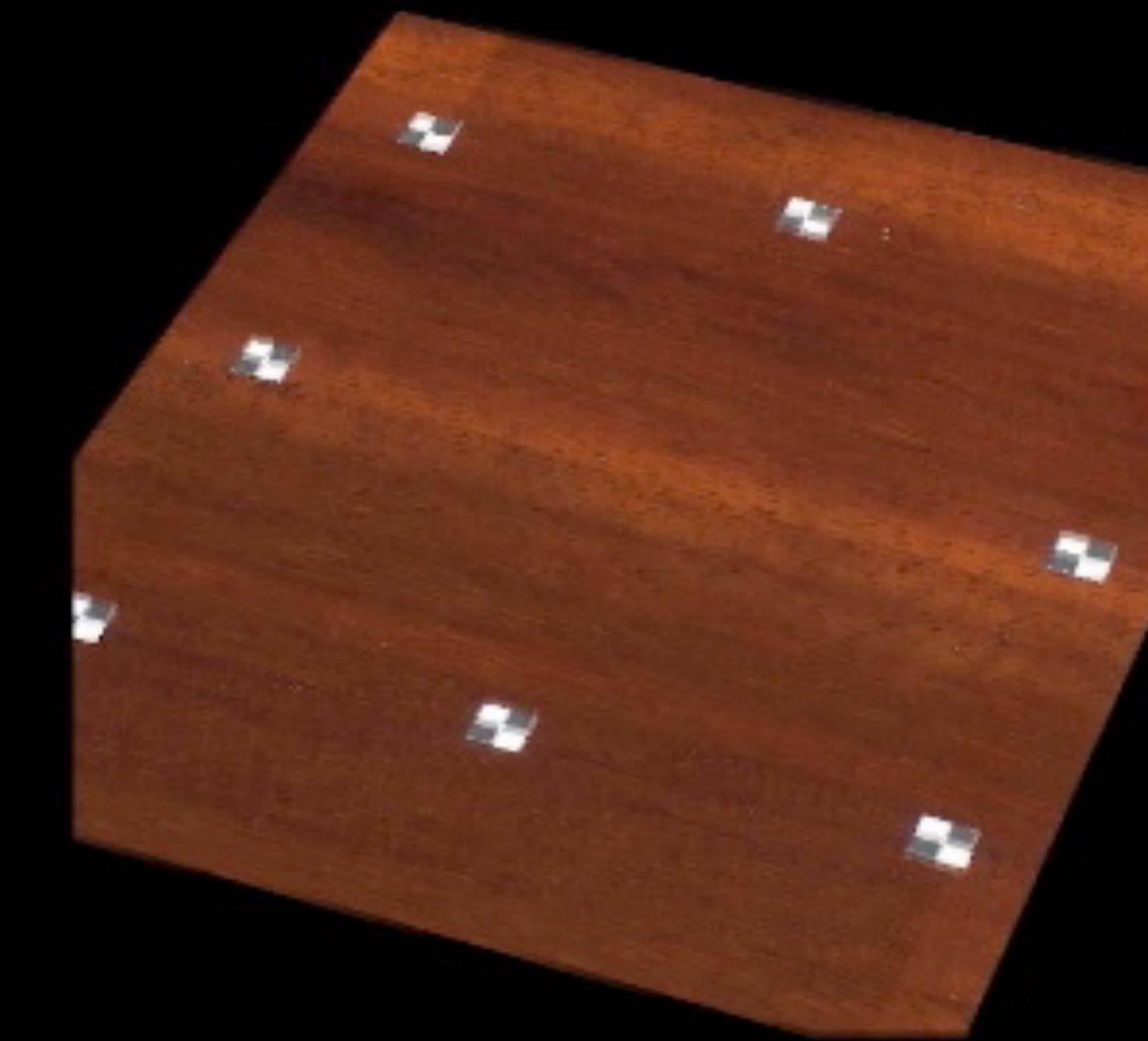


rendering

padauk



video



rendering

cloth mechanics

yarn-based cloth modeling

cloth mechanics

yarn-based cloth modeling

Jonathan Kaldor, Doug James, and Steve Marschner. "Simulating Knitted Cloth at the Yarn Level." SIGGRAPH 2008

Jonathan Kaldor, Doug James, and Steve Marschner. "Efficient Yarn-based Cloth with Adaptive Contact Linearization." SIGGRAPH 2010

Cem Yuksel, Jonathan Kaldor, Doug James, and Steve Marschner. "Stitch Meshes for Modeling Knitted Clothing with Yarn-level Detail." SIGGRAPH 2012

Why Yarns Are Important

- Cloth is not a continuum
 - Discrete yarn behavior drives overall cloth behavior
- Particularly evident in knit fabrics



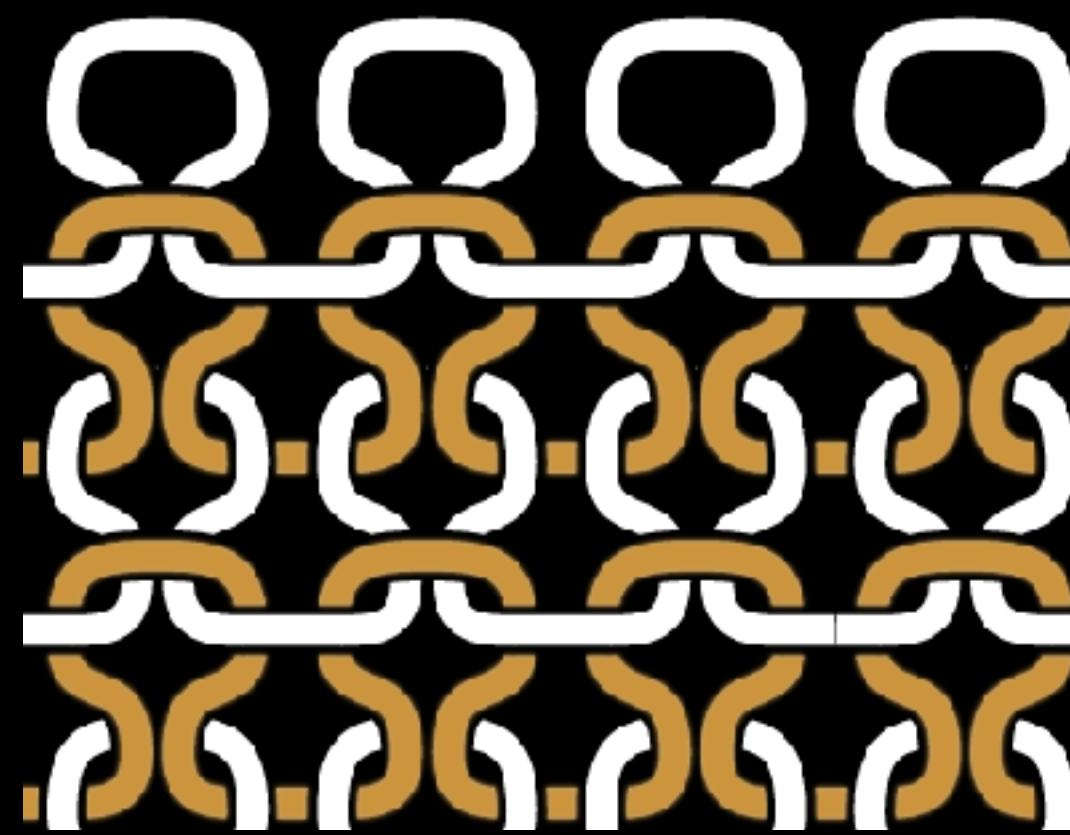
<http://toveb.typepad.com/>

Why Yarns Are Important

- Cloth is not a continuum
 - Discrete yarn behavior drives overall cloth behavior
- Particularly evident in knit fabrics



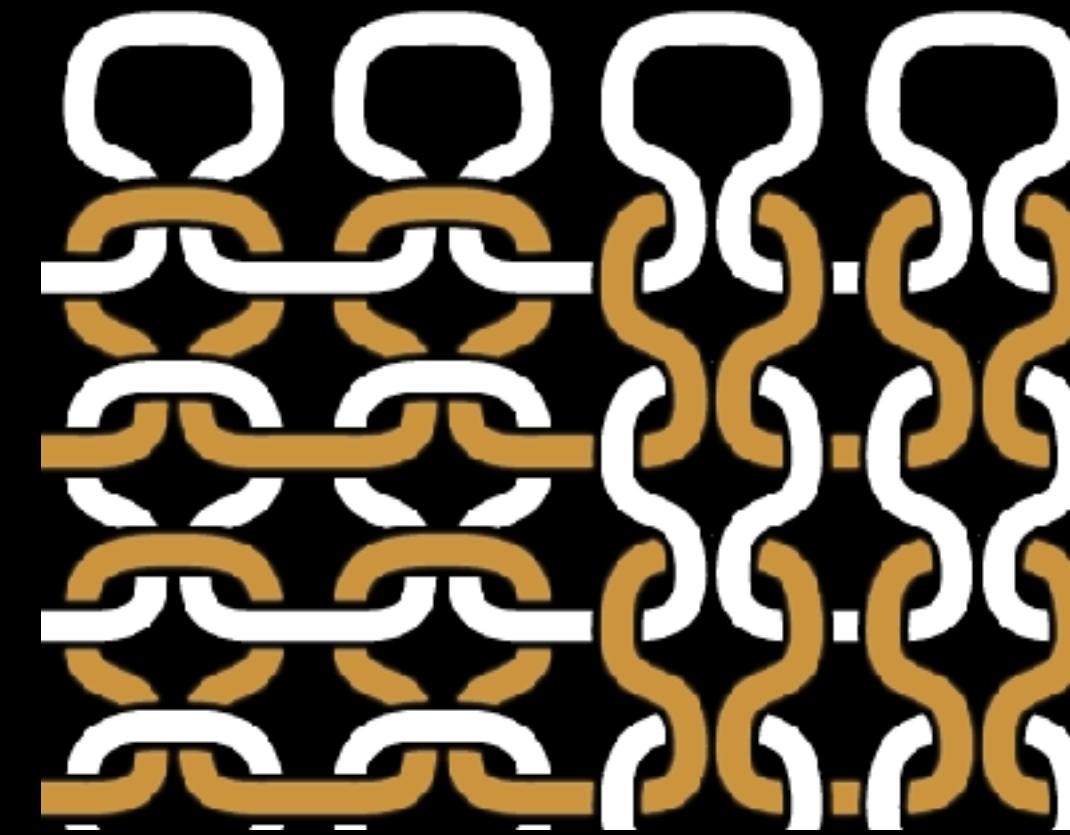
Structure-Dependent Behavior



Garter



Stockinette



Rib



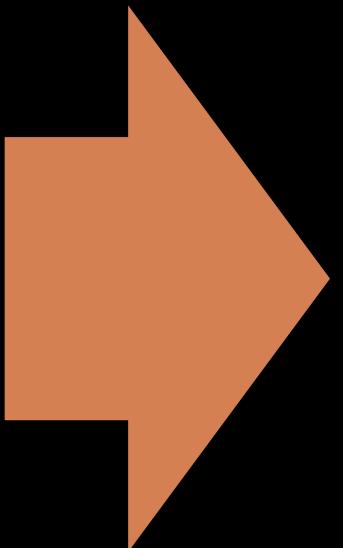
Yarn Properties

- Thin, flexible rods, with many degrees of freedom
- Strongly resist stretching
- Weakly resist bending
- Can compress laterally
- Friction between yarns



Yarn Properties

- Thin, flexible rods, with many degrees of freedom
- Strongly resist stretching
- Weakly resist bending
- Can compress laterally
- Friction between yarns



- Constrained Lagrangian dynamics
 $M\ddot{q} = f - \nabla E - \nabla D$
- Inextensibility constraints
- Bending, twisting energies
- Collision energy
- Velocity filter for damping

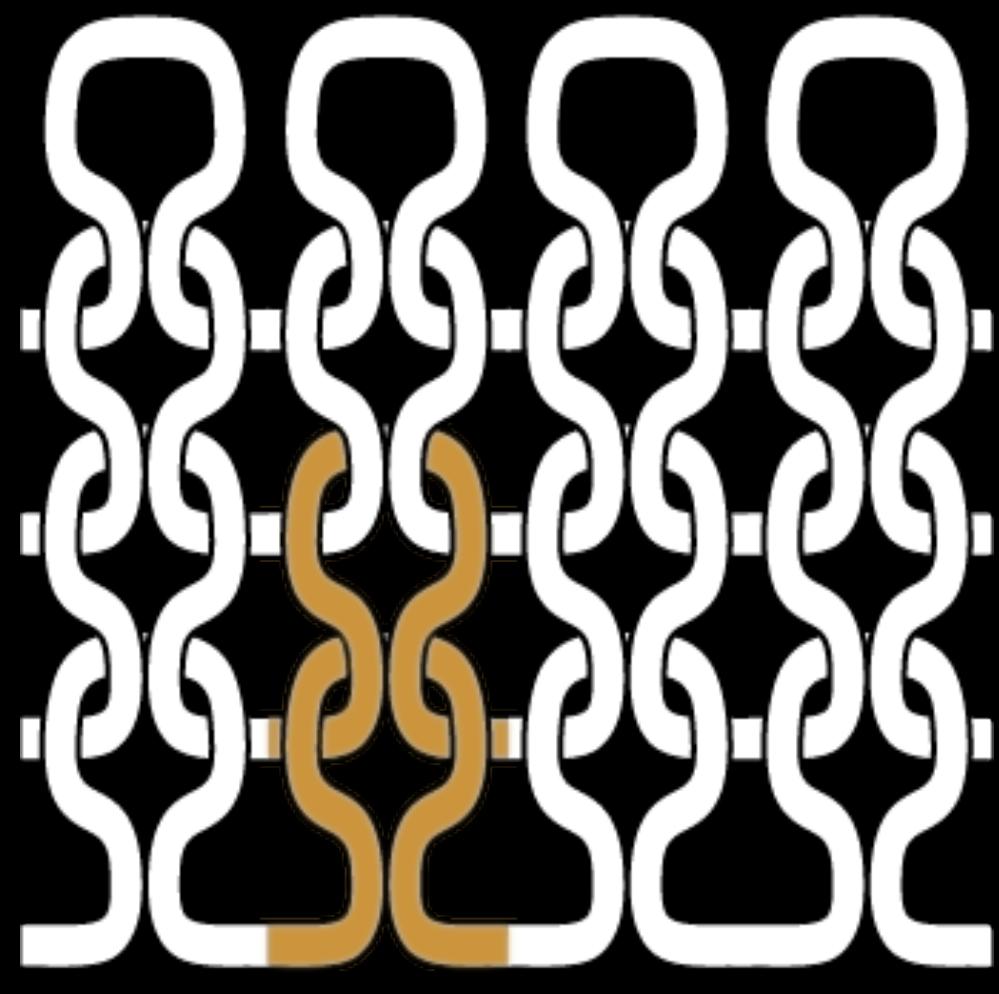
Modeling Dissipation

- Damp yarn-yarn contacts
- Damp non-rigid motion
 - [Müller et al. 2006]
[Rivers and James 2007]
- Small regions: stabilizing collisions
- Large regions: damp cloth-level motion

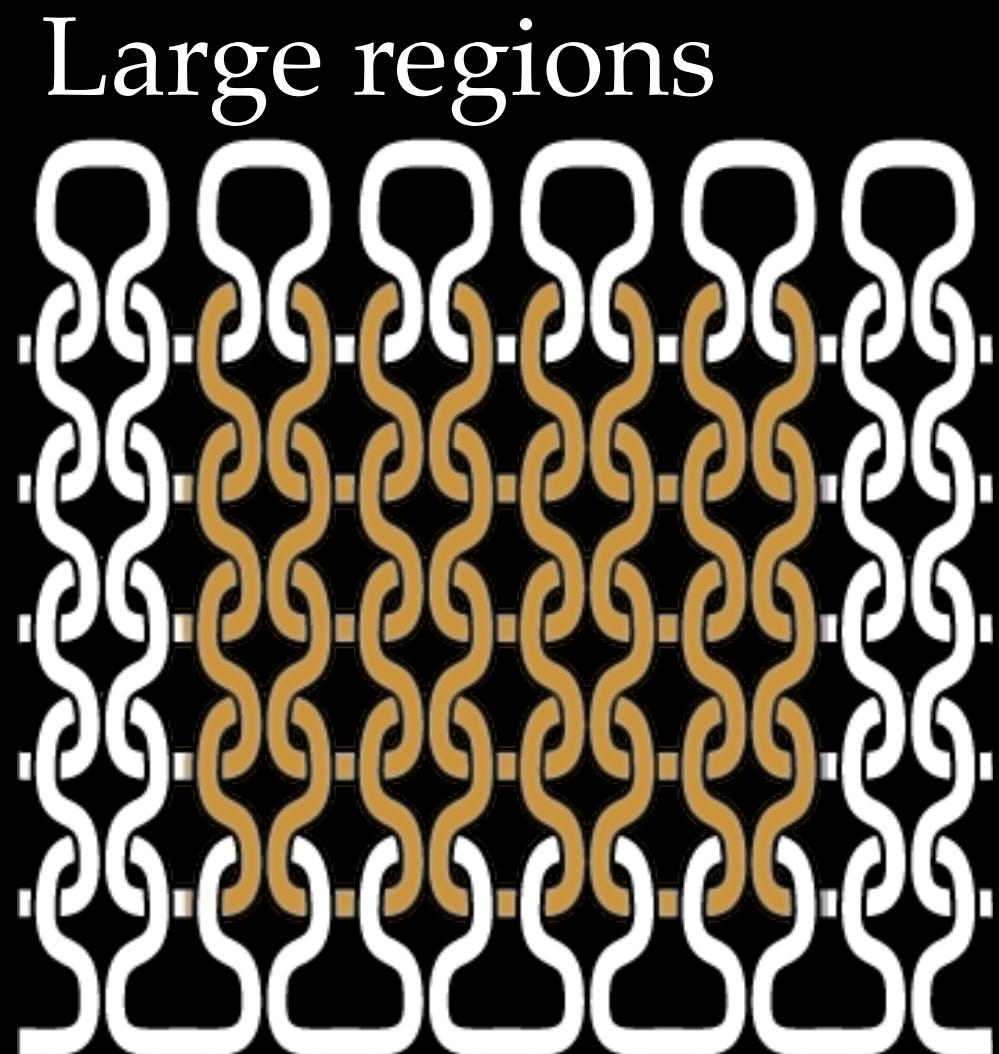


Modeling Dissipation

- Damp yarn-yarn contacts
- Damp non-rigid motion
 - [Müller et al. 2006]
[Rivers and James 2007]
- Small regions: stabilizing collisions
- Large regions: damp cloth-level motion



Small regions



Large regions

Relaxed Models



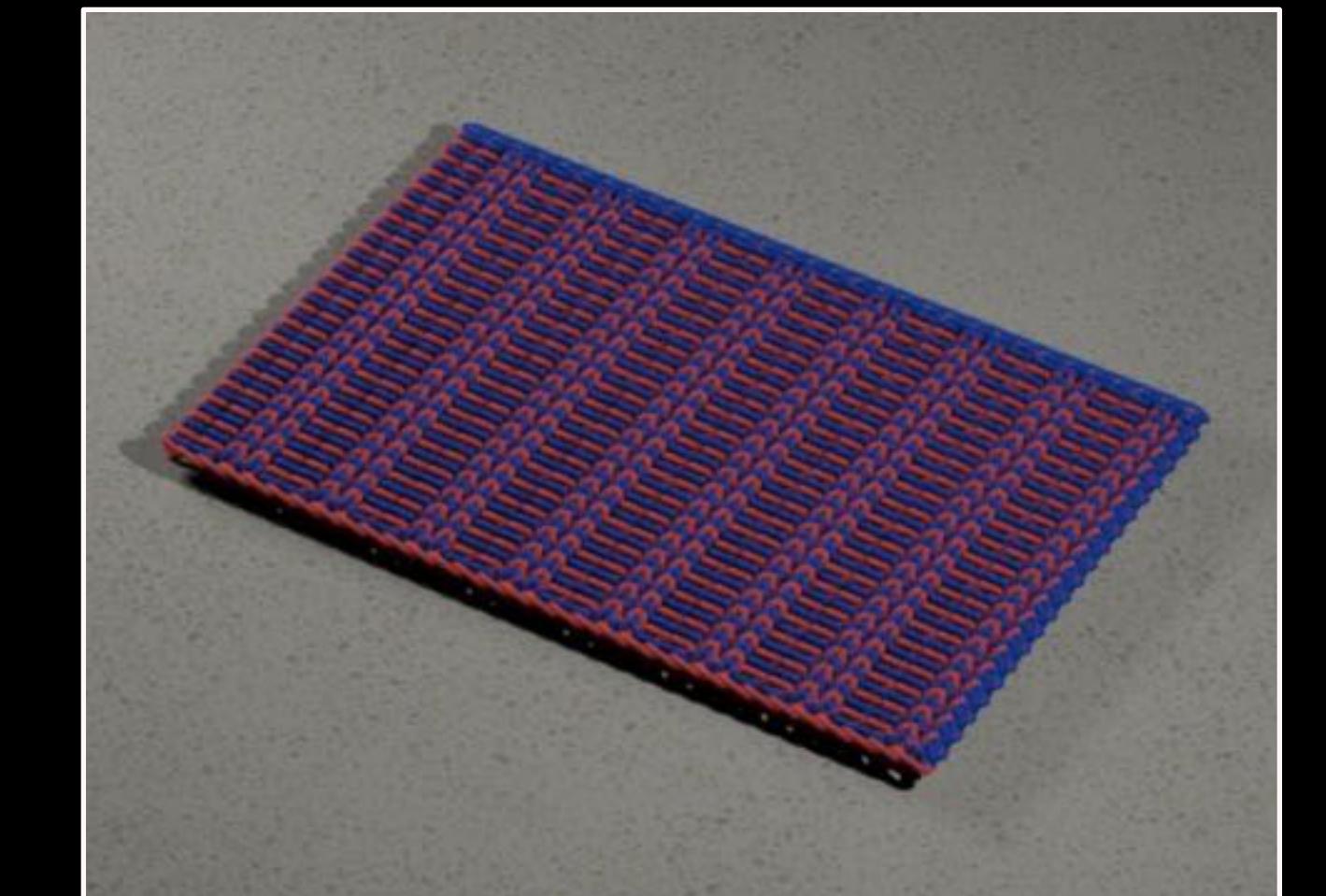
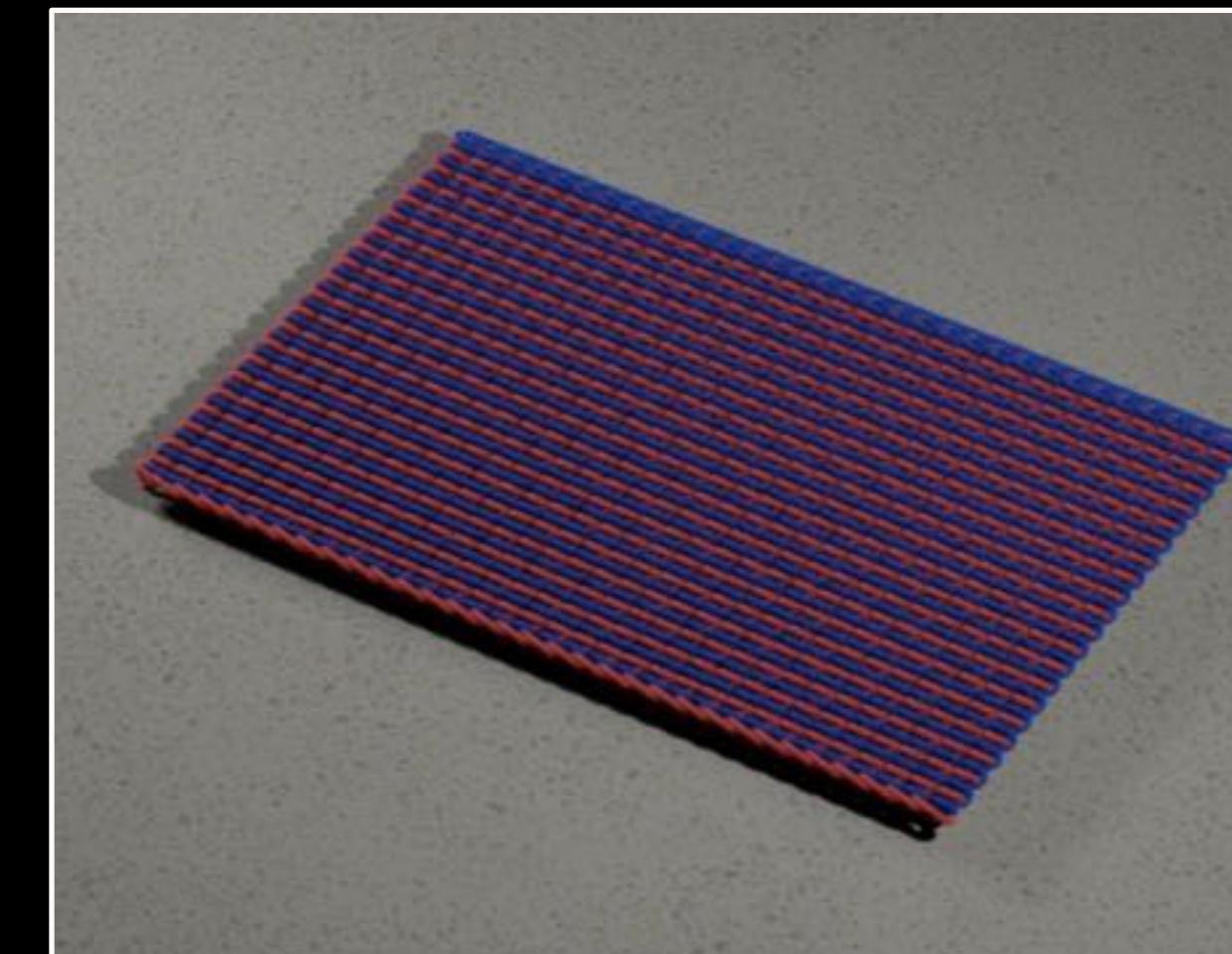
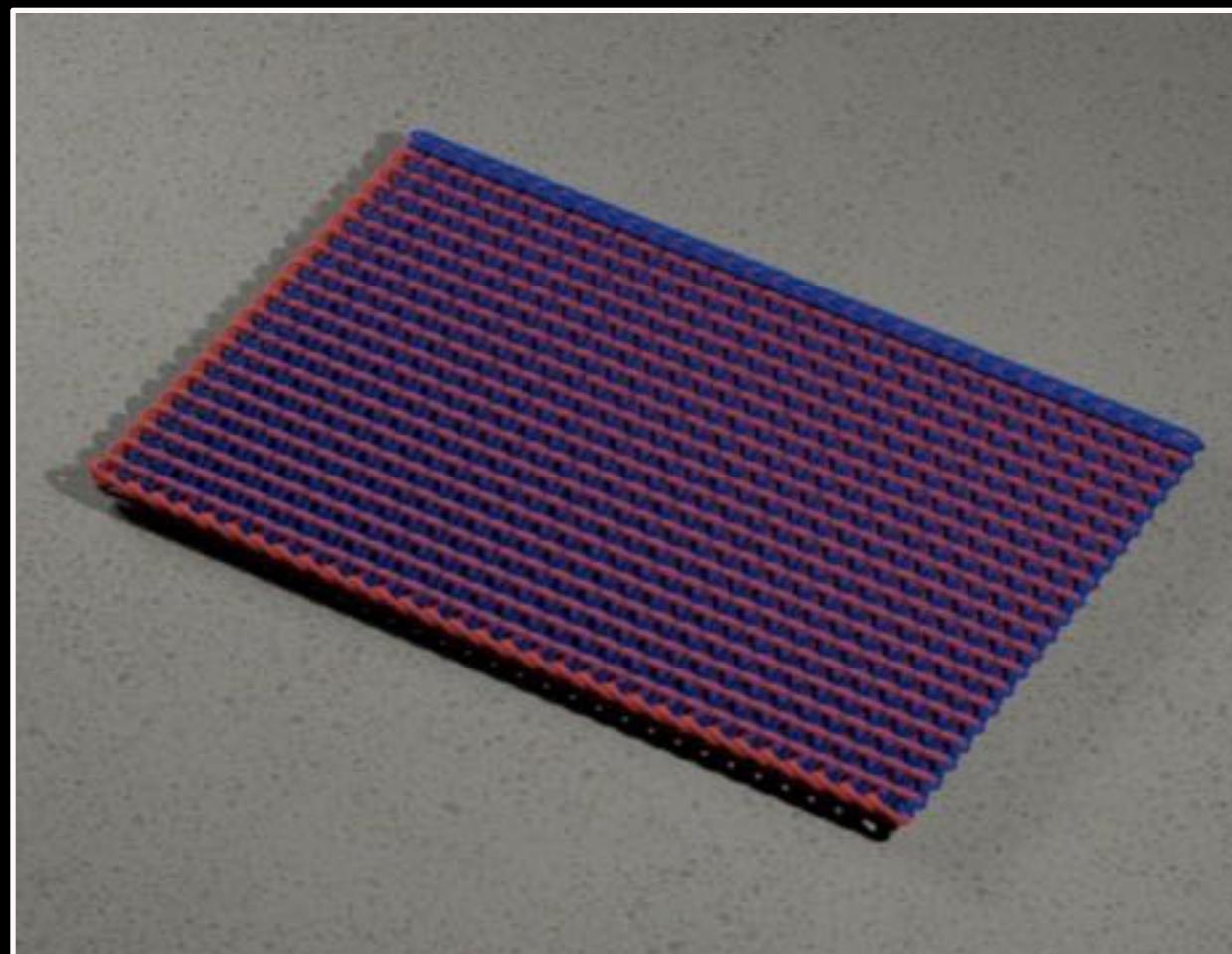
Garter



Stockinette



Rib



Relaxed Models



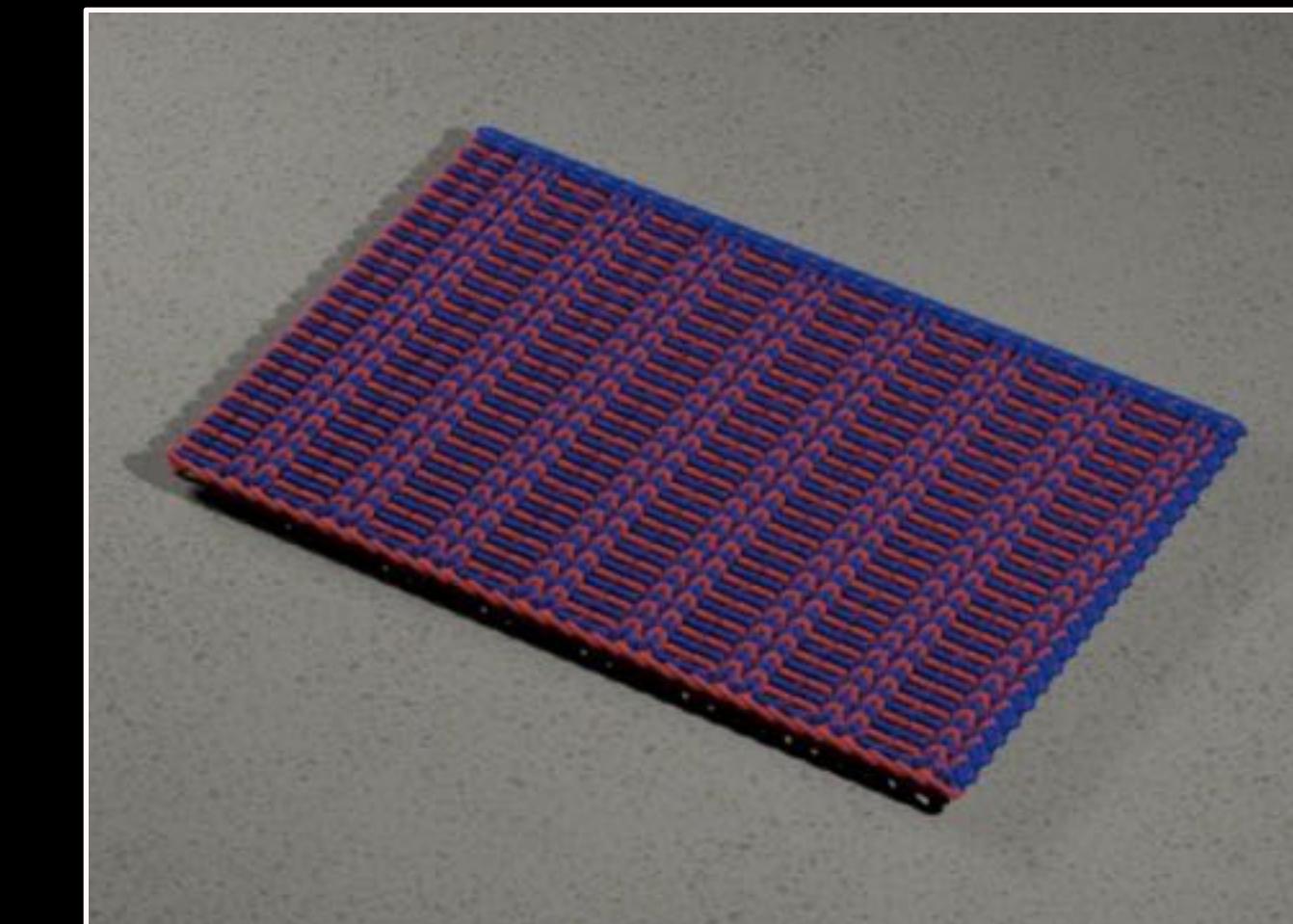
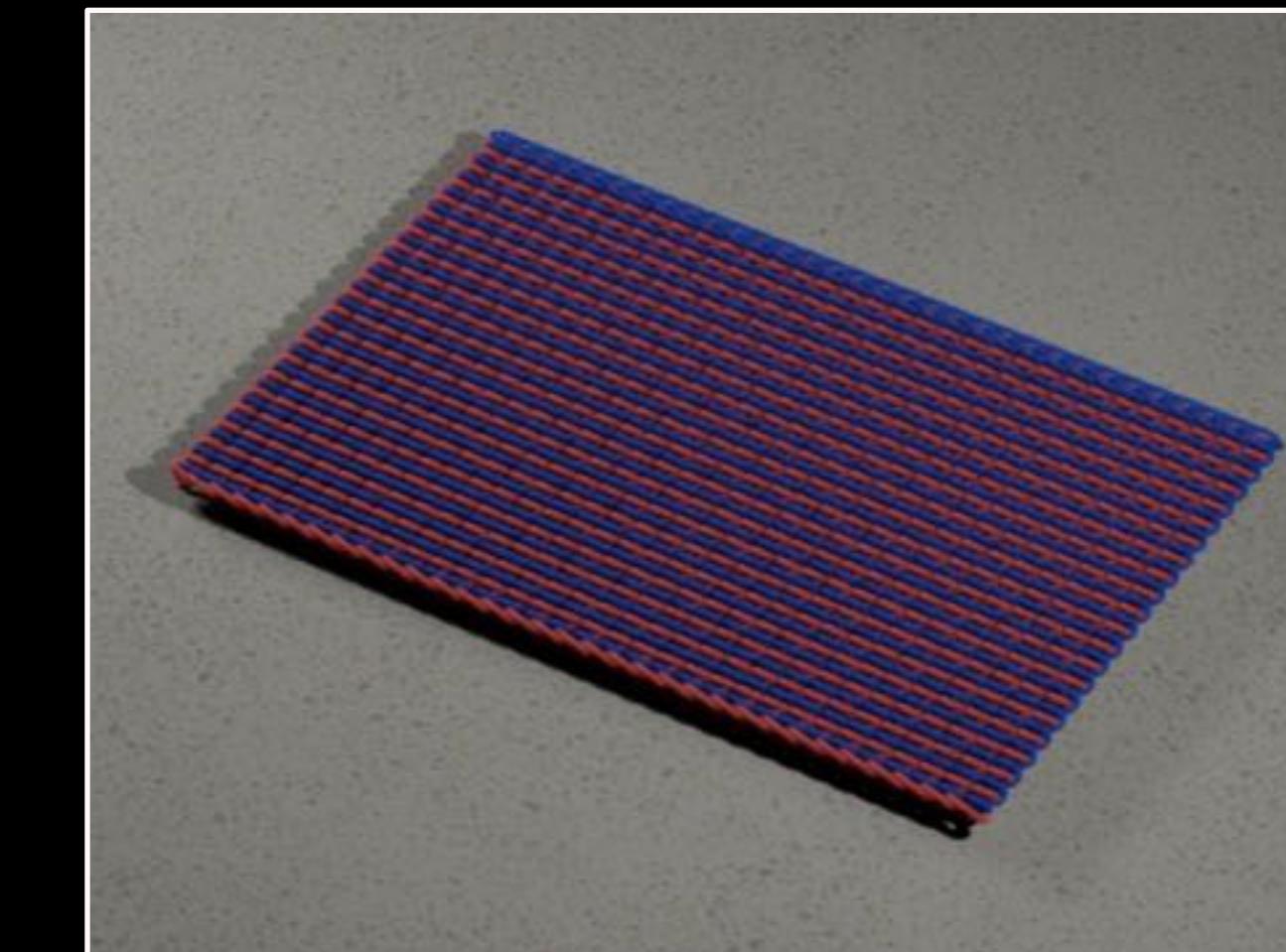
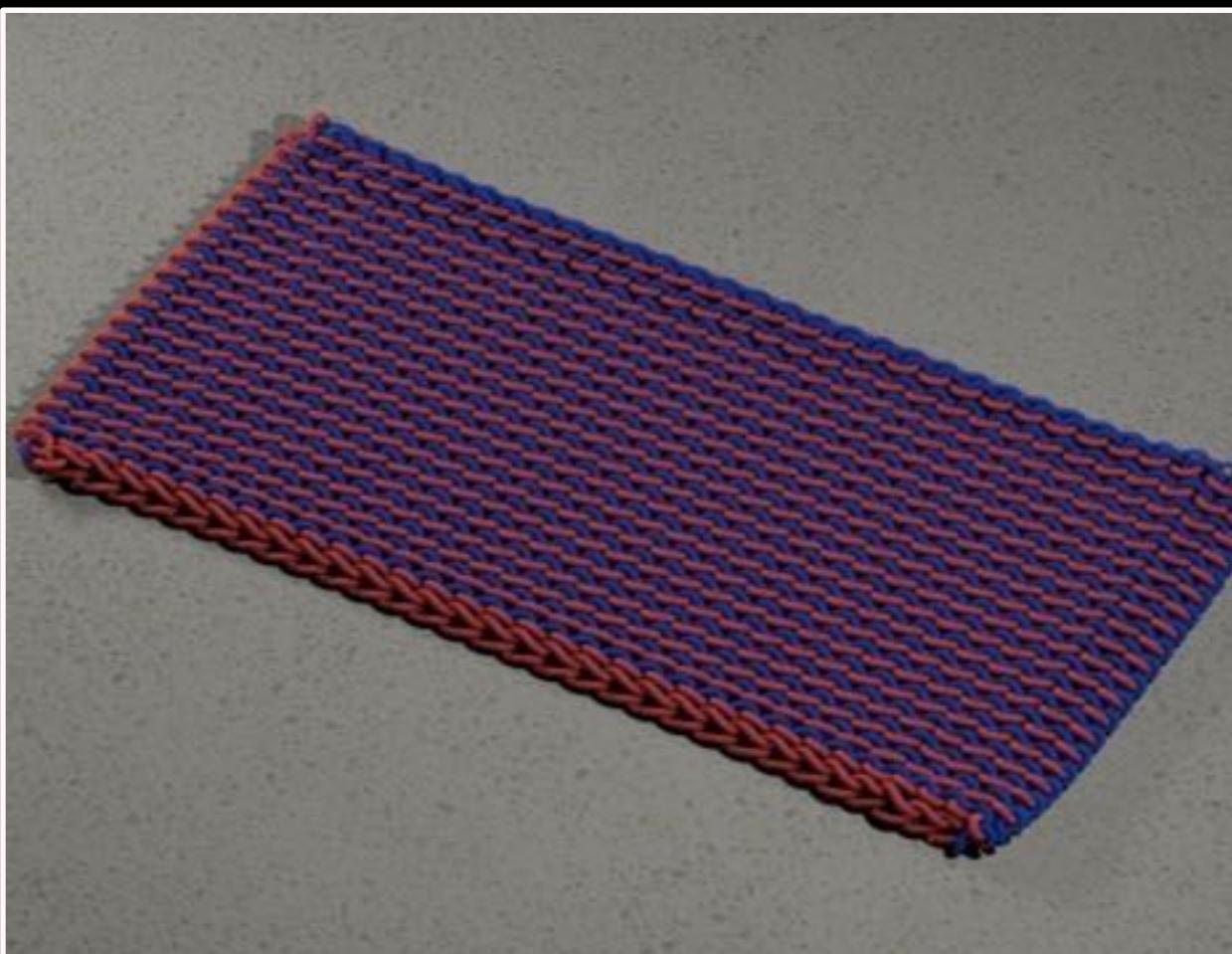
Garter



Stockinette



Rib



Relaxed Models



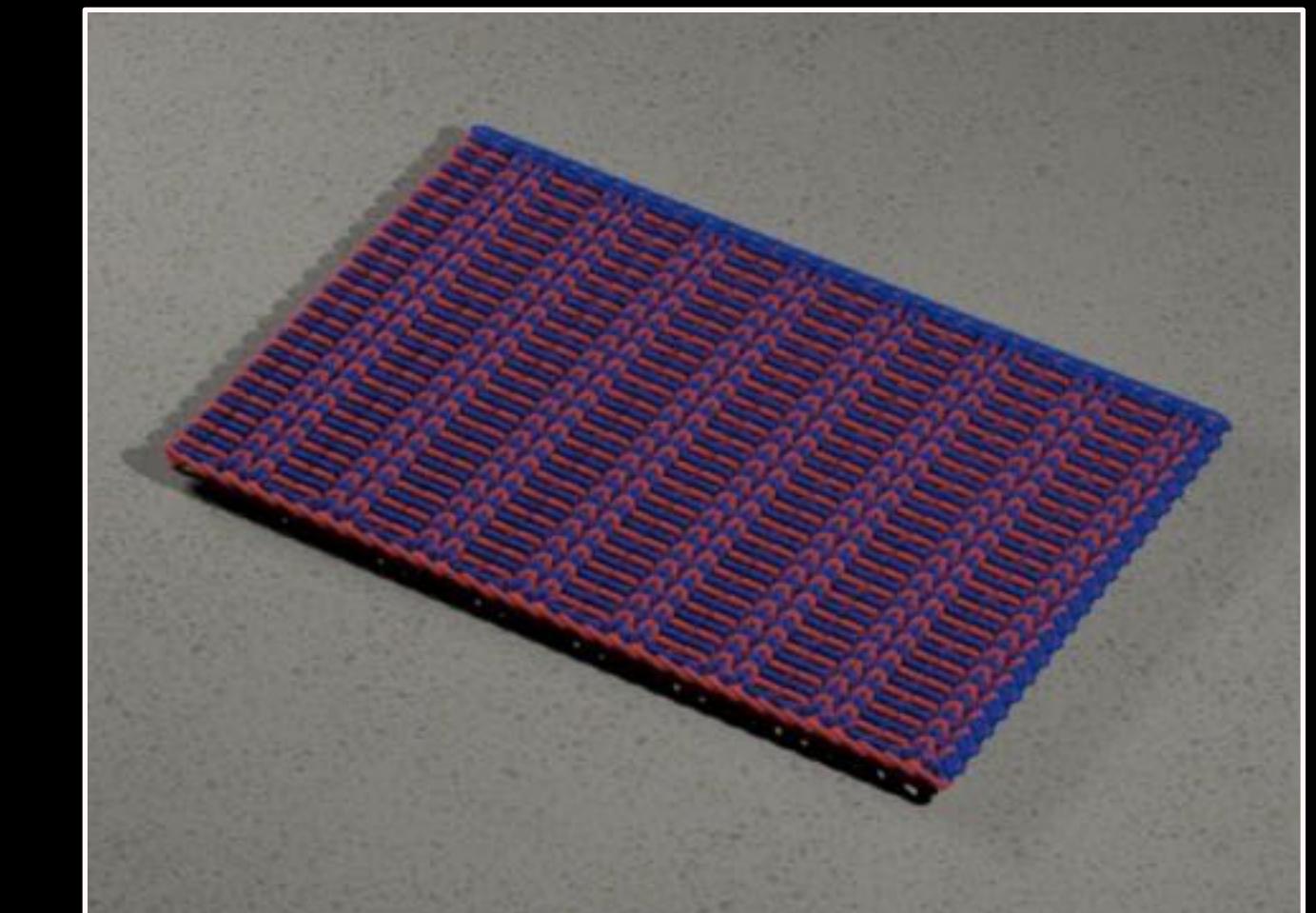
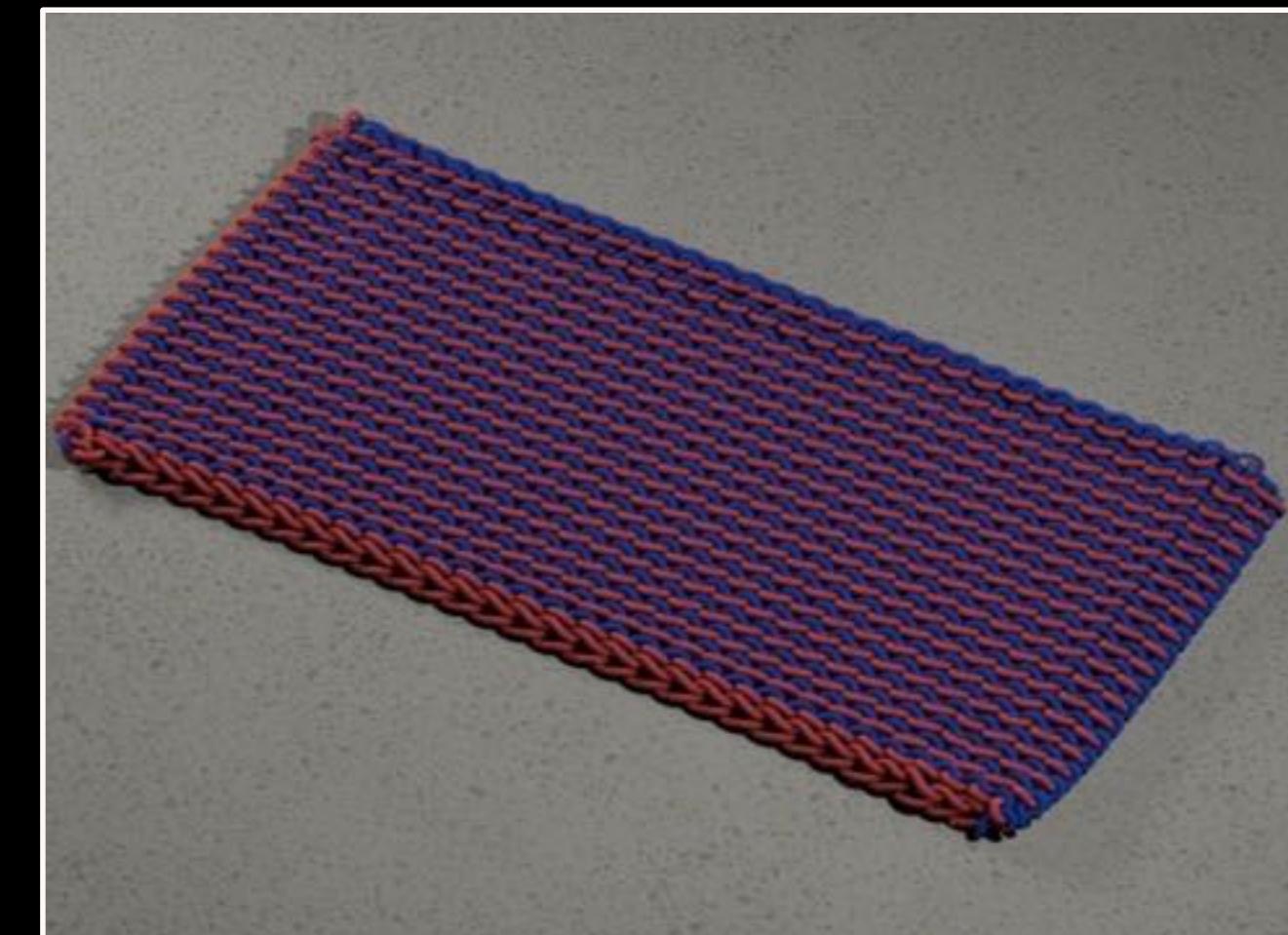
Garter



Stockinette



Rib



Relaxed Models



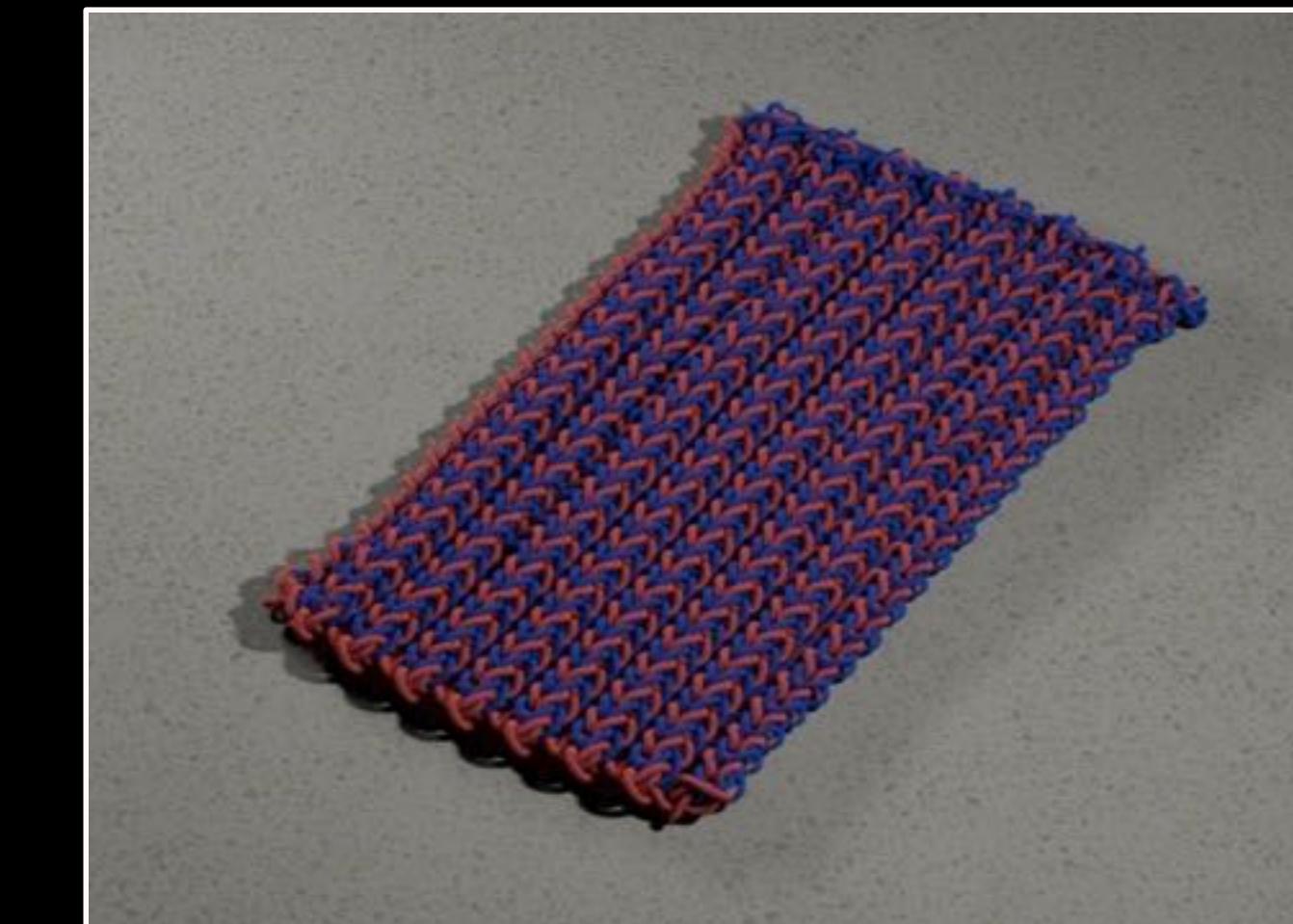
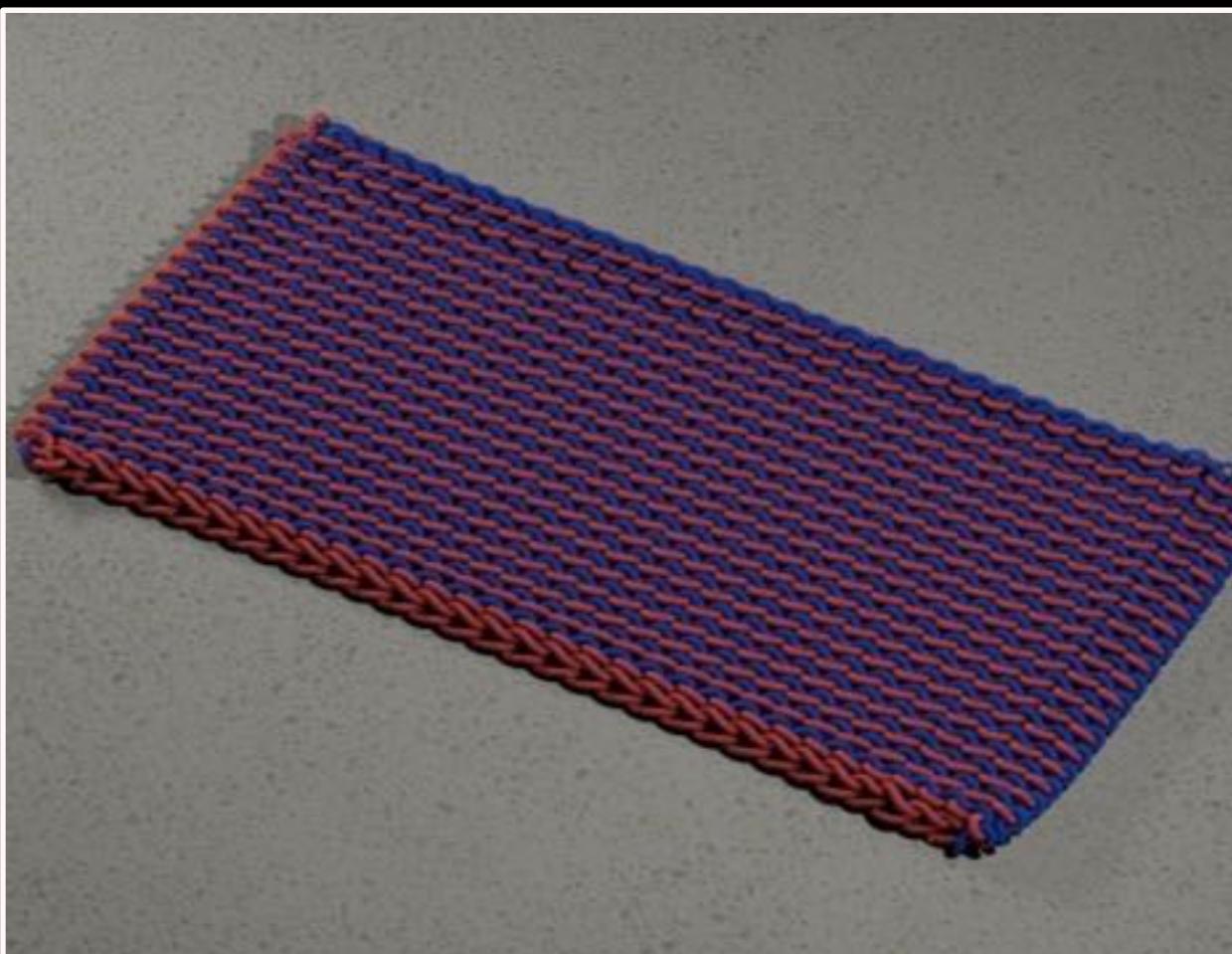
Garter



Stockinette



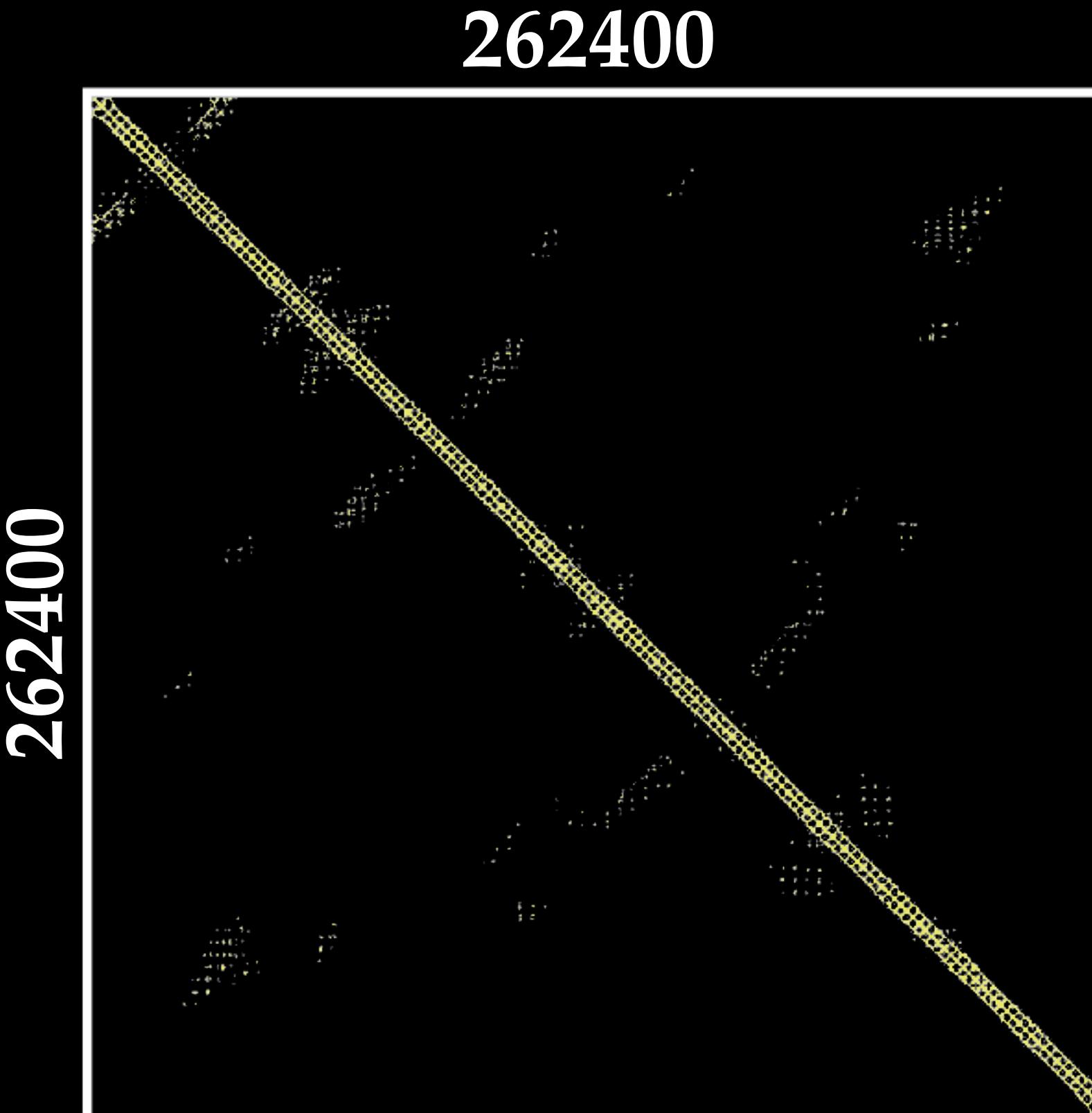
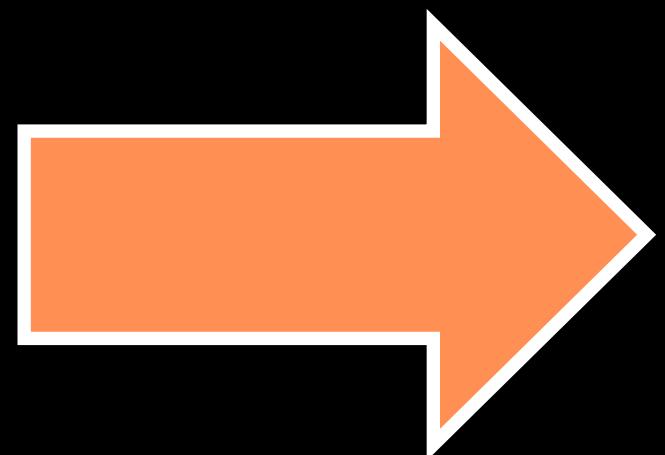
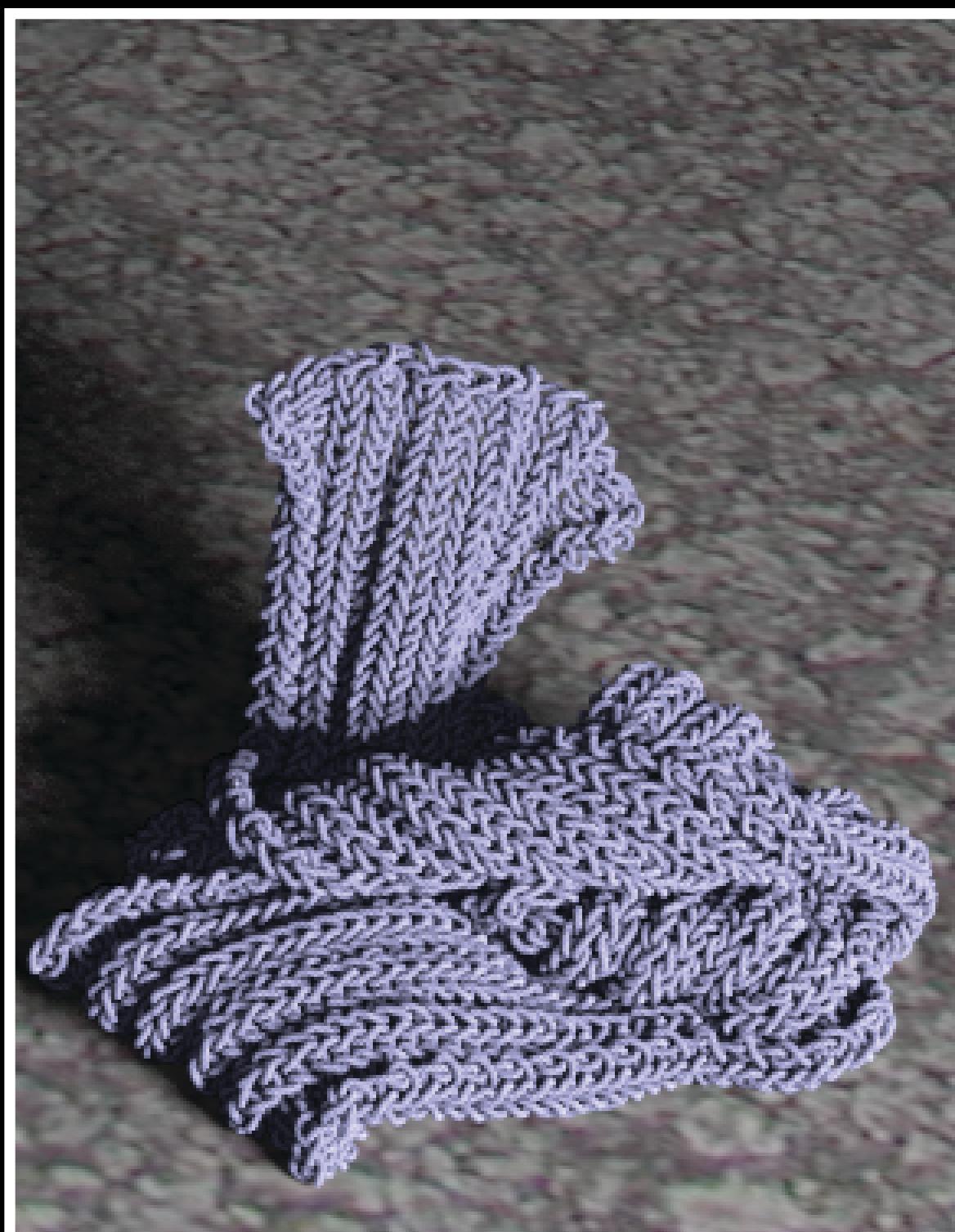
Rib

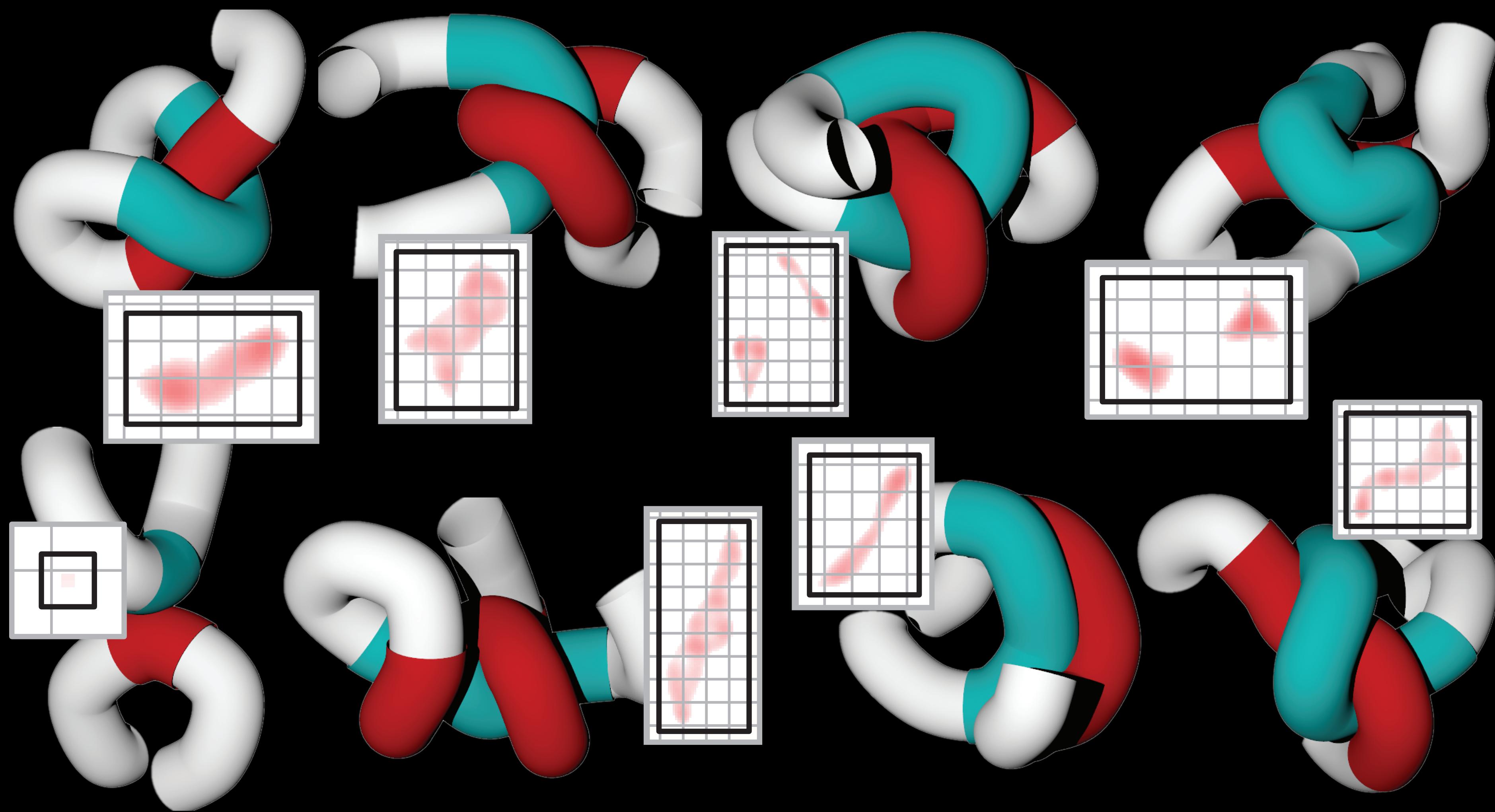


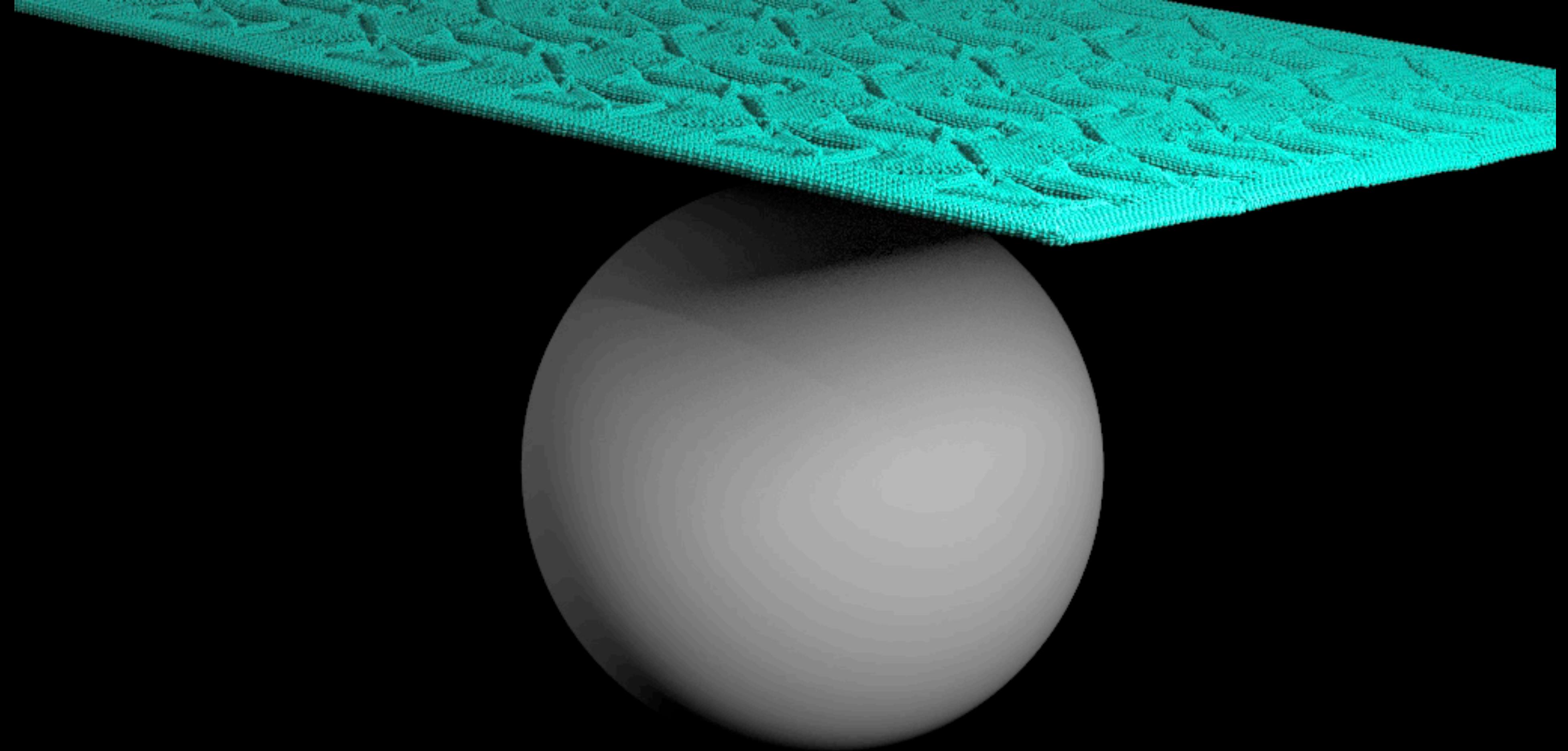




Contact Matrix

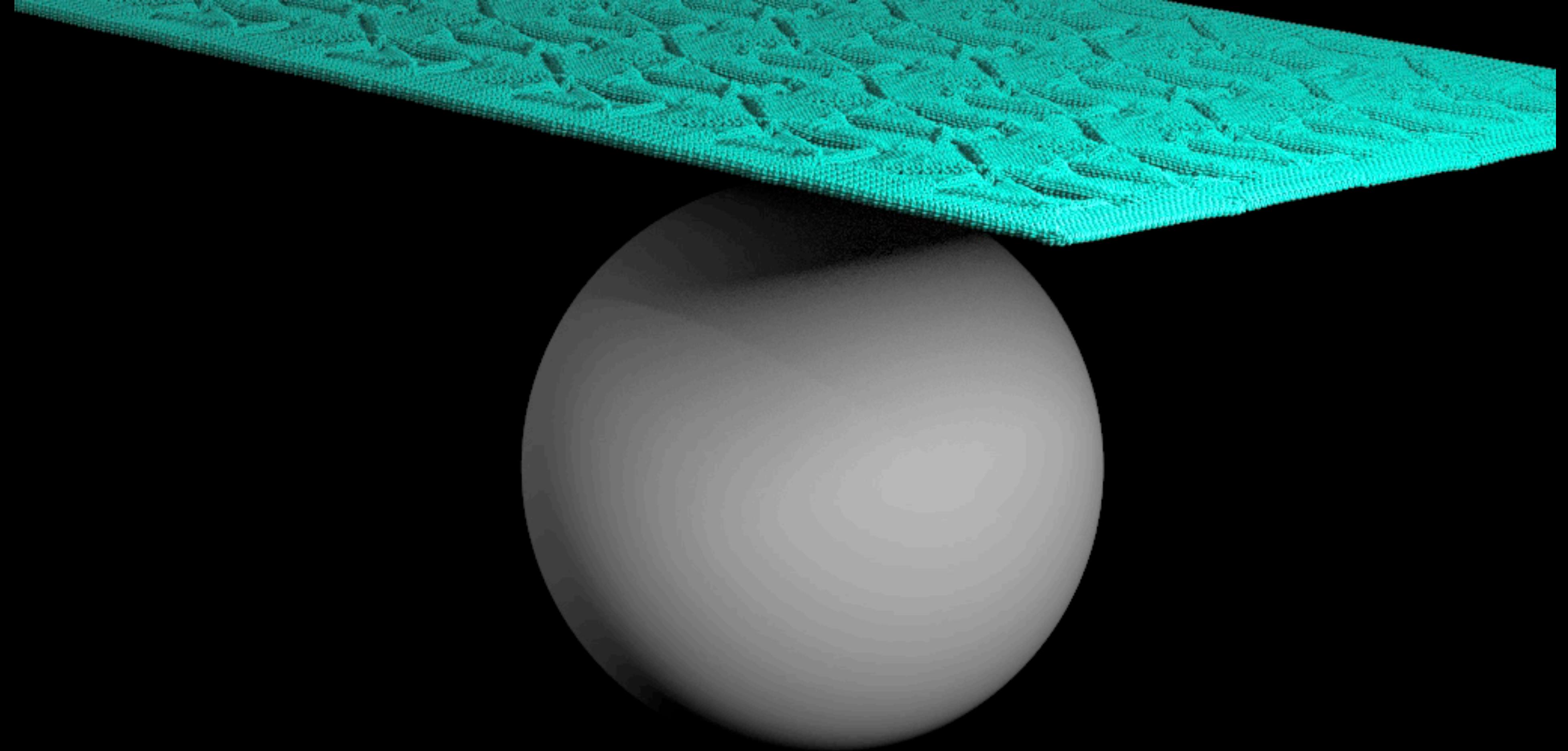






54,340 knit loops, ~365K contact sets
6.7X contact force speedup, 4.2X overall
10.5m per 1/30s frame

$\frac{1}{3}$ speed



54,340 knit loops, ~365K contact sets
6.7X contact force speedup, 4.2X overall
10.5m per 1/30s frame

$\frac{1}{3}$ speed



45,960 knit loops, ~295K contact sets
9.1X contact force speedup, 5.0X overall
8m per 1/30s frame

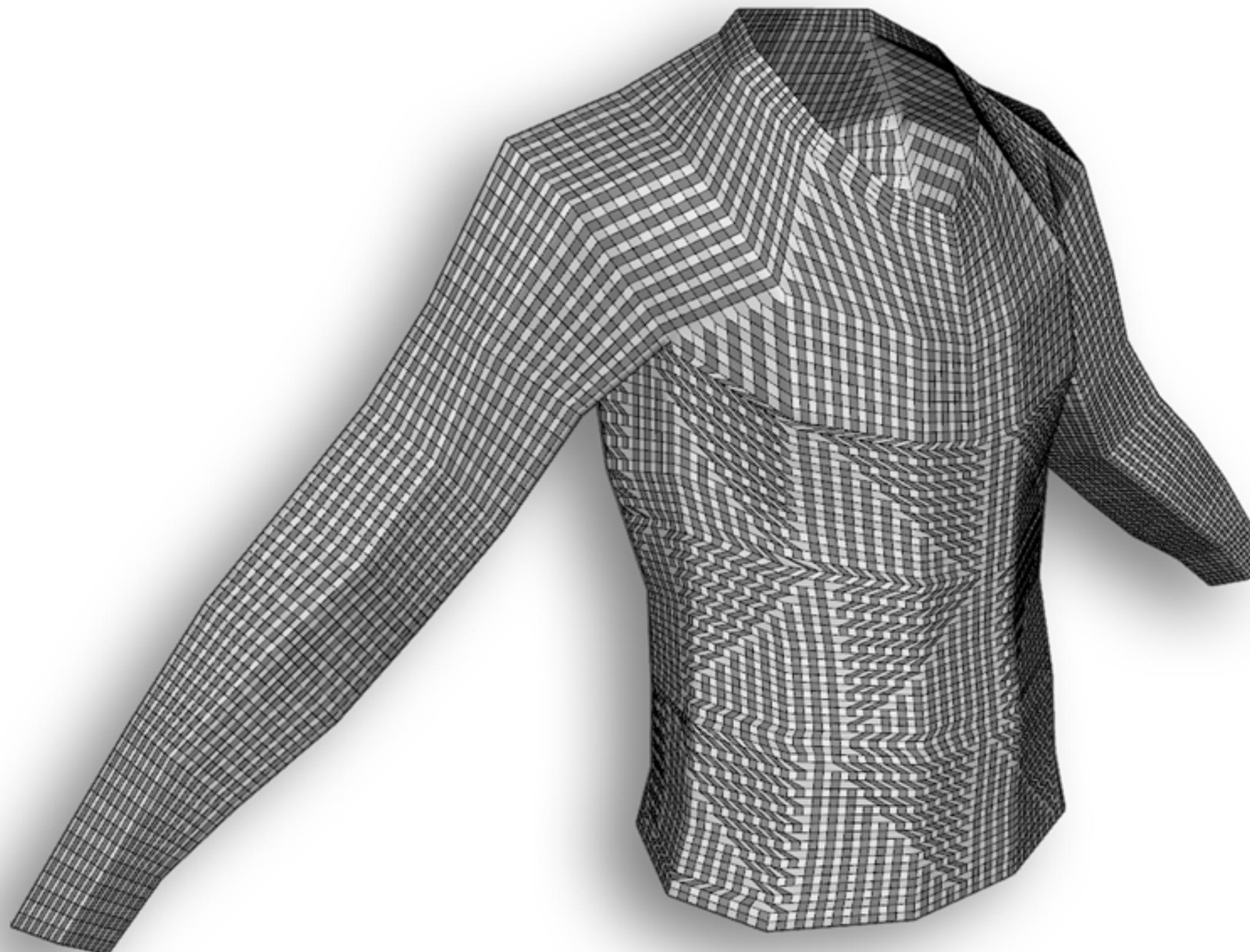
½ speed



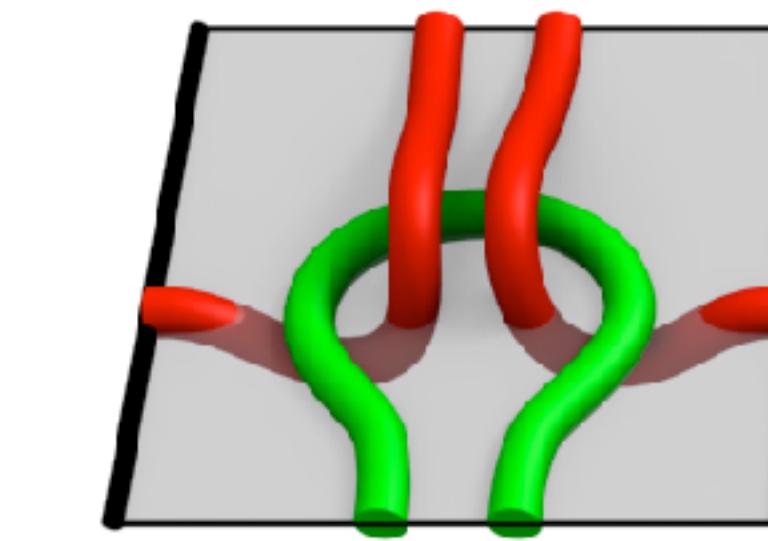
45,960 knit loops, ~295K contact sets
9.1X contact force speedup, 5.0X overall
8m per 1/30s frame

½ speed

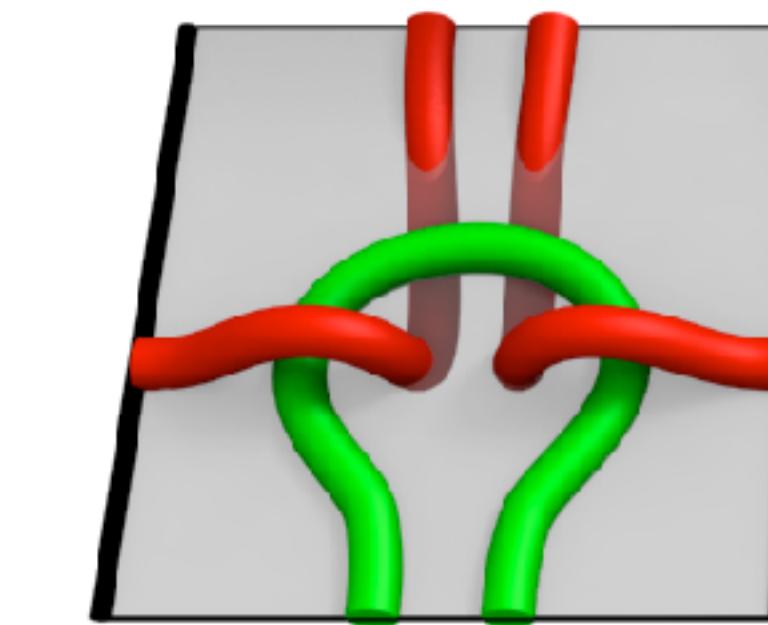
Stitch Meshes



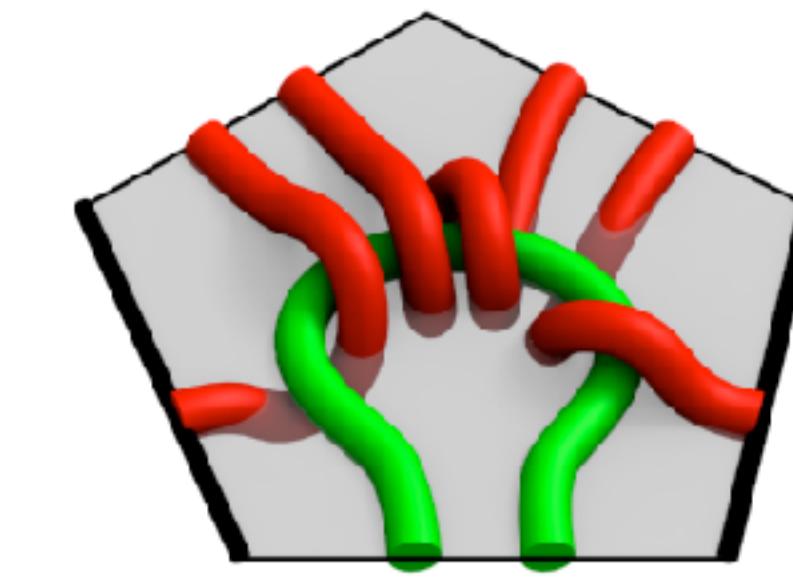
Stitch Mesh



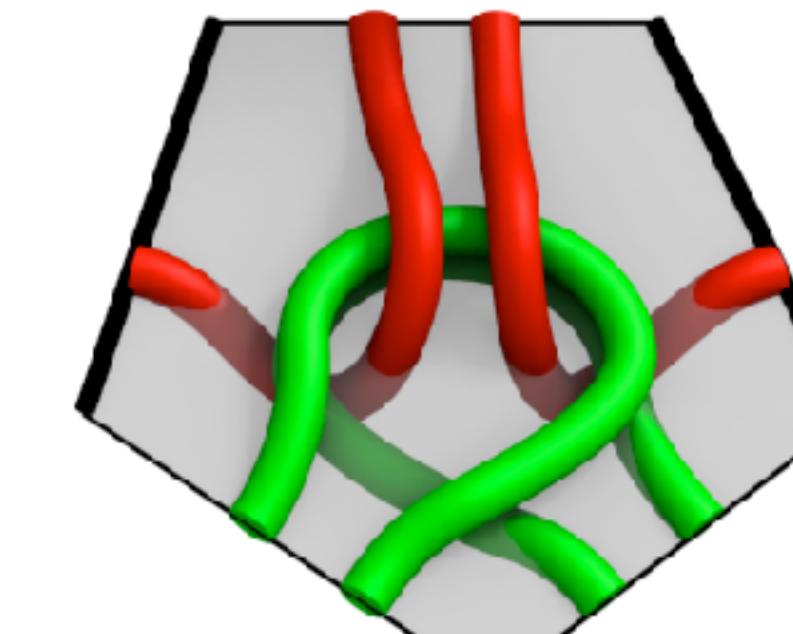
k



p



kp

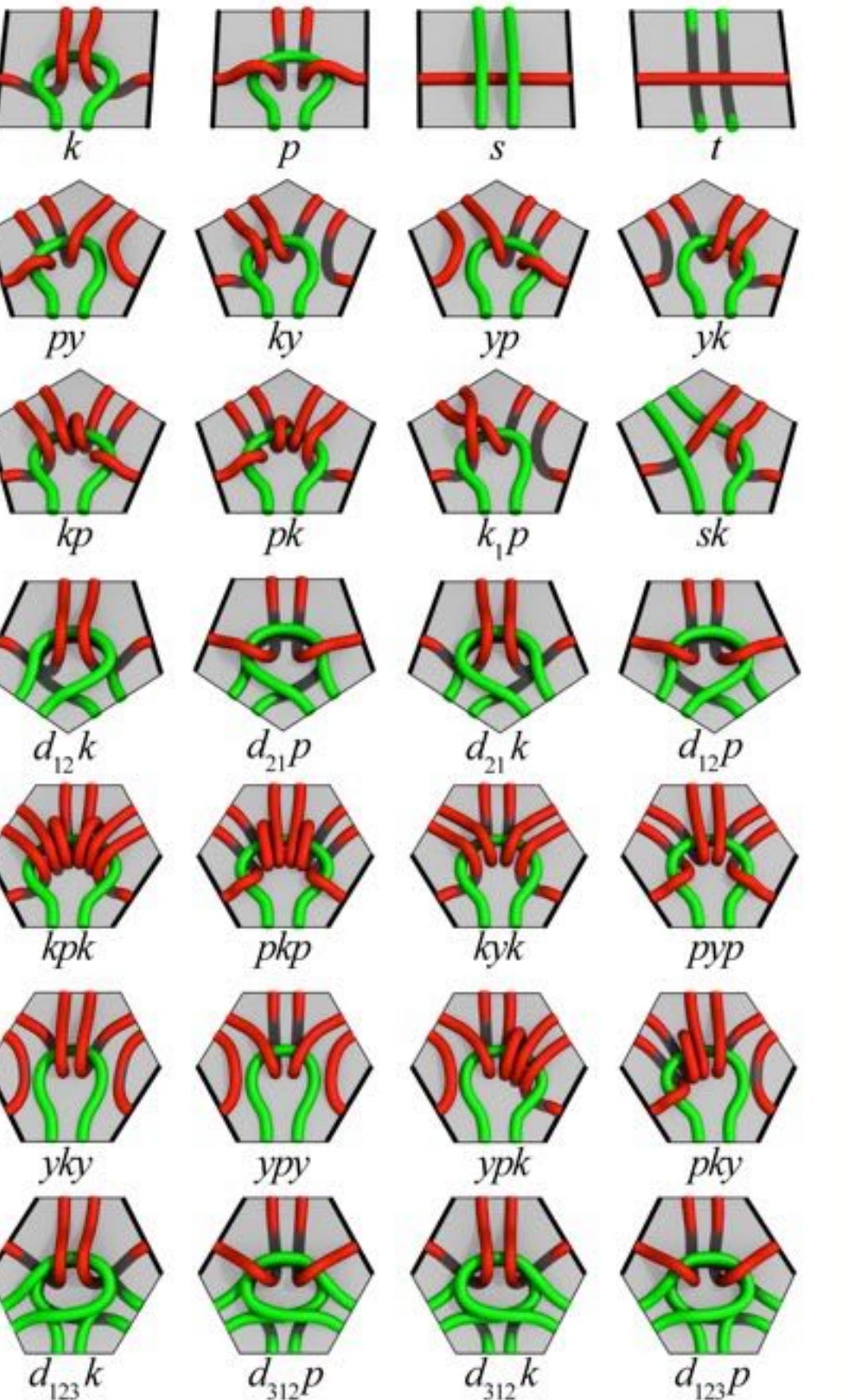


$d_{12}k$

Stitch Mesh Faces

Stitch Type Library

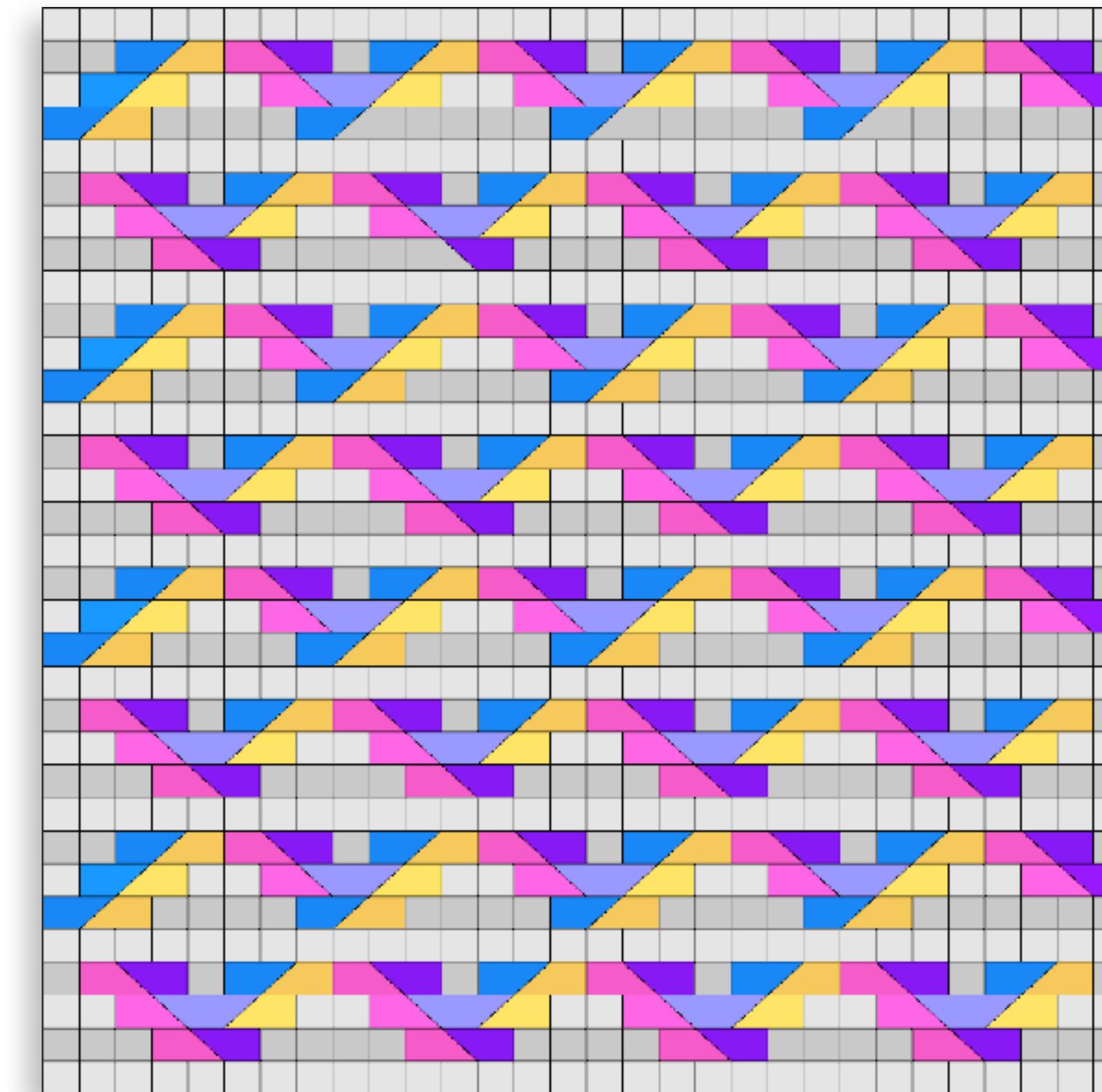
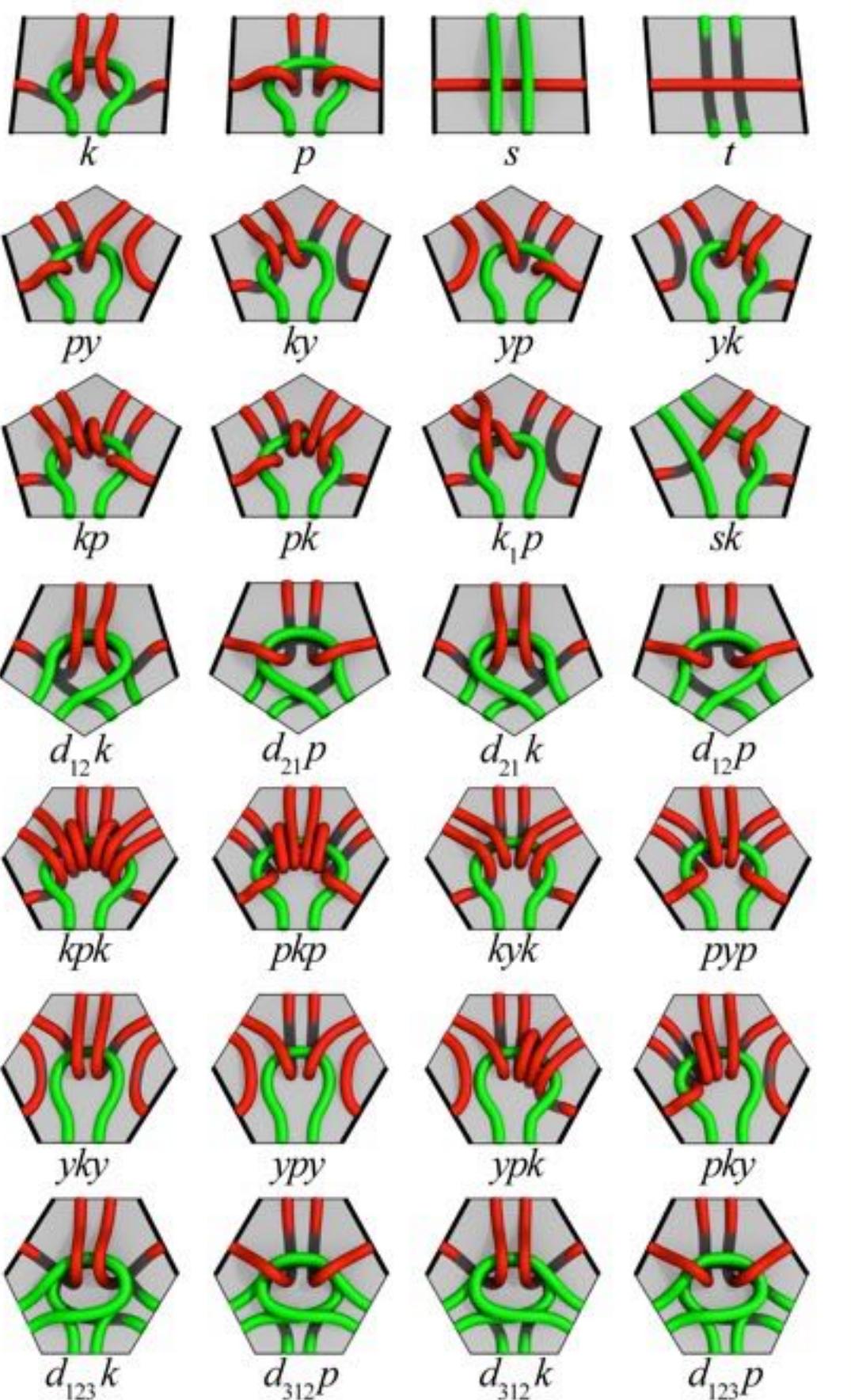
Stich Type Library



Stitch Type Library



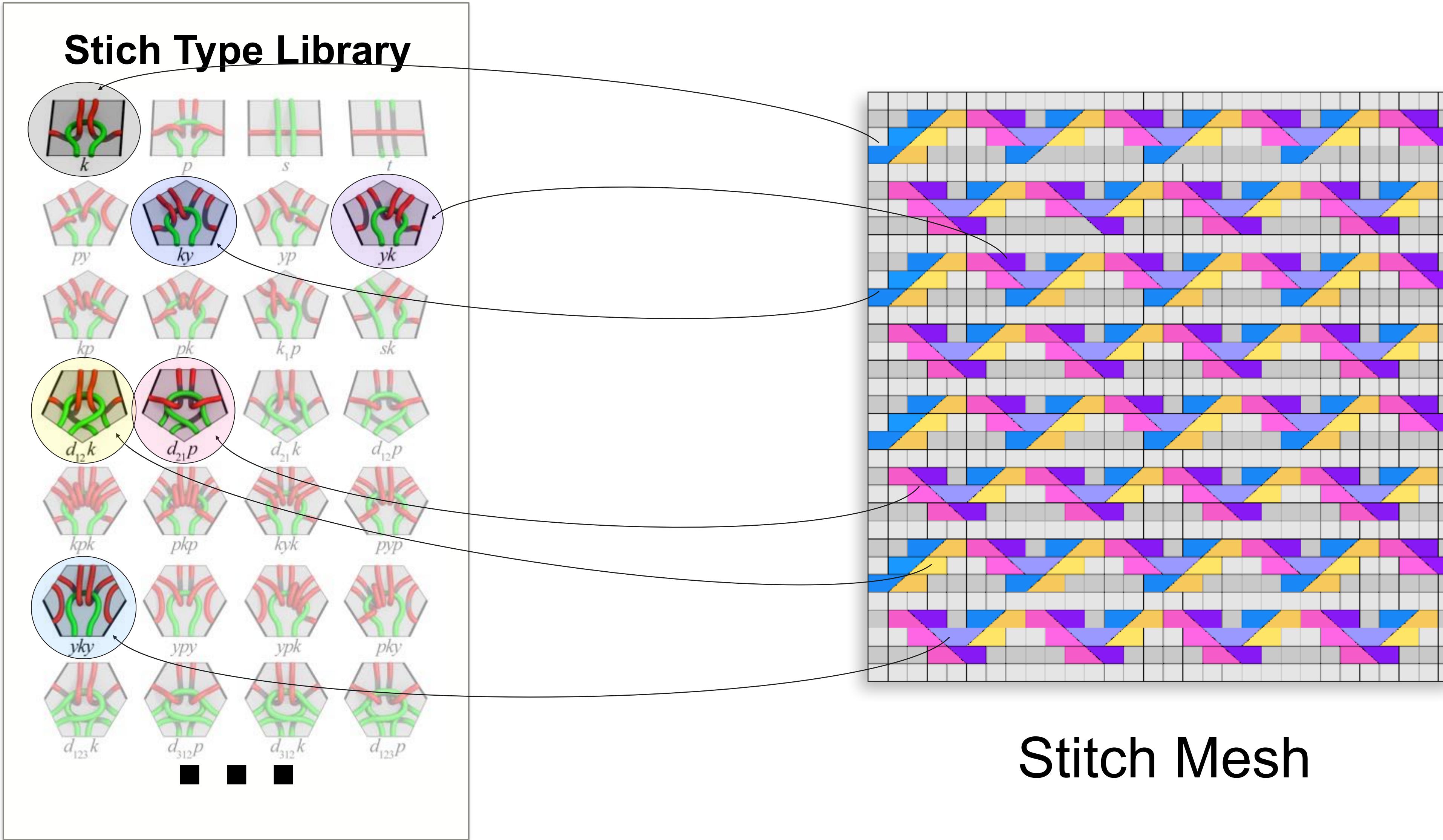
Stich Type Library



Stitch Mesh

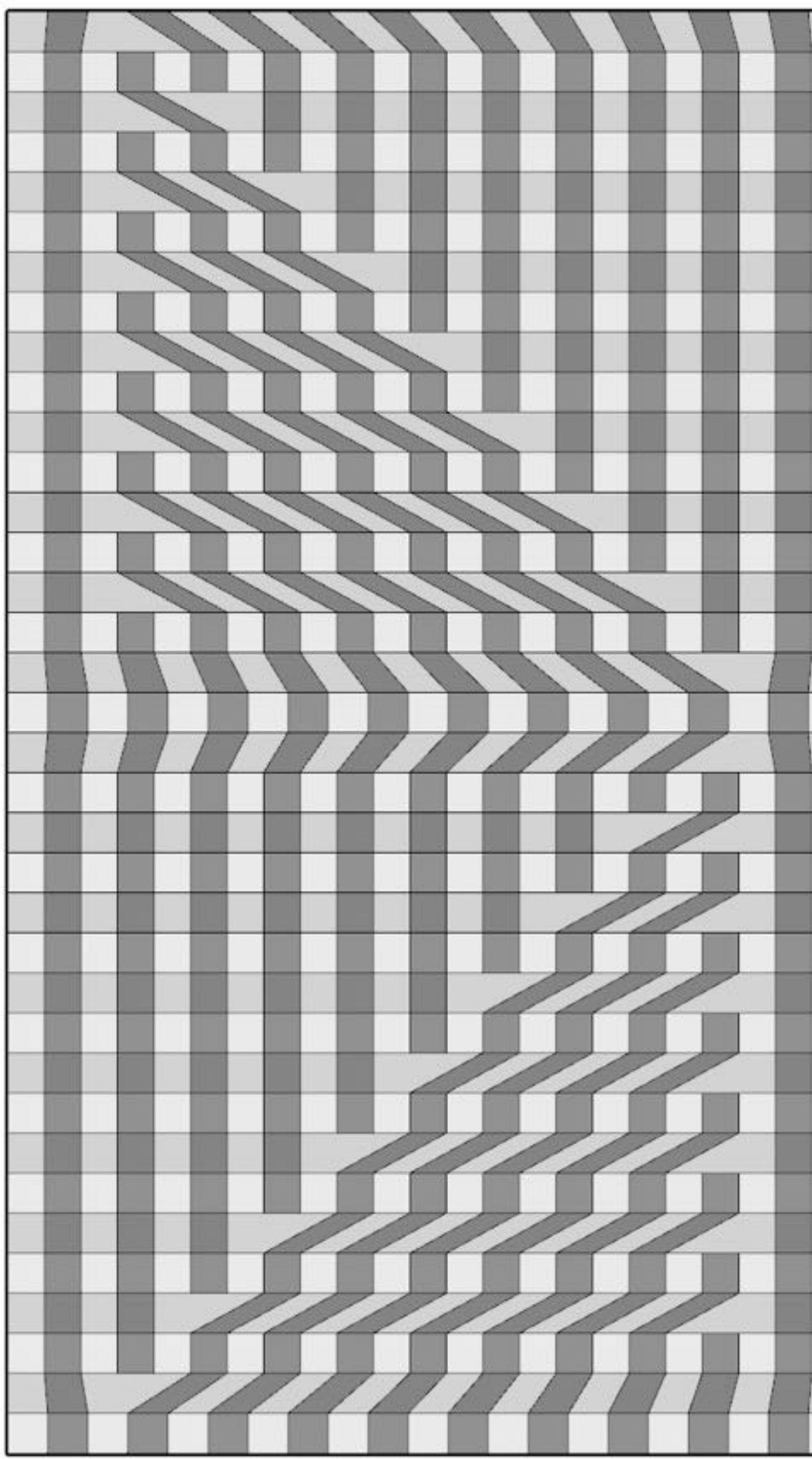
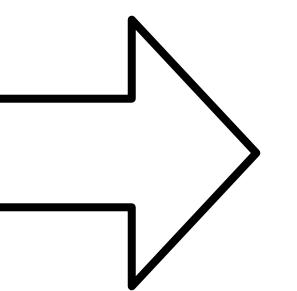
Stitch Type Library

SIGGRAPH2012

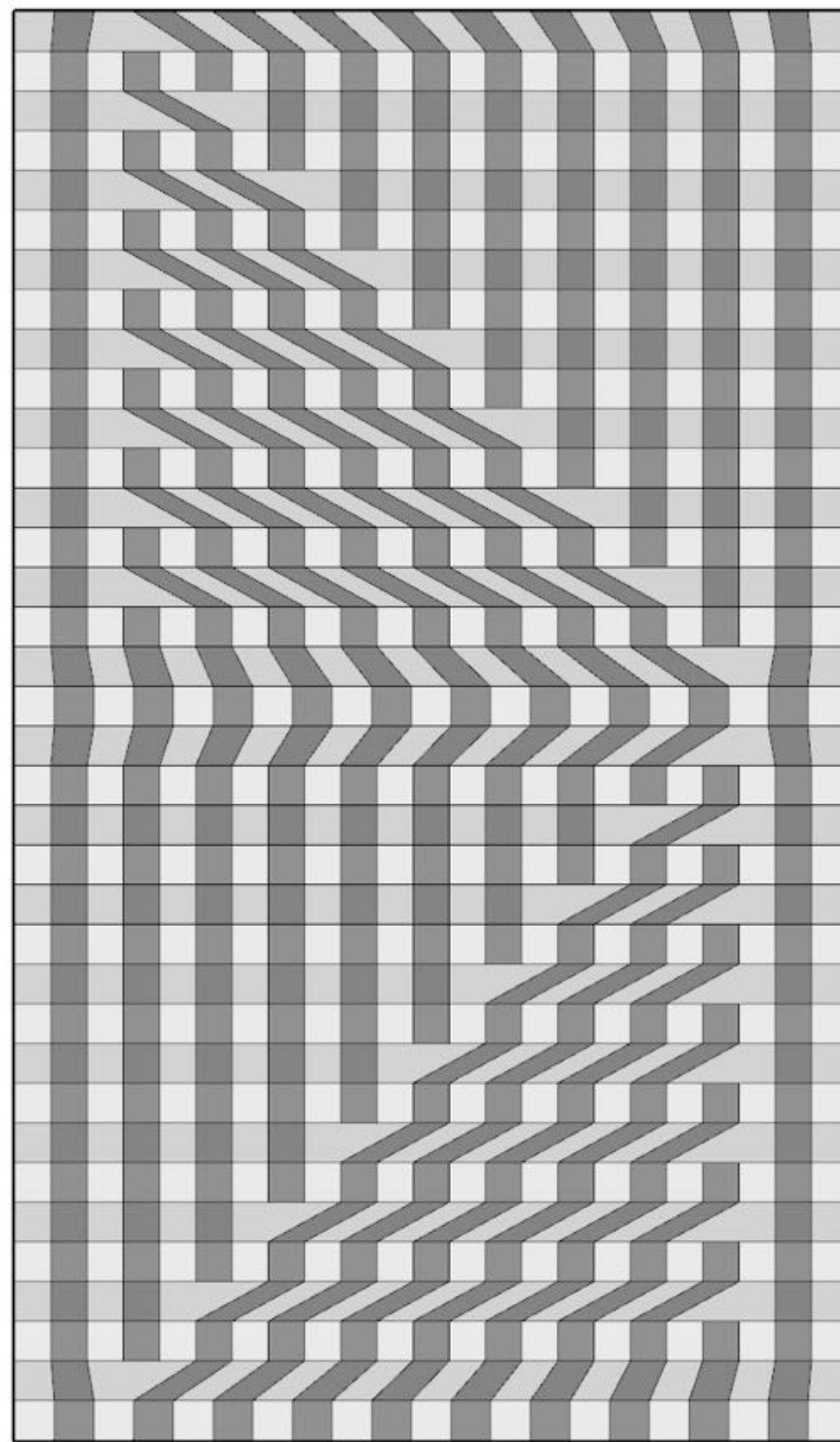
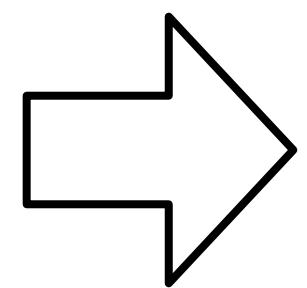


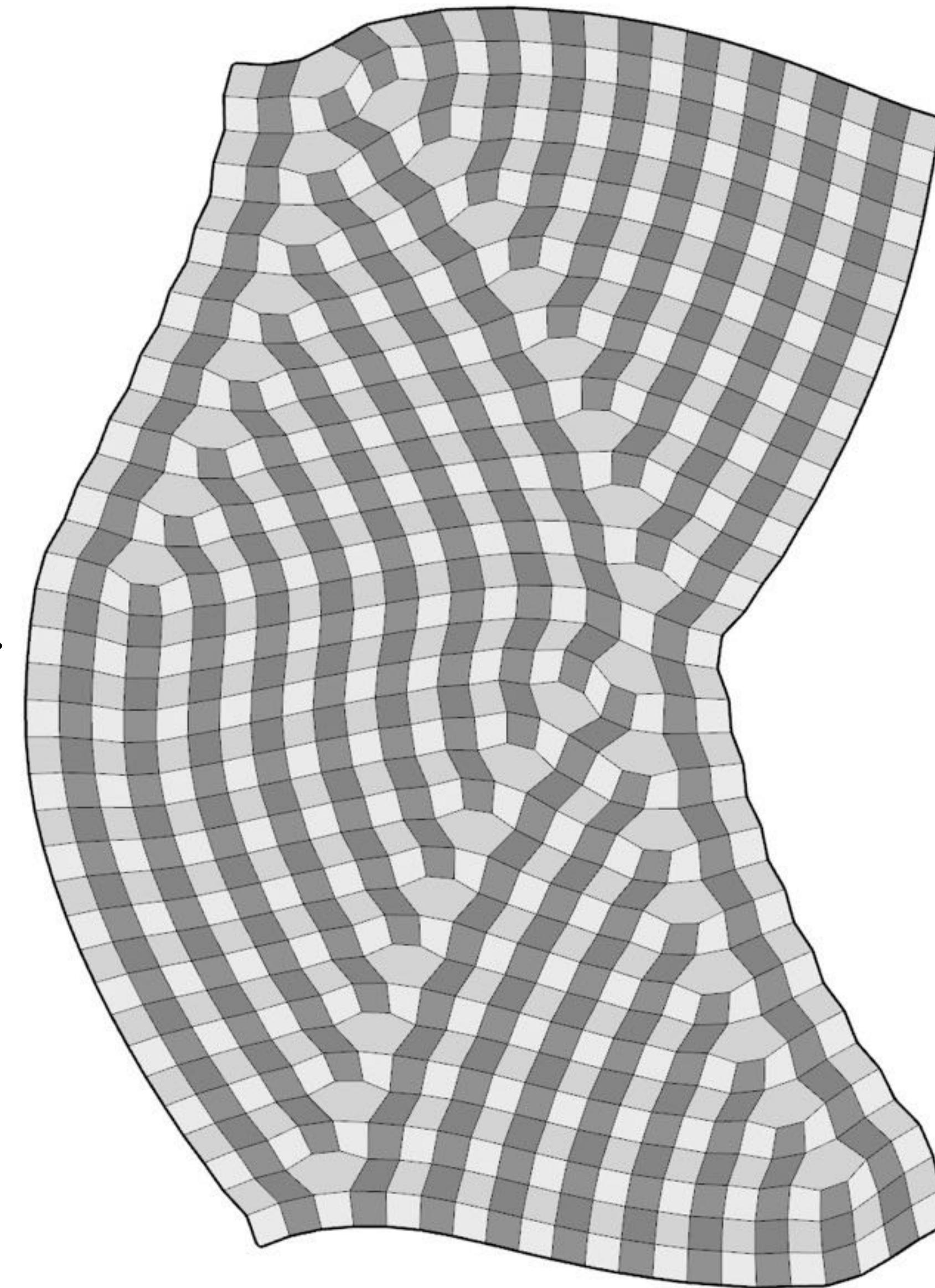
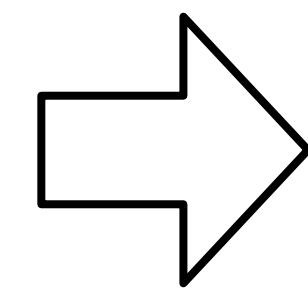
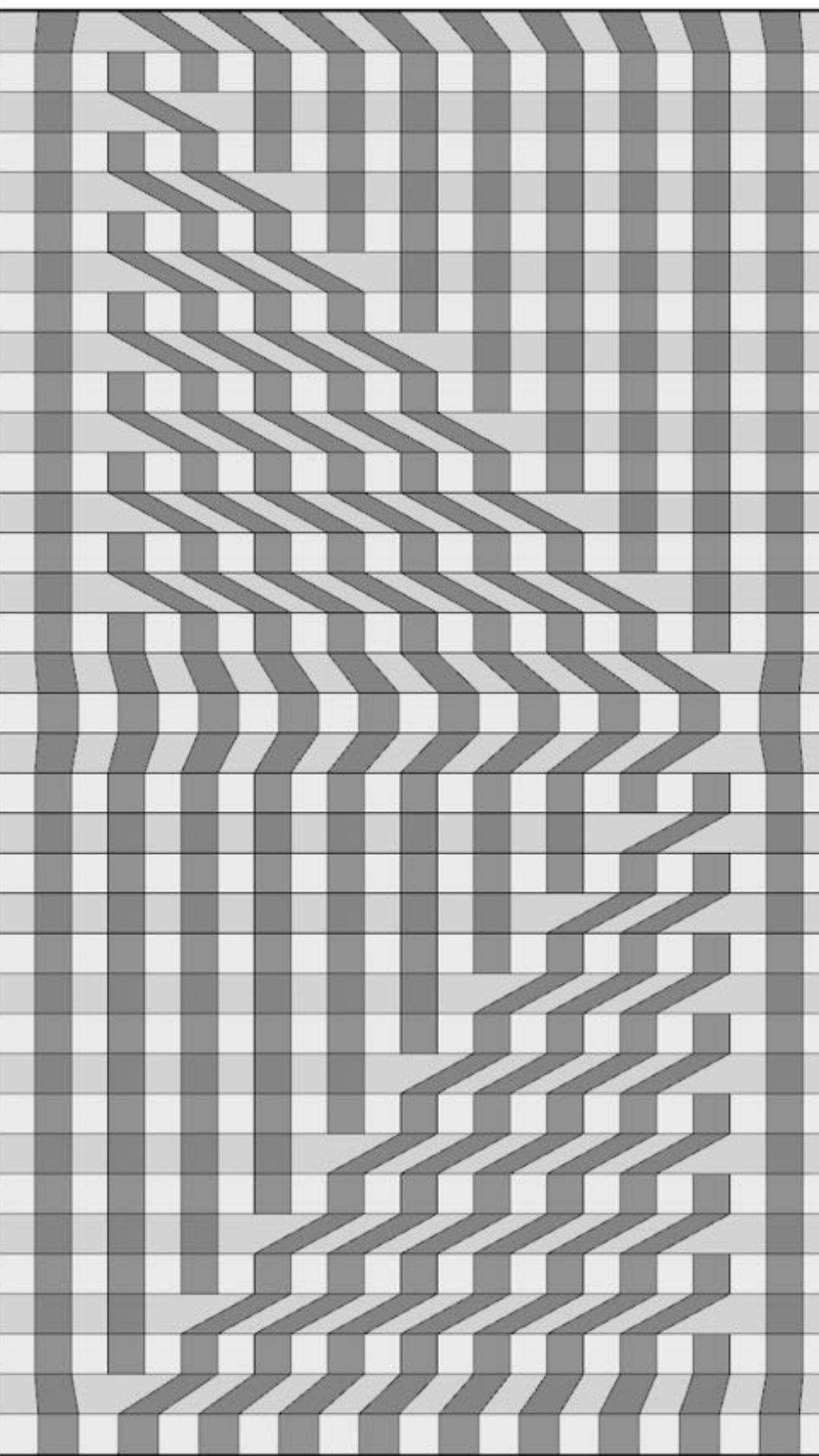
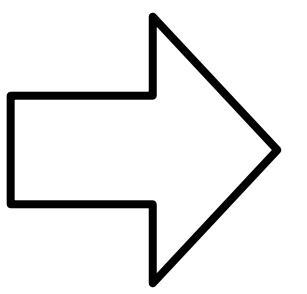
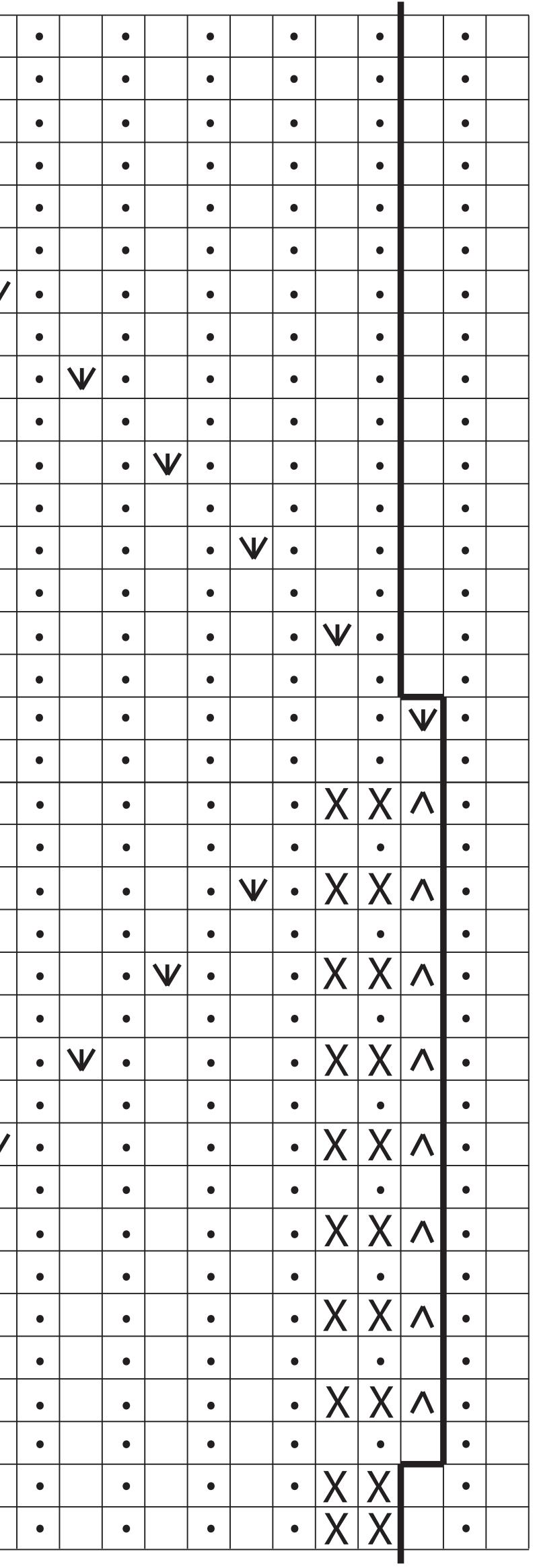
The image shows a 20x20 grid of squares. Some squares contain symbols: 'X' or 'V' (representing downward-pointing triangles) and 'A' (representing upward-pointing triangles). The remaining squares are empty or contain a small black dot. There are two thick black vertical lines: one on the far left and one on the far right. In the first column, there are two 'X's at the top, followed by a 'V' at row 6, and another 'X' at row 12. In the second column, there is an 'A' at the top. In the third column, there are two 'X's at the top. In the fourth column, there is a 'V' at the top. In the fifth column, there is an 'A' at the top. In the sixth column, there are two 'X's at the top. In the seventh column, there is a 'V' at the top. In the eighth column, there is an 'A' at the top. In the ninth column, there are two 'X's at the top. In the tenth column, there is a 'V' at the top. In the eleventh column, there is an 'A' at the top. In the twelfth column, there are two 'X's at the top. In the thirteenth column, there is a 'V' at the top. In the fourteenth column, there is an 'A' at the top. In the fifteen column, there are two 'X's at the top. In the sixteen column, there is a 'V' at the top. In the seventeen column, there is an 'A' at the top. In the eighteen column, there are two 'X's at the top. In the nineteenth column, there is a 'V' at the top. In the twentieth column, there is an 'A' at the top. The remaining squares are mostly empty or contain a small black dot.

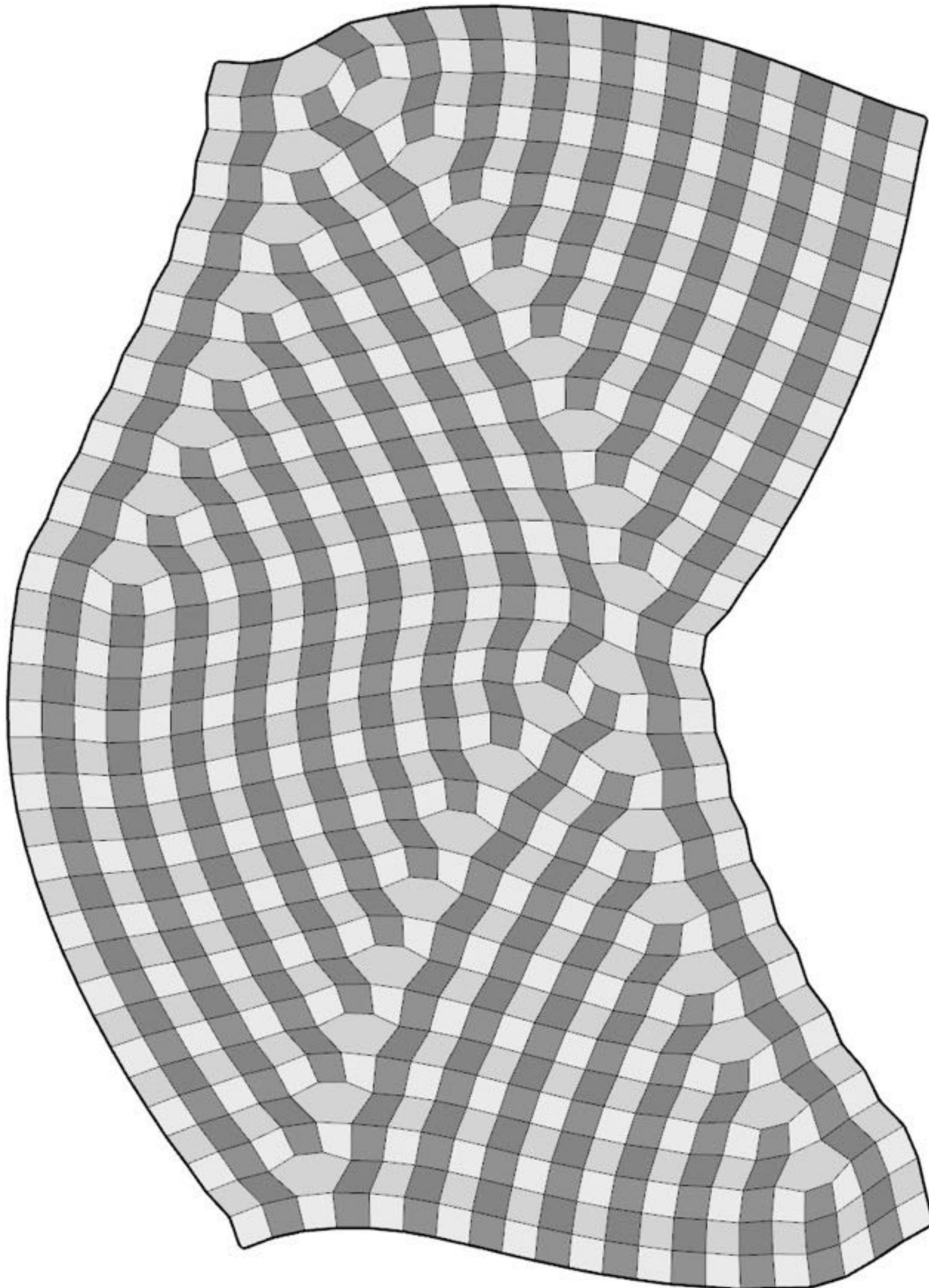
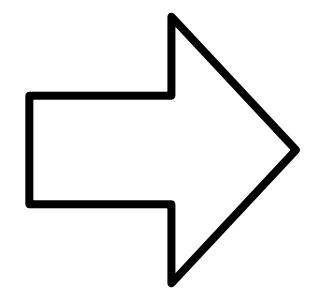
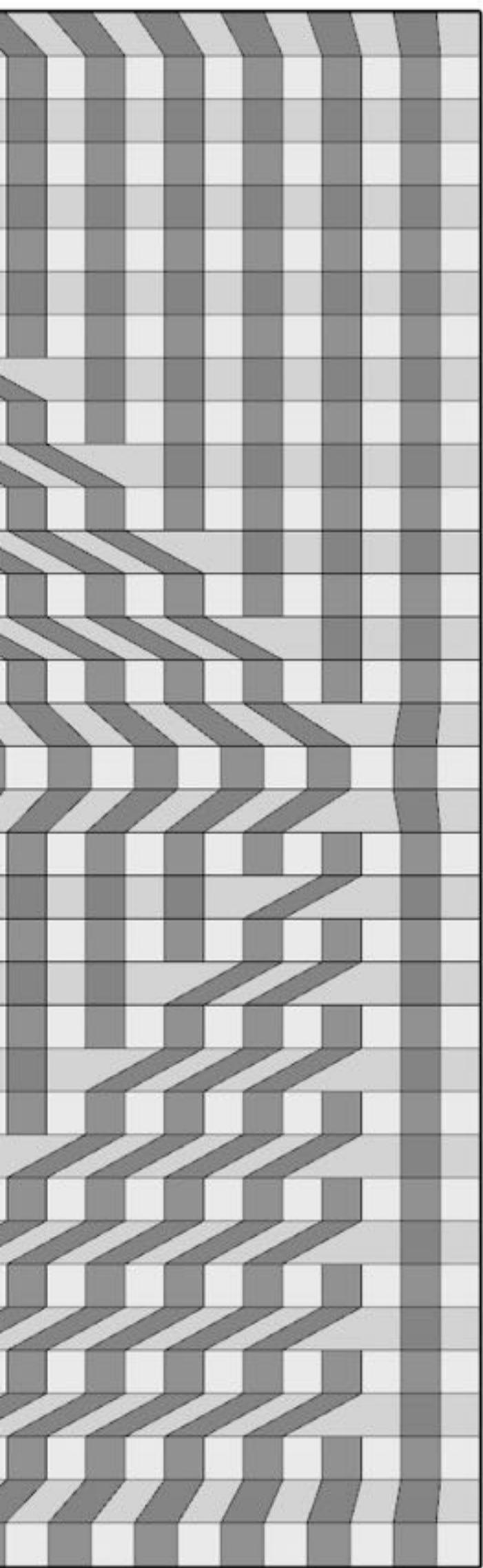
The image shows a 2D grid puzzle. The grid consists of a 20x20 area of small squares. Some squares contain symbols: 'X' or 'A' in large bold font, or a small dot. Thick black lines form several rectangular regions: a vertical column on the left, a horizontal row at the bottom, and two L-shaped structures in the middle-right area. A small portion of the grid is highlighted with a light gray background.

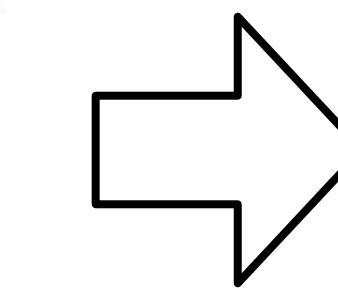
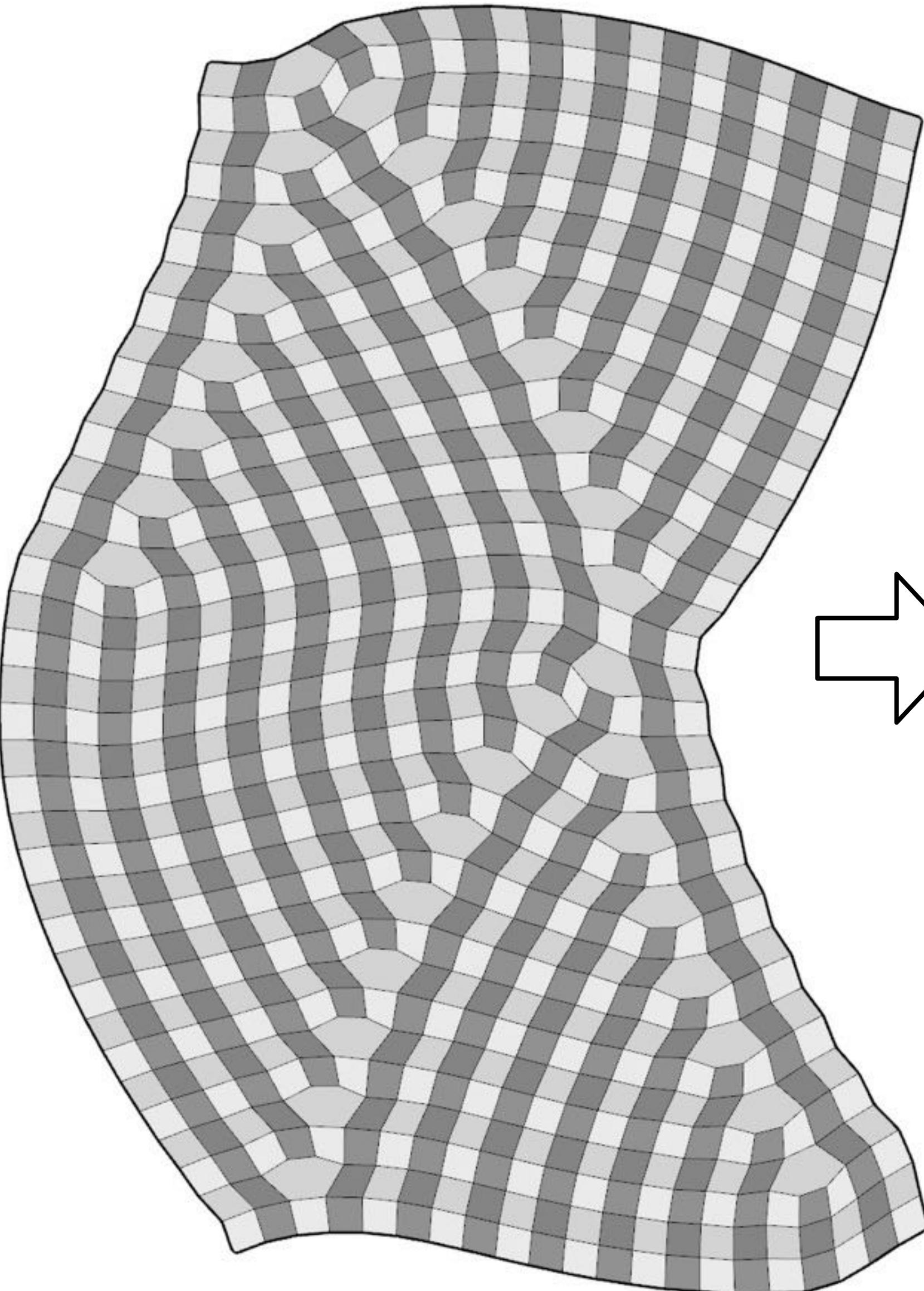
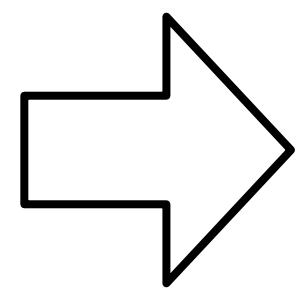
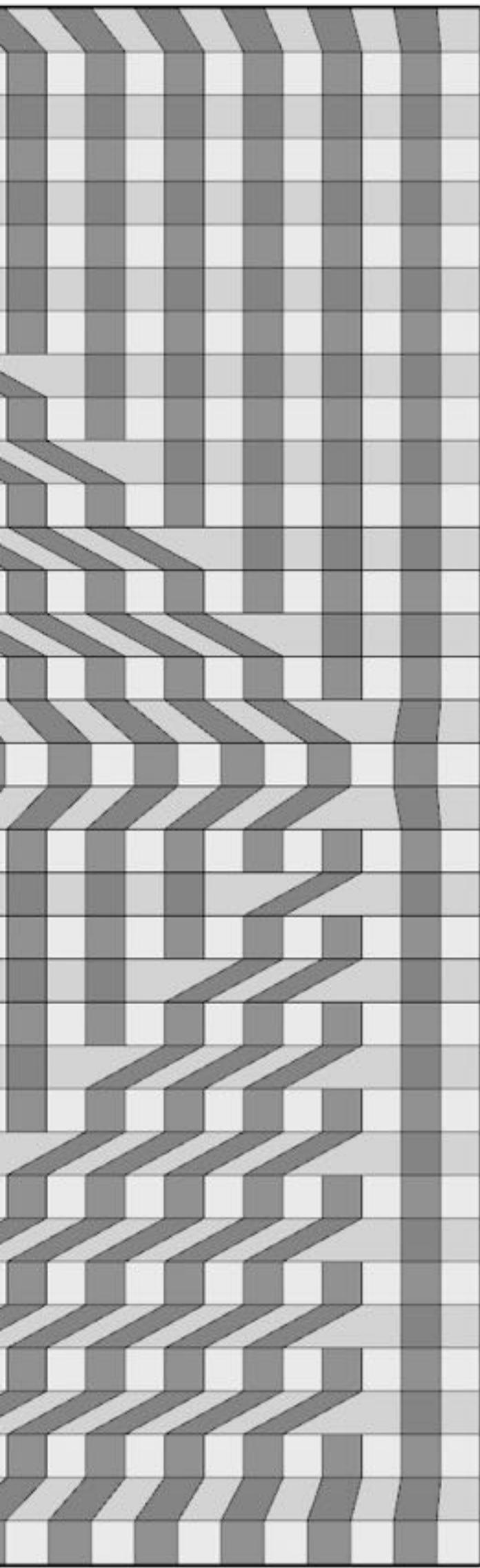


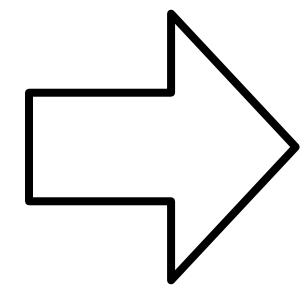
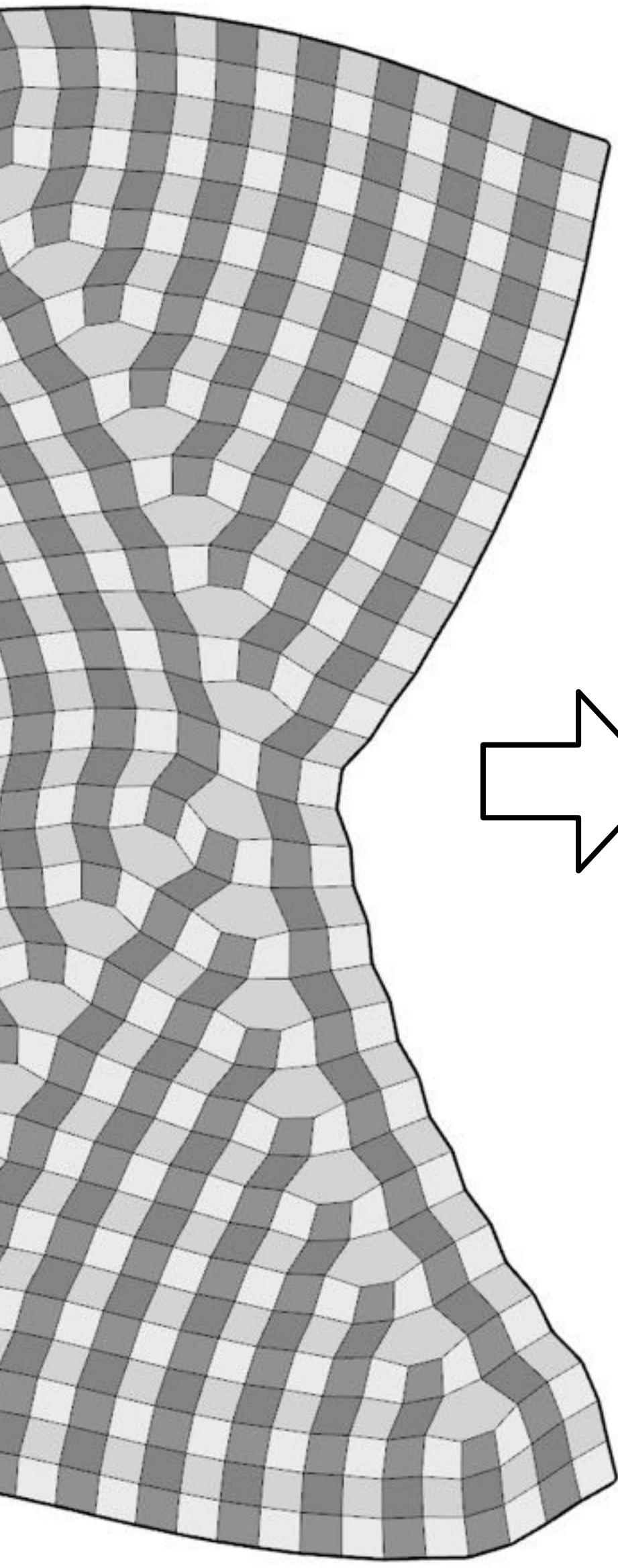
The image shows a 10x10 grid of squares. A thick vertical black line runs down the center of the grid. The grid contains several symbols: small black dots, large black 'V' shapes pointing downwards, large black 'X' shapes, and large black '^' shapes. The symbols are placed in a pattern that suggests a path or a sequence. For example, there are two 'V' shapes in the first column, one 'X' shape in the second column, and one '^' shape in the third column. The symbols continue in this pattern across the grid, with some variations in the later columns. The grid is bounded by a thin black border.

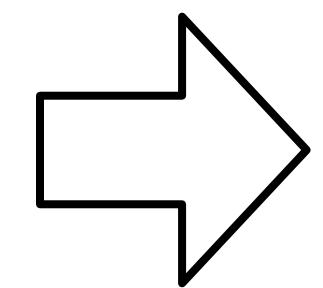
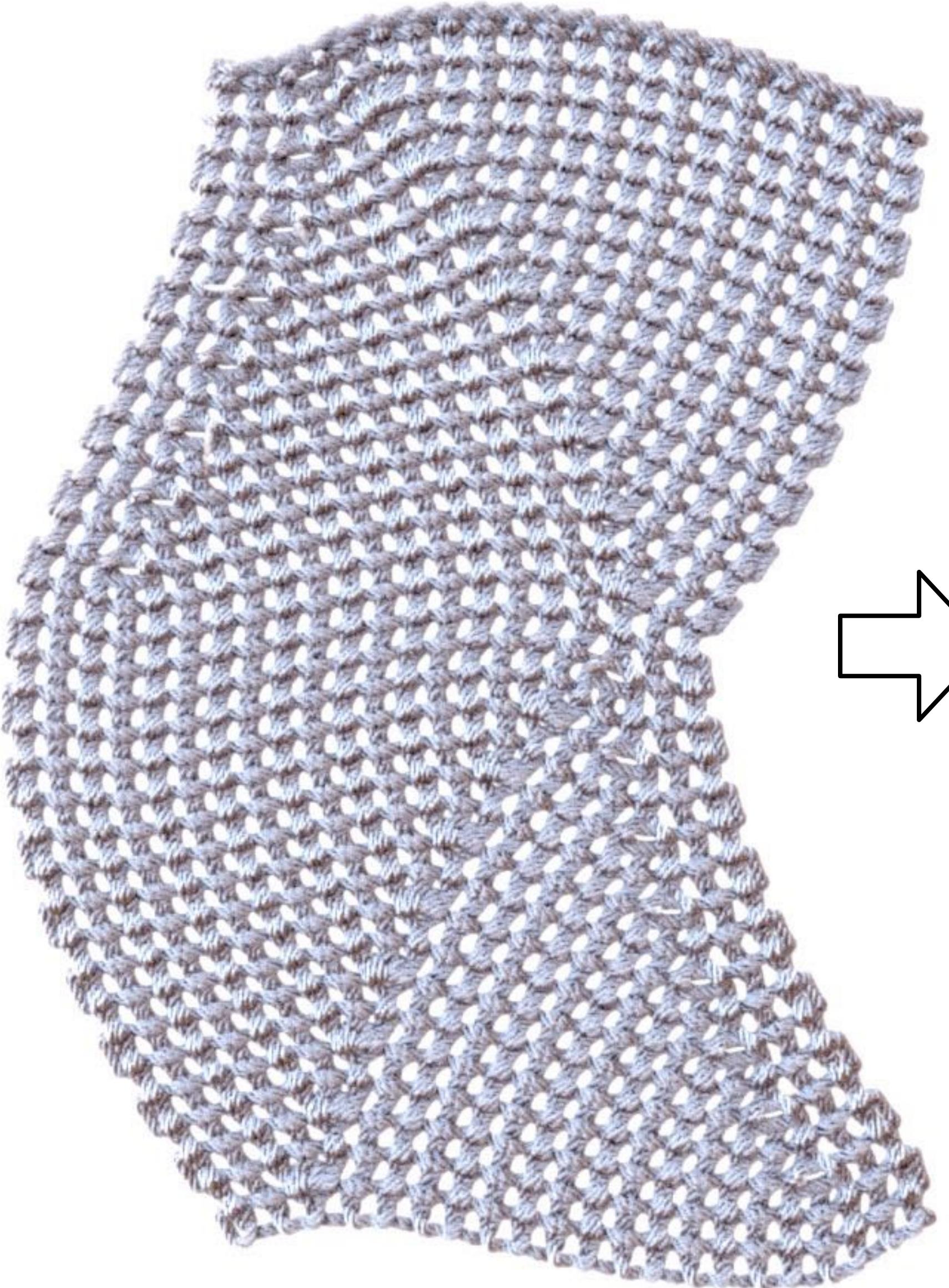
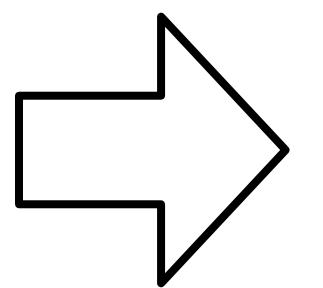
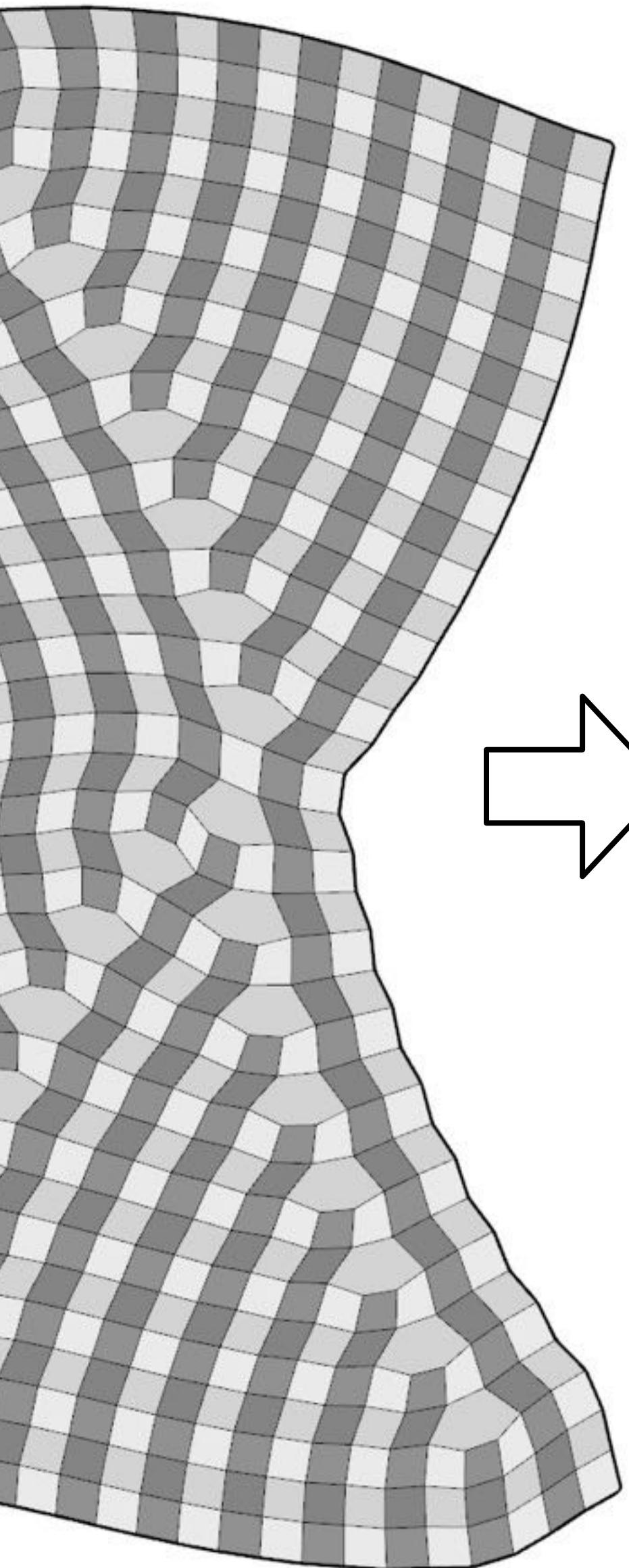


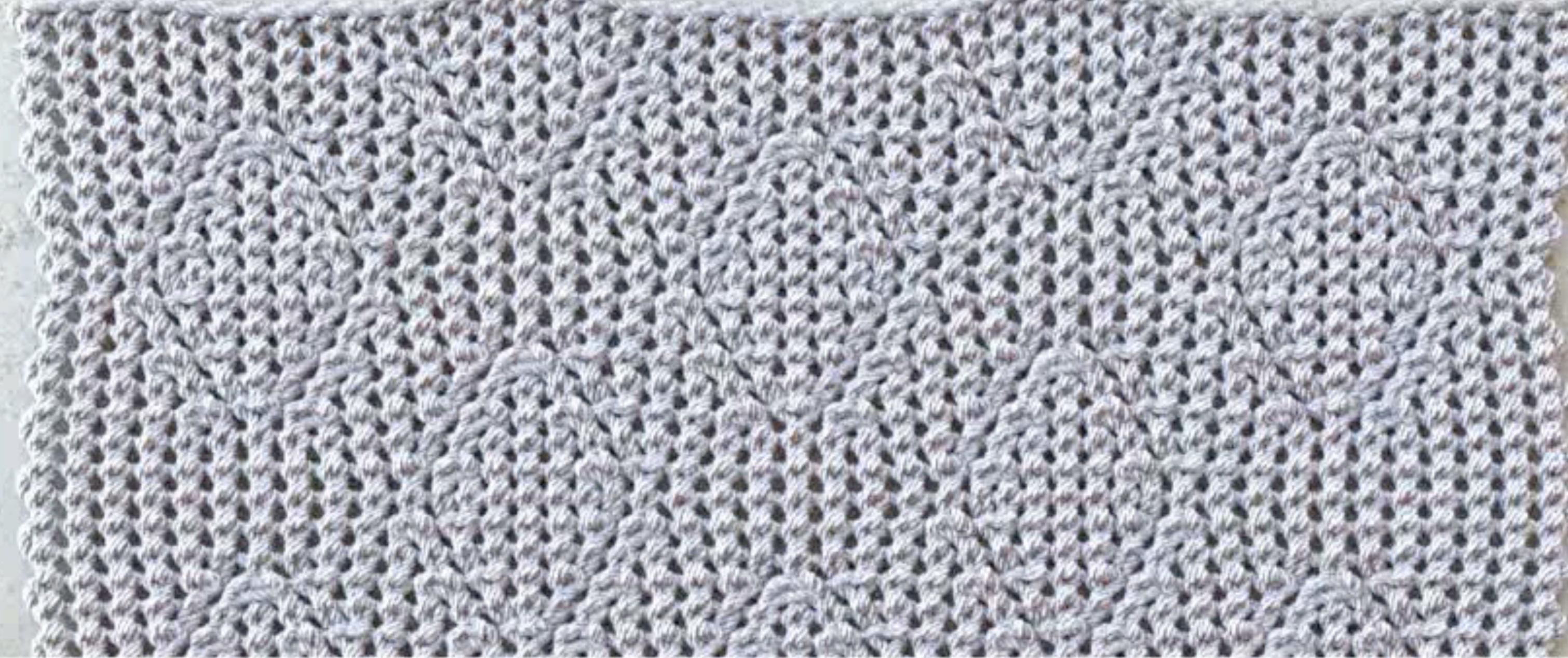




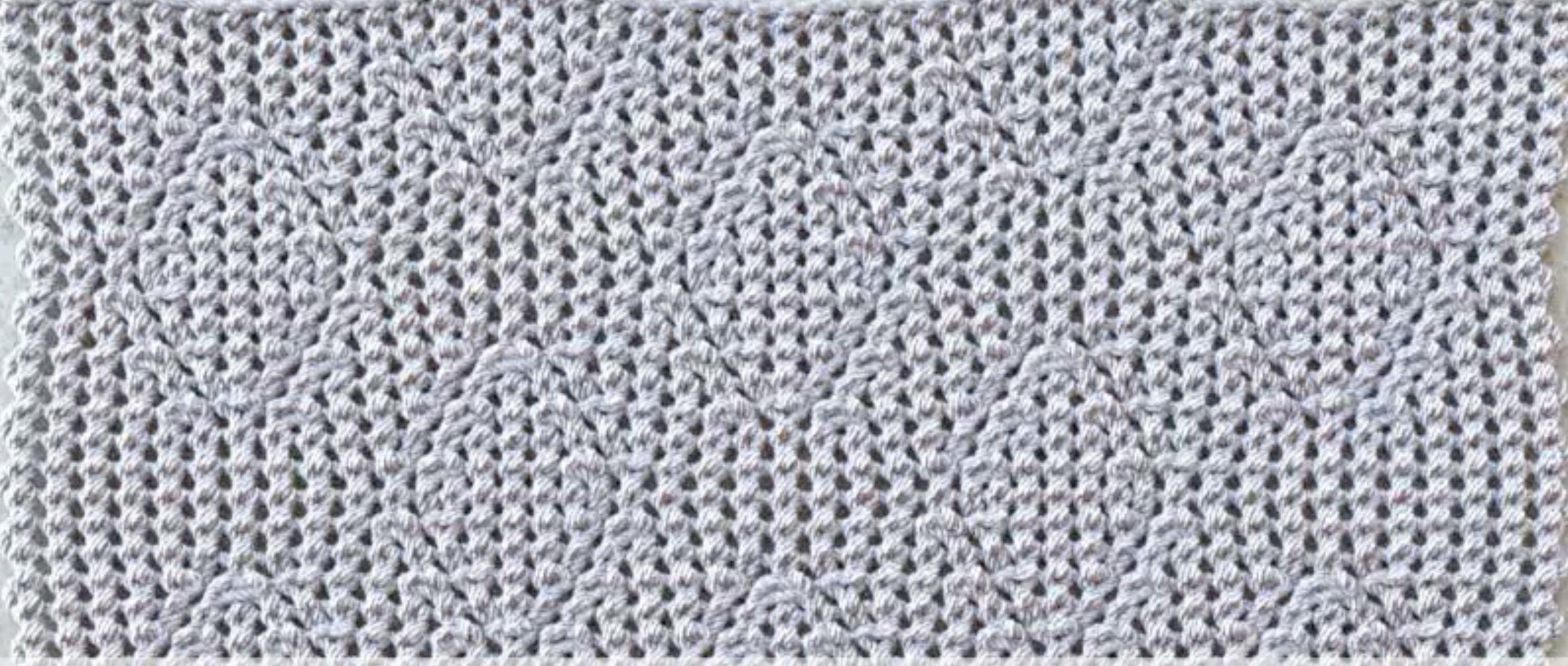






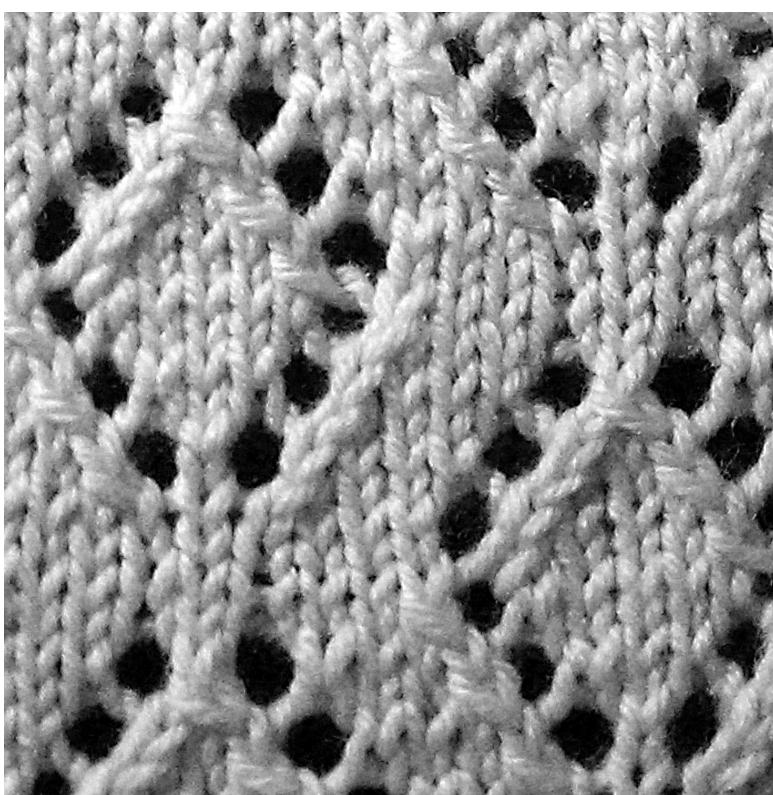
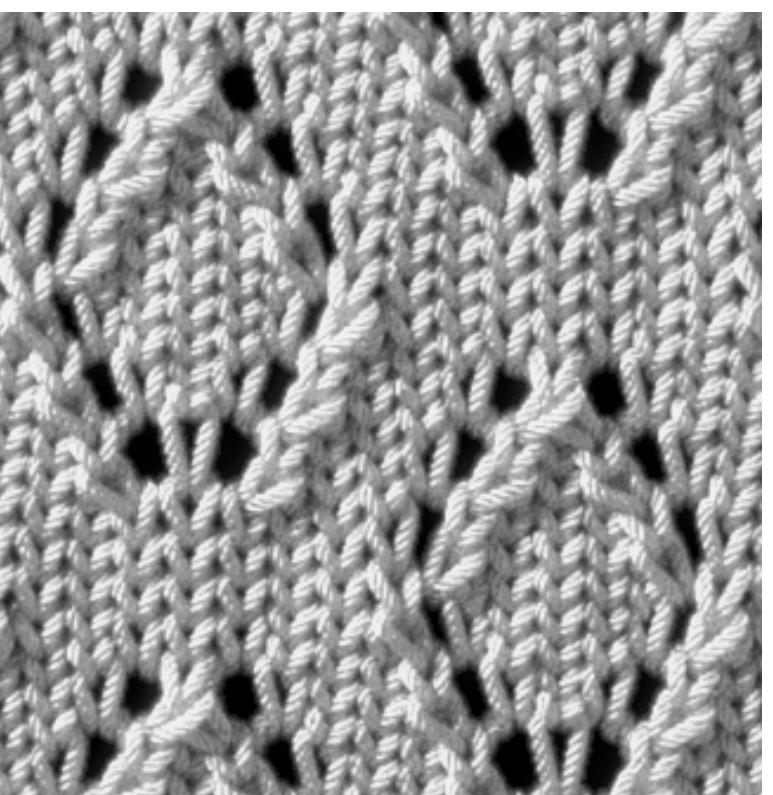
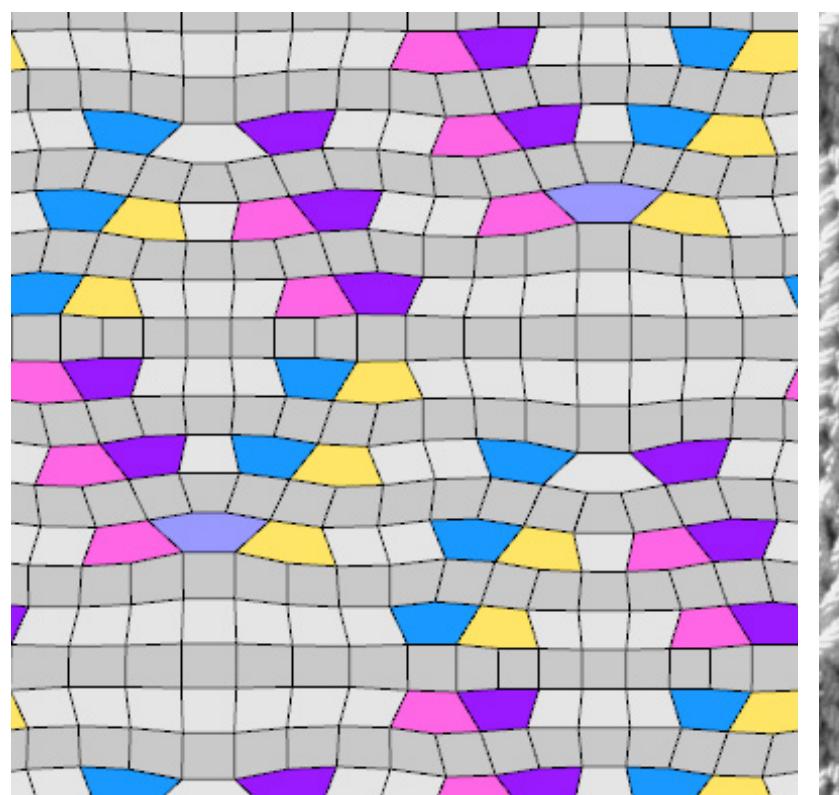


Mrs. Montague's Pattern

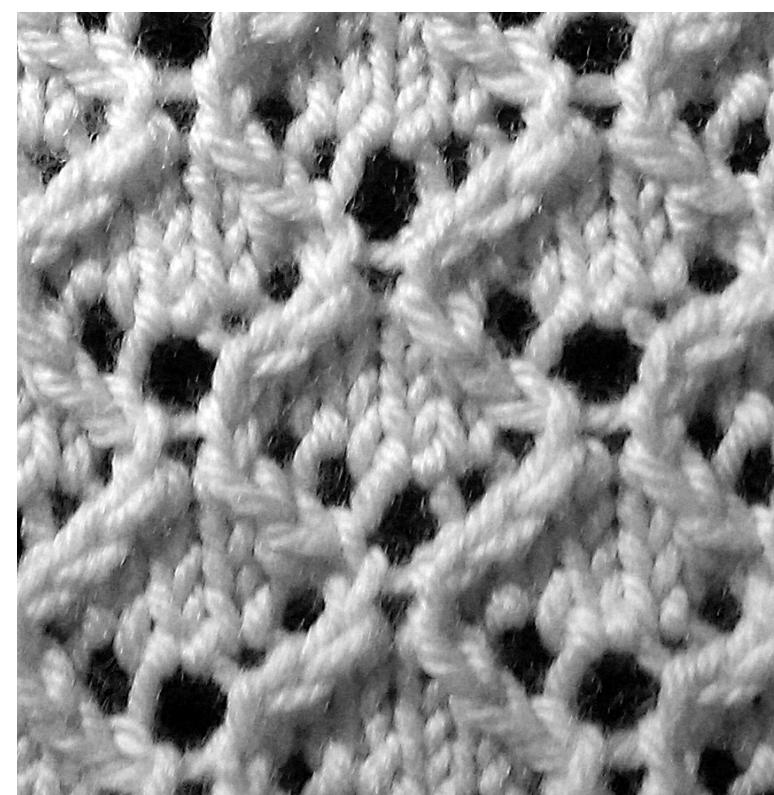
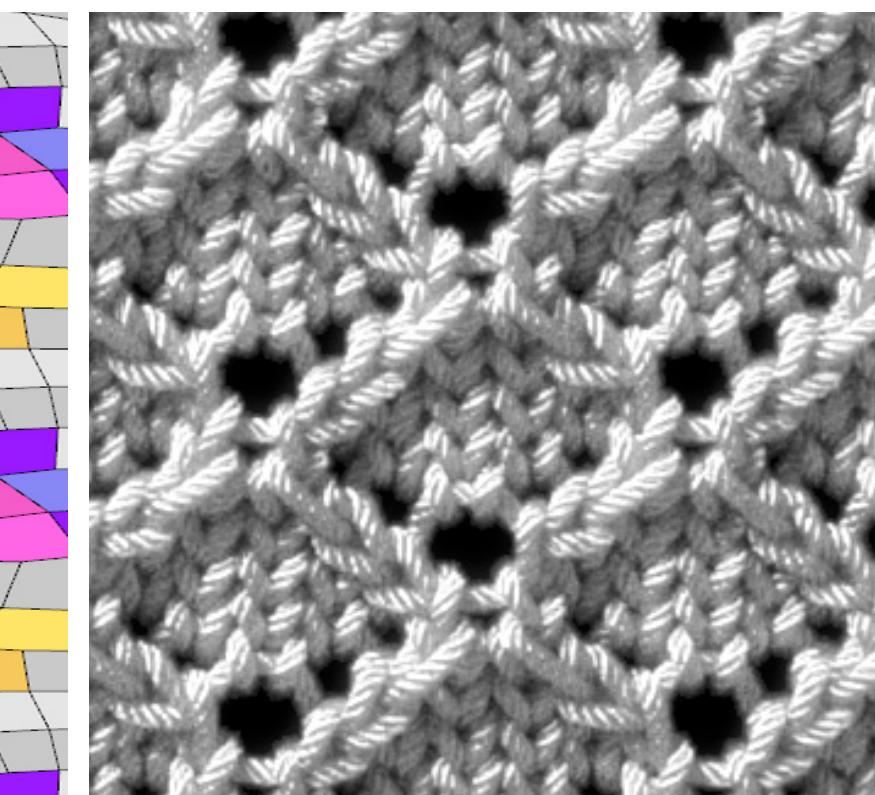
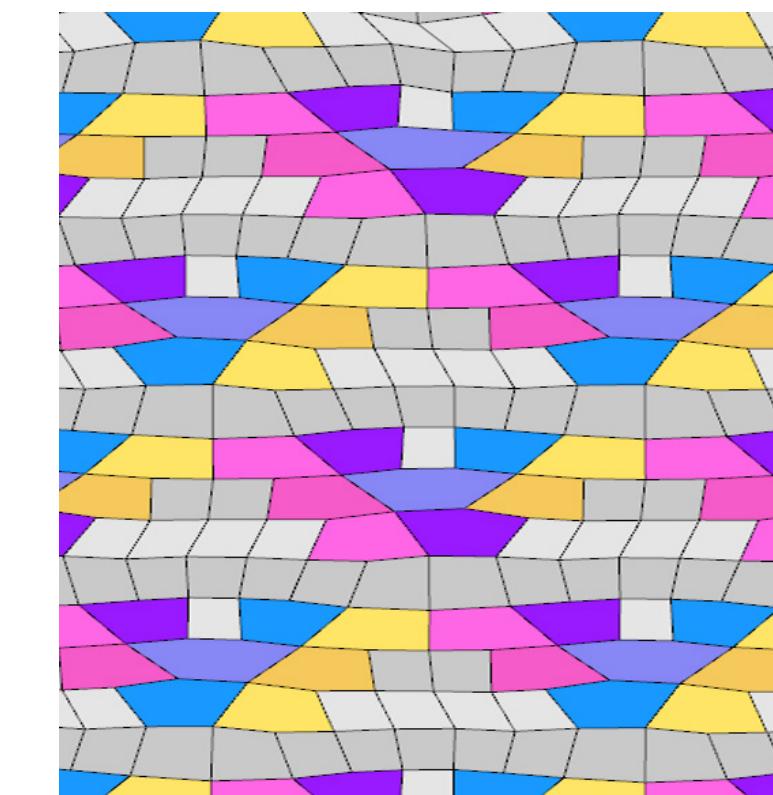


Mrs. Montague's Pattern

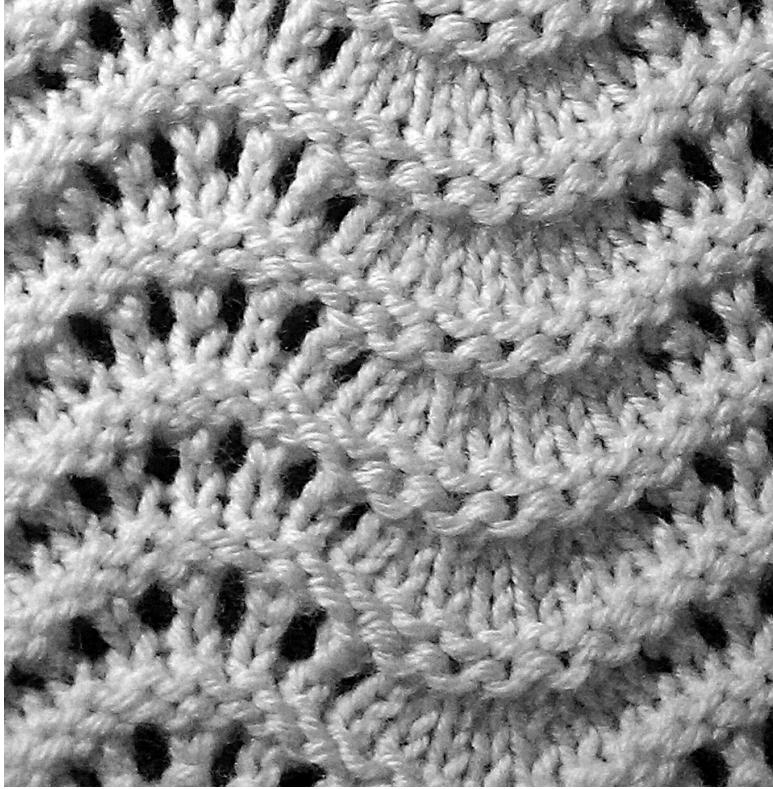
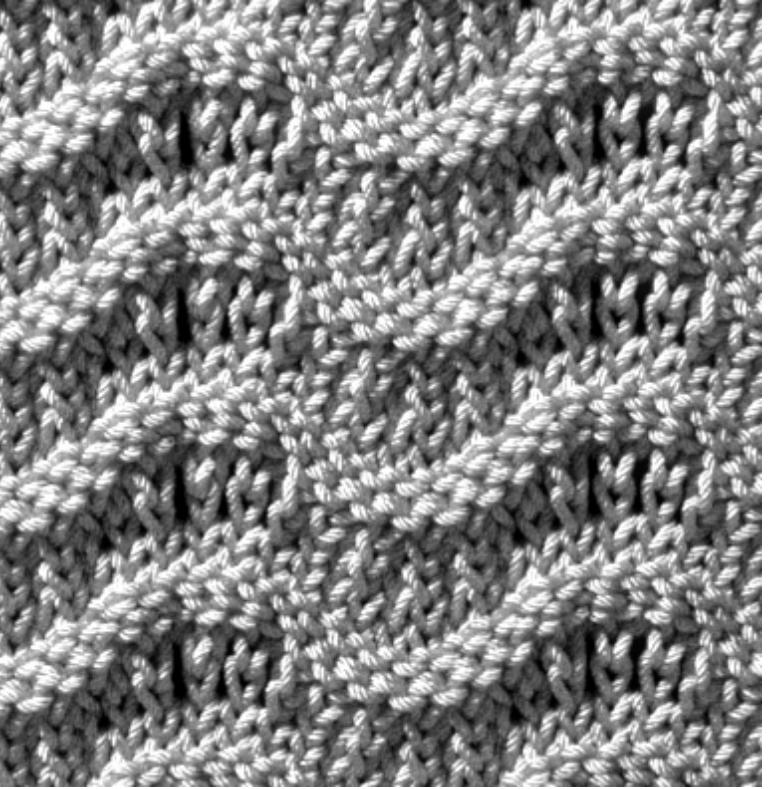
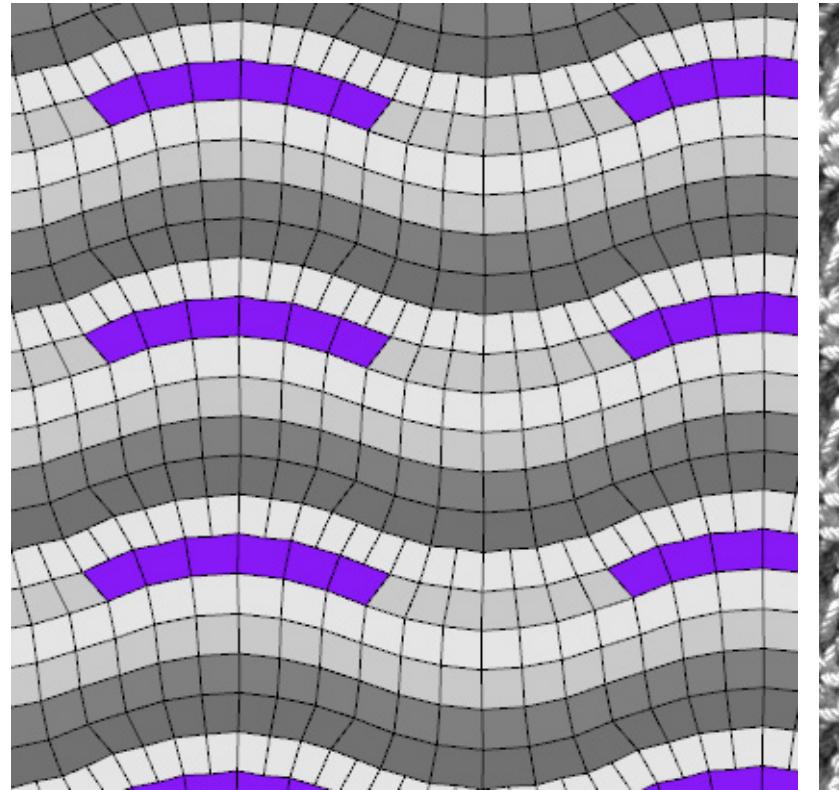




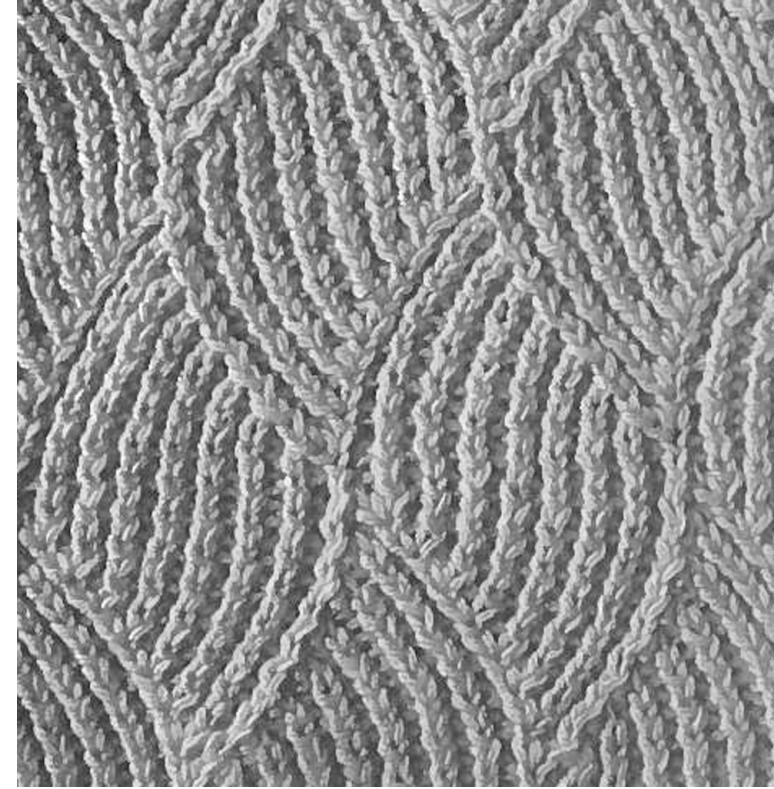
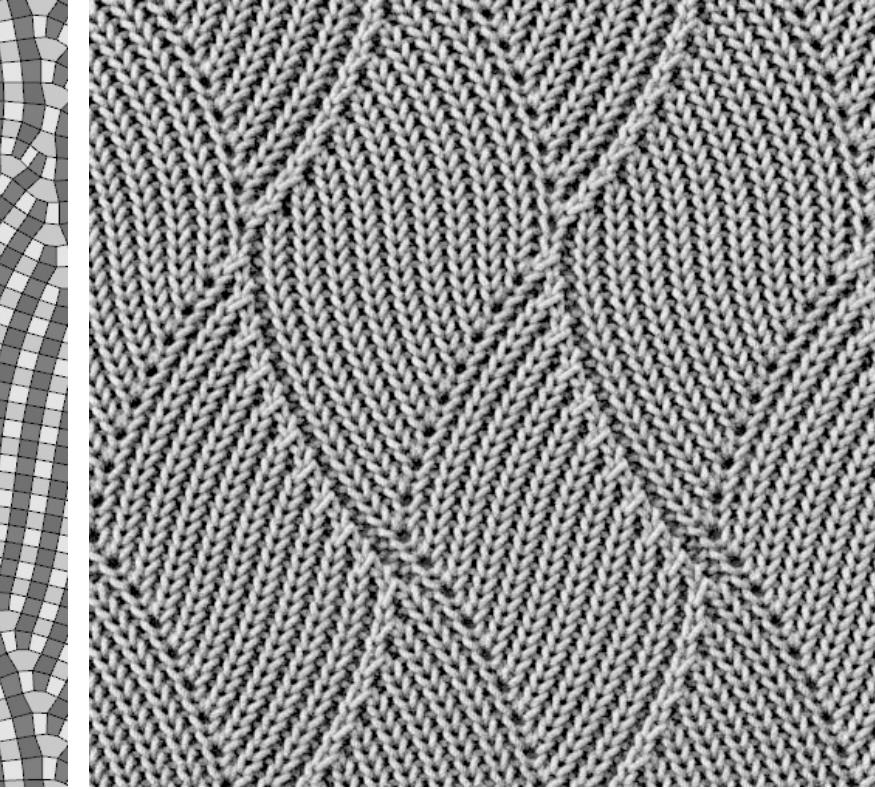
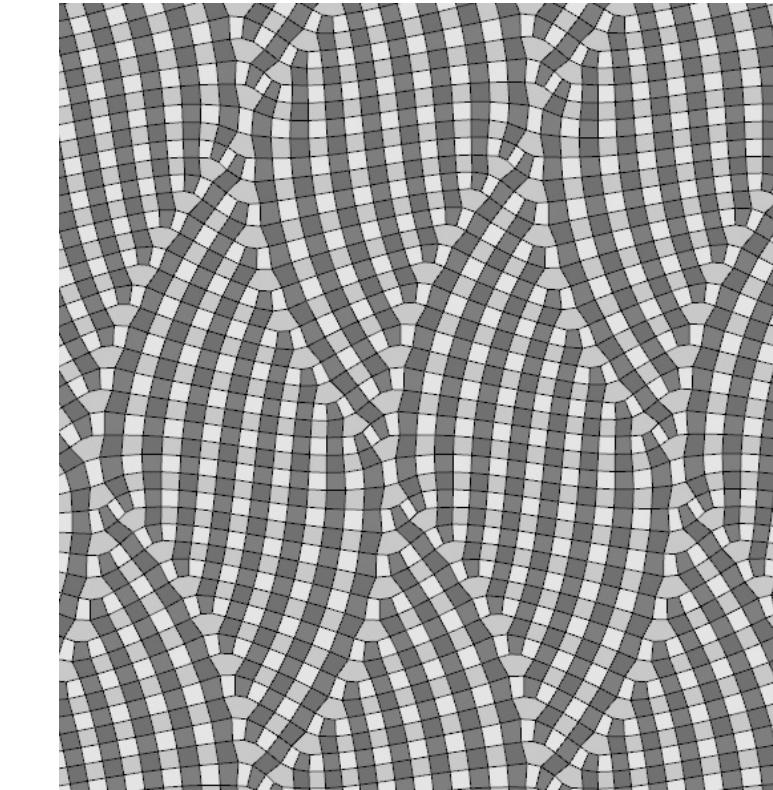
Mrs. Montague's Pattern [Matthews 1984]



Openwork Trellis Pattern [Matthews 1984]

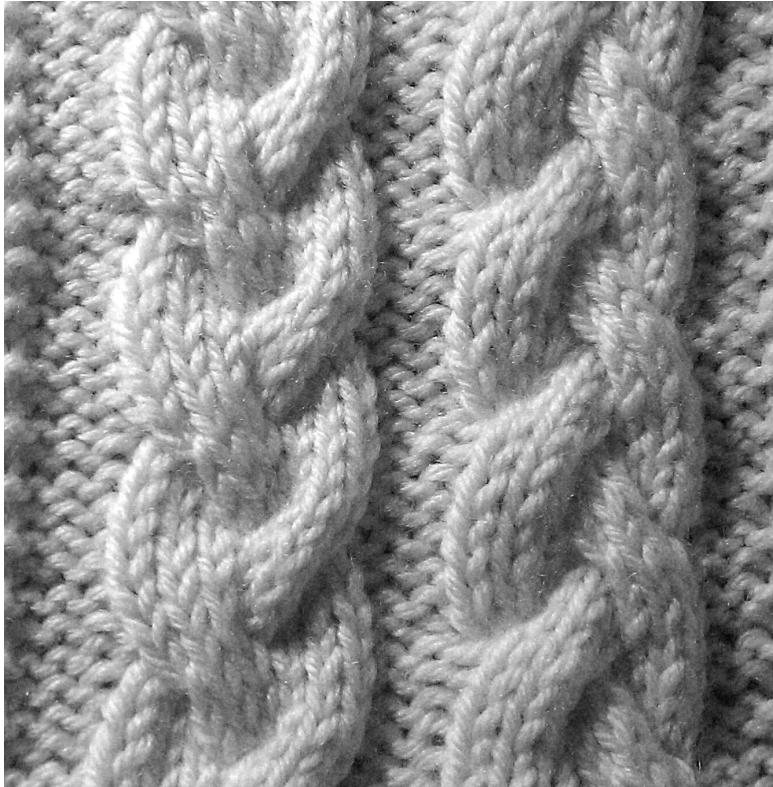
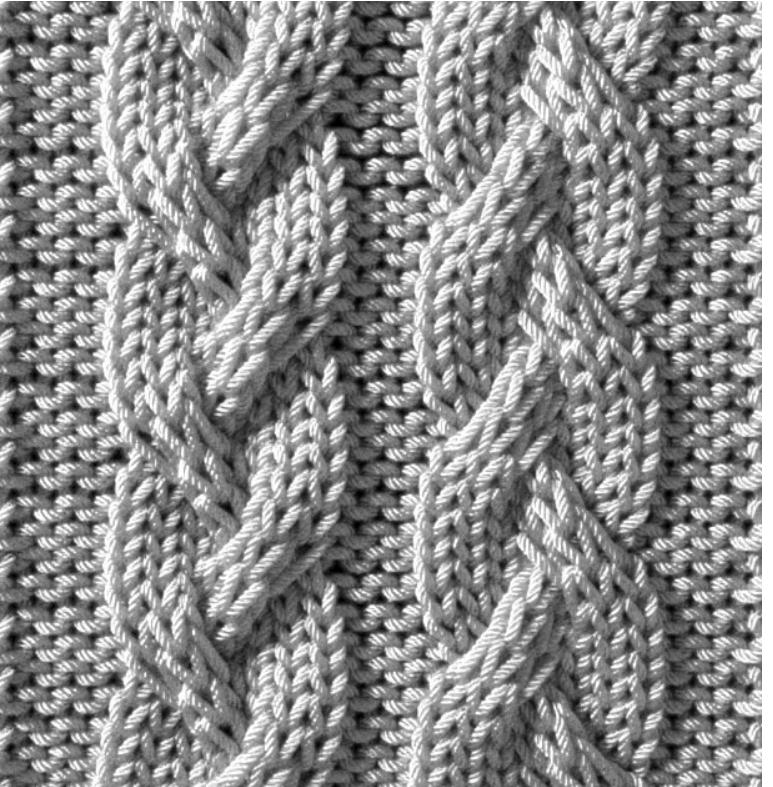
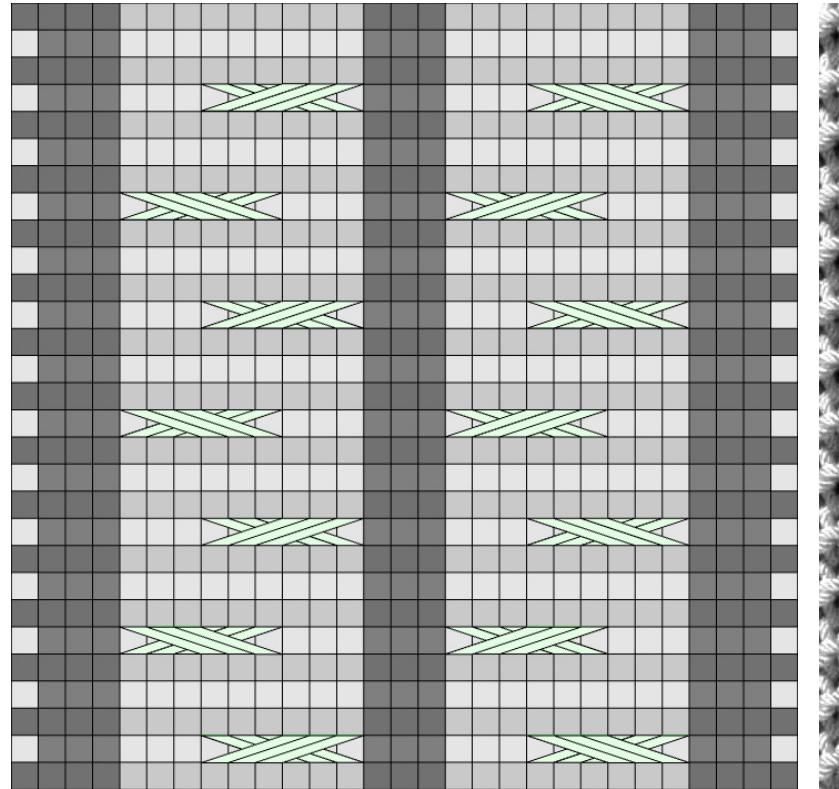


Ridged Feather Pattern [Matthews 1984]

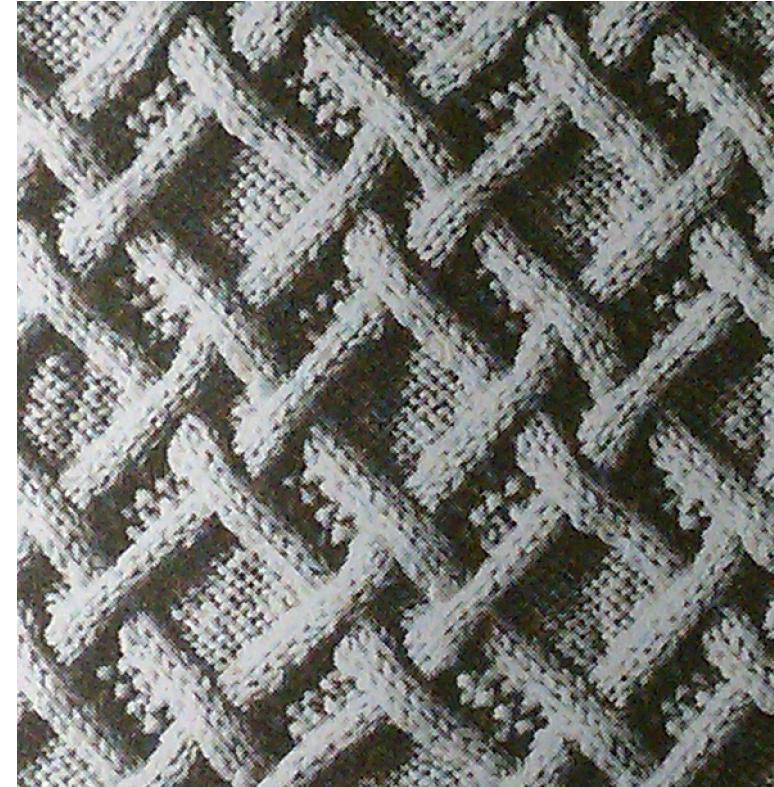
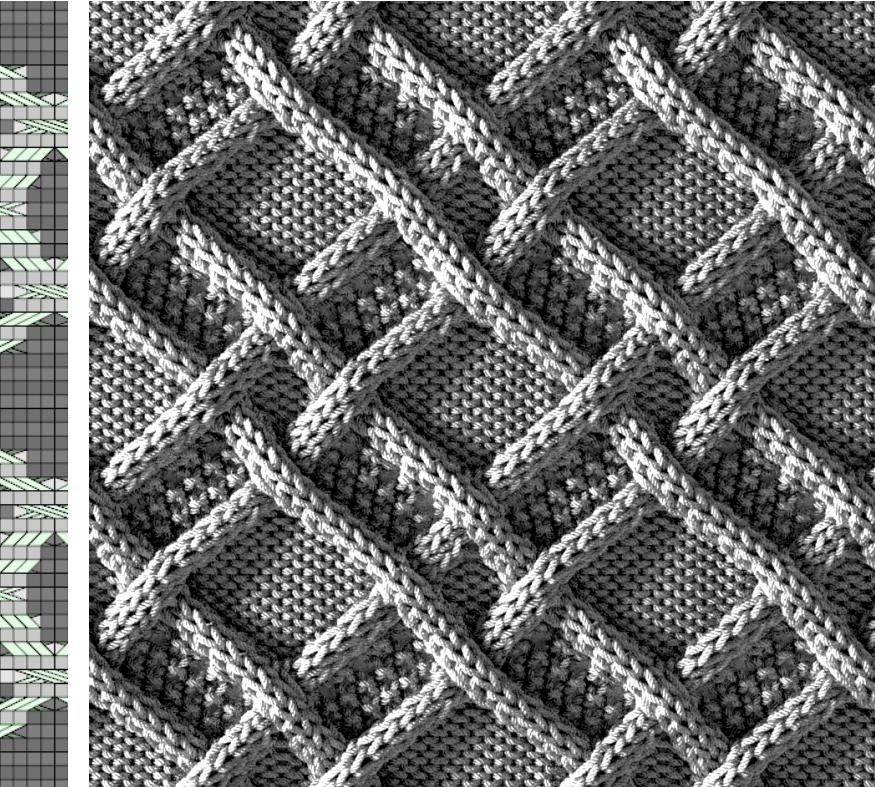
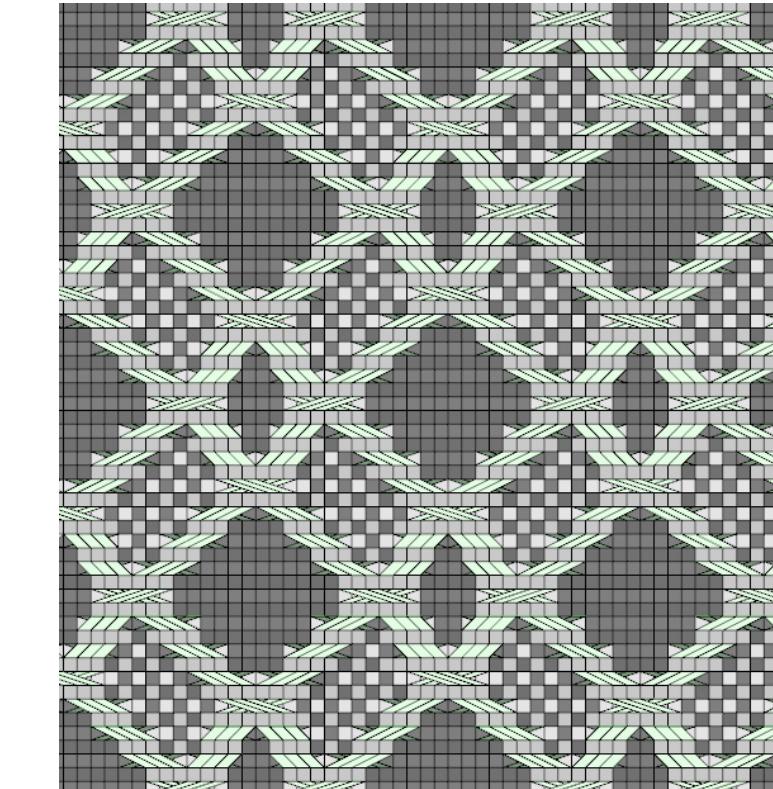


Flame Ribbing Pattern [Walker 2001]

Photo courtesy of Schoolhouse Press



Braid Cables Pattern [Allen et al. 2008]



Cable Work Pattern [Walker 2001]

Photo courtesy of Schoolhouse Press







<https://www.youtube.com/watch?v=5YvIHREdVX4>