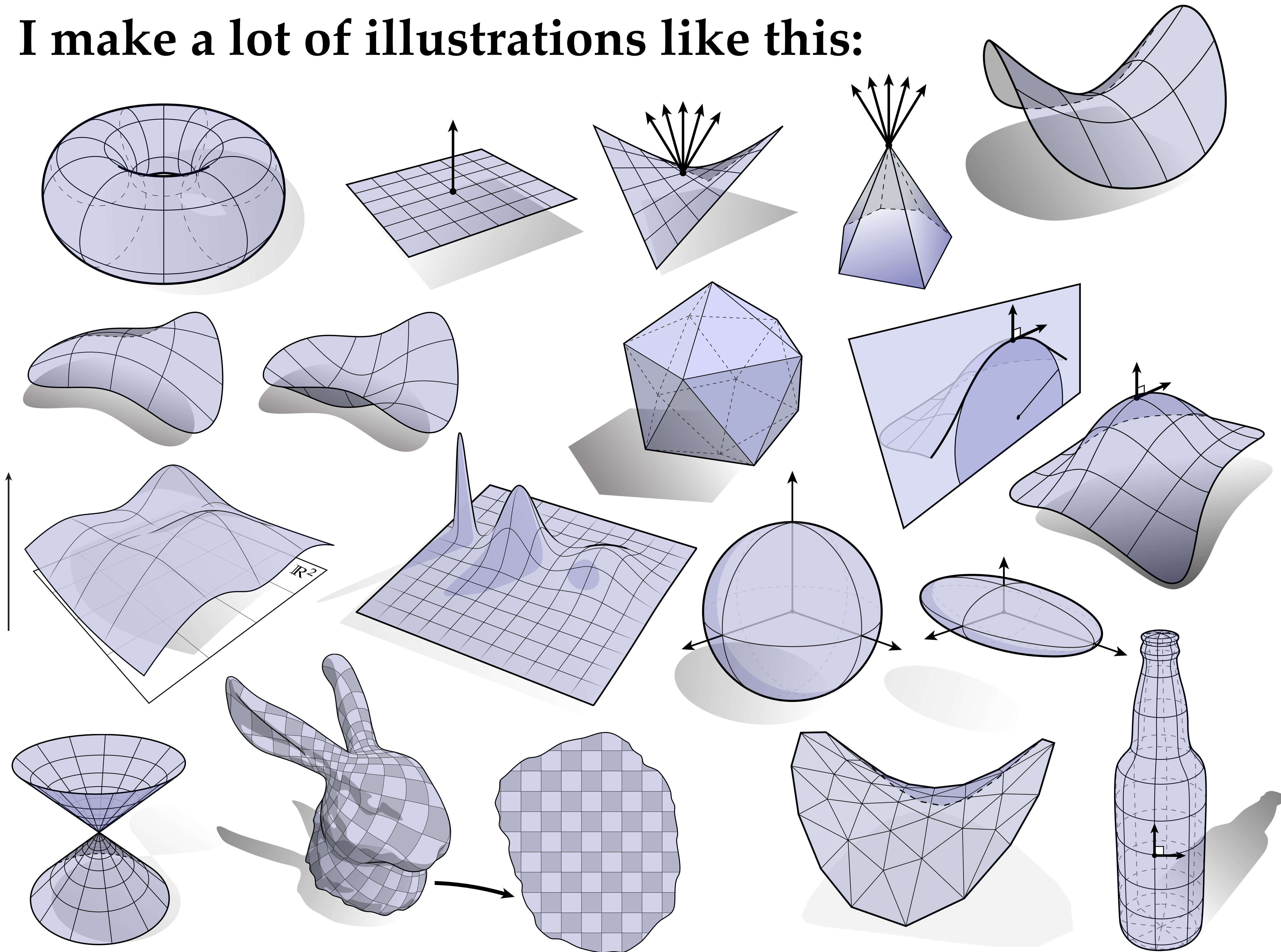


# ILLUSTRATING GEOMETRY

Keenan Crane

I make a lot of illustrations like this:



# And I get a lot of email like this:

Thesis Renders - taught myself Modo last > week, thank you for the recommendation

How do you make your diagrams? - for creating figures is fairly labor intensive. I >> s

cs177

CS 177 - for the figures, it's unfortunately not as easy as writing some TikZ c

Question from a Ph.D. student - creating these figures is fairly labor intensive. Right n

A barrage of comments, questions, and unsolicited advice - typesetting, figures, and p

Great Notes - for creating figures is fairly >> labor intensive. Right now I start out in a

How to draw beautiful figures in papers? - for creating figures is fairly labor intensive.

Tools that you use? - the geometry figures, I start out in a 3D modeler (Luxology's mo

Diagrams for your papers - awesome! - trying to figure out > where the best fit for the

(4) Siggraph course - for the figures, sadly there is no automatic tool. Right now I start >

About images in your thesis / Discrete Differential Geometry course - making these fi

How do you create awesome illustrates in your thesis and SIG course notes? - makin

You have been thanked! - . The figures look great :) --Hossein On Fri, Jun 7, 2013 at

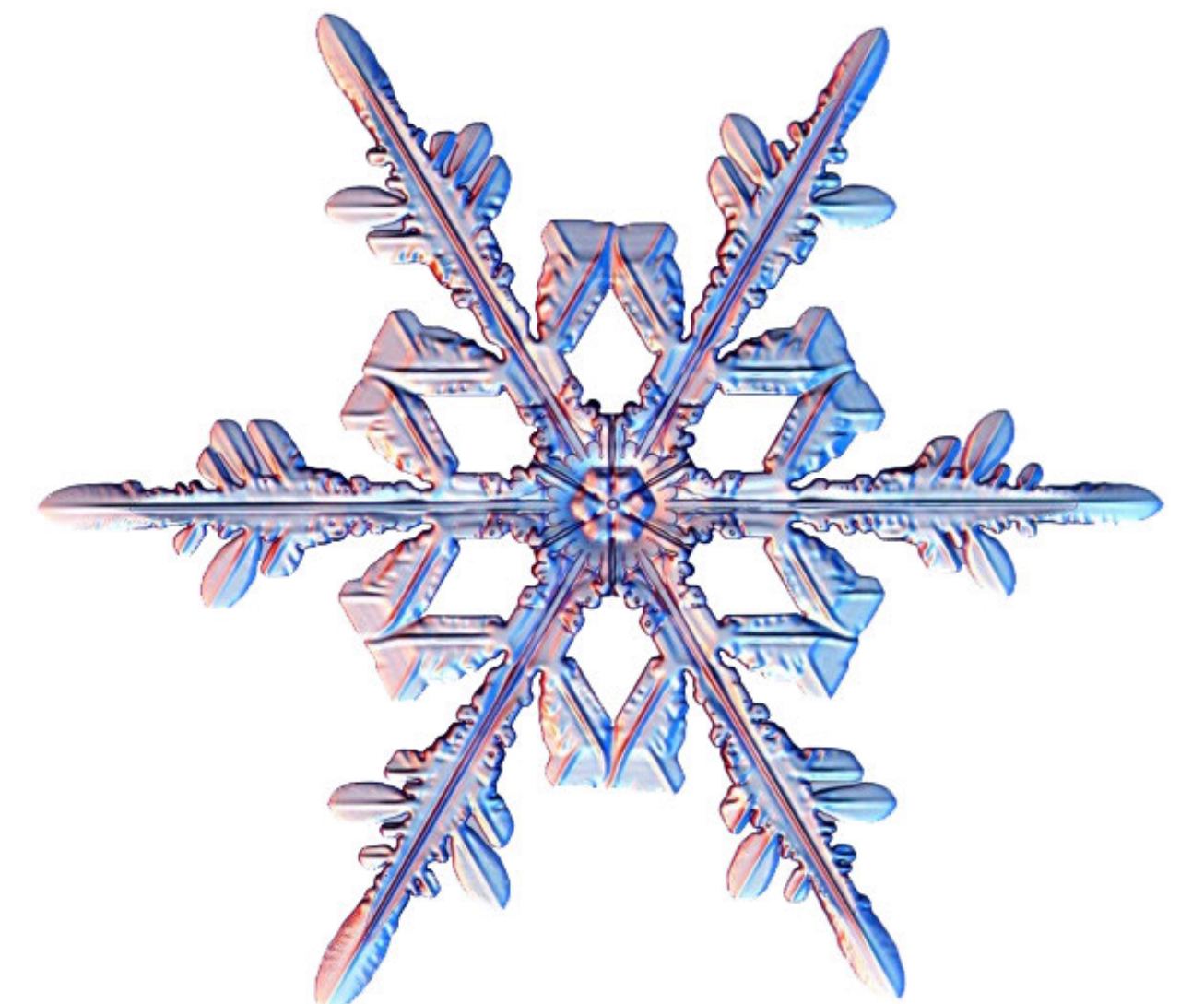
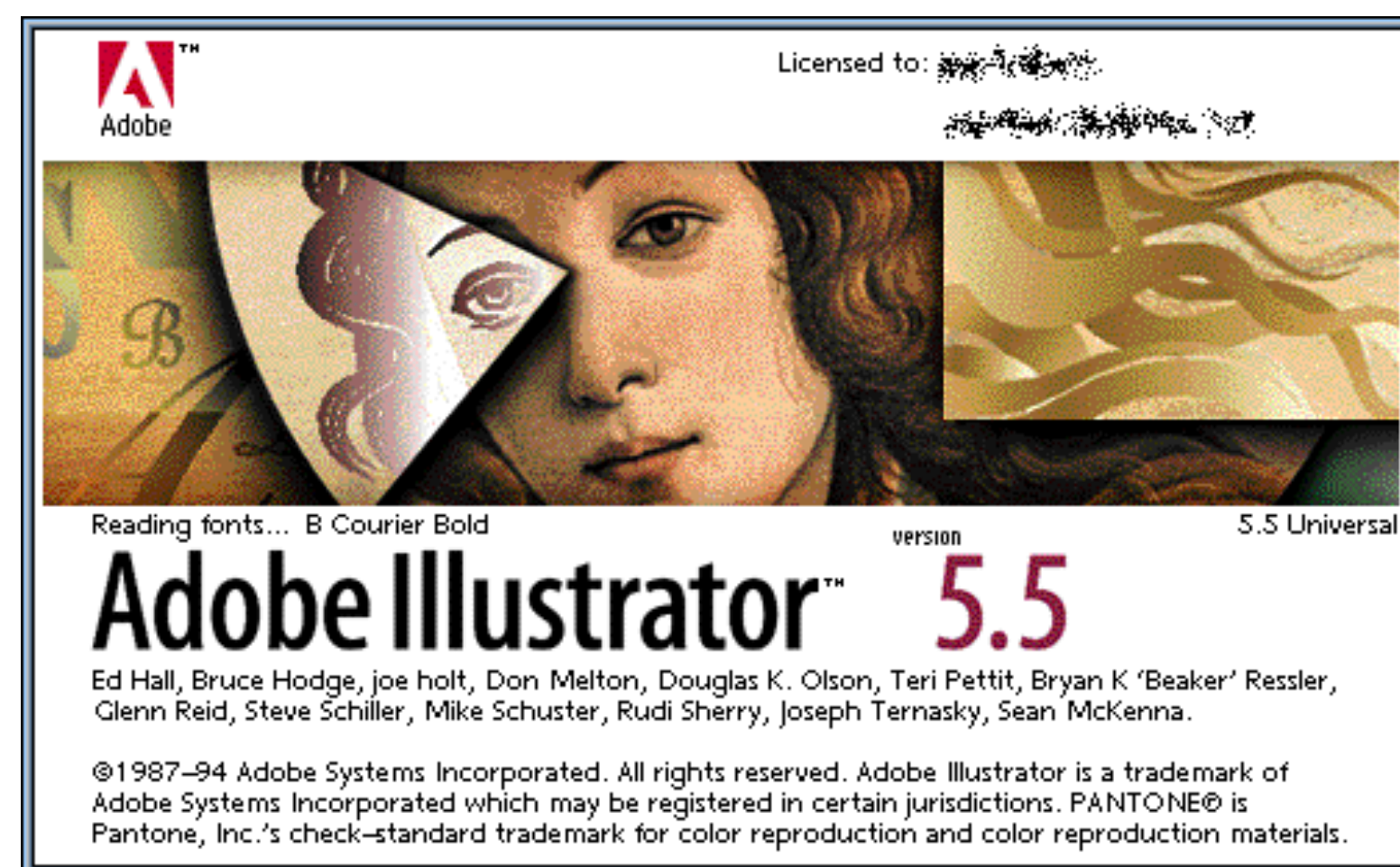
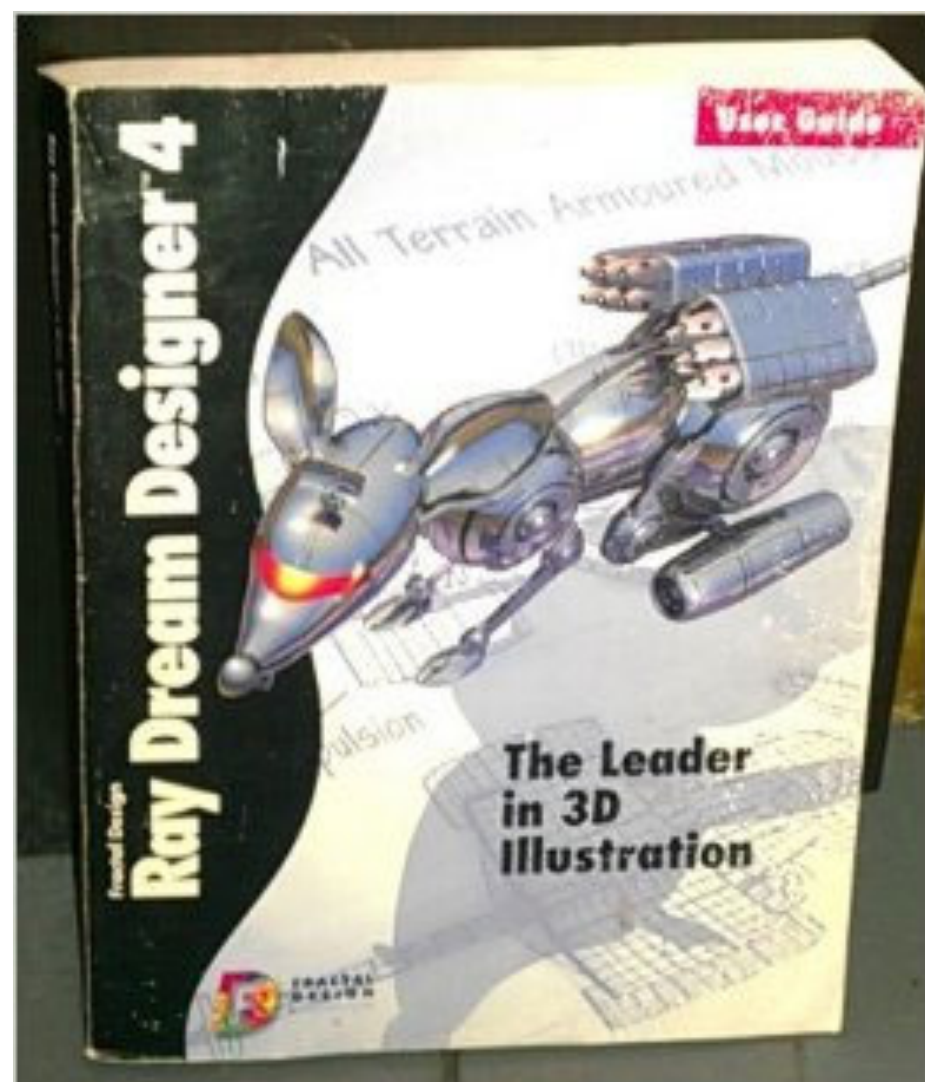
excellent notes on DDG fa11 The figures are generated using a couple different s

**What everybody wants to know:**

**"WHAT PROGRAM DO YOU USE  
TO MAKE YOUR FIGURES?"**

# Unfortunately, not that easy!

- *have been using Adobe Illustrator since ~1994*
- *modo/Lightwave since ~1997 (“RayDream” before that)*
- *lots of drawing/painting/photography classes*
- *differential geometry since ~2004*
- *have drawn 200+ figures in this particular style*
- *also, I am a unique snowflake*
- *...would like to think that some of these factors contribute.*

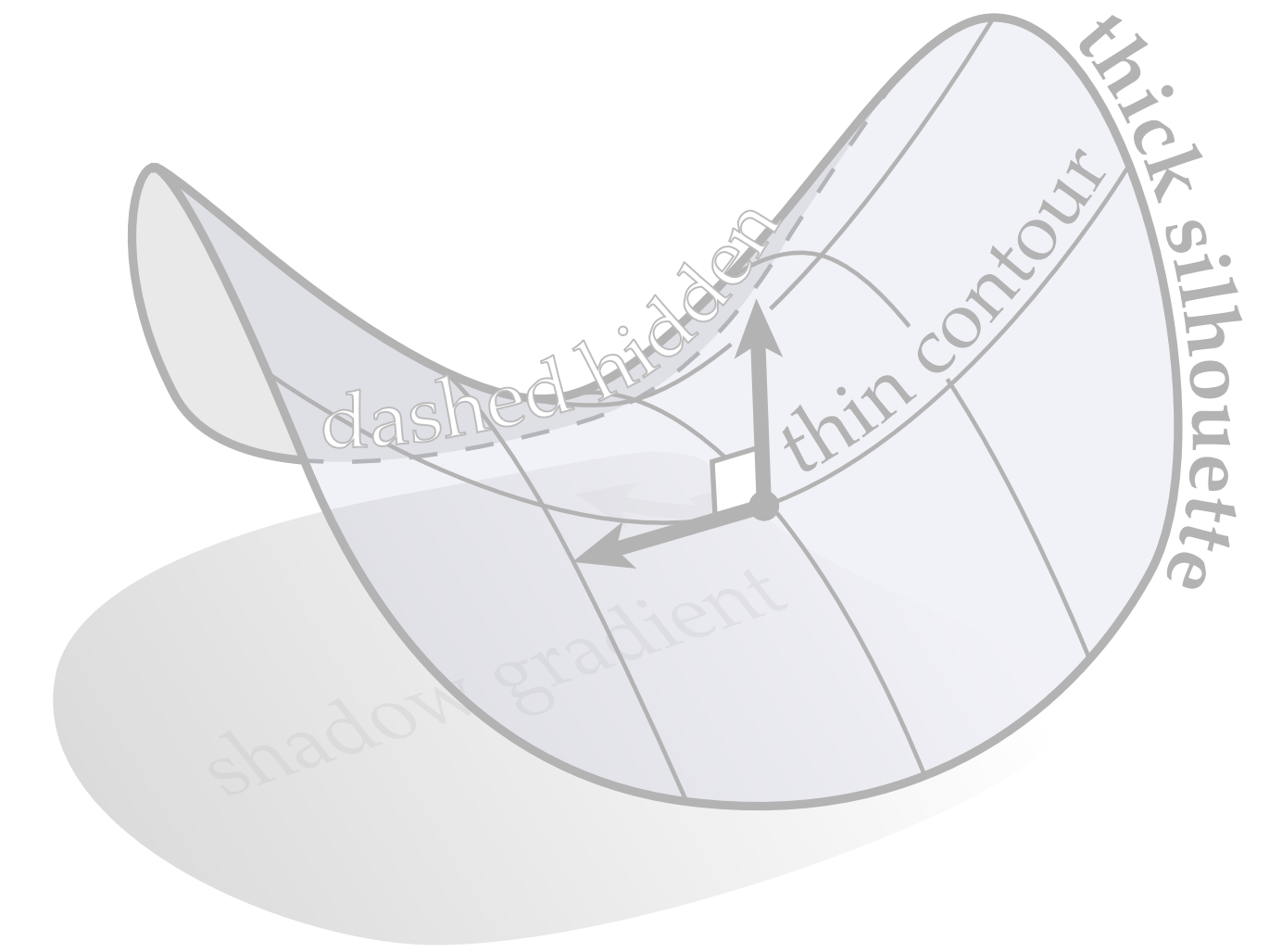


# Goals of this talk:

- show examples of figures I've made
- show *how* they're made
- discuss workflow
- even if Keenan is a snowflake, *can't it be automated?*
- what design aspects are easy to formalize?
- what's difficult to formalize?
- where do current tools (unnecessarily) fall short?
- general discussion about design & technology

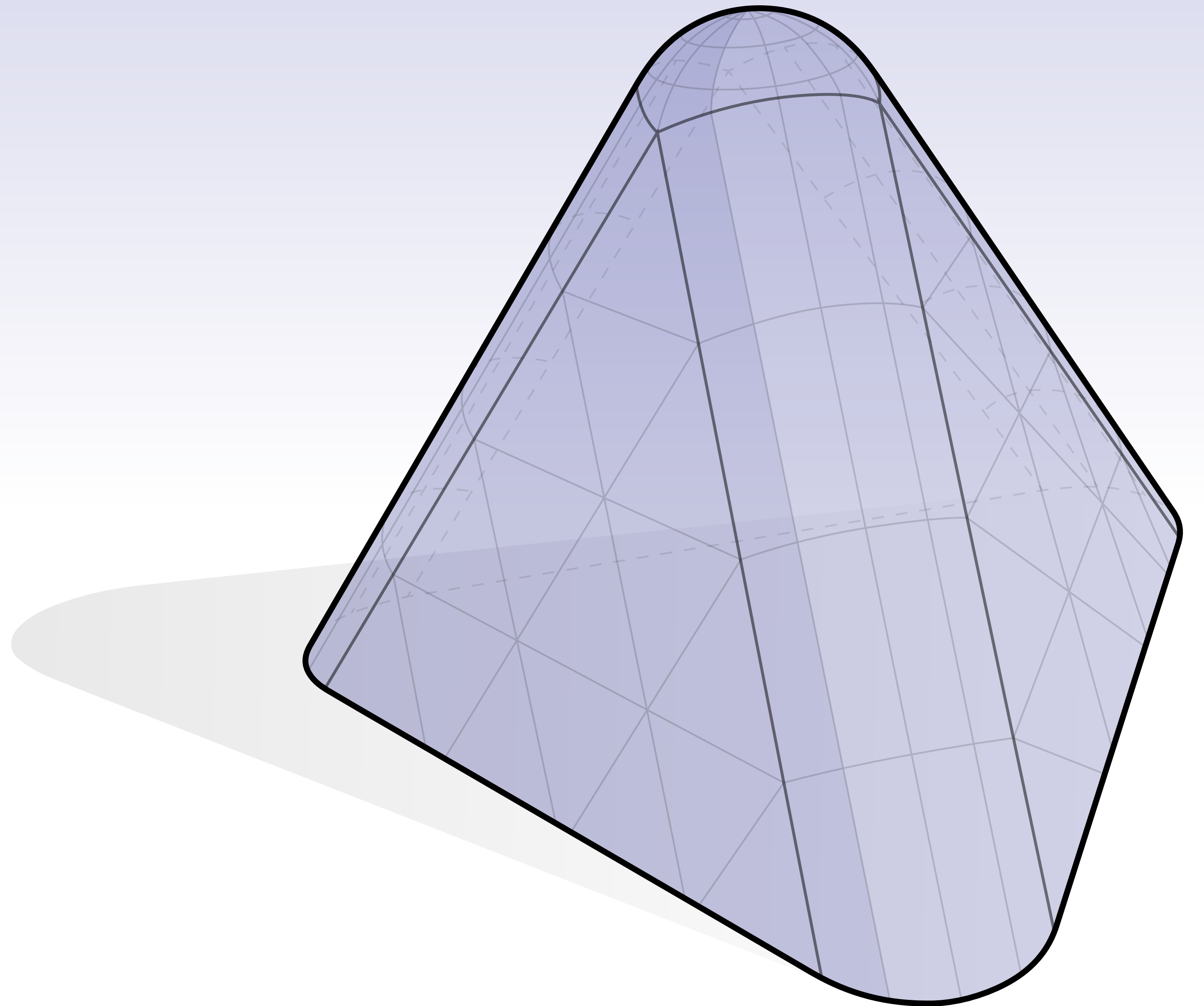
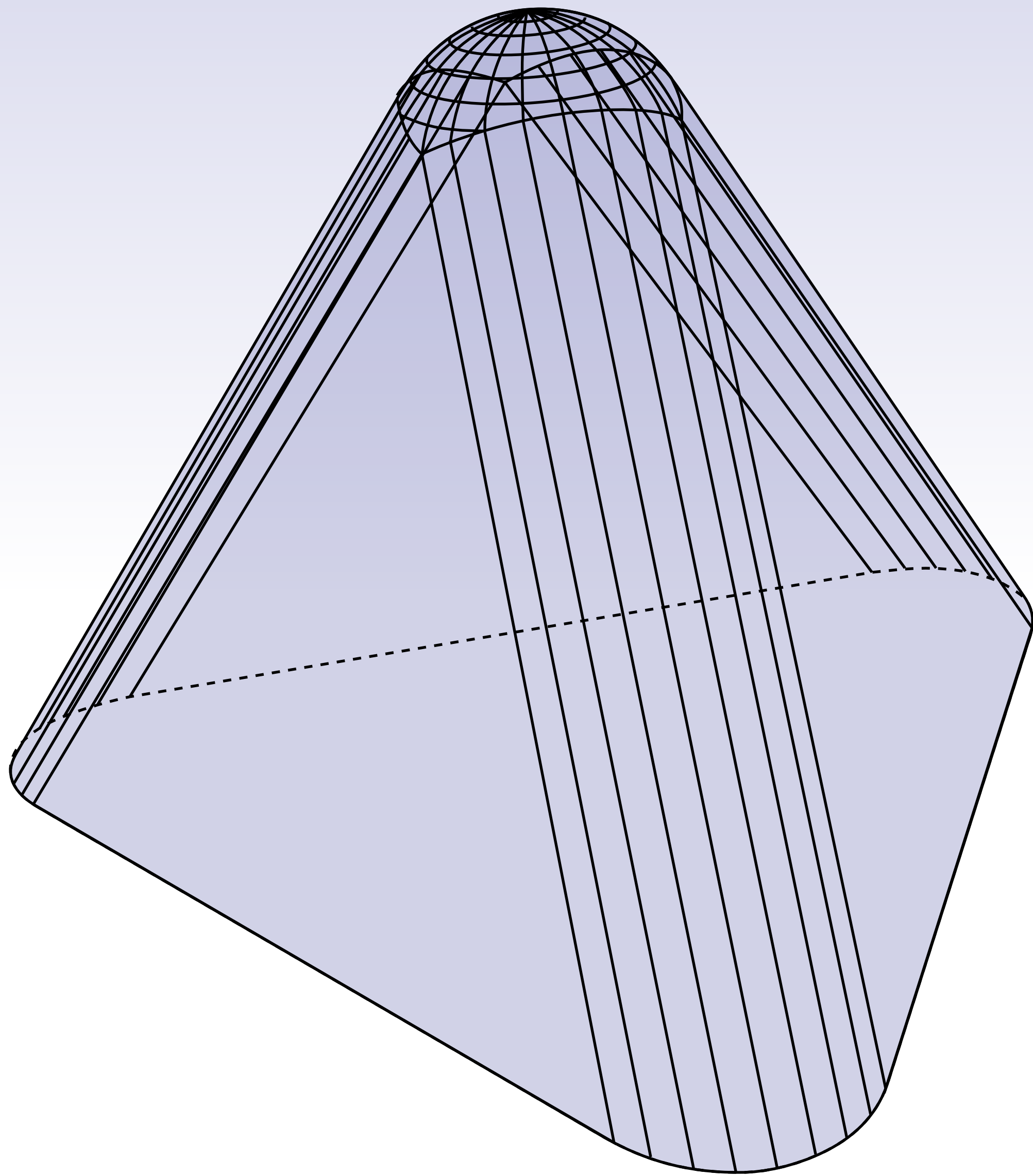
*1b1f8a*

*20% opacity*



(Show More Examples!)

*“People don’t notice the things you do...”*



*...until you stop doing them!”*

# *Common Decisions*

What's the geometry?

Where does the camera go, and what's the focal length?

Where's the light/shadow?

Do we want to include shading?

Do we want a separate light for the shadow vs. the shading?

Which "geometric" lines should be included?

Always the silhouette.

What about other contours?

Which "combinatorial" lines should be included?

E.g., grid lines.

Should we automatically trace contours, or do it by hand?

Are there any components that can be algorithmically generated?

What's the line thickness, for various classes of lines?

What's the line style for hidden lines?

What's the line style for partial lines?

What's the fill color for various regions?

Should we use different colors/brightnesses to indicate lighting?

Should we use gradients for shading?

How should we color occluded regions?

How dark is the shadow?

What direction does the shadow gradient go?

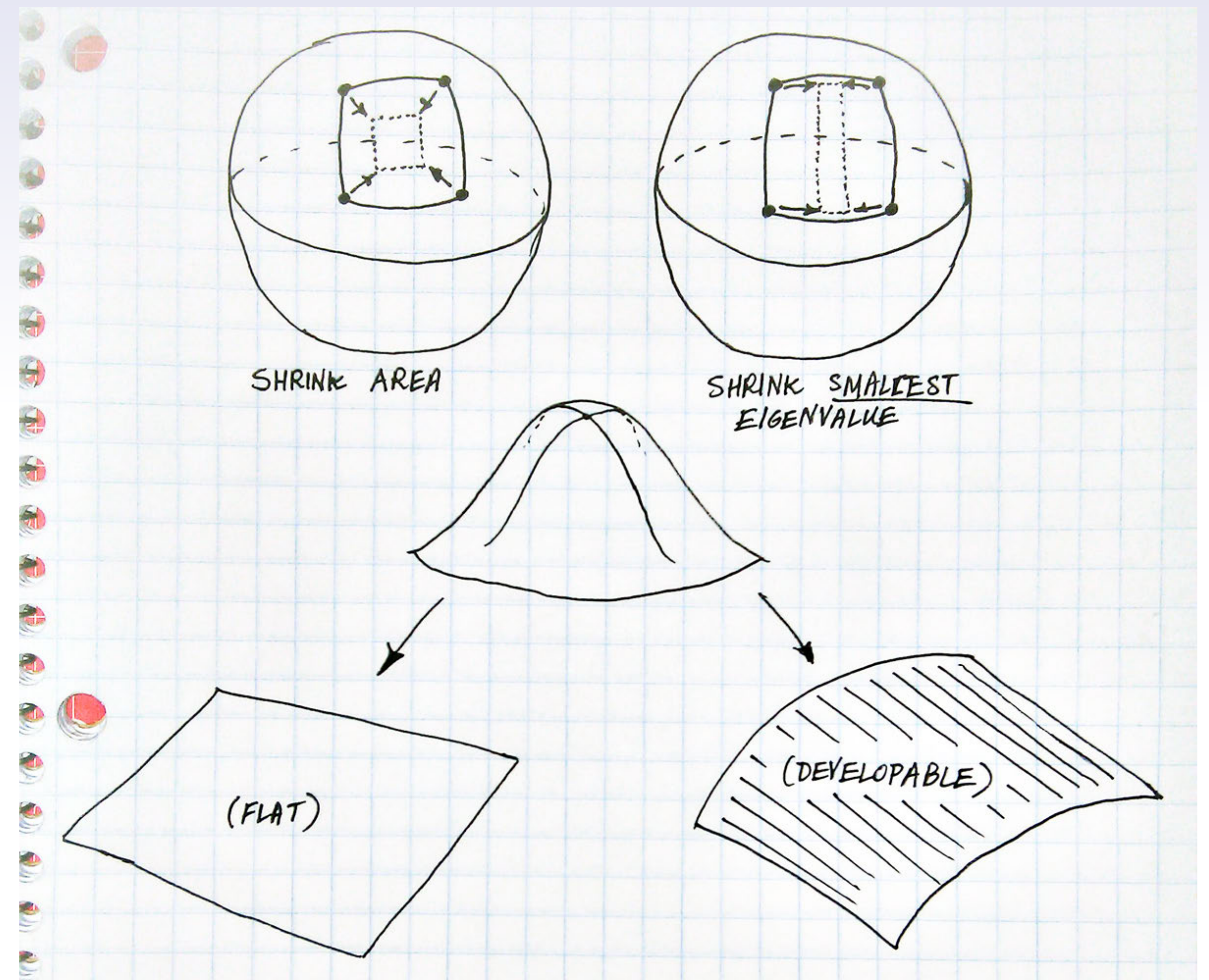
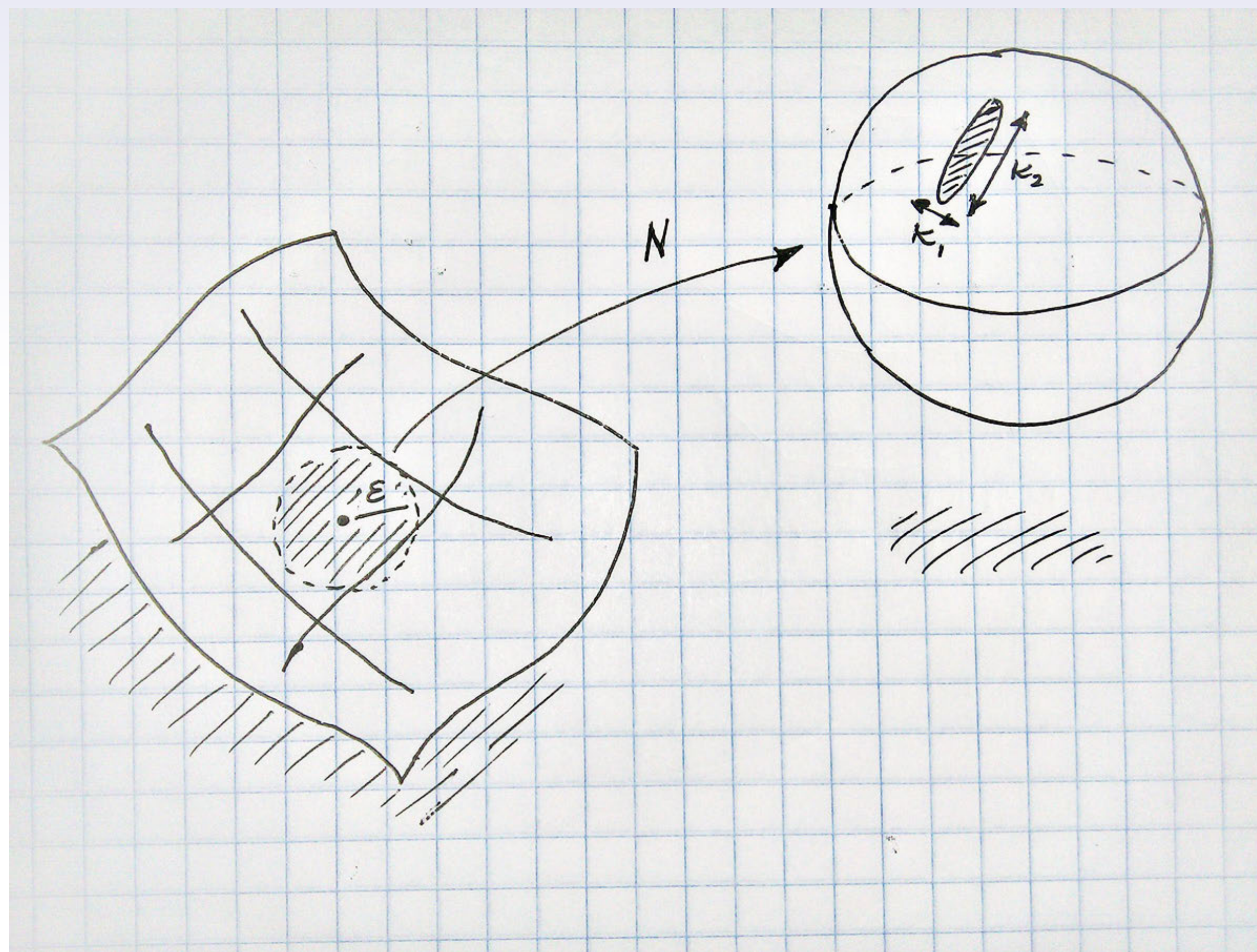
How do we label the figure?

What gets labeled?

Where do labels go? (How) should they occlude/be occluded by geometry?

# What's the Geometry?

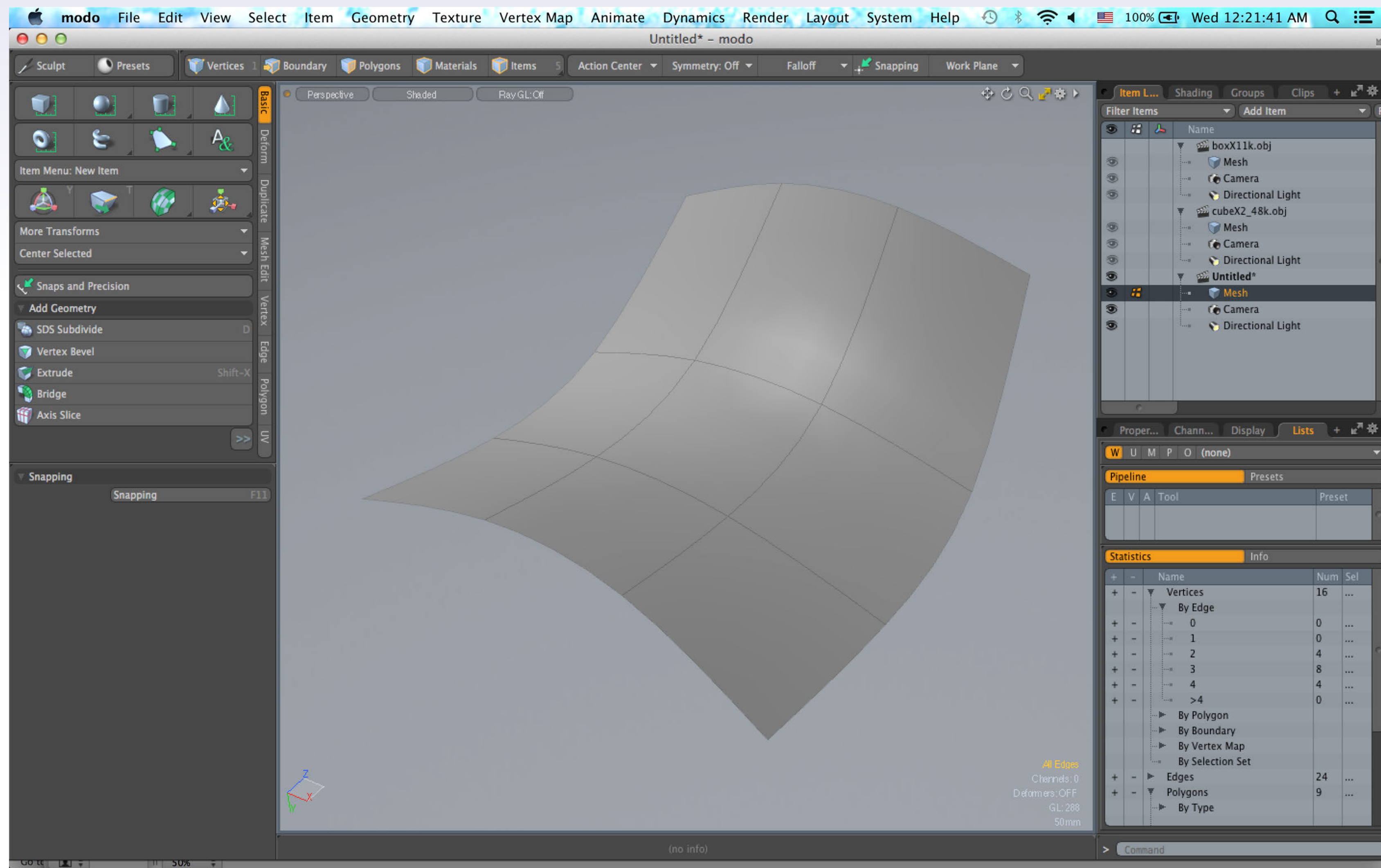
Most important question... and hardest to answer!



Often starts with a sketch (or two or three).

# Create the Geometry

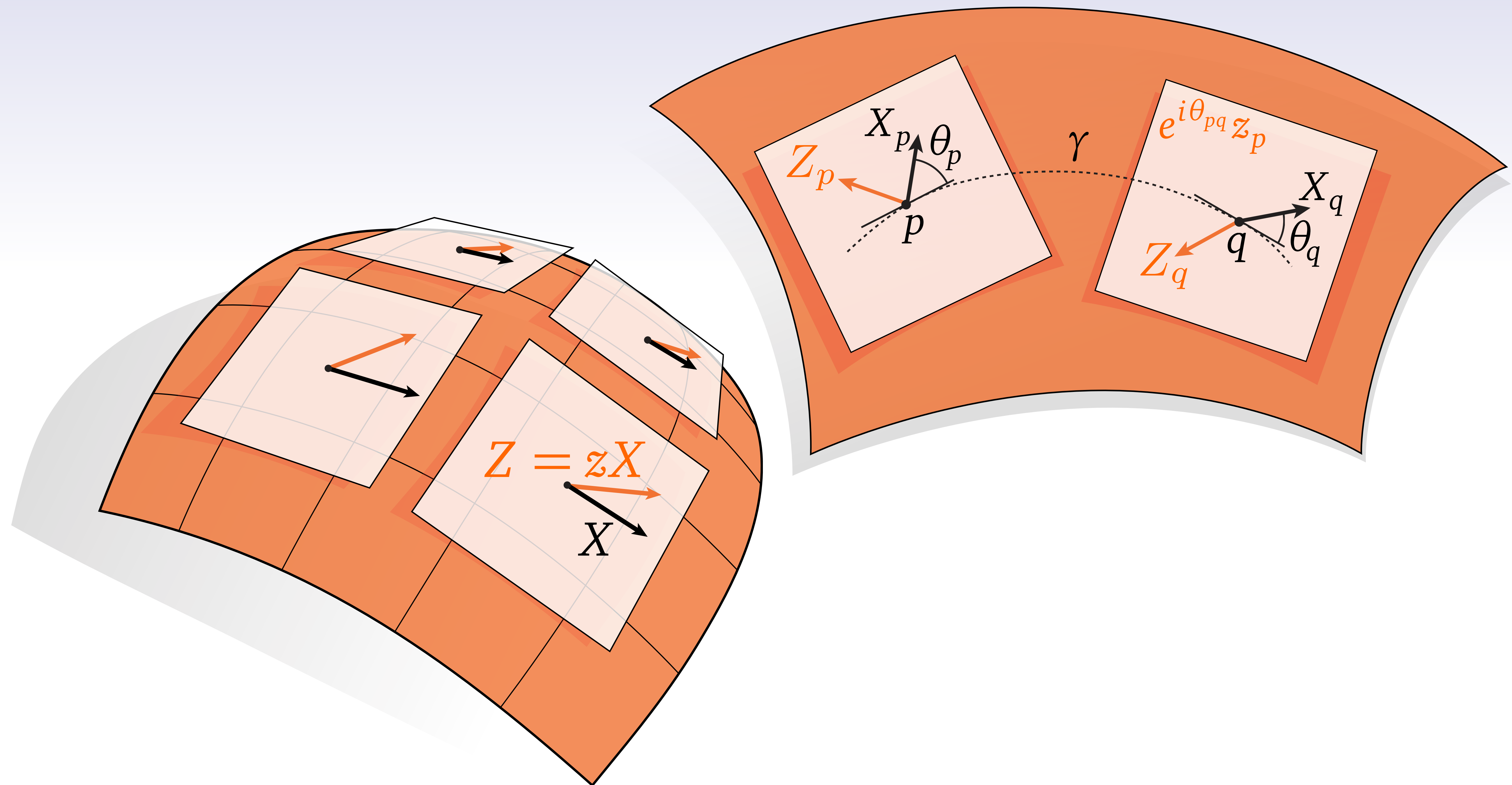
Playing in 3D often gives you new ideas / forces you to change your initial idea.



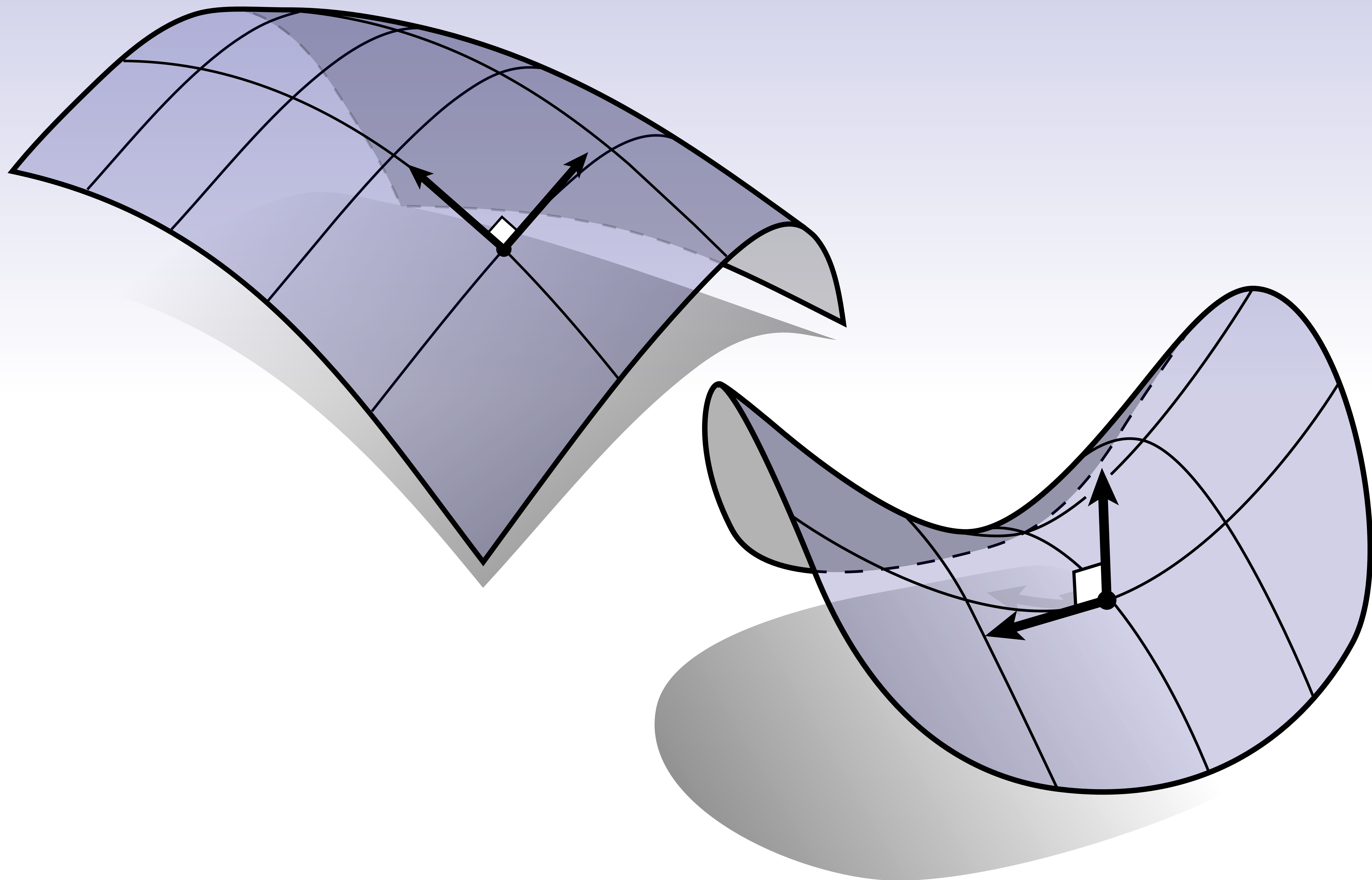
I use “modo,” mostly because I know how!

# Really, Create the Geometry!

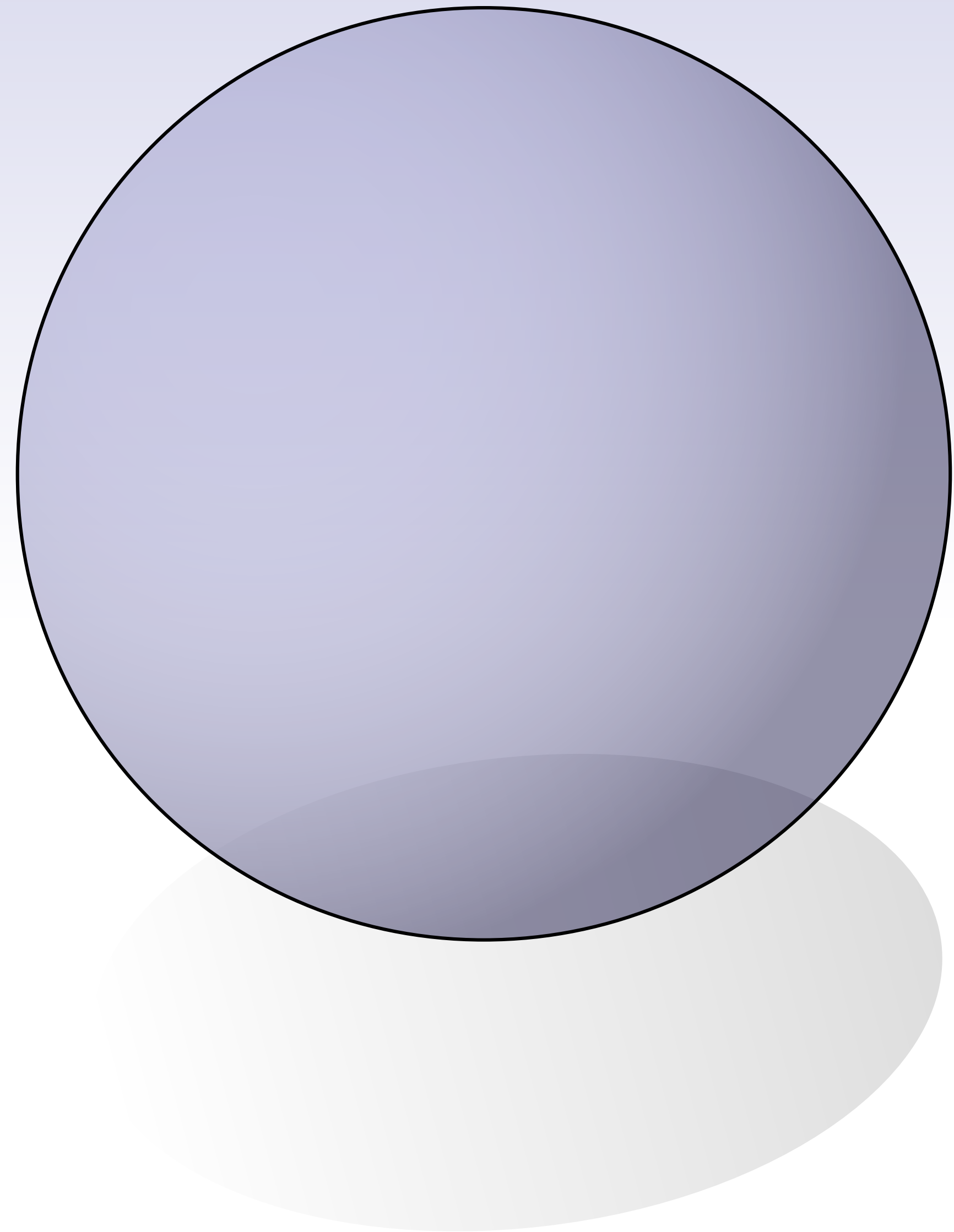
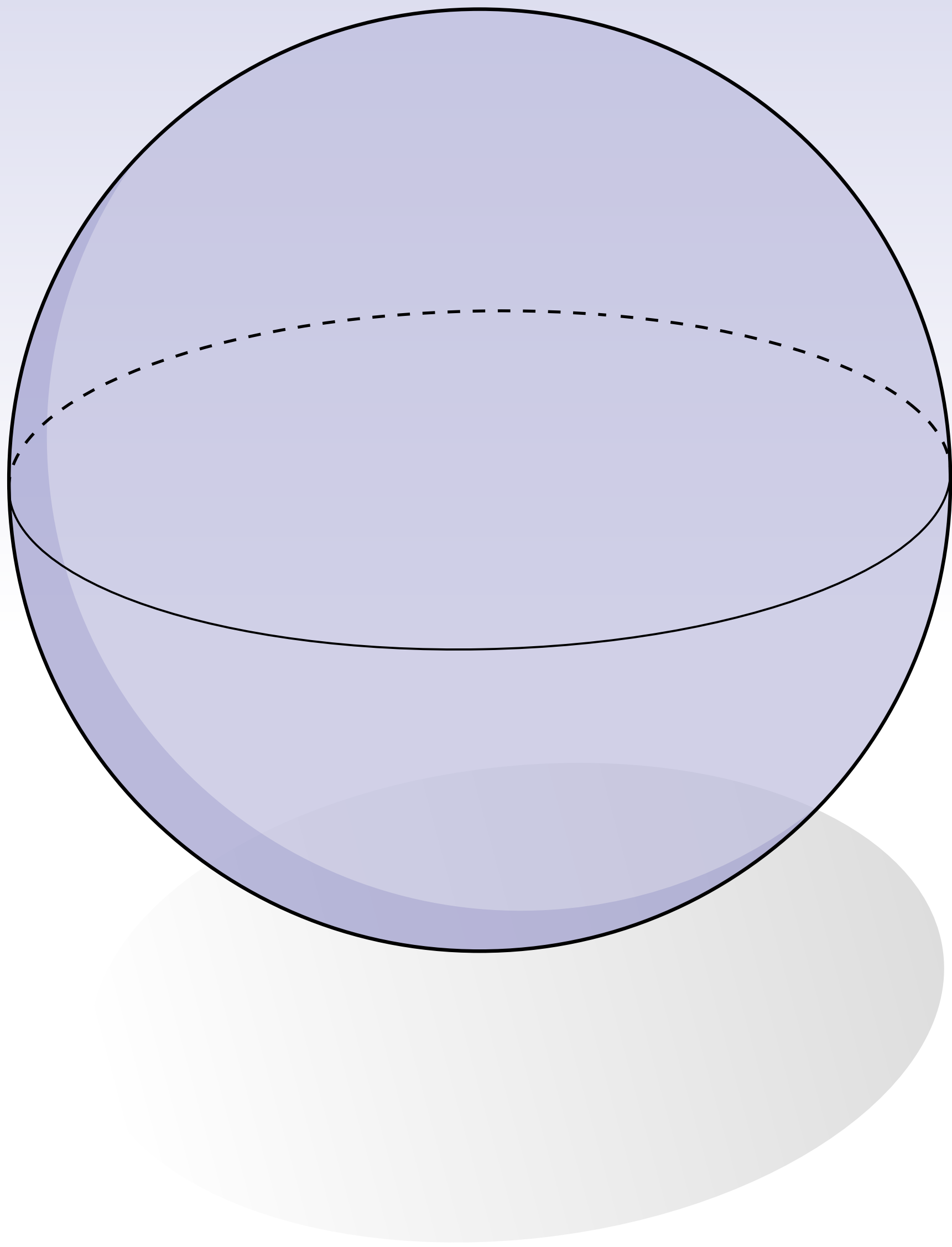
Really do it in 3D. Faking it *never* works.



# *Cheating the Light*

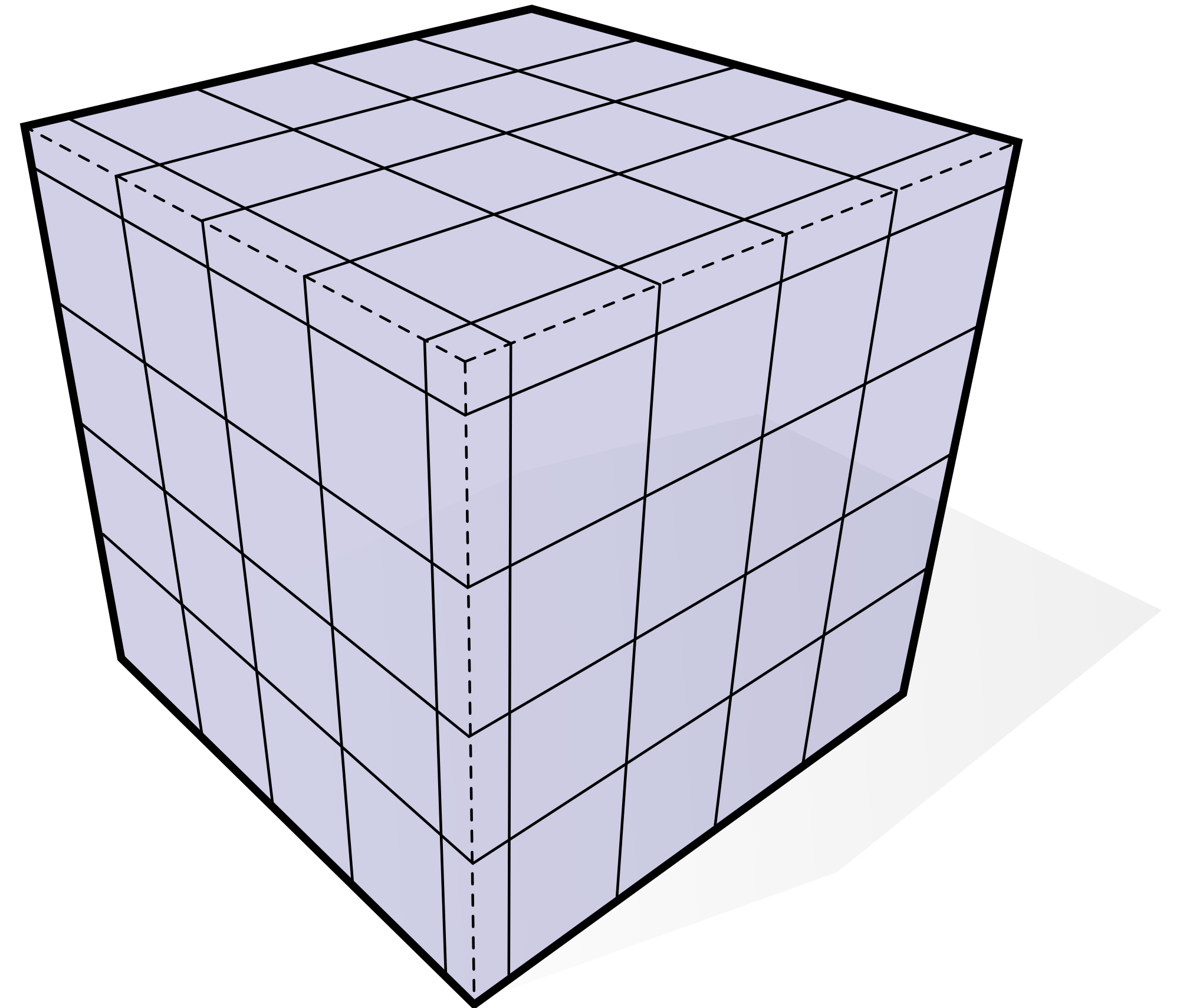
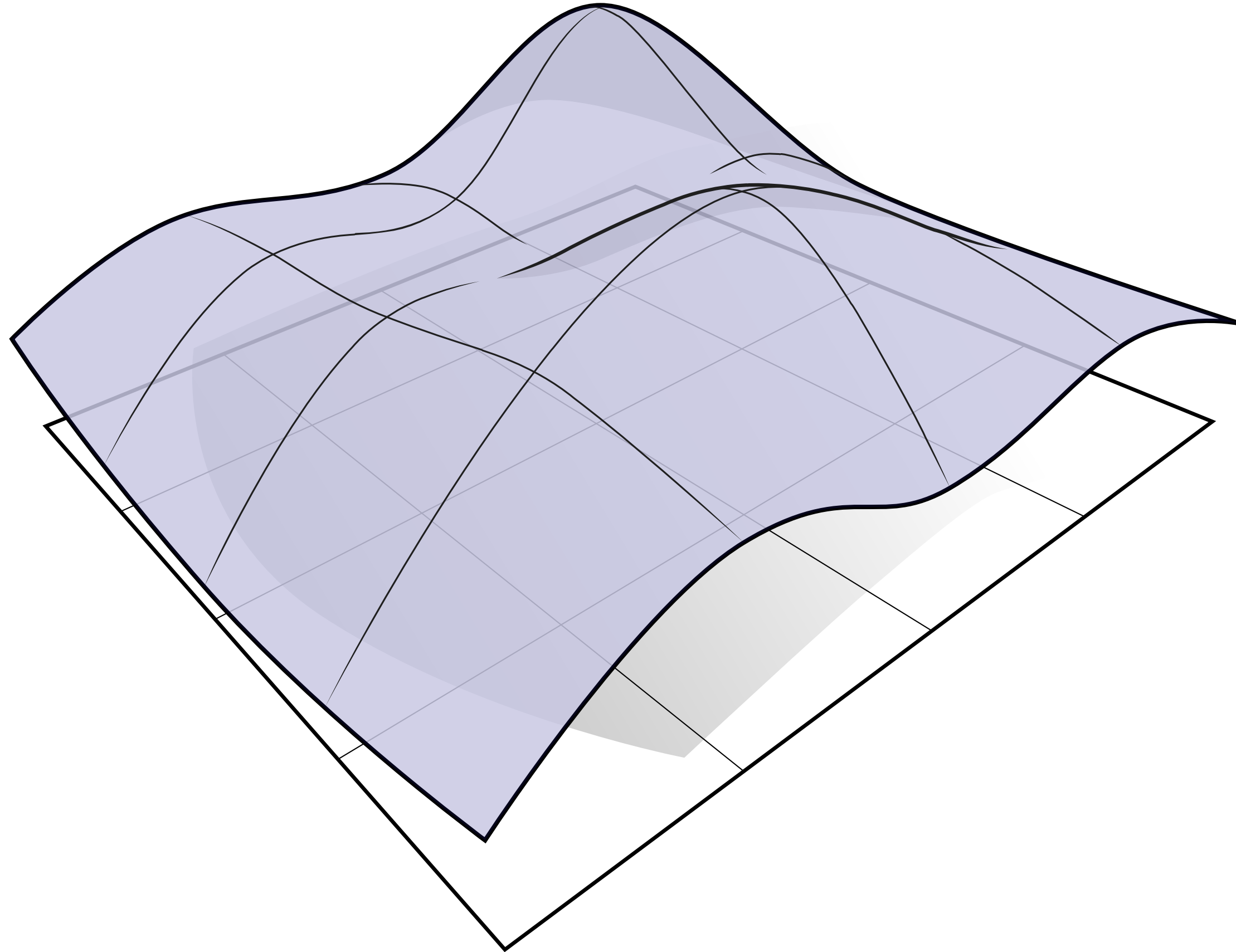
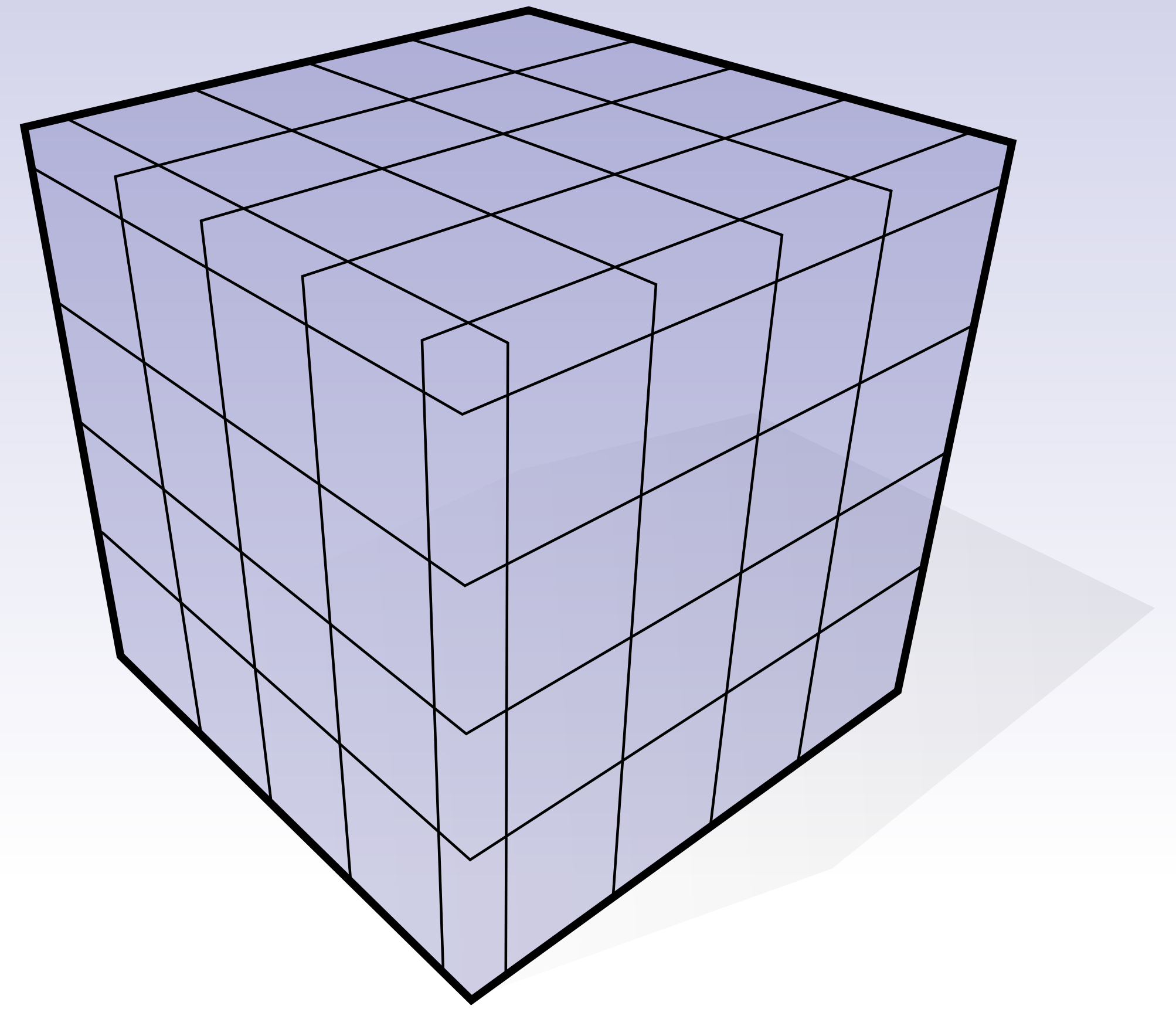
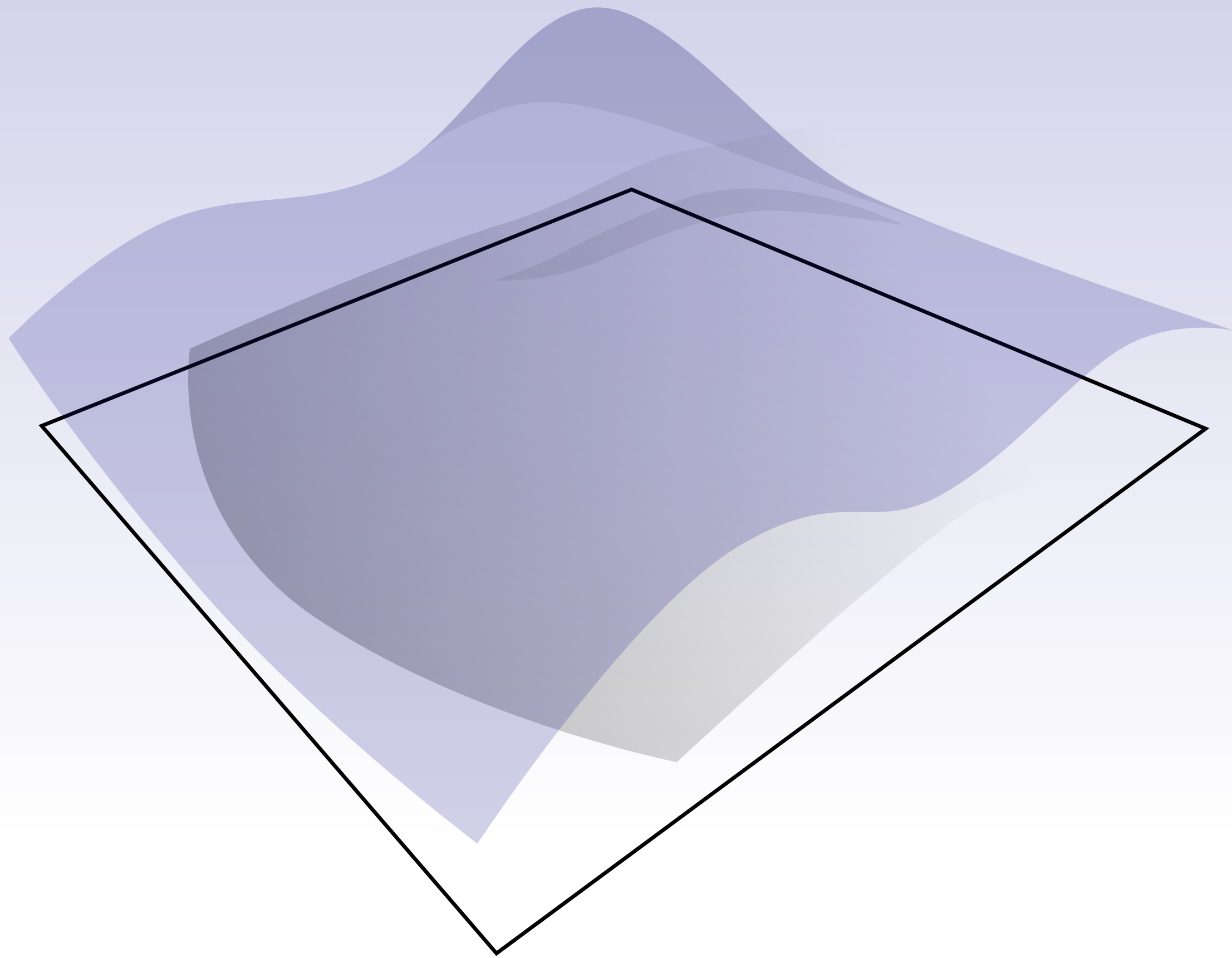


*Shading?*

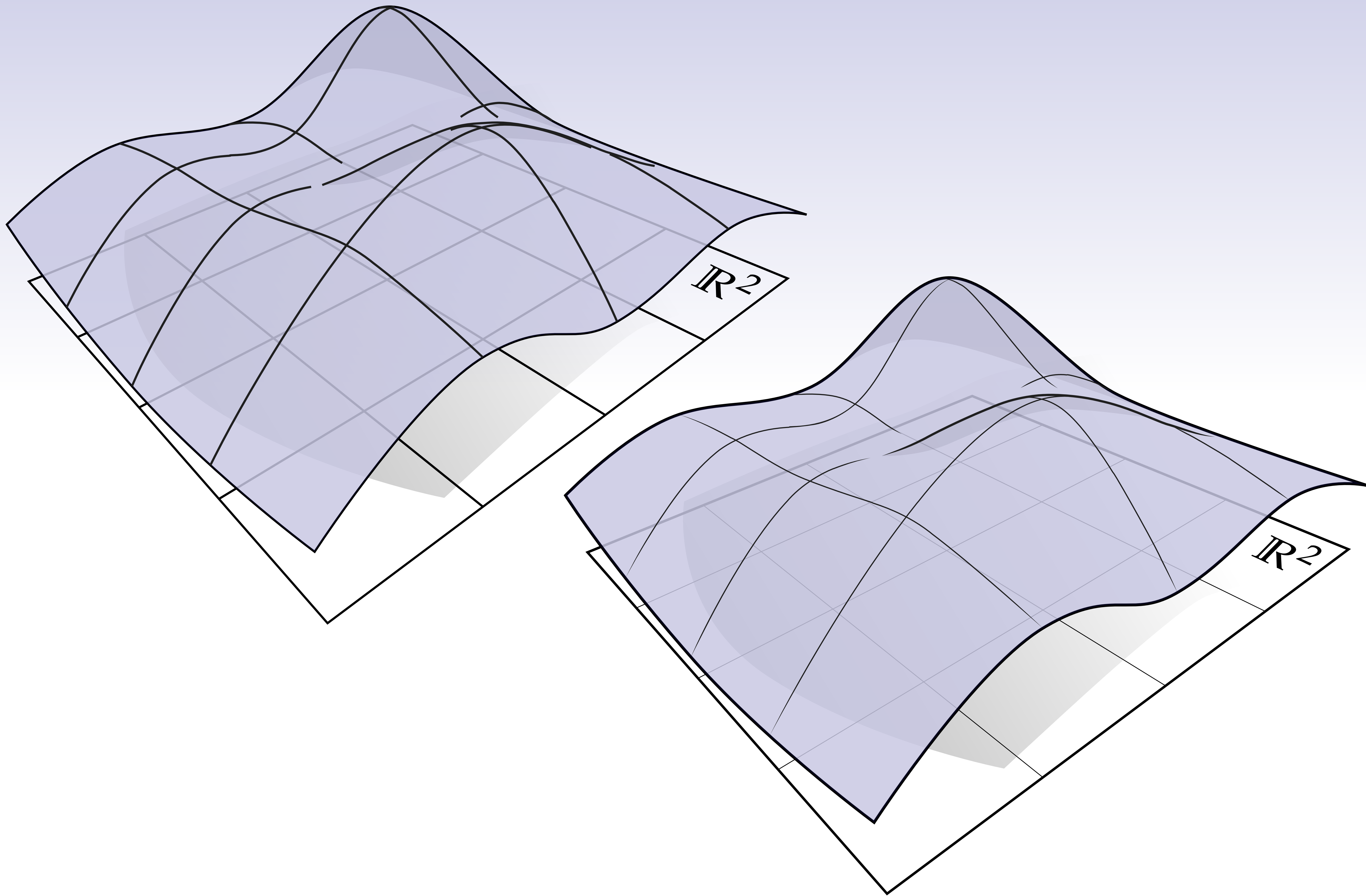


interaction of style & technological limitations

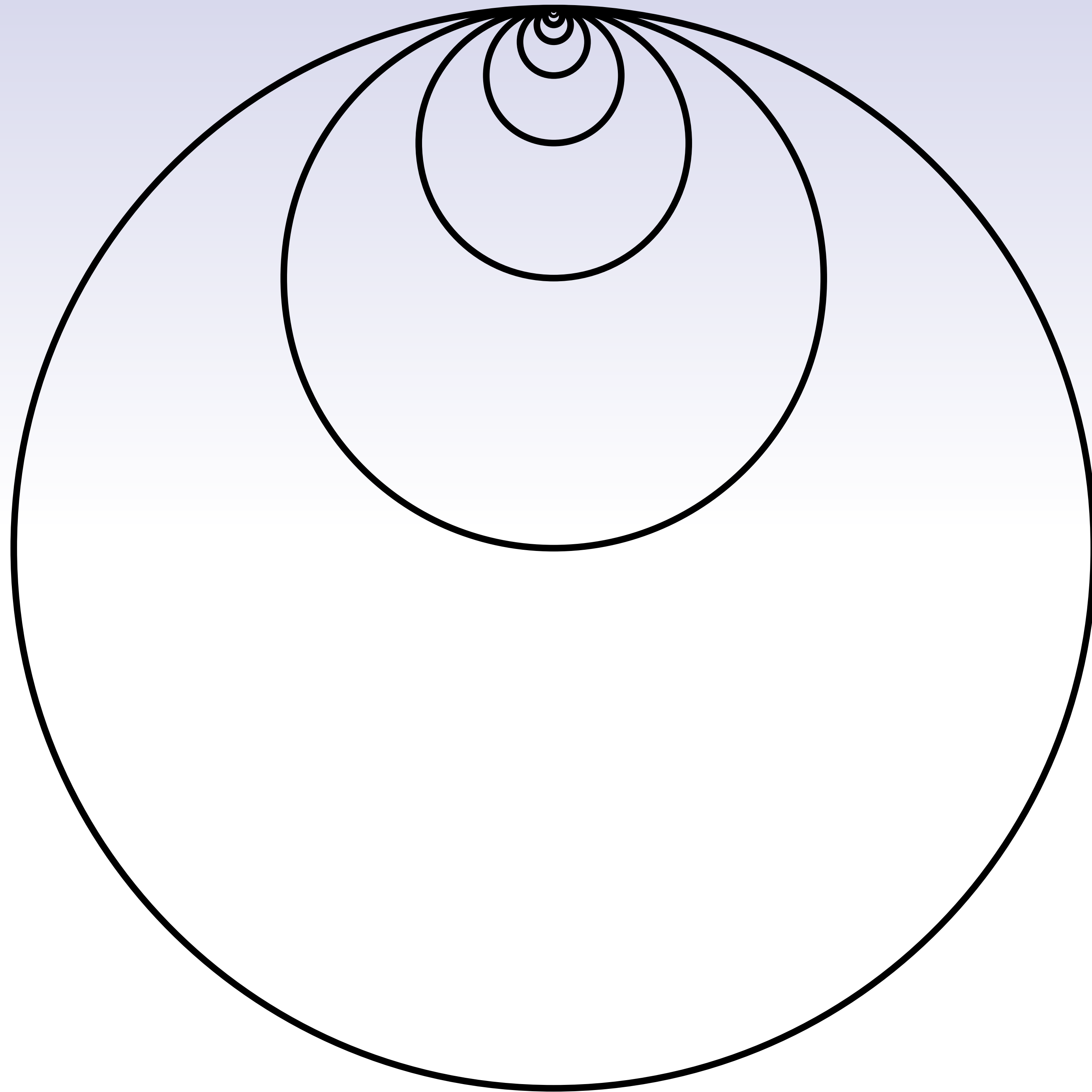
# *The Importance of Lines*



# *The Importance of Line Width*

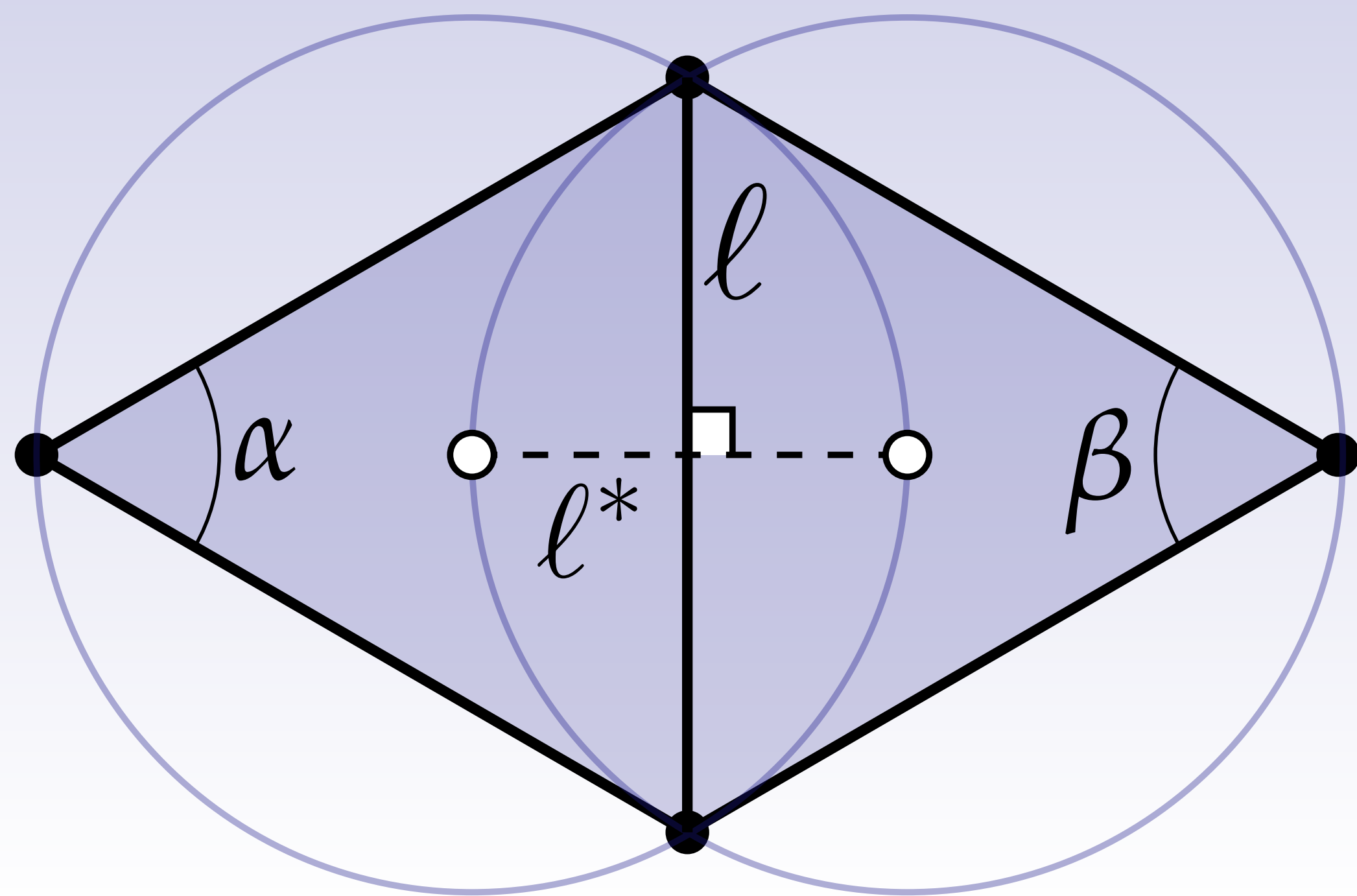


# *Abstraction vs. Accuracy*

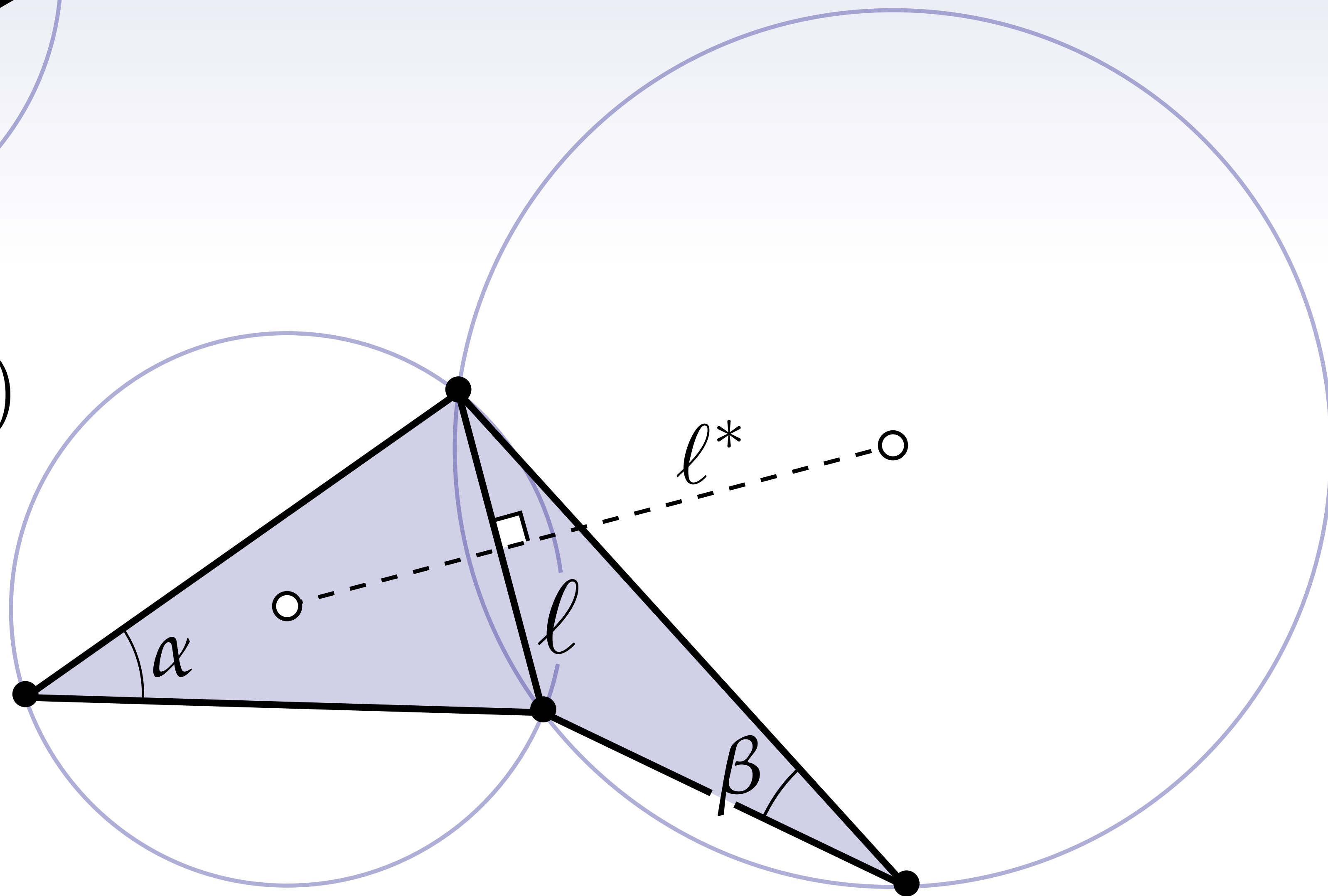


topological space

# *Is This Figure Misleading?*

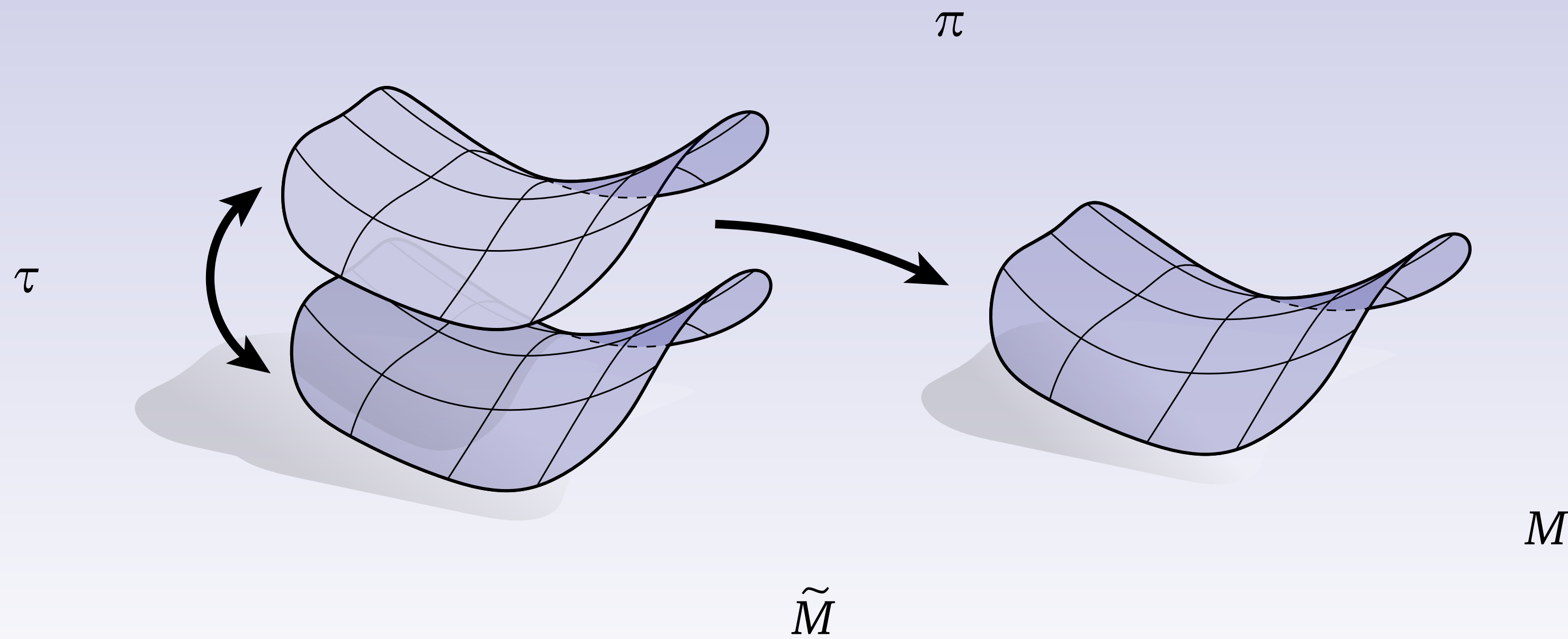


$$\frac{l^*}{l} = \frac{1}{2}(\cot \alpha + \cot \beta)$$

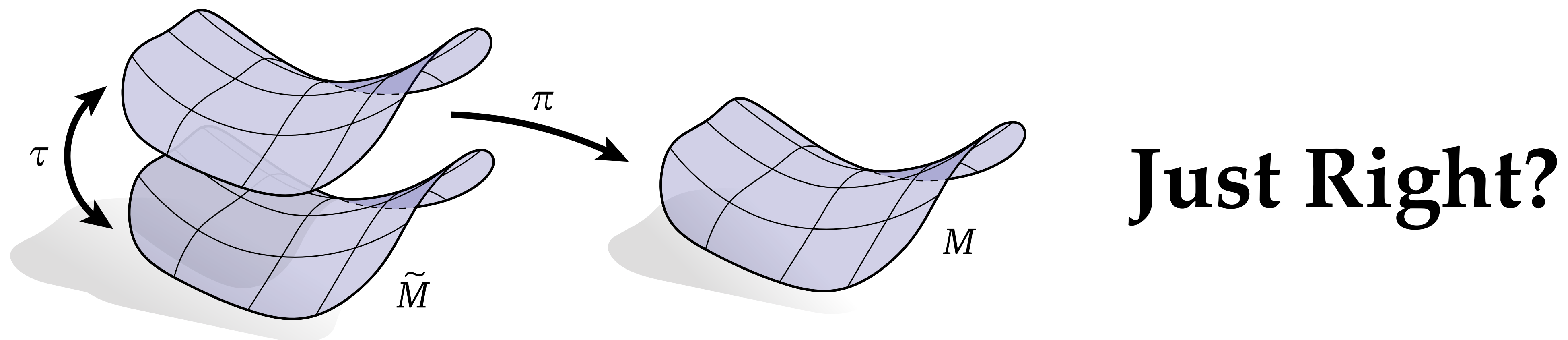
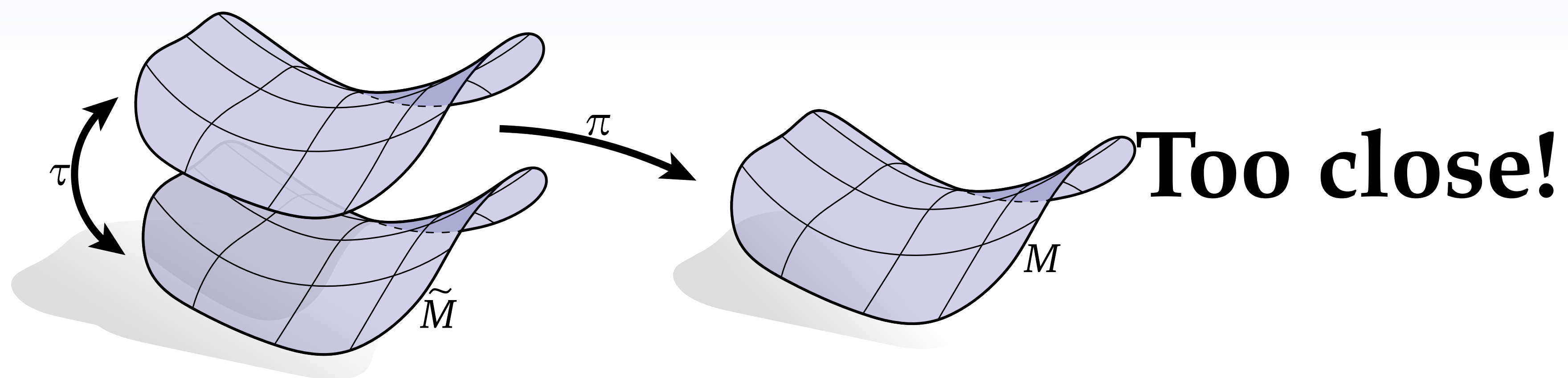


$$\frac{l^*}{l} = \frac{1}{2}(\cot \alpha + \cot \beta)$$

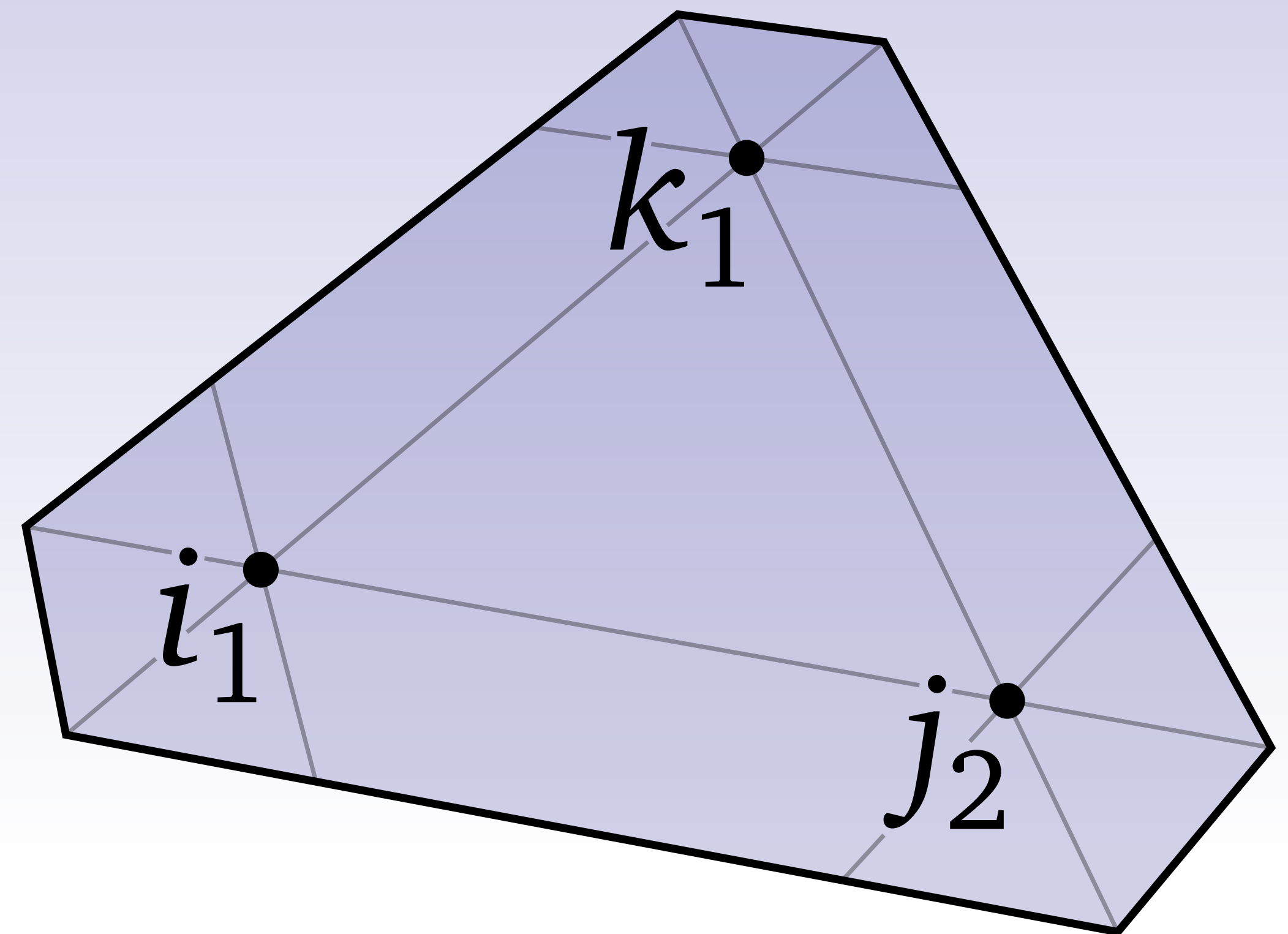
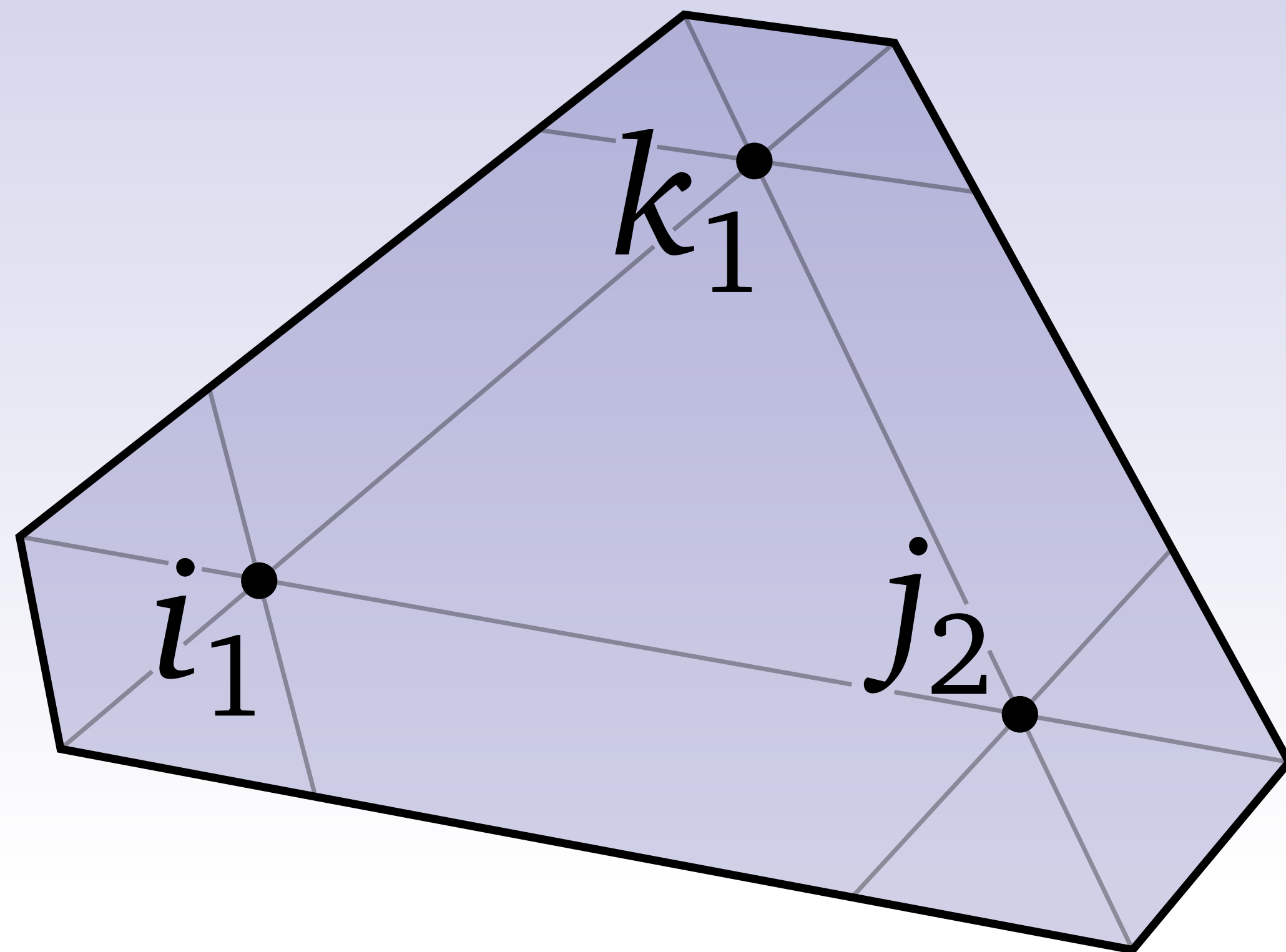
# Labeling - Local



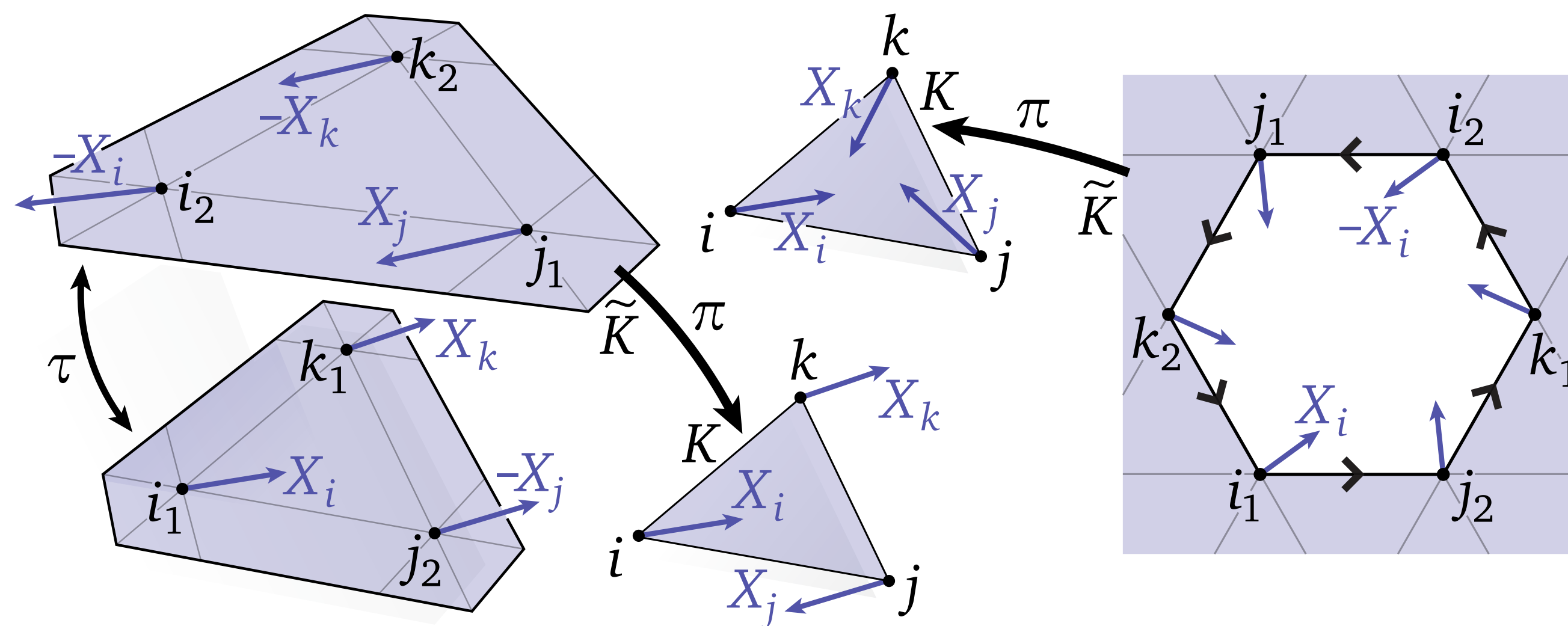
**Too far.**



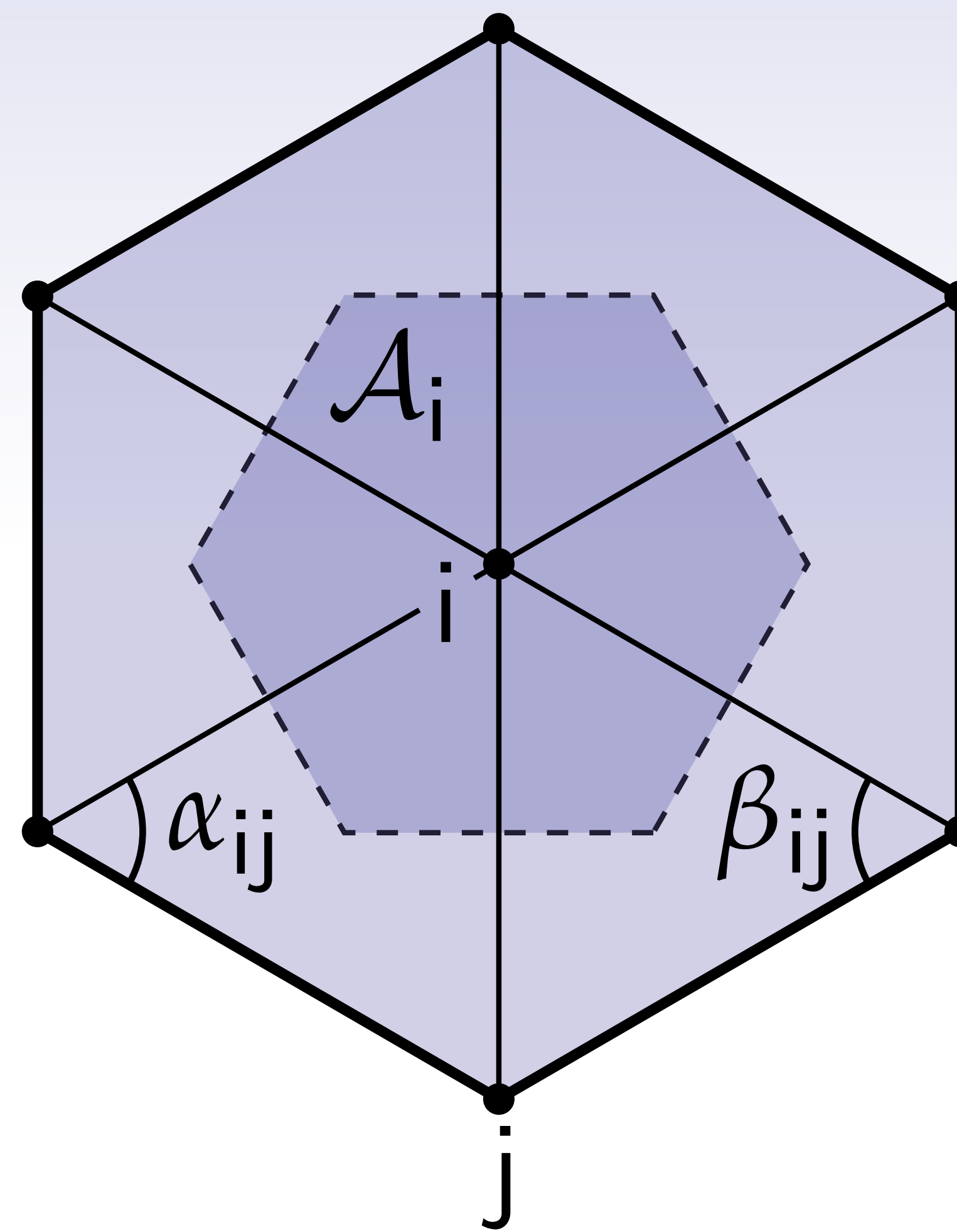
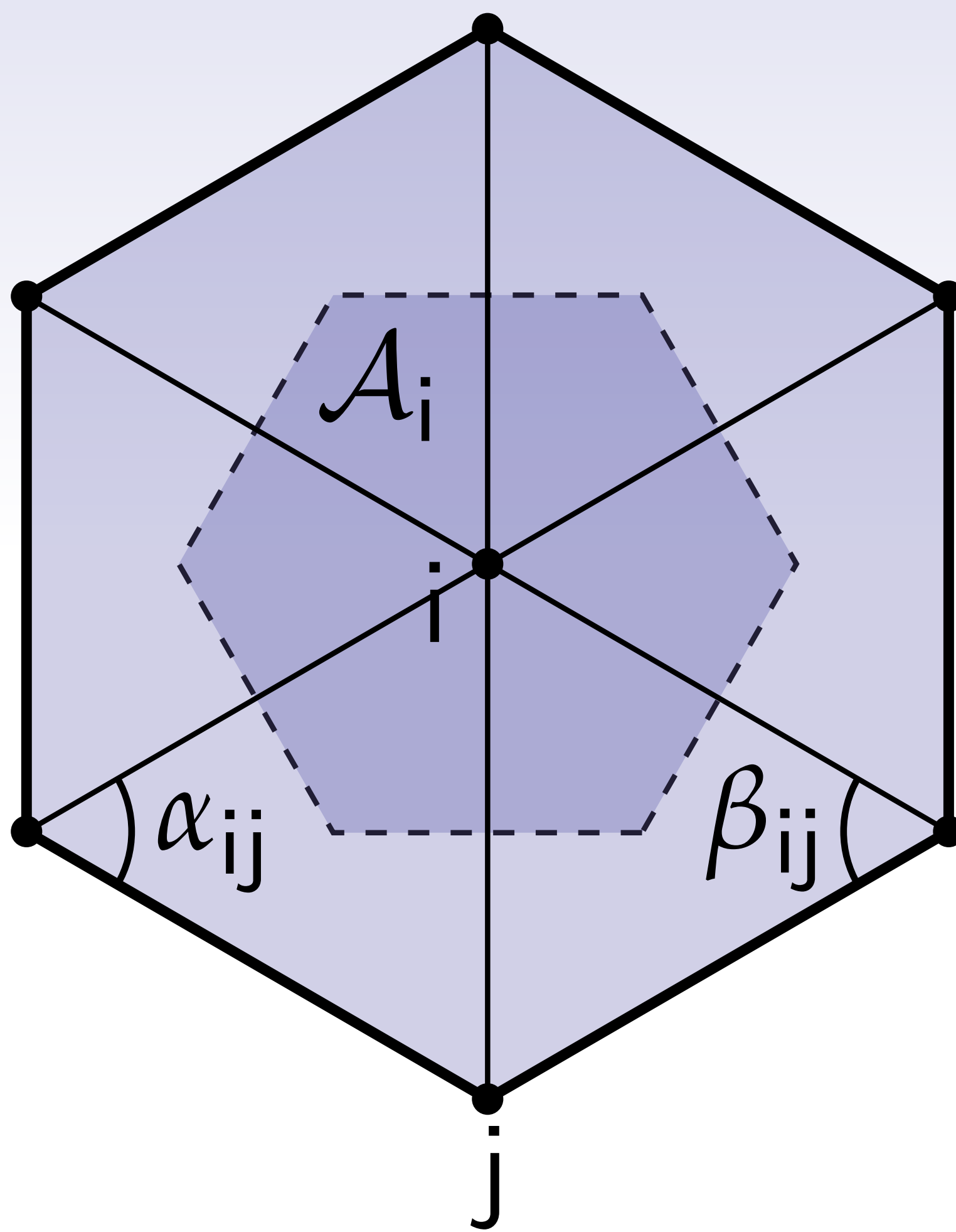
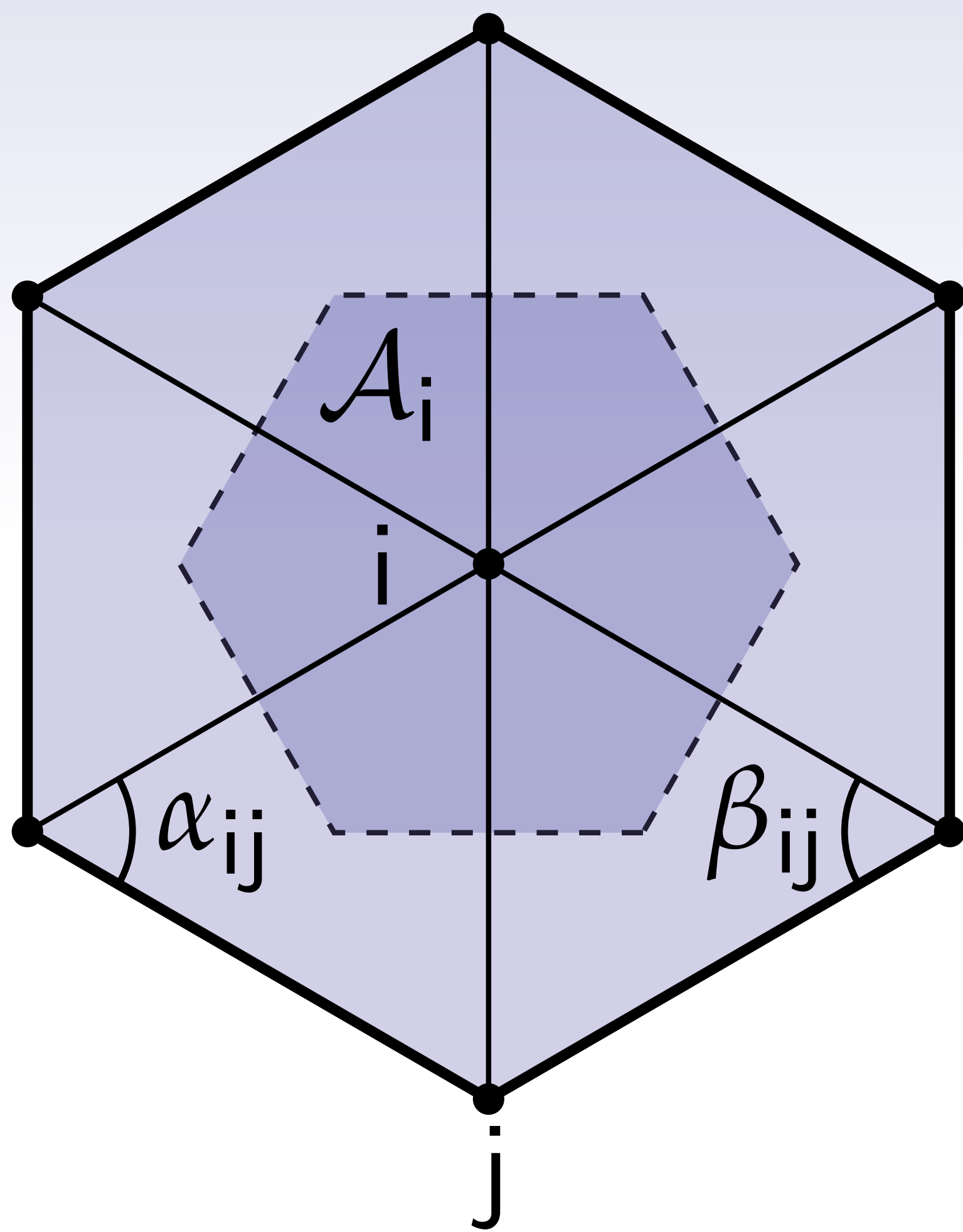
# Labels - Global Placement



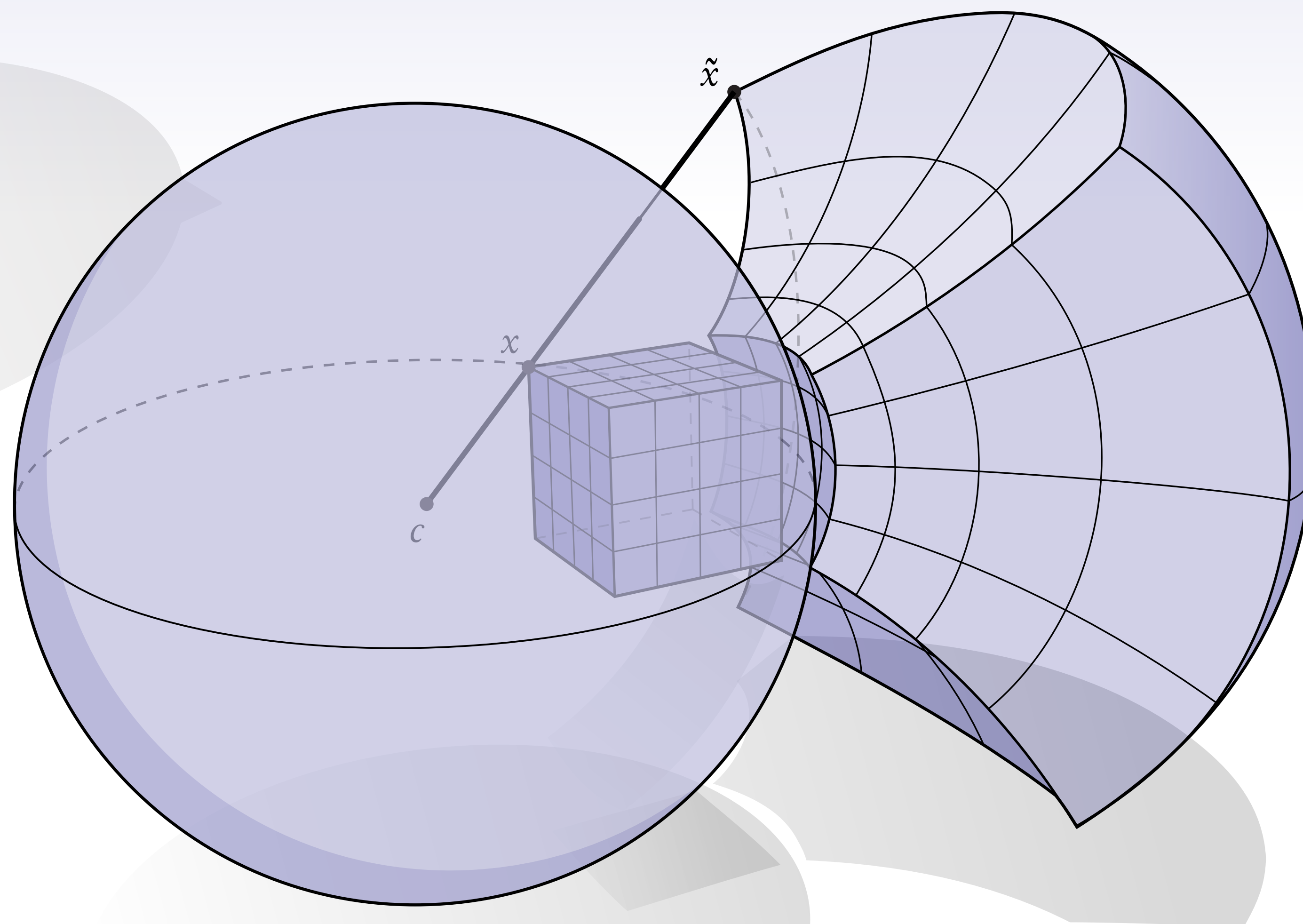
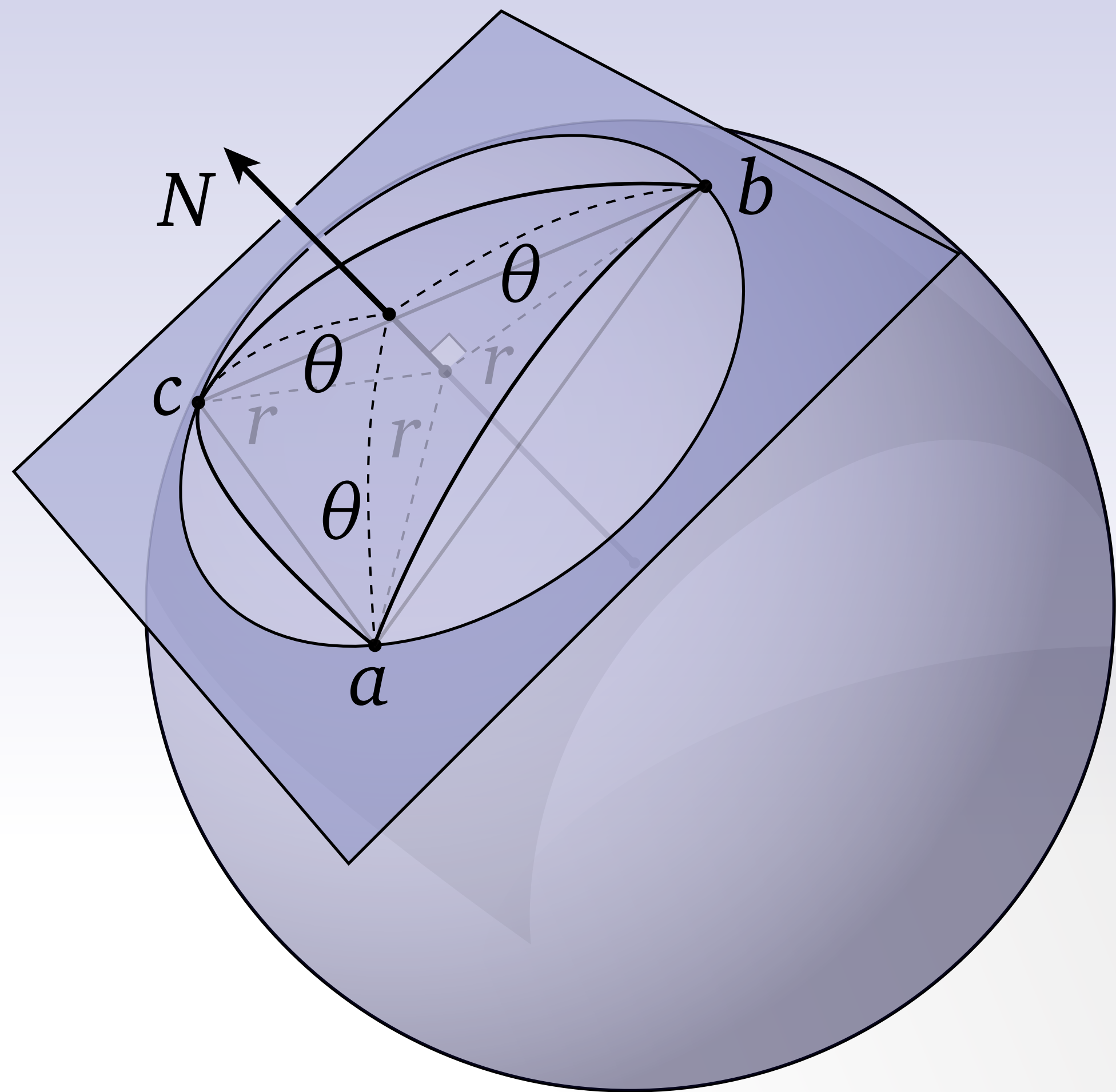
...In context, lots of constraints!



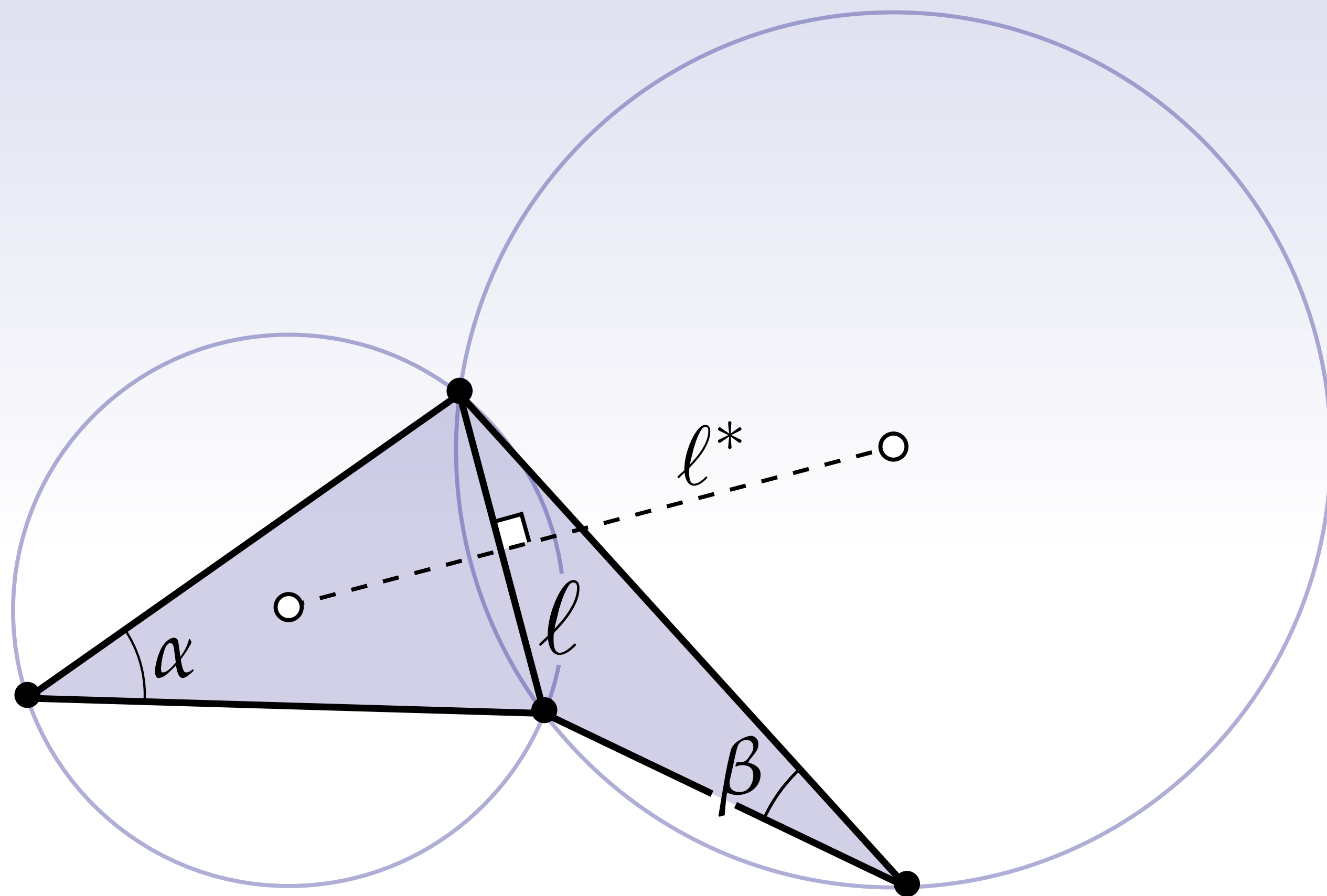
# *Labeling - Hidden Lines*



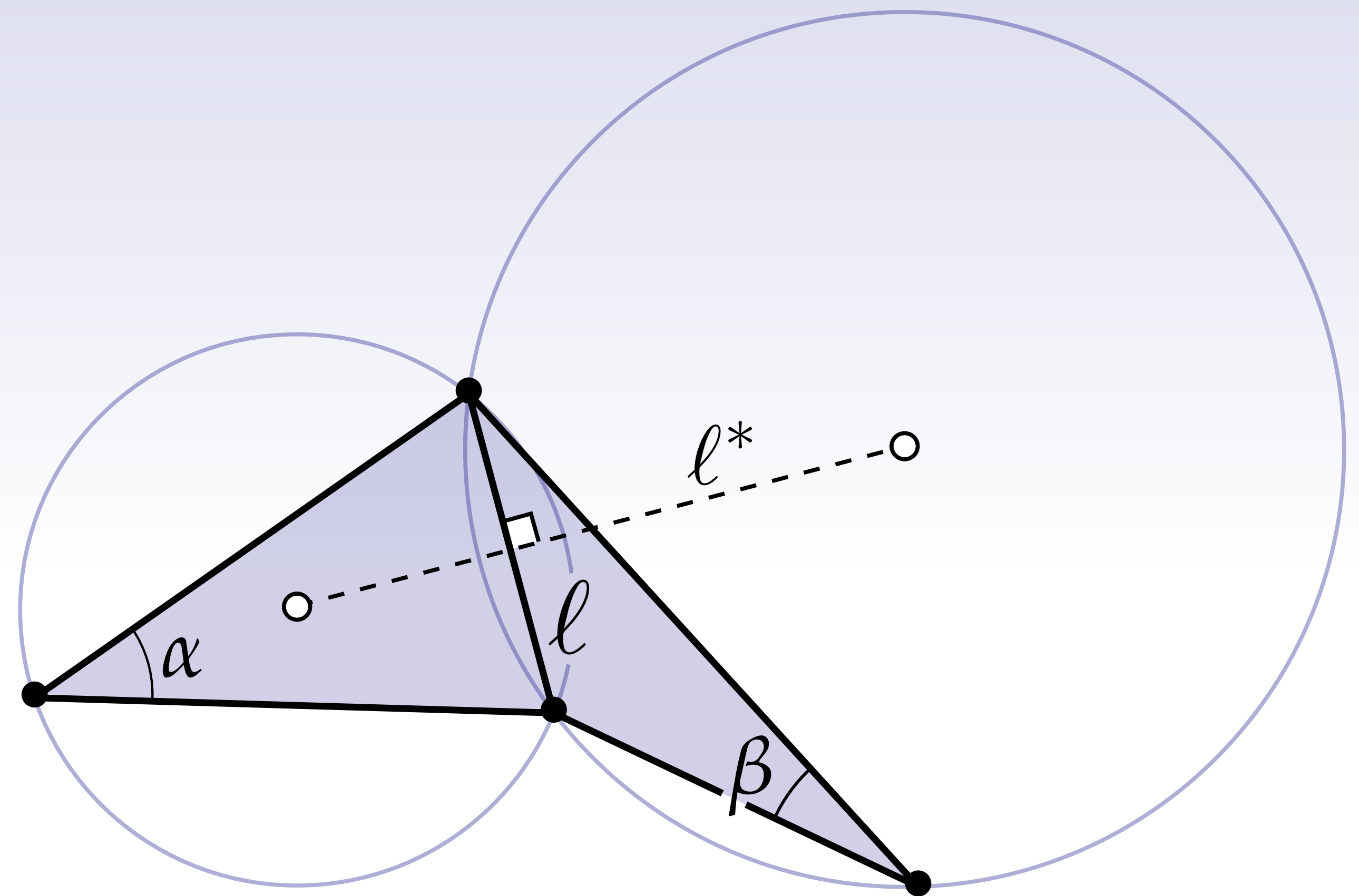
# *Labeling - Occlusion*



# Labeling - Which One is Centered?

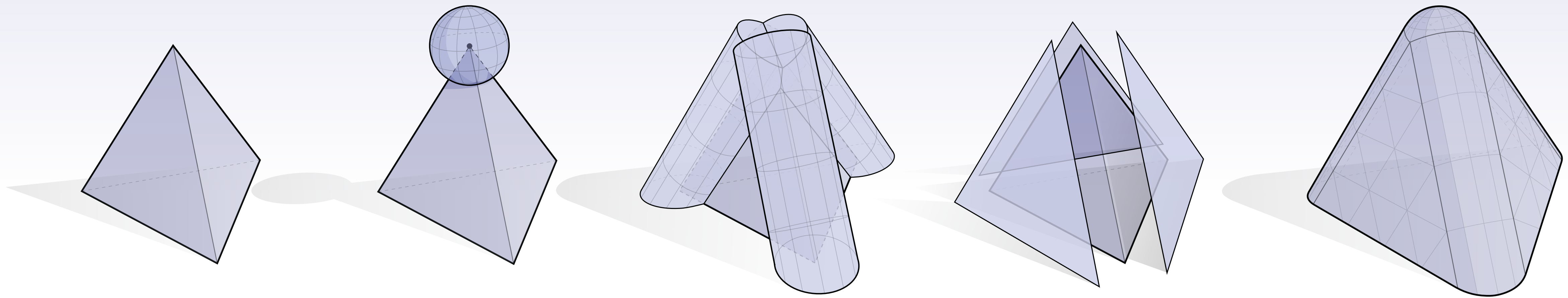


$$\frac{\ell^*}{\ell} = \frac{1}{2}(\cot \alpha + \cot \beta)$$



$$\frac{\ell^*}{\ell} = \frac{1}{2}(\cot \alpha + \cot \beta)$$

*Instead of more slides...*



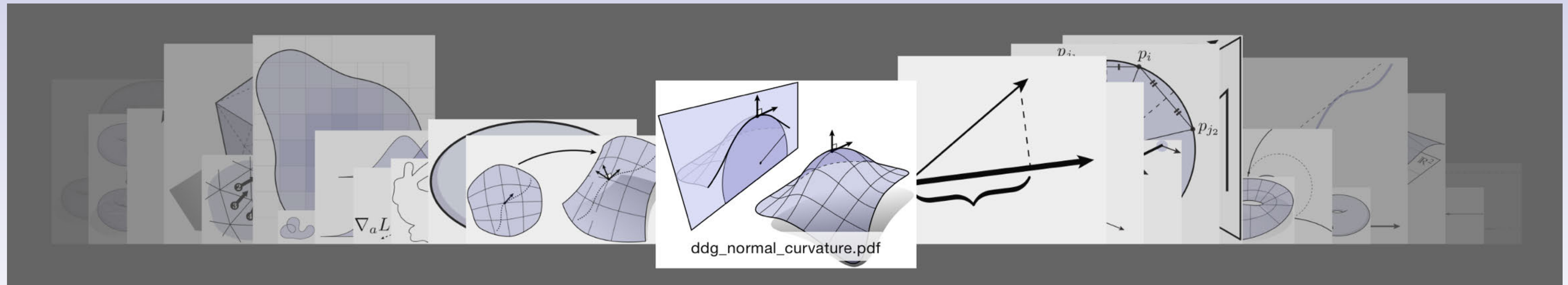
...Why not just show you how this really happens?

(Note: *not* real time! ~6 hours)

# *Future Opportunities?*

- **“Easy”** — 3D Illustrator
  - *convert 3D geometry into 2D strokes*
  - *opens the door to animation*
- **“Medium”** — TeX for mathematical illustration
  - *codify best practices of professional illustrators*
- **“Hard”** — automatic generation of figures from text
  - *start with very narrow domain? (e.g., set theory)*
  - *potential to change the world*

# Bonus Question: Search?



Name	^	Date Modified	Size	Kind
ddg_greensidentity_cancellation.pdf		May 10, 2013, 7:04 PM	117 KB	PDF Document
ddg_half_turn.pdf		Apr 21, 2013, 6:37 PM	255 KB	PDF Document
ddg_harmonic_generator_single_face.pdf		May 9, 2013, 4:06 PM	212 KB	PDF Document
ddg_harmonic_generator.pdf		May 9, 2013, 4:18 PM	272 KB	PDF Document
ddg_hat_function.pdf		May 10, 2013, 6:59 PM	130 KB	PDF Document
ddg_hatfunction_gradient_cotan.pdf		May 10, 2013, 7:19 PM	116 KB	PDF Document
ddg_hatfunction_gradient.pdf		May 10, 2013, 7:12 PM	116 KB	PDF Document
ddg_hatfunction_selfgradient_cotan.pdf		May 10, 2013, 7:15 PM	118 KB	PDF Document
ddg_heat_equation.pdf		May 9, 2013, 6:10 PM	209 KB	PDF Document
ddg_hodge_cotan_proof.pdf		May 9, 2013, 6:10 PM	237 KB	PDF Document
ddg_hodge_cotan.pdf		May 10, 2013, 7:38 PM	121 KB	PDF Document
ddg_hodge_decomposition_torus.pdf		May 5, 2013, 7:50 PM	547 KB	PDF Document
ddg_hodge_potential.pdf		May 6, 2013, 1:05 PM	444 KB	PDF Document
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ddg_icosahedron.pdf		May 9, 2013, 6:10 PM	240 KB	PDF Document
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ddg_integration.pdf		May 10, 2013, 3:17 PM	162 KB	PDF Document
ddg_irregular_homotopy.pdf		May 9, 2013, 6:10 PM	51 KB	PDF Document
ddg_l2_inner_product.pdf		May 9, 2013, 6:10 PM	219 KB	PDF Document
ddg_length_gradient.pdf		May 9, 2013, 6:10 PM	51 KB	PDF Document
ddg_loop_closure.pdf		May 9, 2013, 6:10 PM	62 KB	PDF Document
ddg_noncontractible_loop.pdf		May 8, 2013, 11:11 AM	217 KB	PDF Document
ddg_normal_curvature_derivation.pdf		May 12, 2013, 11:17 AM	134 KB	PDF Document
ddg_normal_curvature.pdf		May 10, 2013, 8:28 AM	235 KB	PDF Document
ddg_one_form.pdf		May 10, 2013, 1:37 PM	112 KB	PDF Document
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ddg_oneform_quadrature.pdf		May 10, 2013, 3:40 PM	114 KB	PDF Document
ddg_onering_edge_bisectors.pdf		May 9, 2013, 6:10 PM	246 KB	PDF Document
ddg_opposite_cotan.pdf		May 10, 2013, 7:58 PM	118 KB	PDF Document
ddg_orientability.pdf		May 9, 2013, 8:28 PM	224 KB	PDF Document

# *Glass Blowing Demo*

