Lecture 18: Recursive Ray Tracing

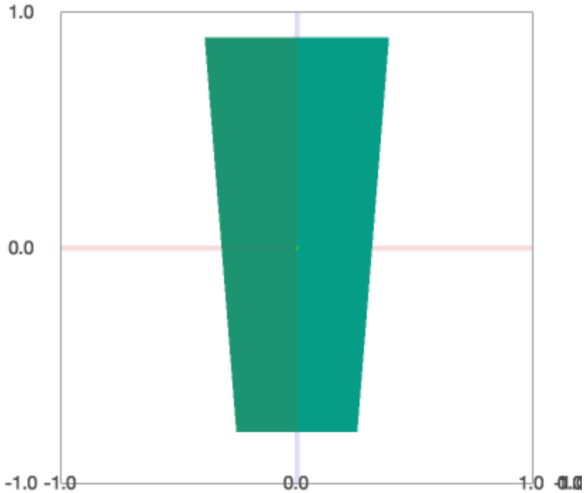
October 24, 2017

First, Old Business

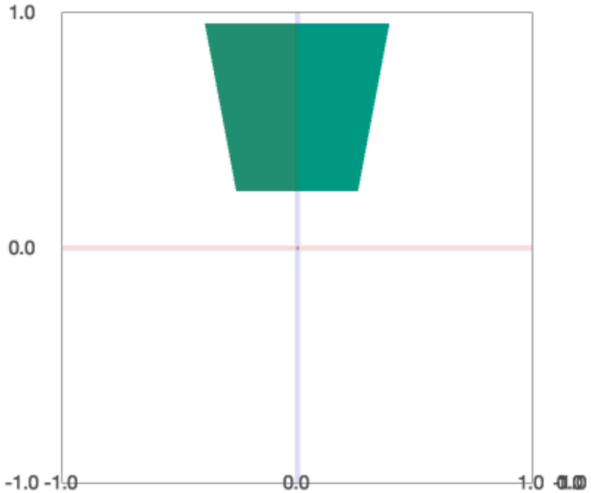
- Z-buffering based upon pseudo-depth is key to modern polygon rendering.
- In lecture Thursday some questions arose about the non-linear nature of depth calculations.
- Here let us briefly dive into the calculation of psuedo-depth with an example.

First the Symptom

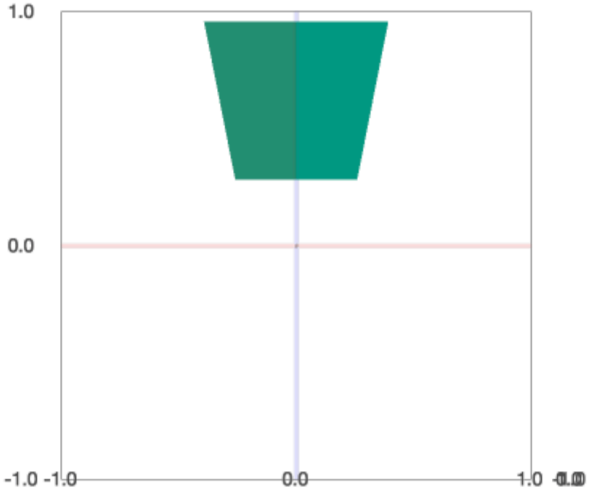
Near = -25
Far = -75



Near = -25
Far = -750



Near = -25
Far = -7500



Remember, the house lies between z of 30 and 54 in world coordinates.

Even pushing the far clipping plane 2 orders of magnitude further back from -75 still results in the house occupying most of the pseudo-depth range between 0 and 1.

Back to the Math

- Camera at origin no world cam. rotation

$$\begin{vmatrix} -\frac{(umax+umin)z}{umax-umin} \\ -\frac{(vmax+vmin)z}{vmax-vmin} \\ \frac{2\,farnear}{far-near} - \frac{(far+near)z}{far-near} \\ z \end{vmatrix} = \begin{vmatrix} \frac{2\,near}{umax-umin} & 0 & -\frac{umax+umin}{umax-umin} & 0 \\ 0 & \frac{2\,near}{vmax-vmin} & -\frac{vmax+vmin}{vmax-vmin} & 0 \\ 0 & 0 & -\frac{far+near}{far-near} & \frac{2\,farnear}{far-near} \\ 0 & 0 & 1 & 0 \end{vmatrix} \begin{vmatrix} 0 \\ 0 \\ z \\ 1 \end{vmatrix}$$

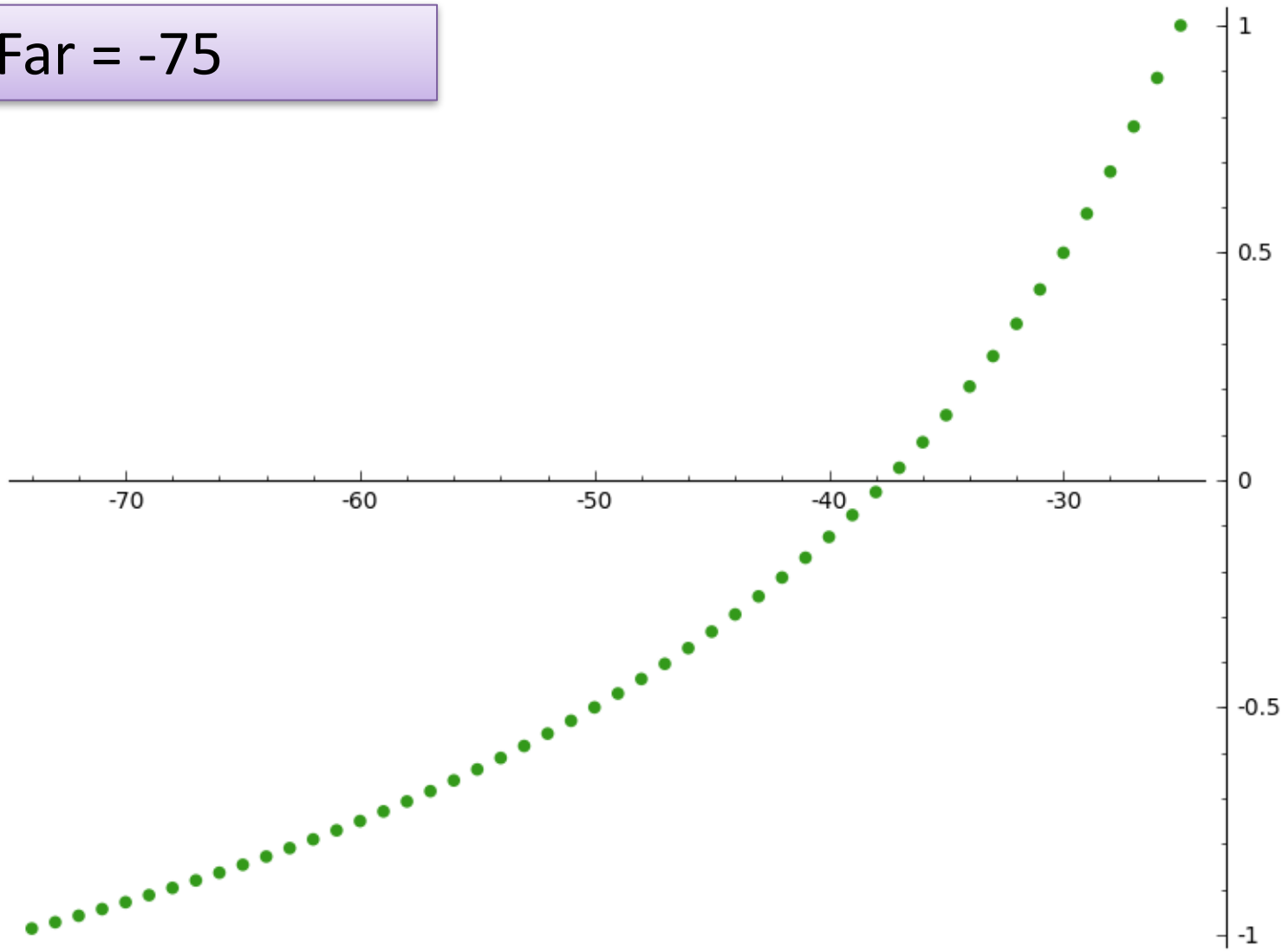
$$P_{cc} = \begin{vmatrix} -\frac{umax+umin}{umax-umin} \\ -\frac{vmax+vmin}{vmax-vmin} \\ \frac{\frac{2\,farnear}{far-near} - \frac{(far+near)z}{far-near}}{z} \\ 1 \end{vmatrix}$$

and the z term only $pz = \frac{\frac{2\,farnear}{far-near} - \frac{(far+near)z}{far-near}}{z}$

Pseudo-depth

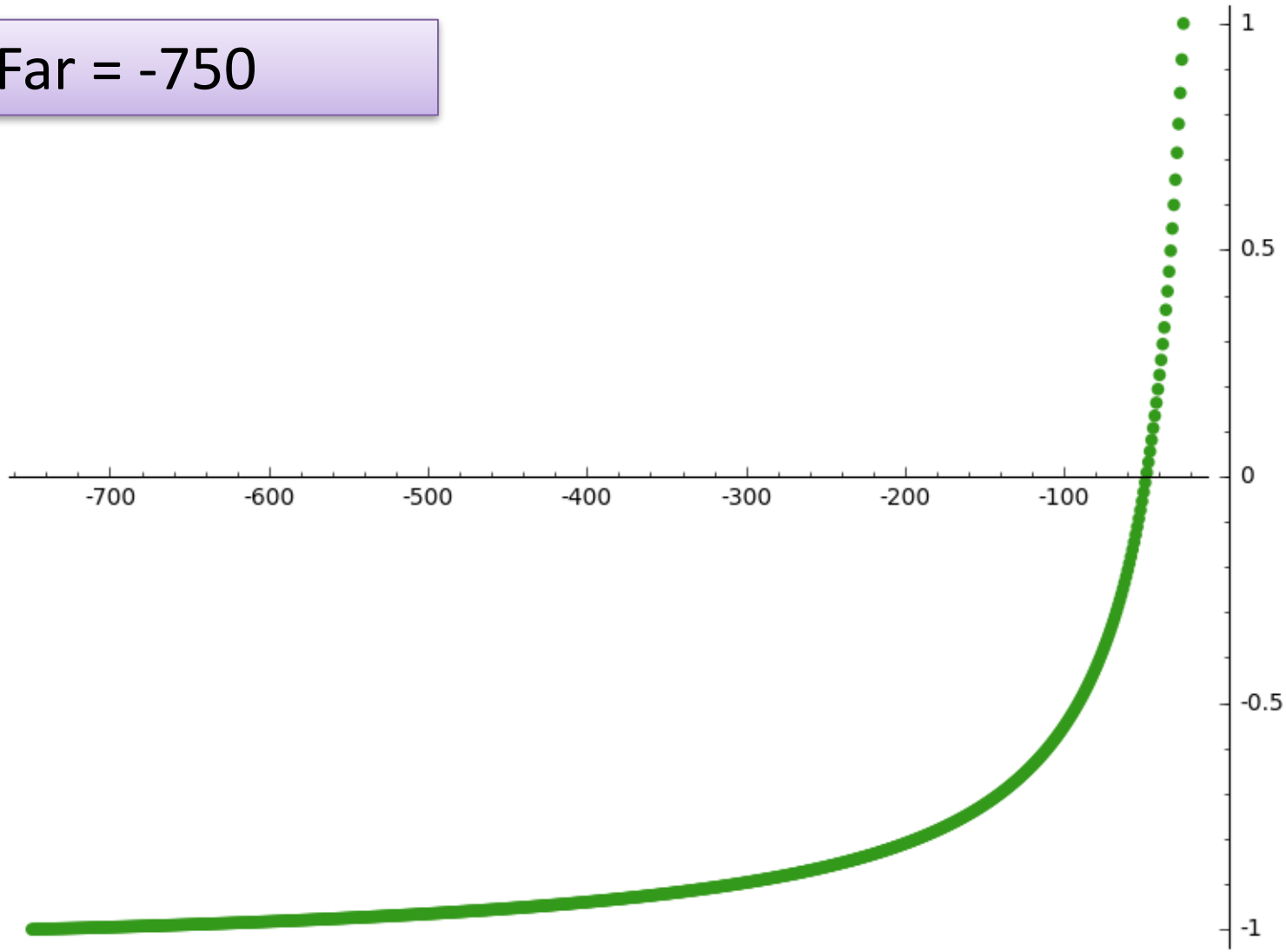
Plot actual Depth to Pseudo-depth

Far = -75



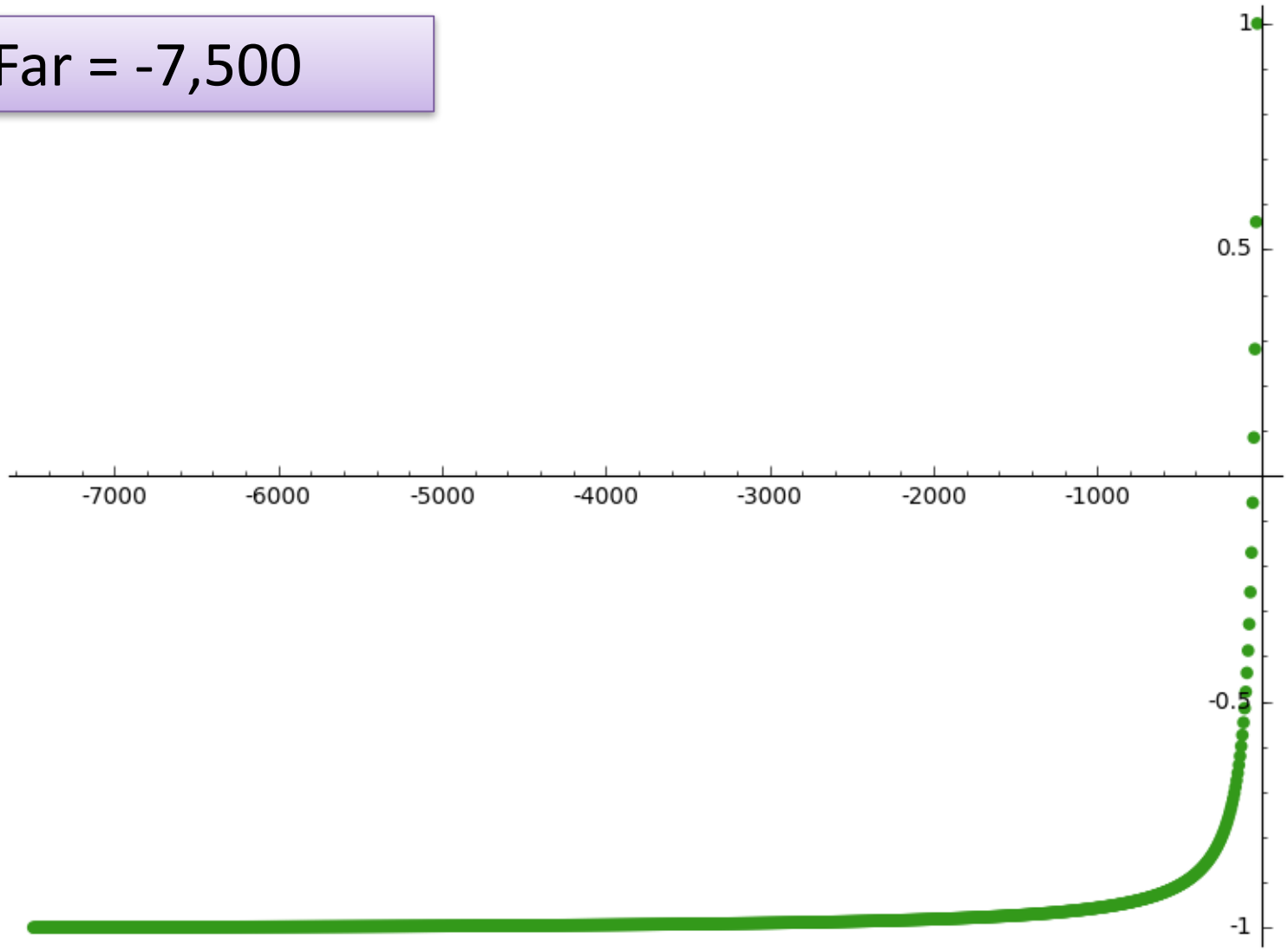
Plot actual Depth to Pseudo-depth

Far = -750



Plot actual Depth to Pseudo-depth

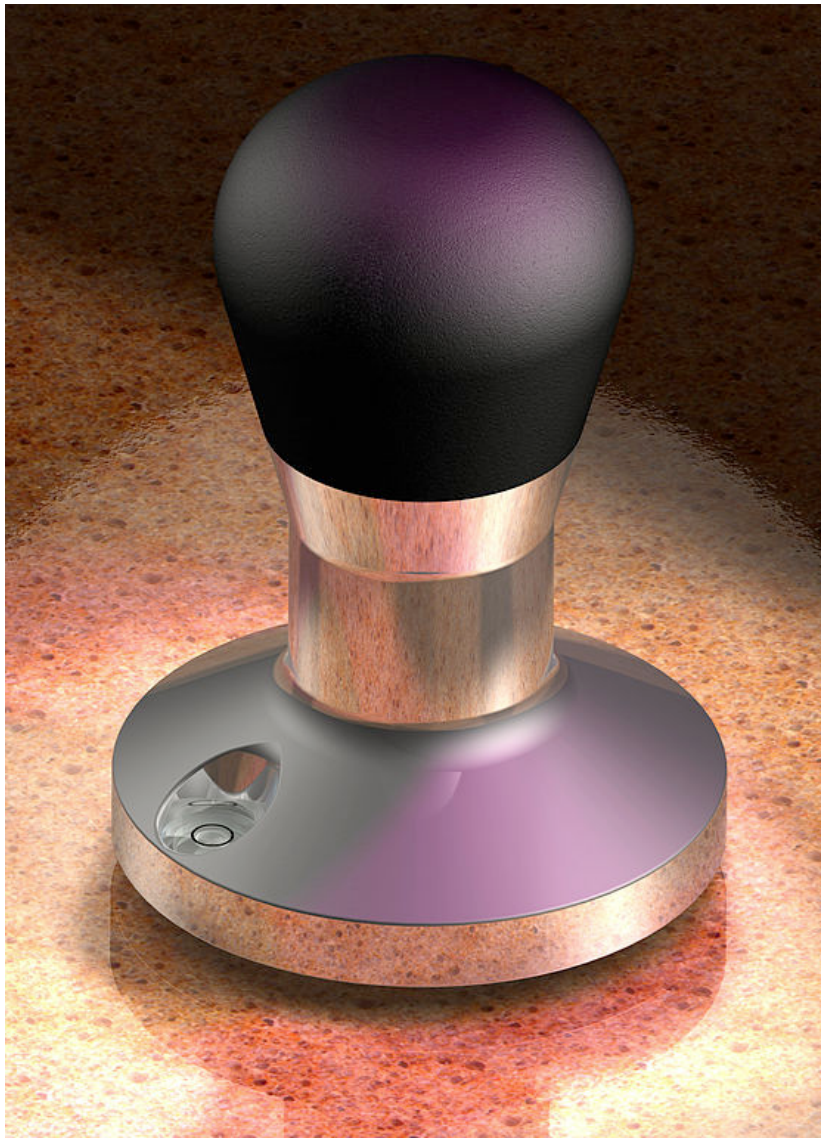
Far = -7,500



How about Reflections?

- Note reflections
- Granite tabletop
- Visible on base
- Also on handle

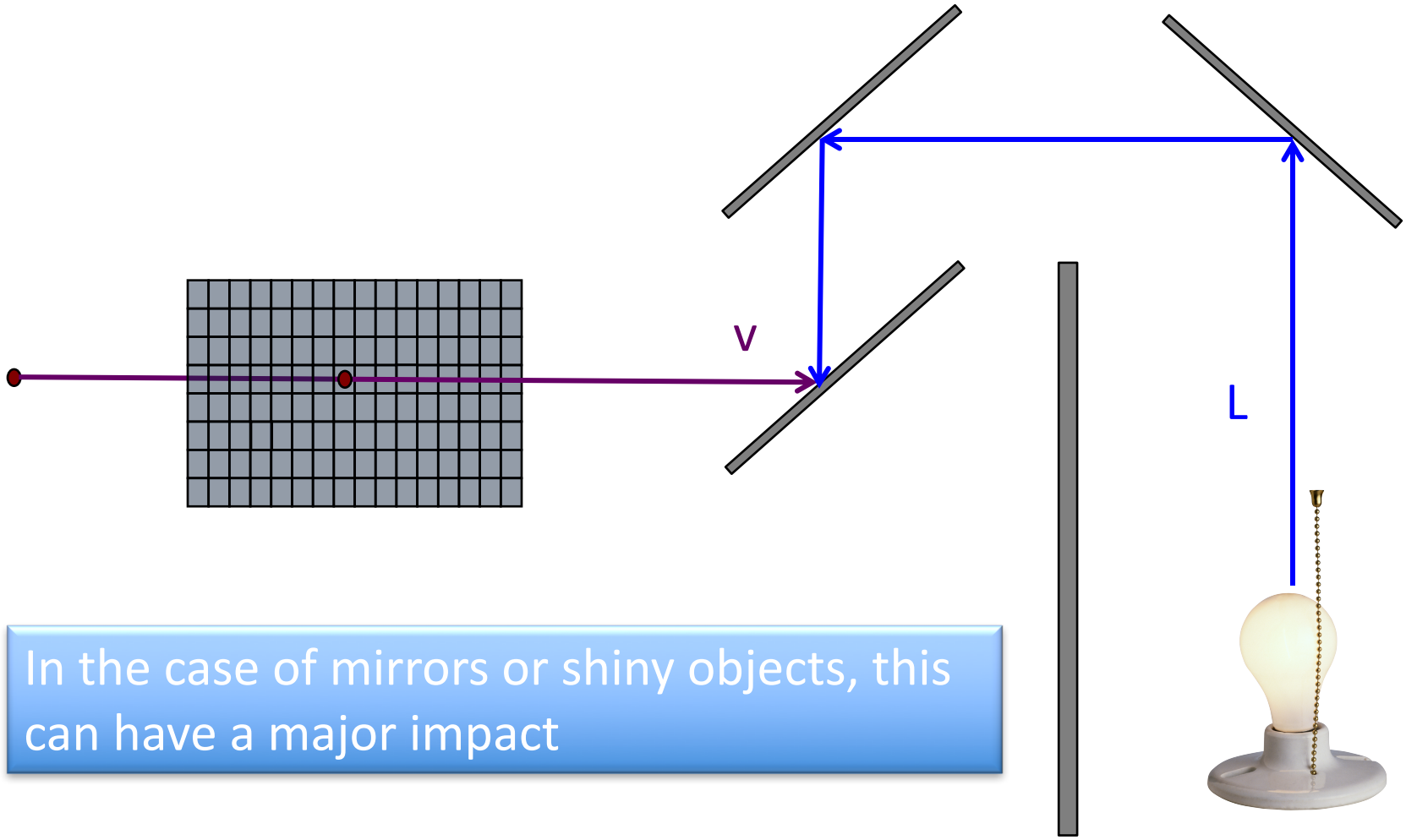
This is a featured picture on the English language Wikipedia (Featured pictures) and is considered one of the finest images. (October 2012)



Rationale for Interreflection

- Not all the light striking a surface comes directly from a light source.
- Some reflects from one surface onto another.
- We ignore diffuse reflected light:
  - Because its small, and we can get away with it
  - Because it is very expensive to compute
- Specular reflection much more sensitive
  - Just consider reflections in previous image.

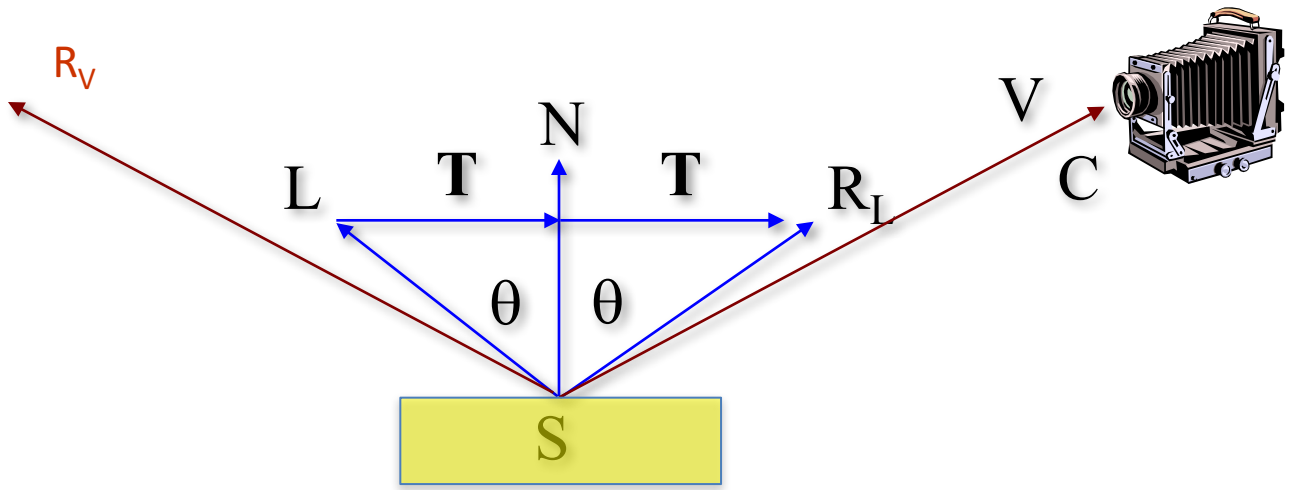
Interreflections



In the case of mirrors or shiny objects, this can have a major impact

Rays of Reflection

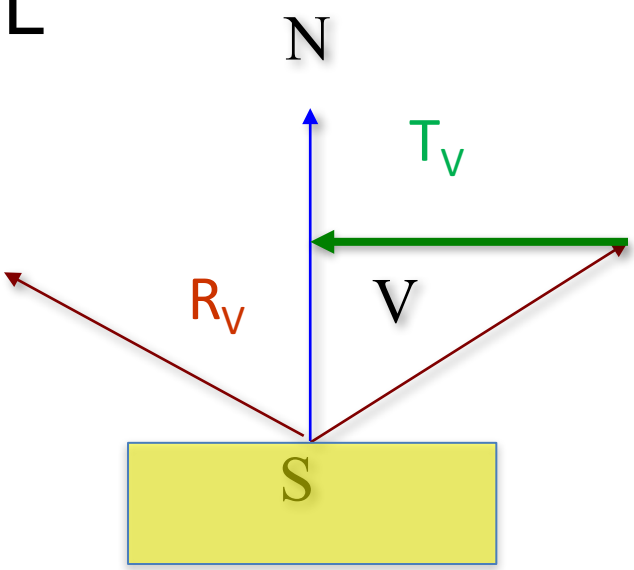
- To add interreflections, we need the light hitting the surface from the reflected viewing ray.



- Add to ambient, diffuse and specular

Computing V_R

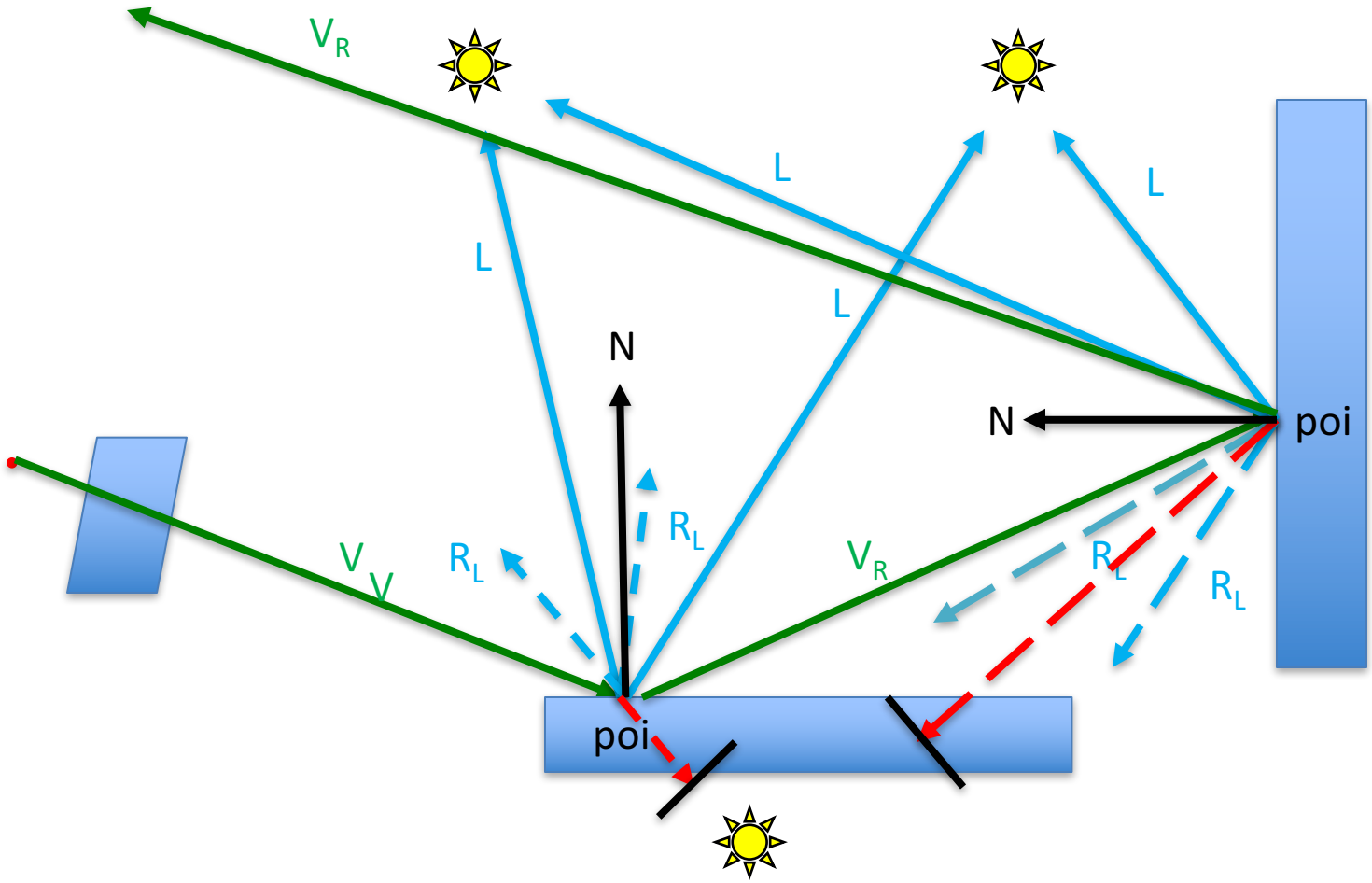
- $R_V = 2(V \cdot N)N - V$
  - Just like R_L, but V replaces L
- To be more detailed…
  - $N_V = (V \cdot N)N$
  - $T_V = N_V - V = (V \cdot N)N - V$
  - $R_V = V + 2T_V = 2(V \cdot N)N - V$



Recursive Ray Tracing

- Generalize ray trace – light from a ray
  - Ray leaves surface from point of intersection
  - In the direction of R_V
- And how does it compute illumination?
- Exactly as we did it before, when …
  - Starting at the pixel
  - In the direction of V
- So ray tracing is recursive!

Illustrating Recursive Ray Tracing



Now in SageMath

- Complete implementation in SageMath
- Scene with three sphere and inter-reflection
- Can modify recursion depth

Reflecting on Spheres

last edited Oct 23, 2017, 3:44:04 PM by admin

Save | Save & quit | Discard & quit

File... | Action. | Data... | sage | Typeset | Load 3-D Live | Use java for 3-D

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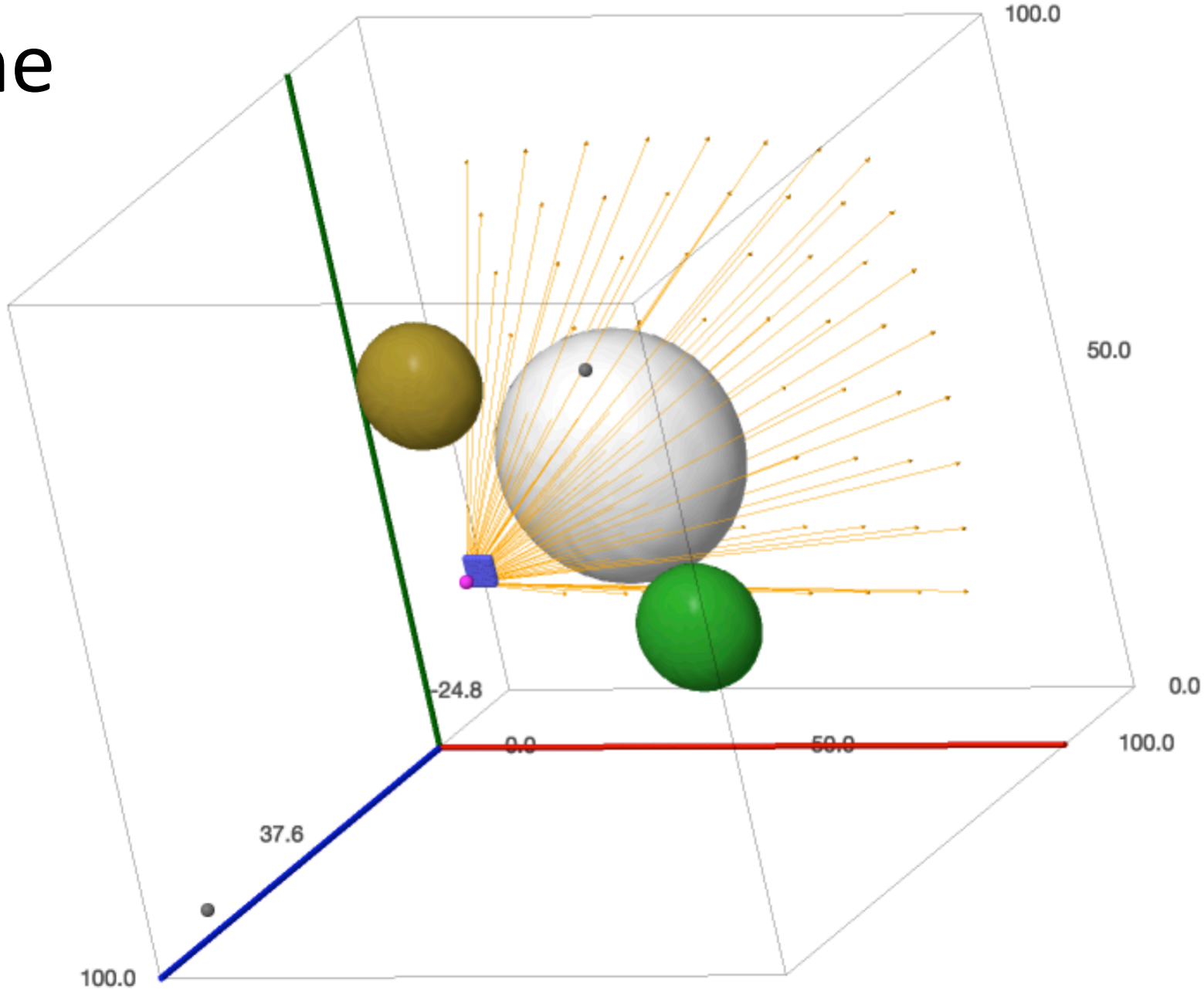
Illumination with Reflection for Spheres

Ross Beveridge, October 24, 2017

In this Notebook is a full implementation of ambient, diffuse and specular reflection - in color - for a scene consisting multiple light sources and multiple spheres. Also in this Notebook is an example of recursive ray tracing. In other words, one object may be seen to reflect on the surface of another. The first bit of code that follows is book keeping to help setup libraries and display defaulst. Read on below to get more about the substance of this ray tracer.

Scene



Rendering