Balancing Risks in Research and Teaching

Oliver Knill

September 30, Dunster, 2010

This talk is a risk itself:

I'm getting too personal,
sound whimsical,
bragging, bitter or naiv.
But this is the topic and I consider this part as an experiment in taking risks.

Lets jump in!

Outline

Having been in the position to balance risks of teaching from the junior faculty position perspective for a long time, I might have something to say.

The talk is divided into to parts:

- Part I: Risks in Research
- Part II: Risks in Teaching

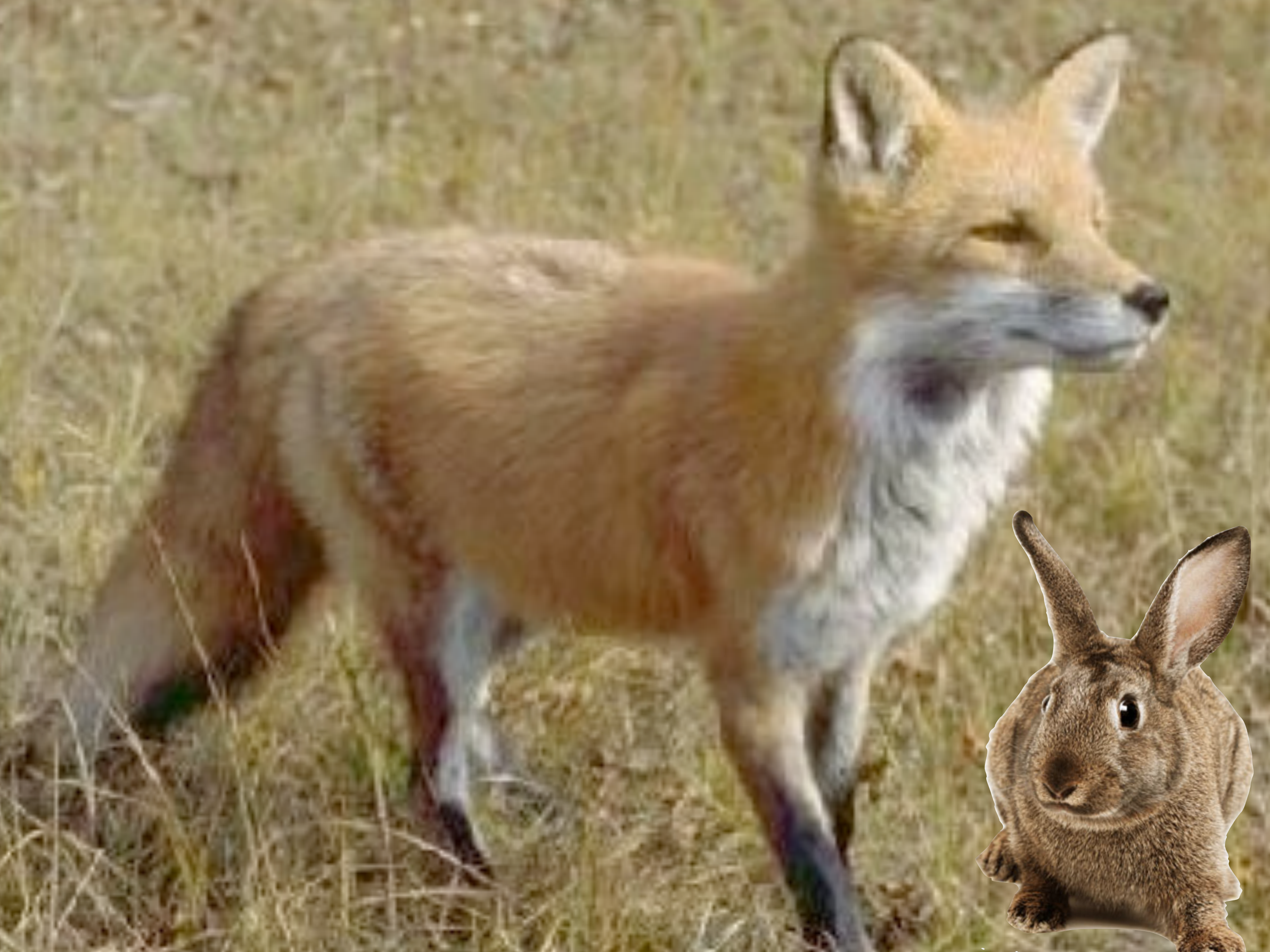
Part I

Research

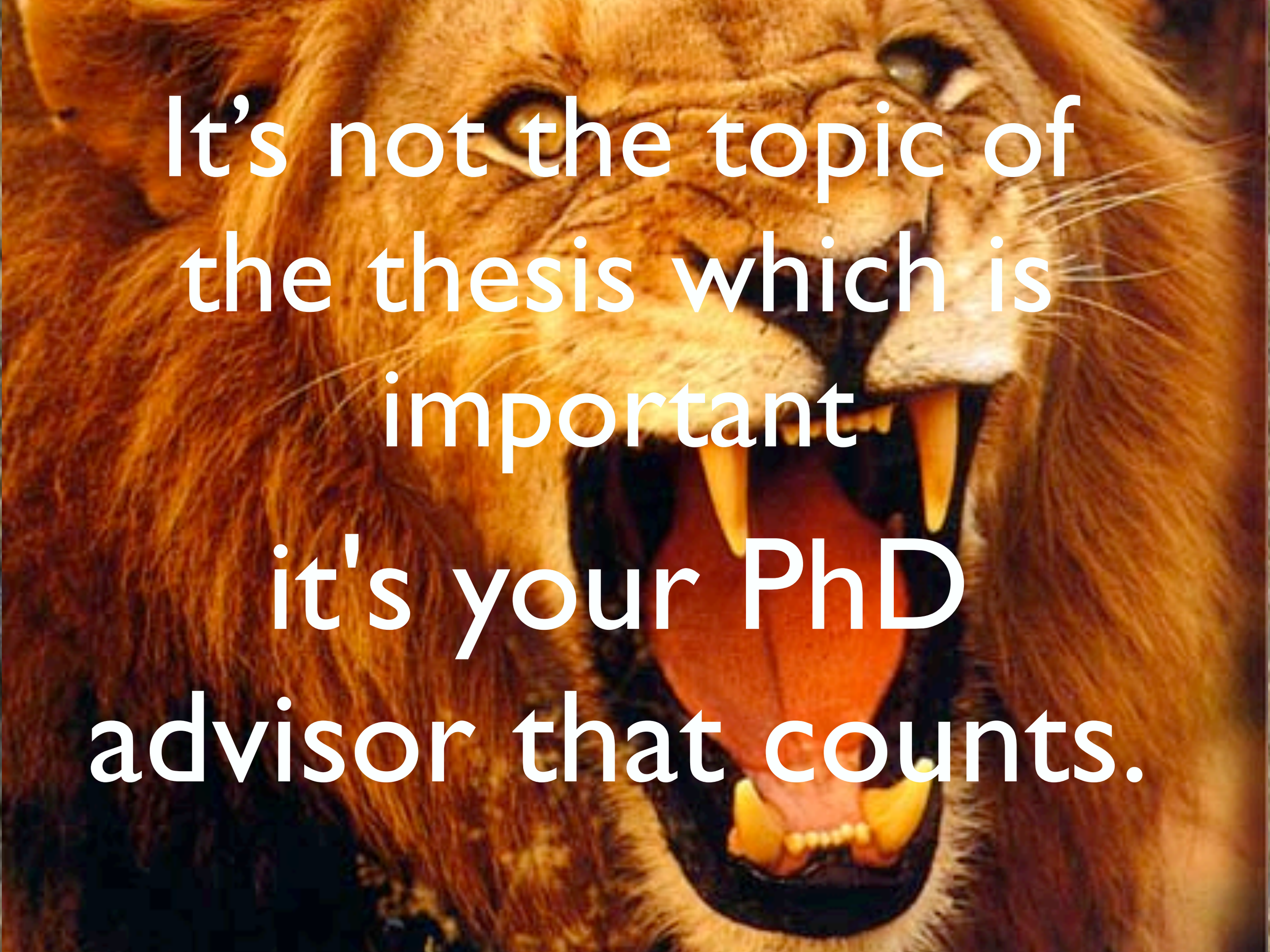
Part I: Research

- Advisor
- Letter writers
- Topic
- Independence?

The Advisor



What is the Moral of the story?

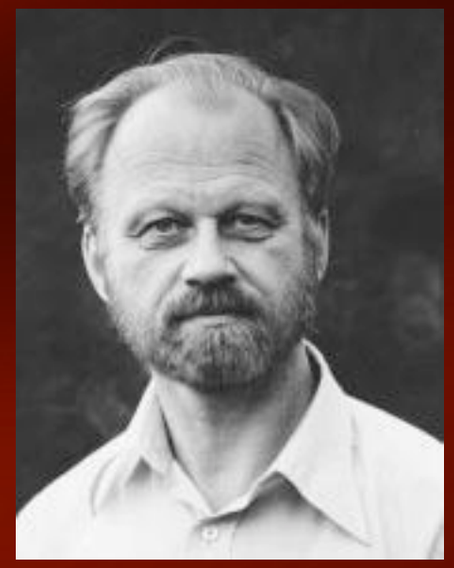

It's not the topic of
the thesis which is
important
it's your PhD
advisor that counts.

MERRIE MELODIES

a WARNER BROS. CARTOON

TECHNICOLOR®

My Advisors



- Juergen Moser
  Undergraduate advisor

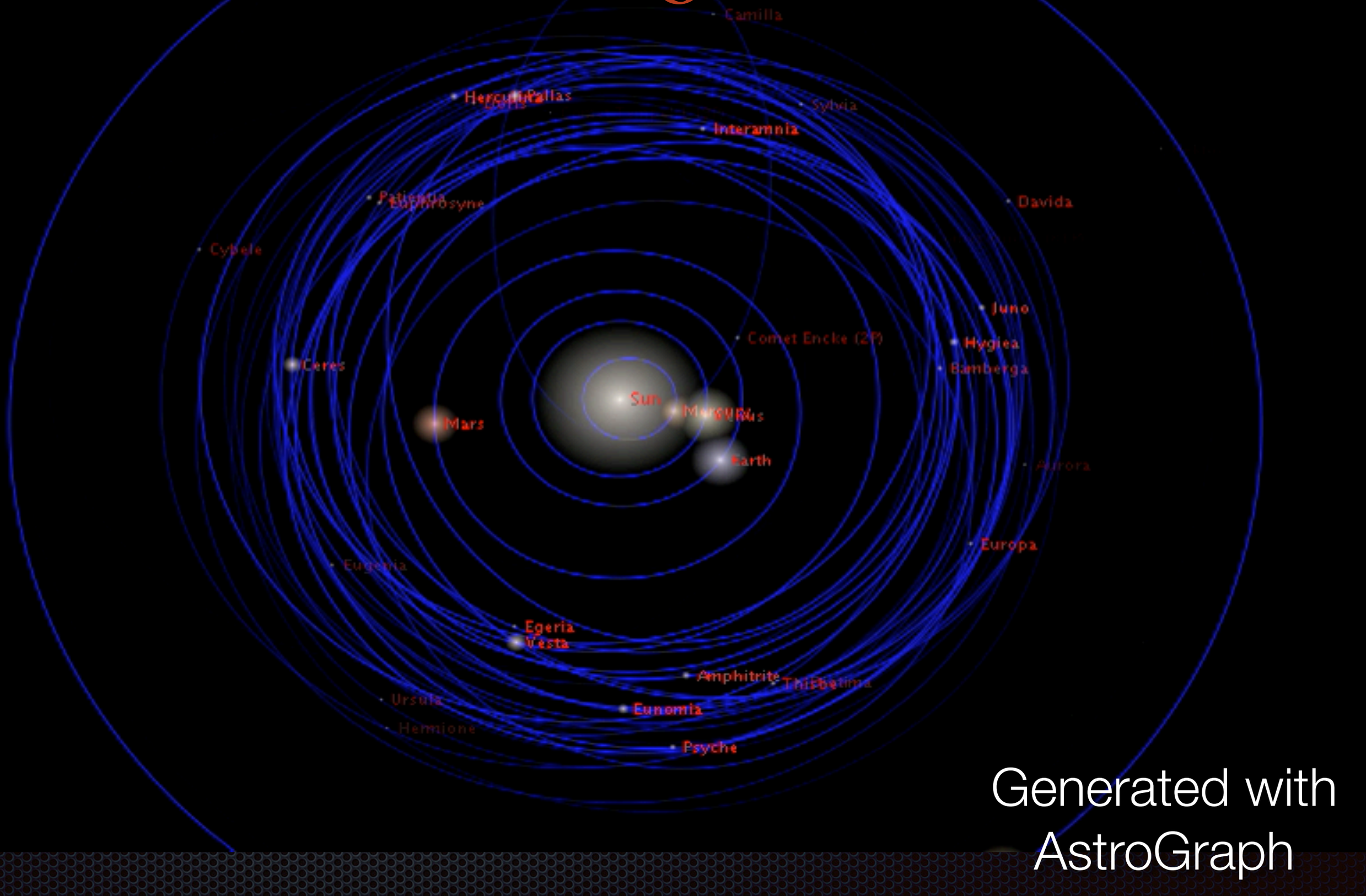
- Oscar Lanford Graduate advisor
- Barry Simon, my postdoc advisor

Three Lions!

$$T\begin{bmatrix} x \\ y \end{bmatrix} =$$

$$\begin{bmatrix} c\sin(x) + 2x - y \\ x \end{bmatrix}$$

Planetary Motion



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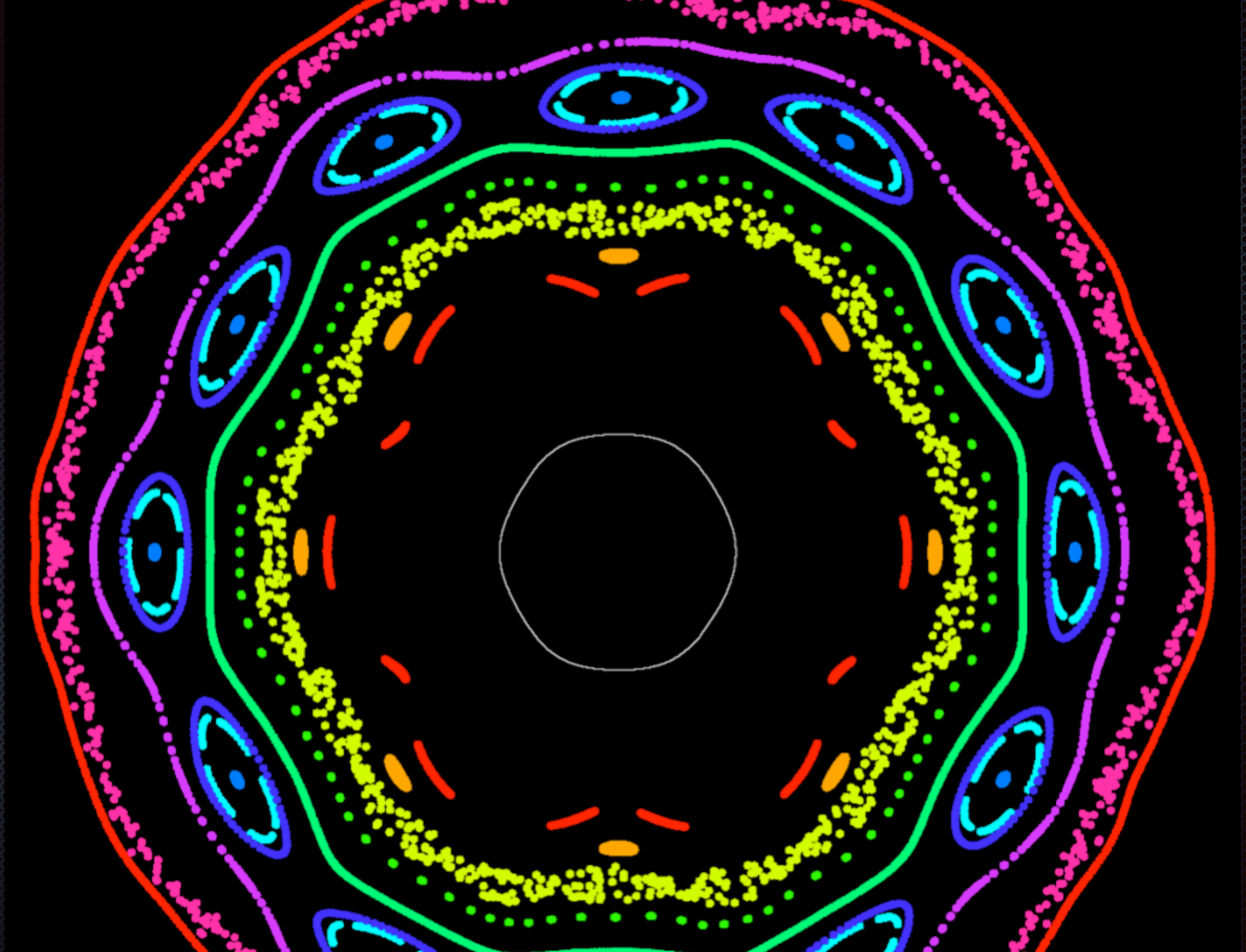
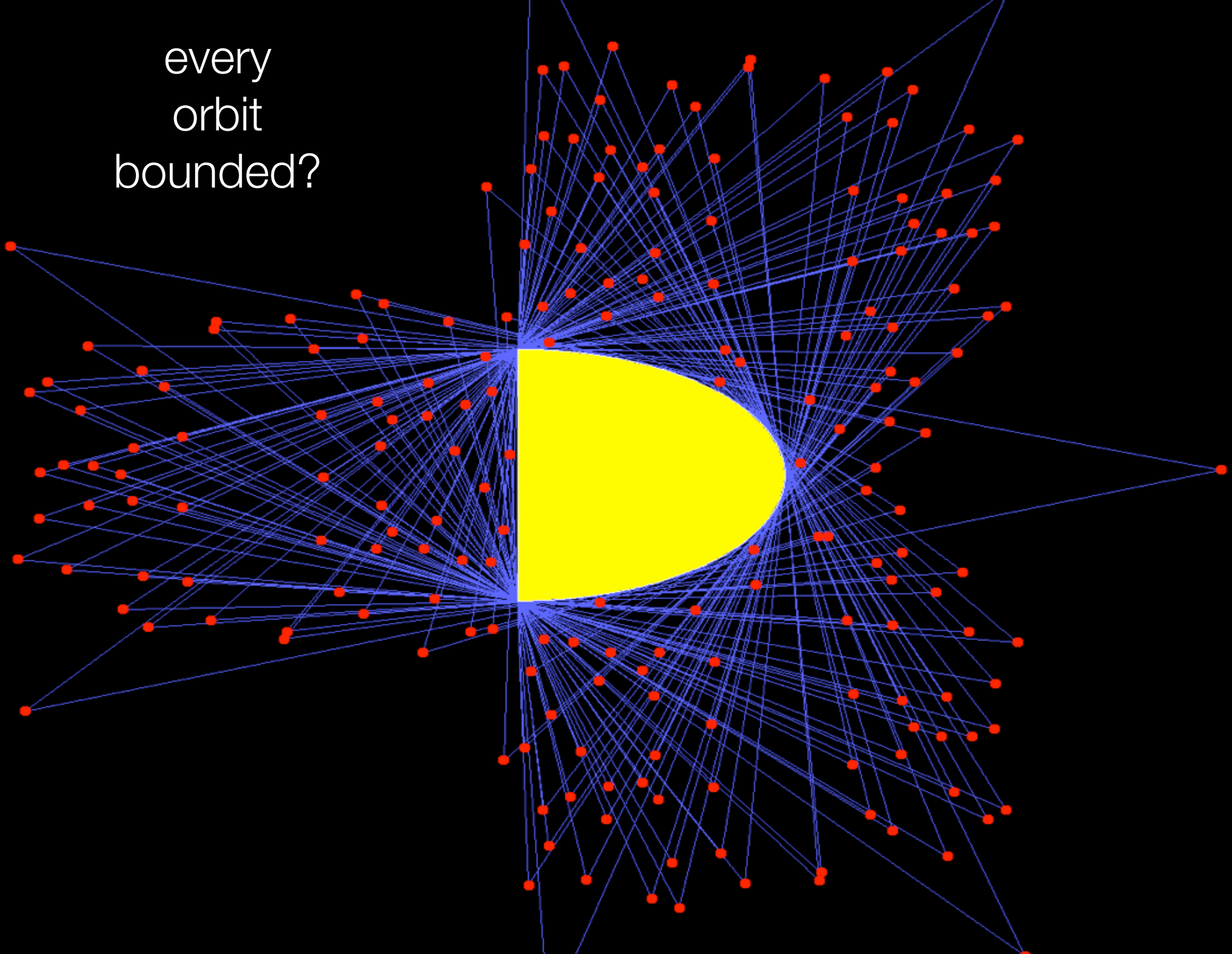
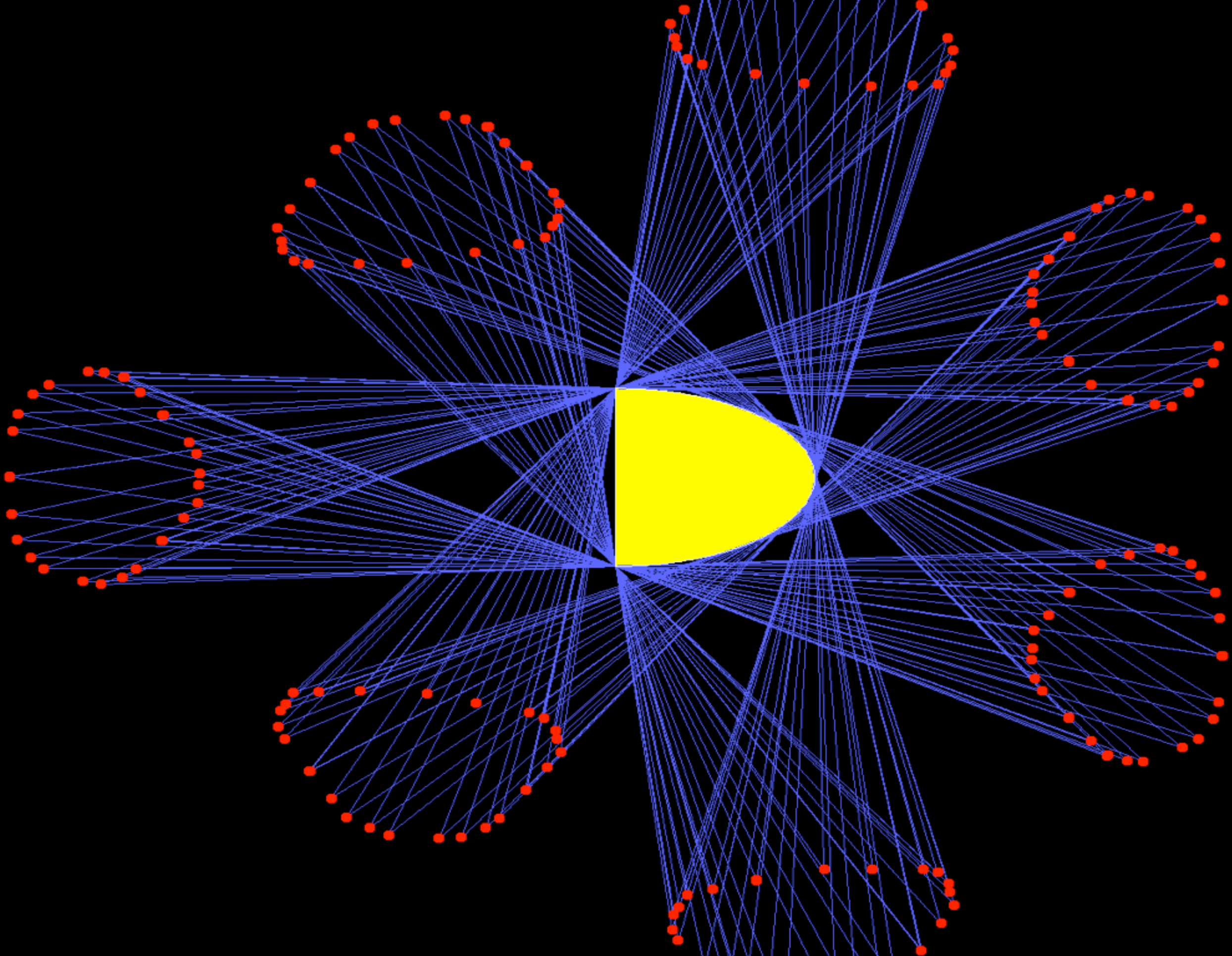
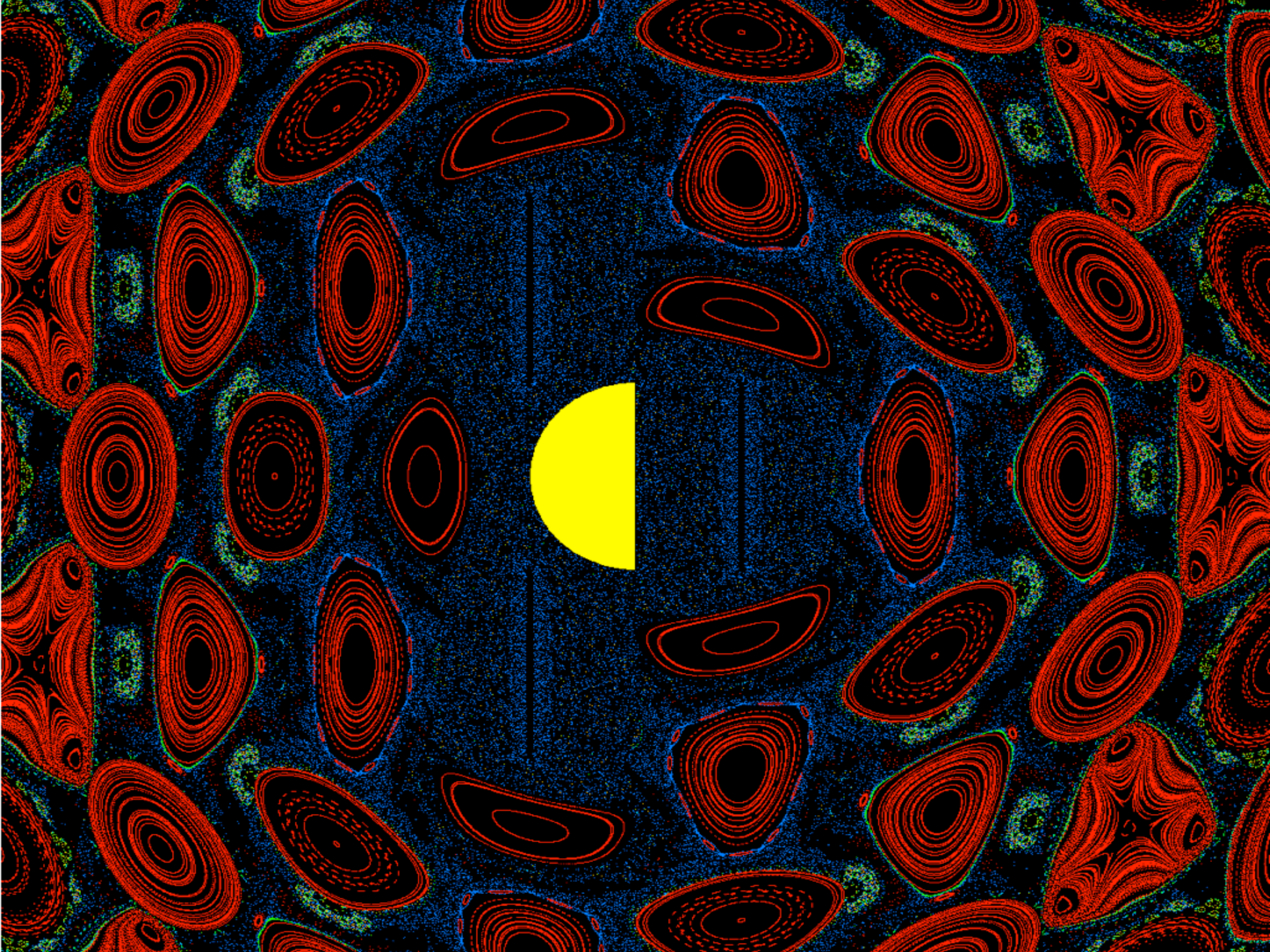


every
orbit
bounded?







x

$T(x) = c\ x\ (1-x)$

Bifurcation diagram of logistic map

3.0

3.5

4.0

c

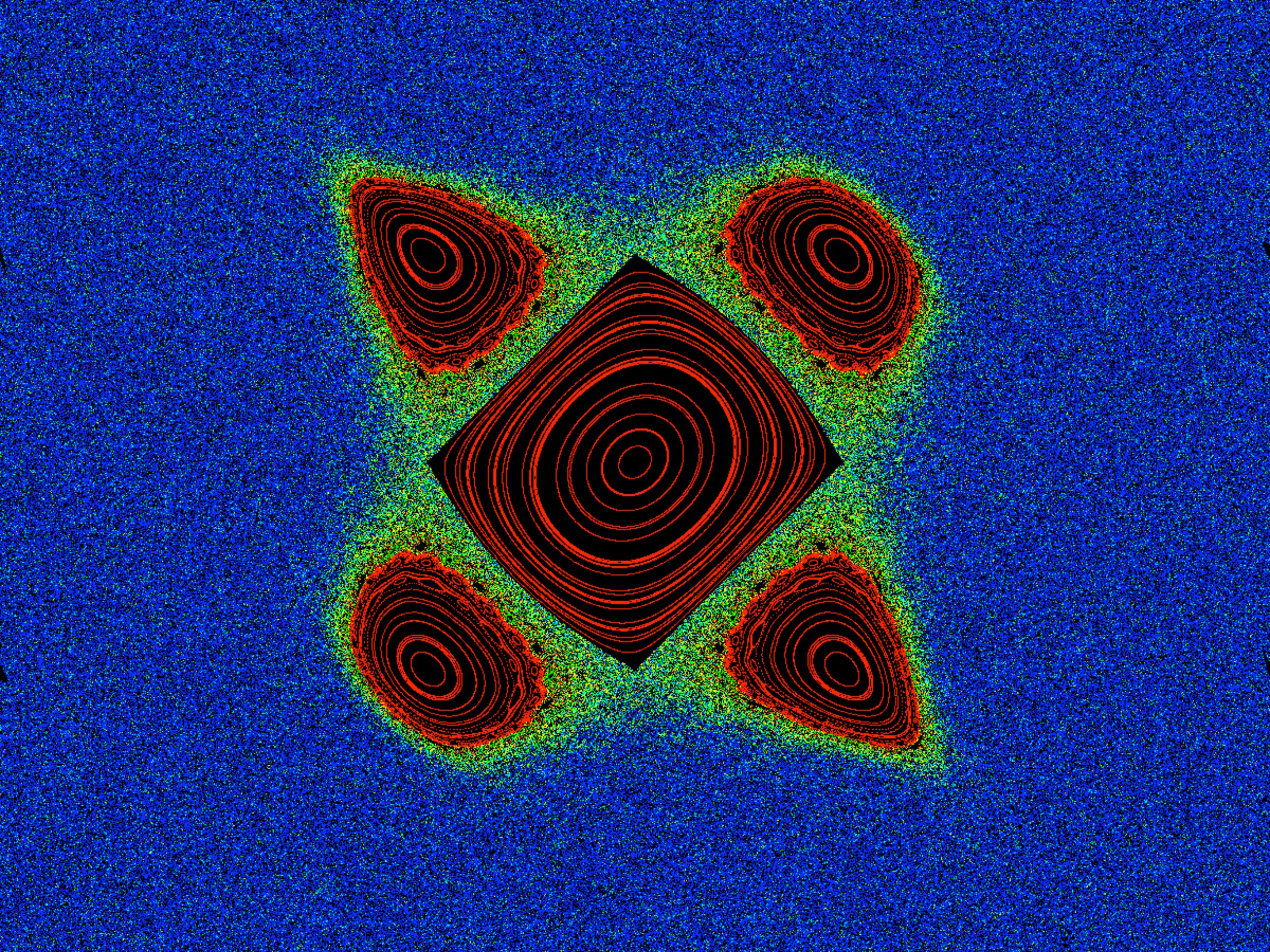
d_1

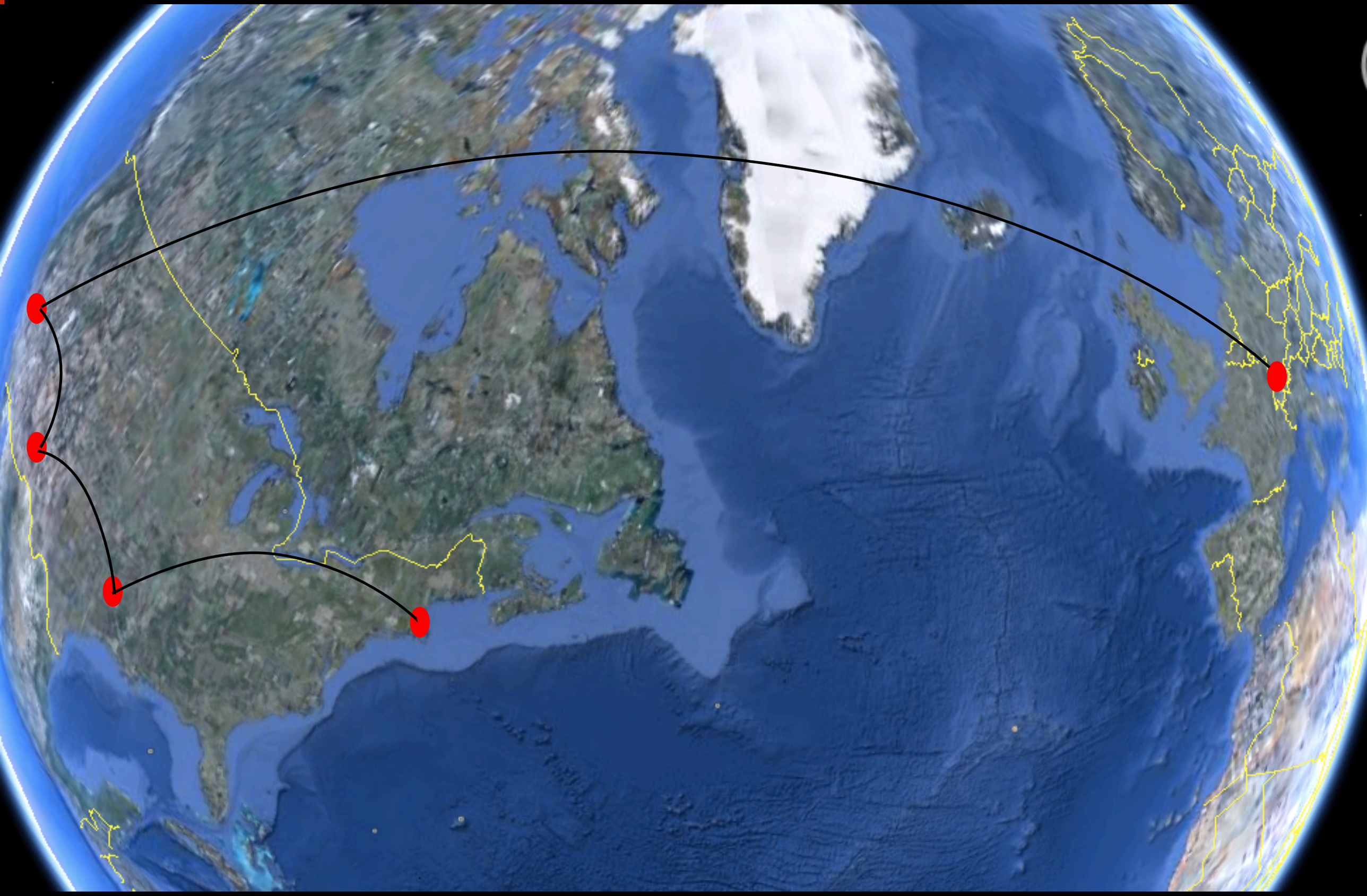
d_2

4.0

c


δ
ε





Letter Writers

This is a crucial thing

- several letters needed
- no control what is written
- one bad letter can be devastating

Dear Search Committee Chair,

I am writing this letter for Mr. Still Student who has applied for a position in your department. I should start by saying that I cannot recommend him too highly. In fact, there is no other student with whom I can adequately compare him, and I am sure that the amount of mathematics he knows will surprise you.

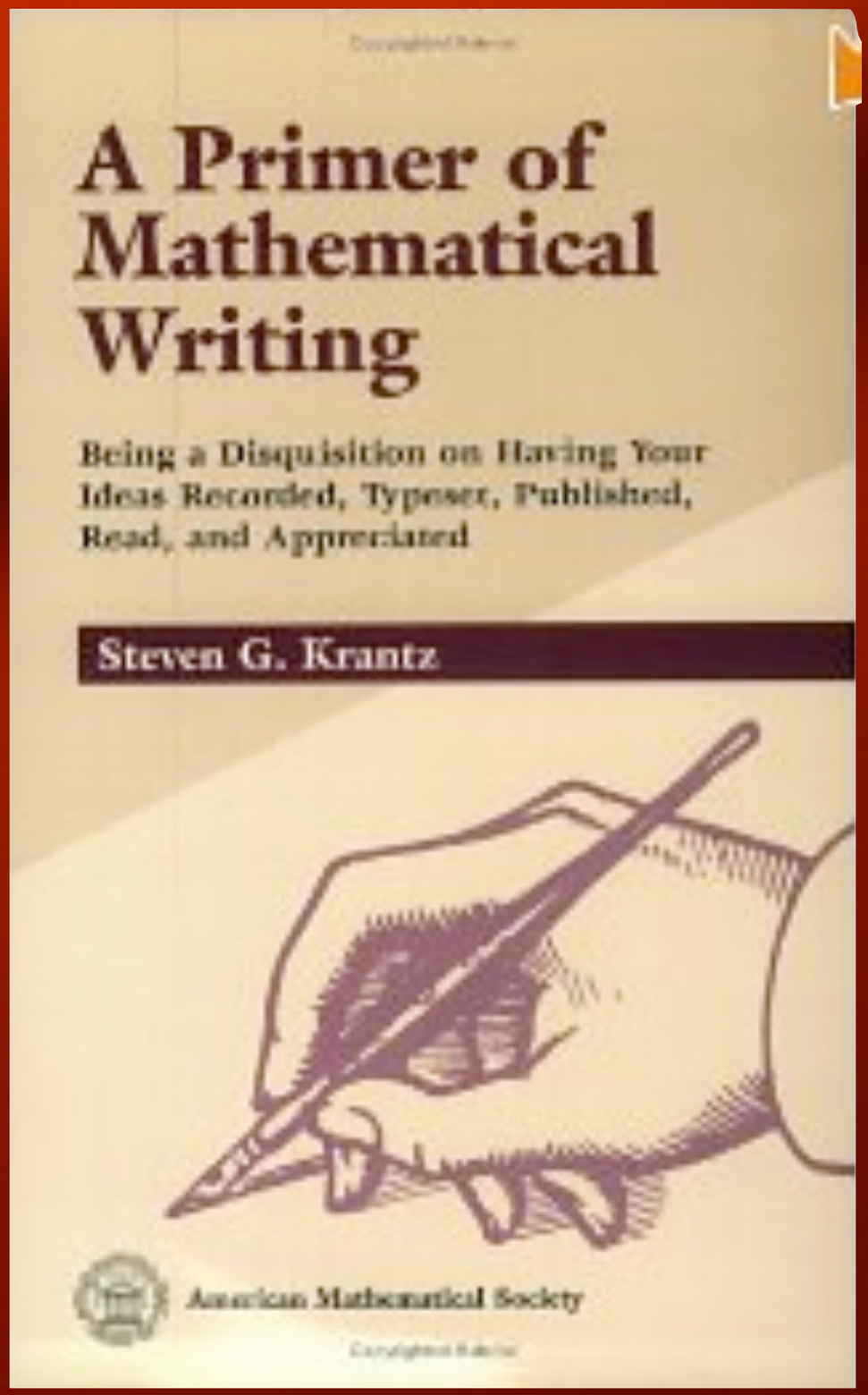
His dissertation is the sort of work you don't expect to see these days. It definitely demonstrates his complete capabilities.

In closing, let me say that you will be fortunate if you can get him to work for you.

Sincerely,
A. D. Advisor (Prof.)

-- from MAA Focus Newsletter

Letter writers



You have asked for my opinion on the tenure, and promotion to Associate Professor, of Dr. Aloysius K. Foofnar. Dr. Foofnar is now six years from the Ph.D., and in that time has produced nothing but some rotten teaching evaluations and a letter to the editor of the Two-Year College Math Journal. Based on that track record, my opinion is that he is worthy of neither tenure nor of promotion.

My own experience

- Grants
- Postdocs
- Green card

Research Topic

Wish List

- Needs to be fresh
- But not too fresh
- Not too crowded
- Not too ambitious

Risks?

- Follow your dreams?
- Try hard problems?
- Work independently?
- Be ambitious?

MIT Seminar
Dangerous Ideas

http://www.ai.mit.edu/lab/dangerous-ideas/

CSAIL

Seminar on

Dangerous Ideas

Five Questions:

Why do I need to **fear** your work?

Why should I **enjoy** your work ?

What can I tell your **mother** from it?

What's your **coolest** discovery ?

What is the most **recent** discovery?

Fear?

It has been said that the First World War was the CHEMISTS' WAR because mustard gas and chlorine were employed for the first time, and that the Second World War was the PHYSICISTS' WAR, because the atom bomb was detonated. Similarly, it has been argued that the Third World War would be the MATHEMATICIANS' WAR, because mathematics will have control over the next great weapon of war – information.


UDA
589
TAC
WIN

Cryptoanalysis

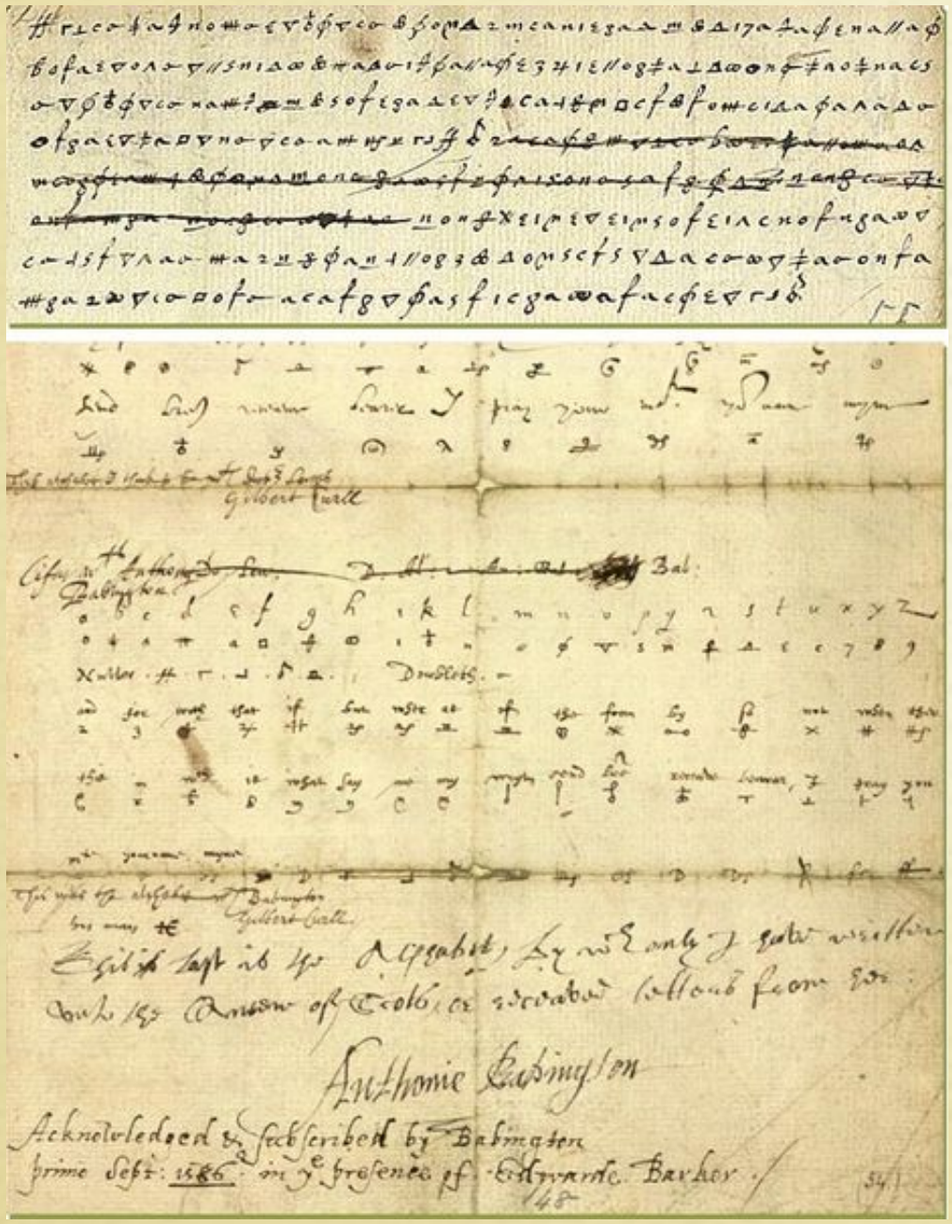
It started a long time ago:

- Al Kindi (801-873) first known recorded explanation of cryptanalysis
- Altbash (Hebrew)
  Cesar (Roman)

Until today: the NSA is the largest Employer of Mathematicians

- Al Kindi

Example I: Babington Plot



Cypher

Babington Plot 1585

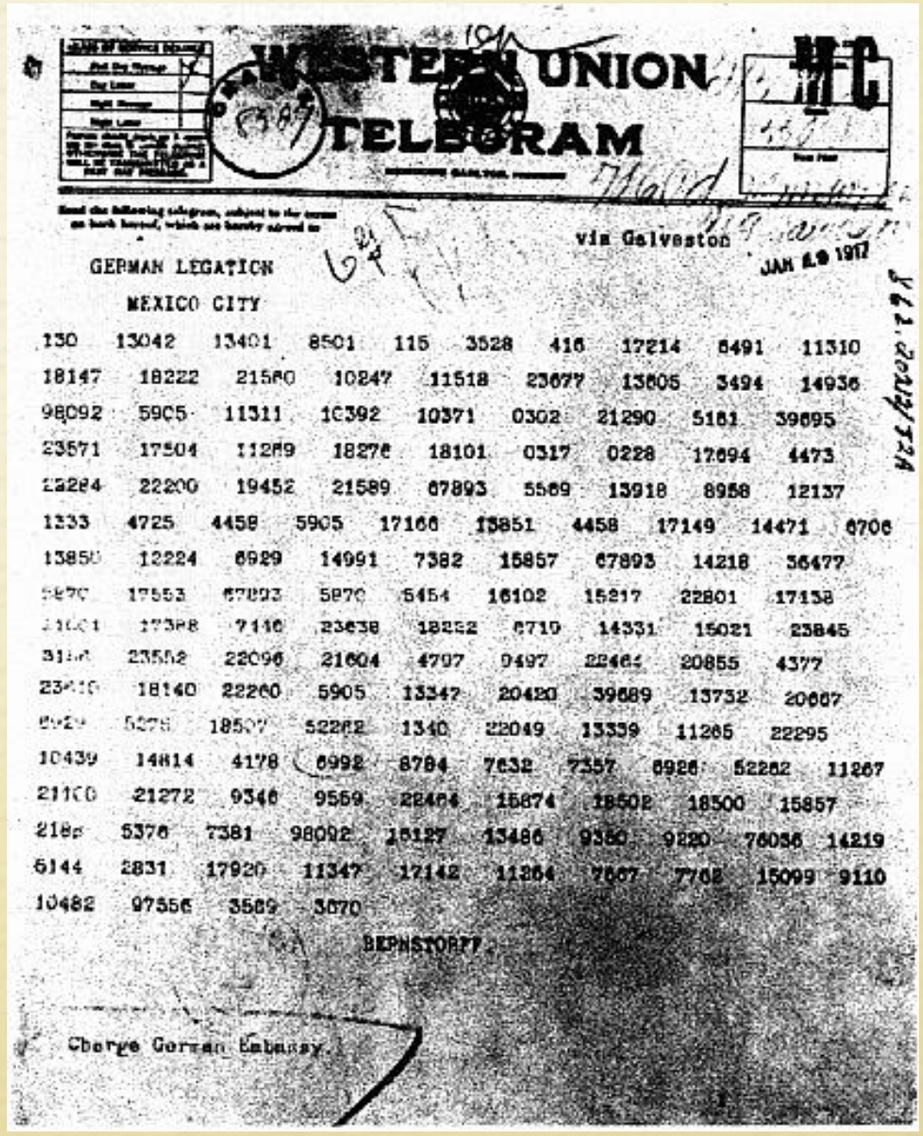
Mary I Queen of Scots
executed 1587

Example 2: Zimmerma Telegram

TELEGRAM RECEIVED.

FROM 2nd from London # 5747.

"We intend to begin on the first of February unrestricted submarine warfare. We shall endeavor in spite of this to keep the United States of America neutral. In the event of this not succeeding, we make Mexico a proposal of alliance on the following basis: make war together, make peace together, generous financial support and an understanding on our part that Mexico is to reconquer the lost territory in Texas, New Mexico, and Arizona. The settlement in detail is left to you. You will inform the President of the above most secretly as soon as the outbreak of war with the United States of America is certain and add the suggestion that he should, on his own initiative, invite Japan to immediate adherence and at the same time mediate between Japan and ourselves. Please call the President's attention to the fact that the ruthless employment of our submarines now offers the prospect of compelling England in a few months to make peace." Signed, ZIMMERMANN.


WESTERN UNION TELEGRAM

via Galveston

JAN 19 1917

GERMAN LEGATION
MEXICO CITY

130 13042 13401 8501 115 3528 416 17214 6491 11310
18147 18222 21560 10247 11518 23677 13605 3494 14936
98092 5905 11311 10392 10371 0302 21290 5161 39695
23571 17504 11269 18276 18101 0317 0228 17694 4473
22284 22200 19452 21589 67893 5569 13918 8958 12137
1333 4725 4458 5905 17166 13851 4458 17149 14471 6706
13850 12224 6929 14991 7382 15857 67893 14218 36477
5870 17553 67893 5870 5454 16102 15217 22801 17138
17388 7110 23638 18252 6719 14331 15021 23845
23552 22096 21604 4797 9497 22464 20855 4377
18140 22260 5905 13347 20420 39689 13732 20667
5278 18507 52262 1340 22049 13339 11265 22295
10439 14814 4178 6992 8784 7632 7357 6926 52262 11267
21100 21272 9346 9559 22464 15874 18502 18500 15857
5376 7381 98092 16127 13486 9350 9220 76036 14219
6144 2831 17920 11347 17142 11264 7667 7762 15099 9110
10482 97556 3569 3070

BERNSTORFF.

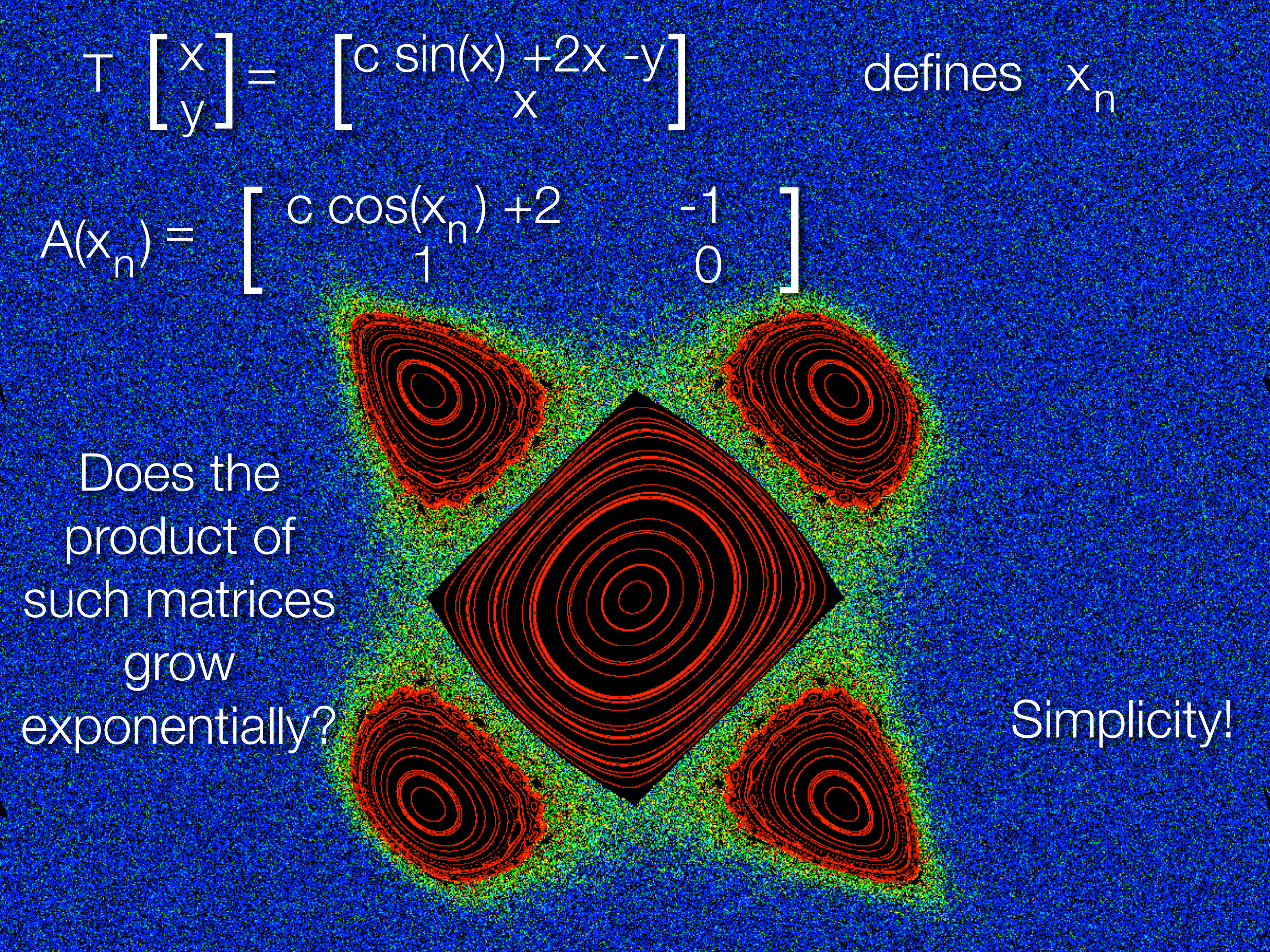
Charge German Embassy.

Sent from Germany to Washington to Mexico January 16, 1917

Enjoy?

$$T\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} c\sin(x) + 2x - y \\ x \end{bmatrix}$$ defines x_n

$$A(x_n) = \begin{bmatrix} c\cos(x_n) + 2 & -1 \\ 1 & 0 \end{bmatrix}$$



Does the product of such matrices grow exponentially?

Simplicity!

Tell Mom?

May 18, 2010

OMNIVIS:

3D Space and Camera Path Reconstruction for Omnidirectional Vision

Oliver Knill
Director

Jeff Parker
Research Advisor

Jose L. Ramirez
Master in IT

OMNIVIS HARVARD

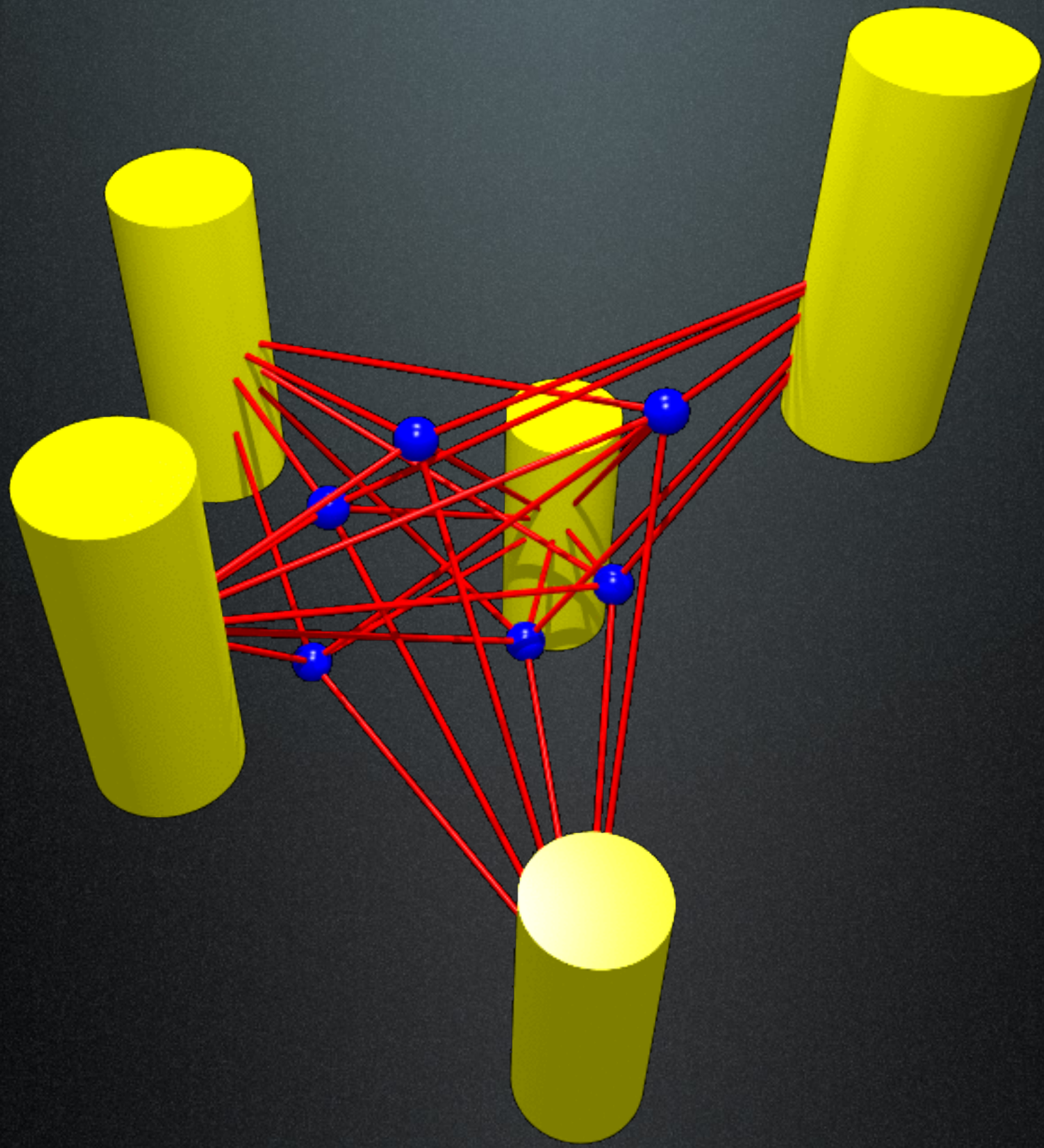
Exhibit

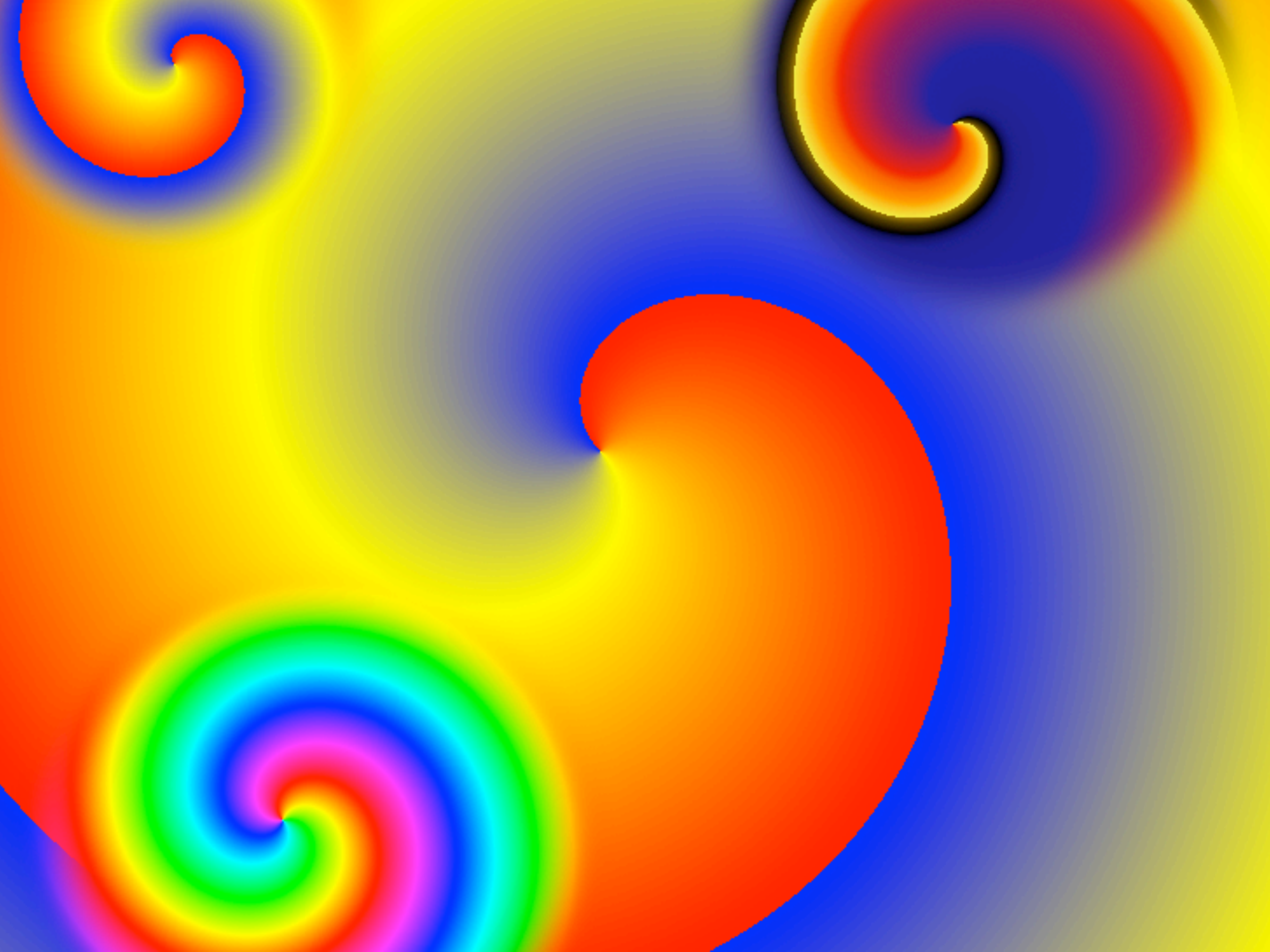
http://math.harvard.edu/~knill/3dscan2/papers/index.html

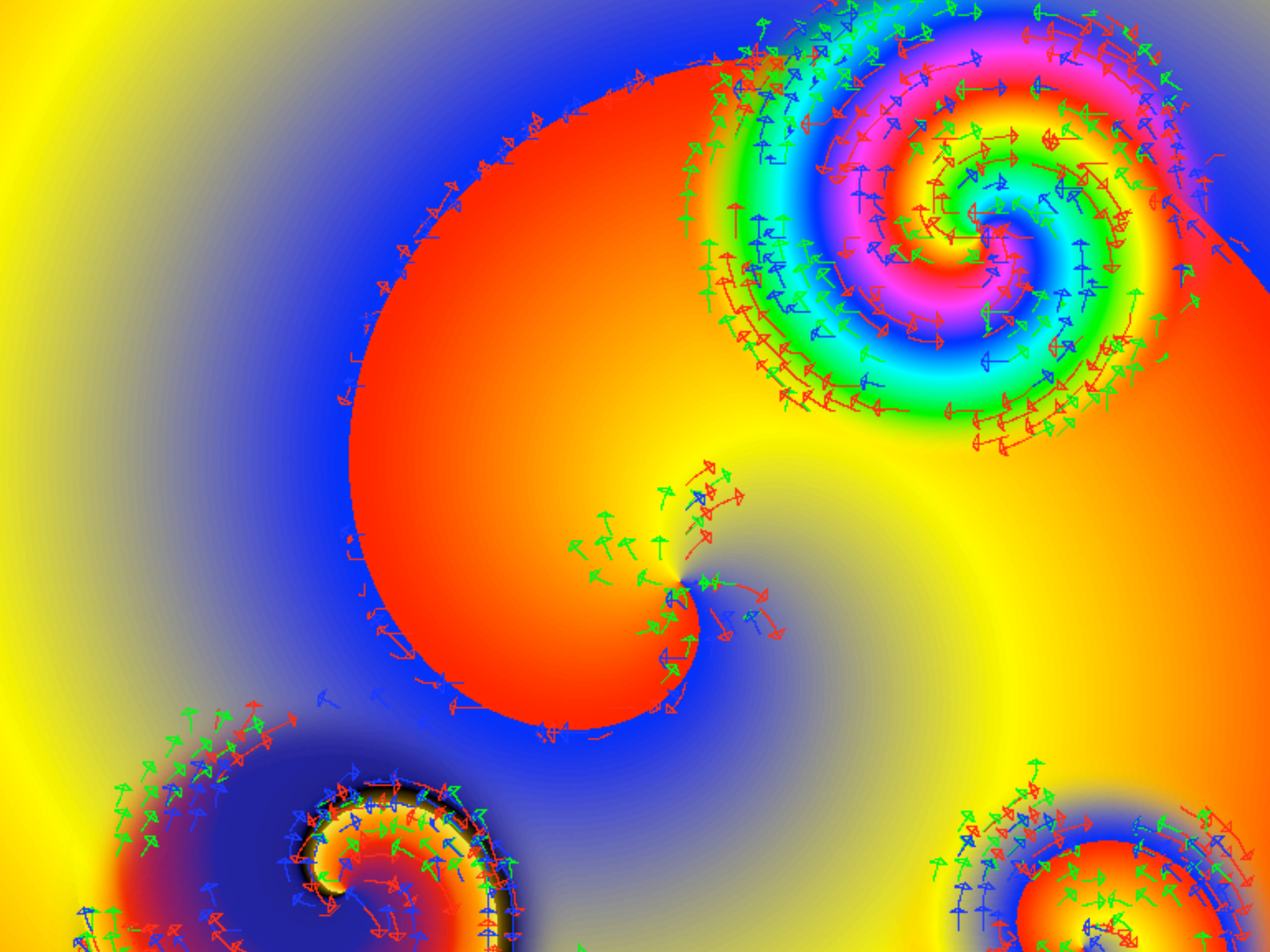

IMMERSIVE
MEDIA

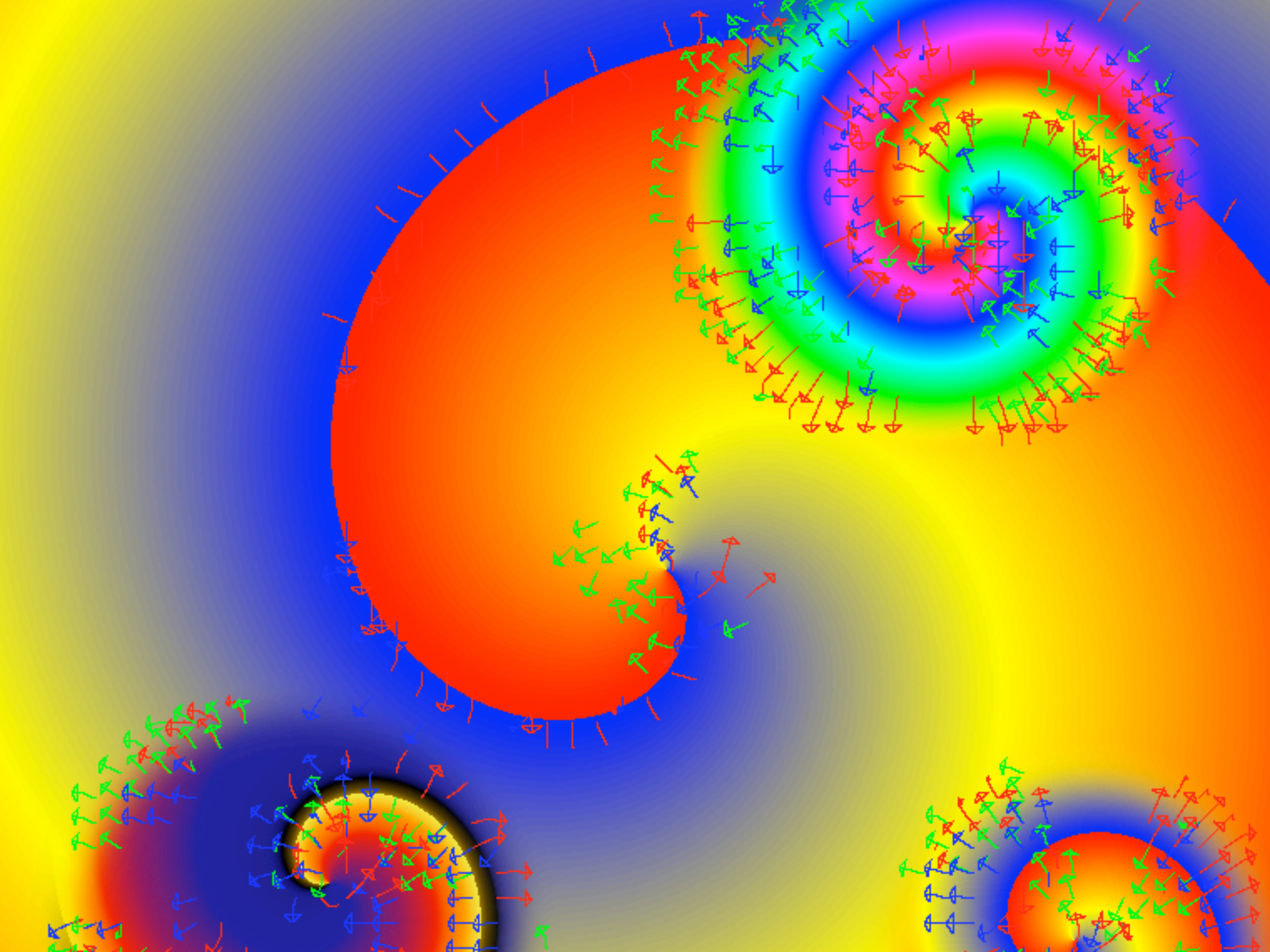
Google Street View Video - Harvard

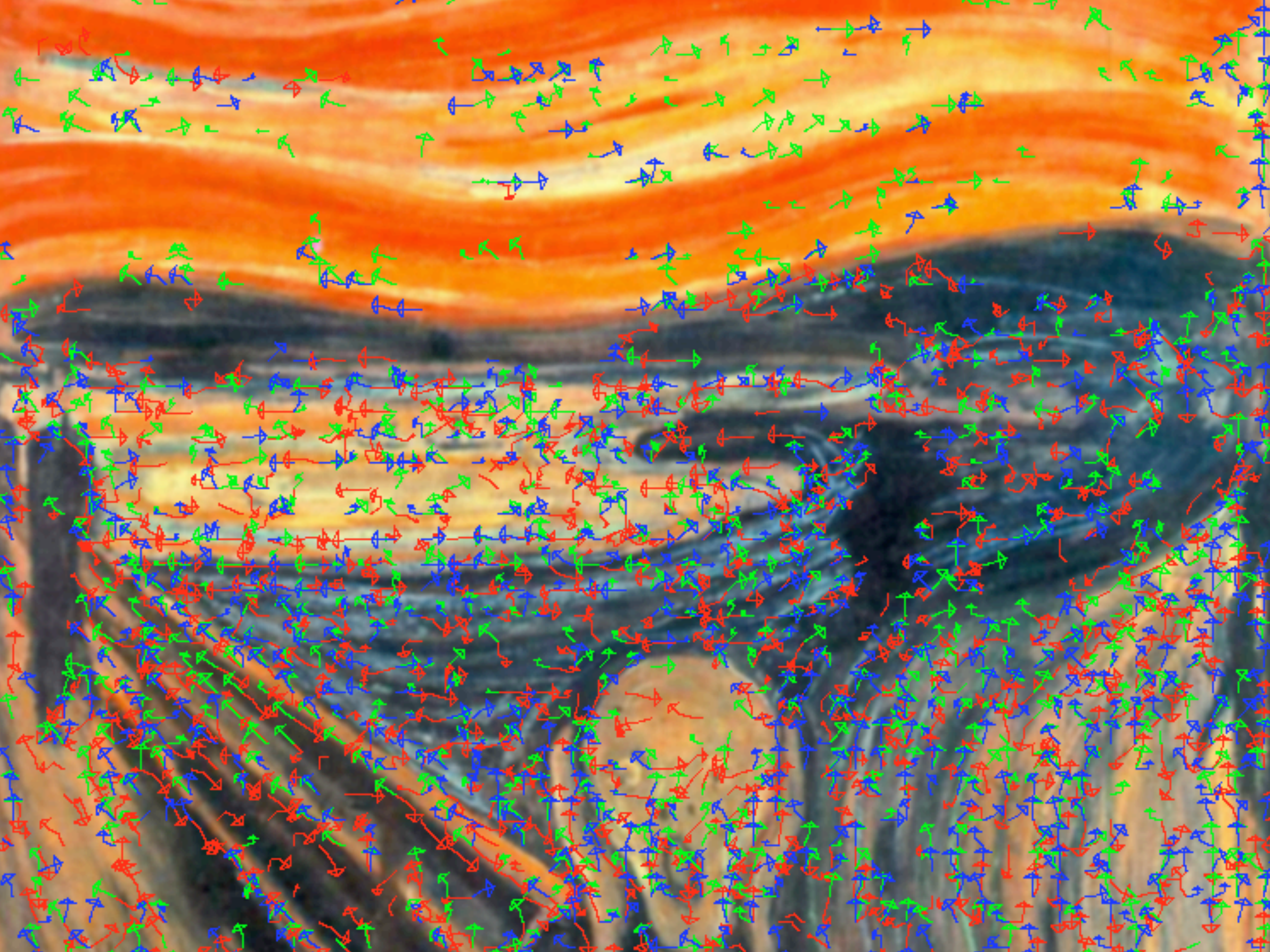
Structure from Motion











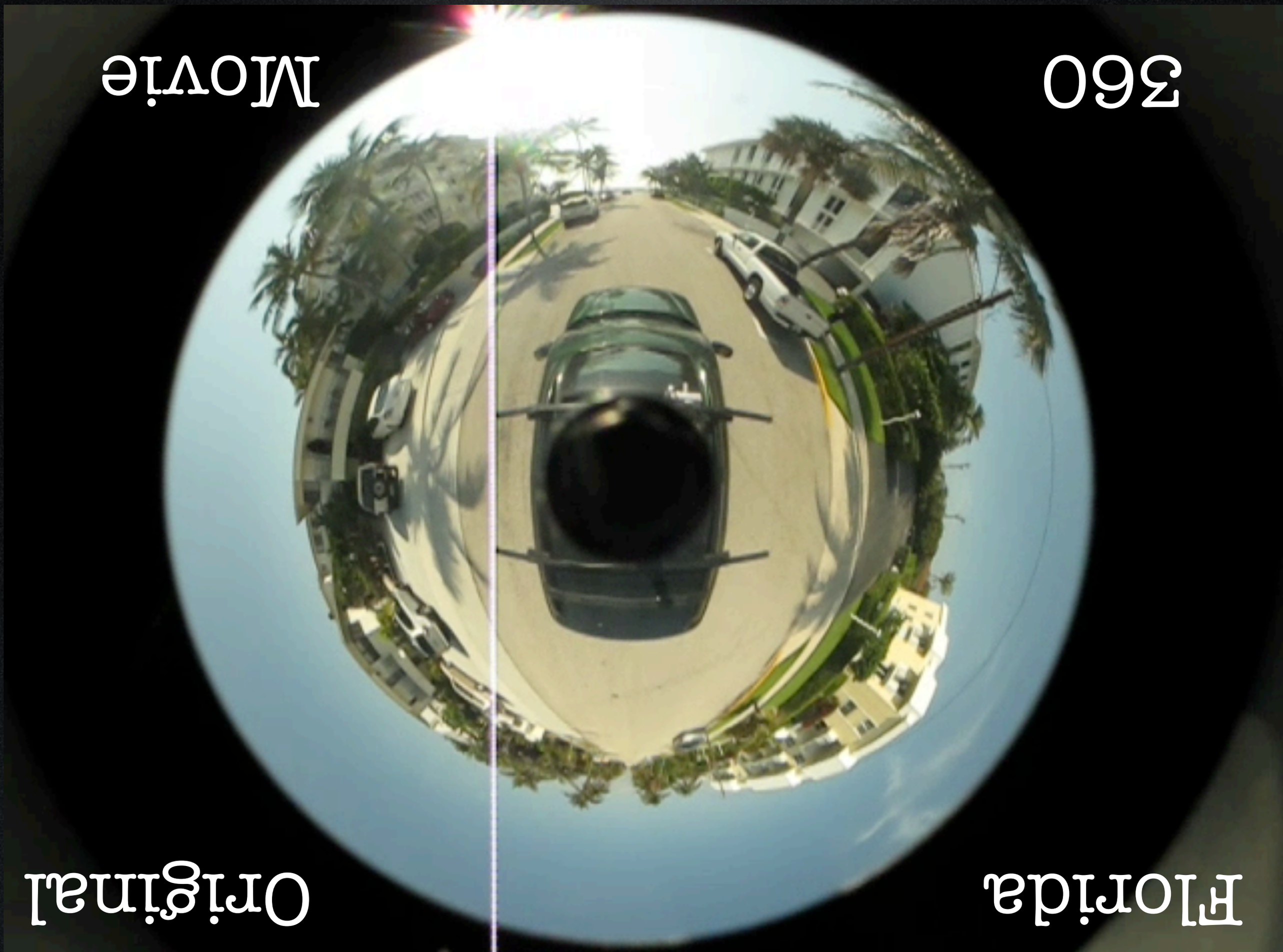

tracing level curves

done with our code

tracing level curves of a picture

360

Movie

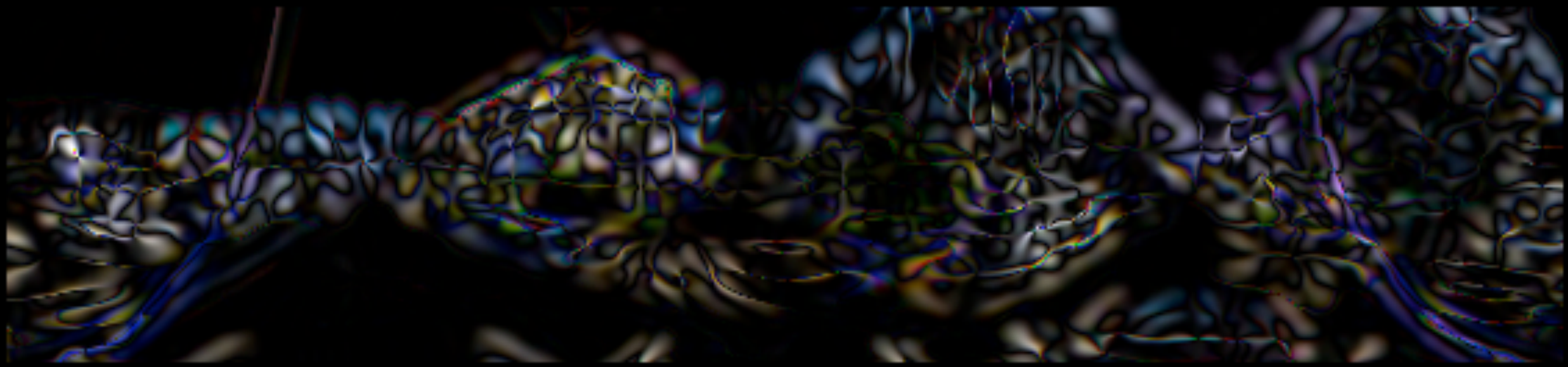


Florida

Original

Florida Scene, Gaussian Smoothing

Florida Scene, Curvature



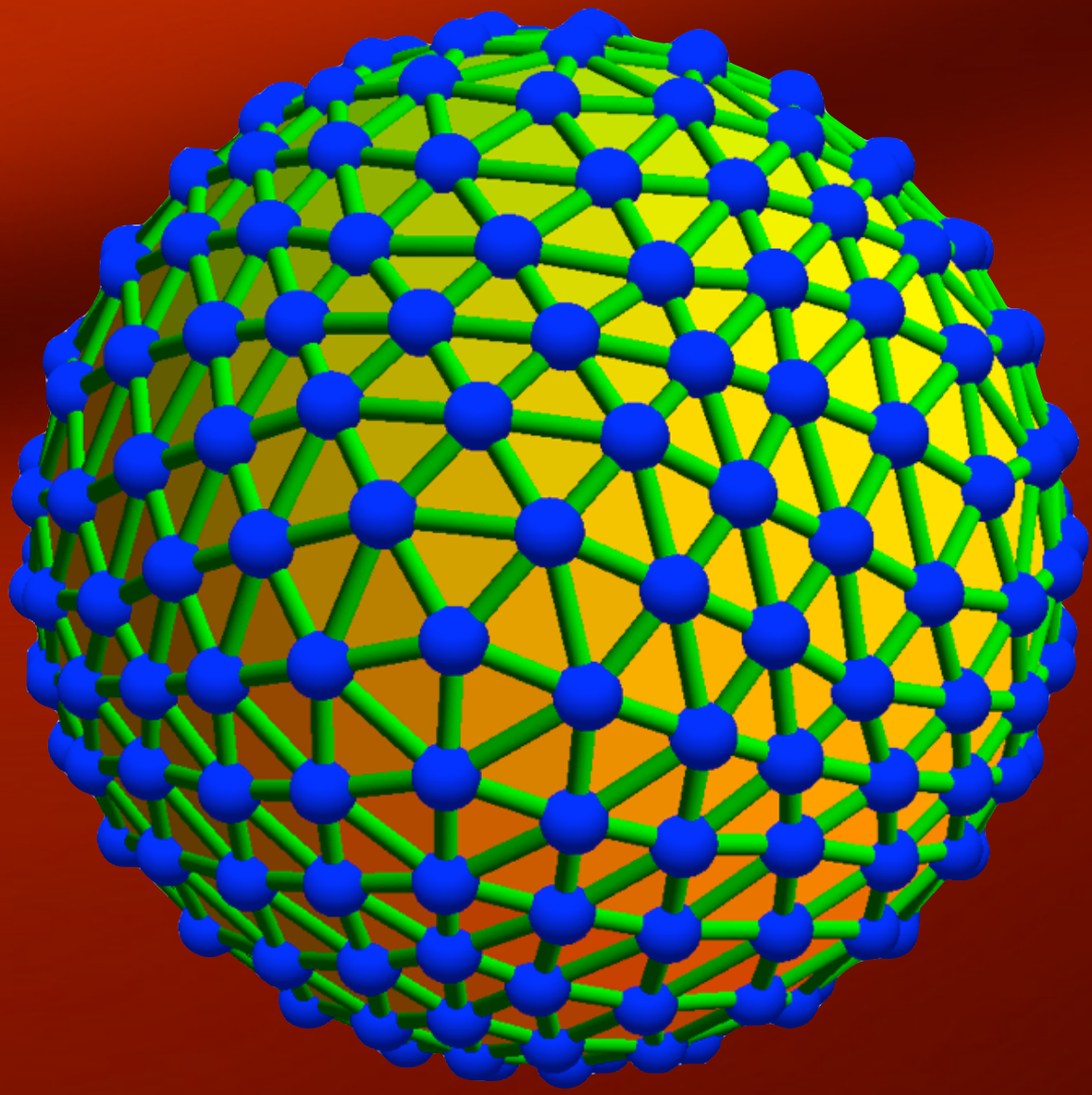
Florida Scene, Gradient

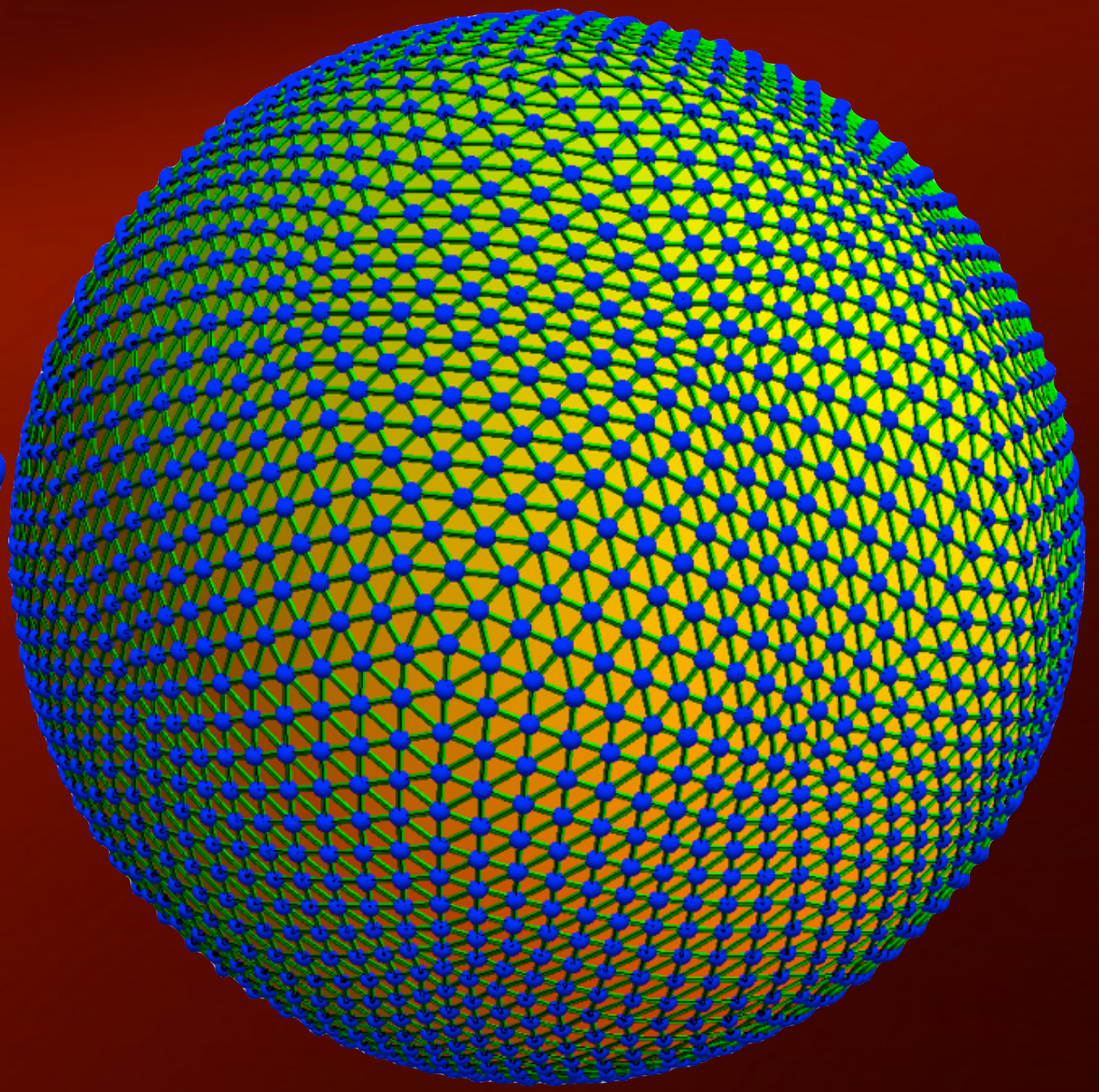
Florida Scene, Tracking

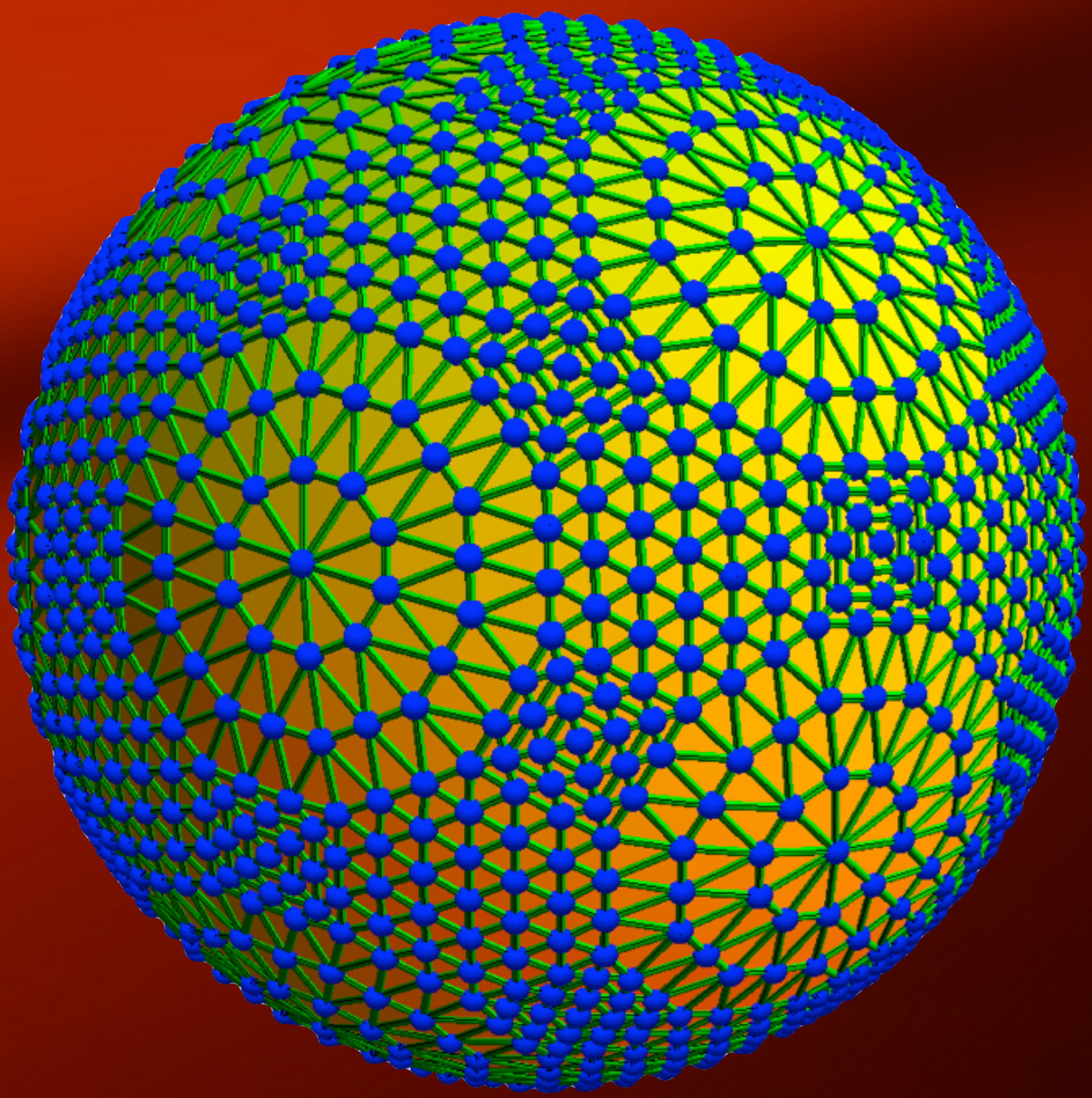
Florida, different Smoothing

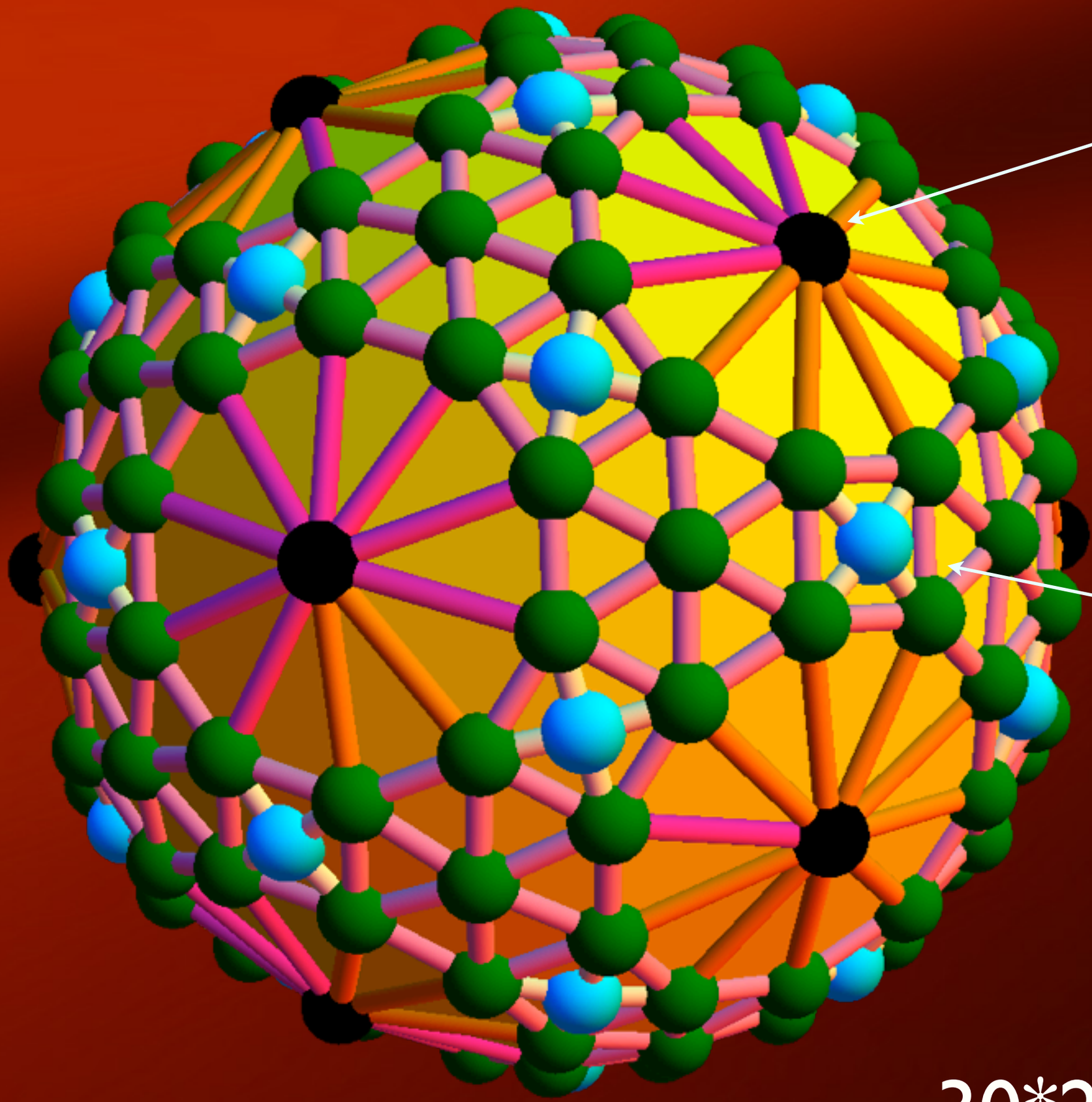
Coolest Discovery

Graphs









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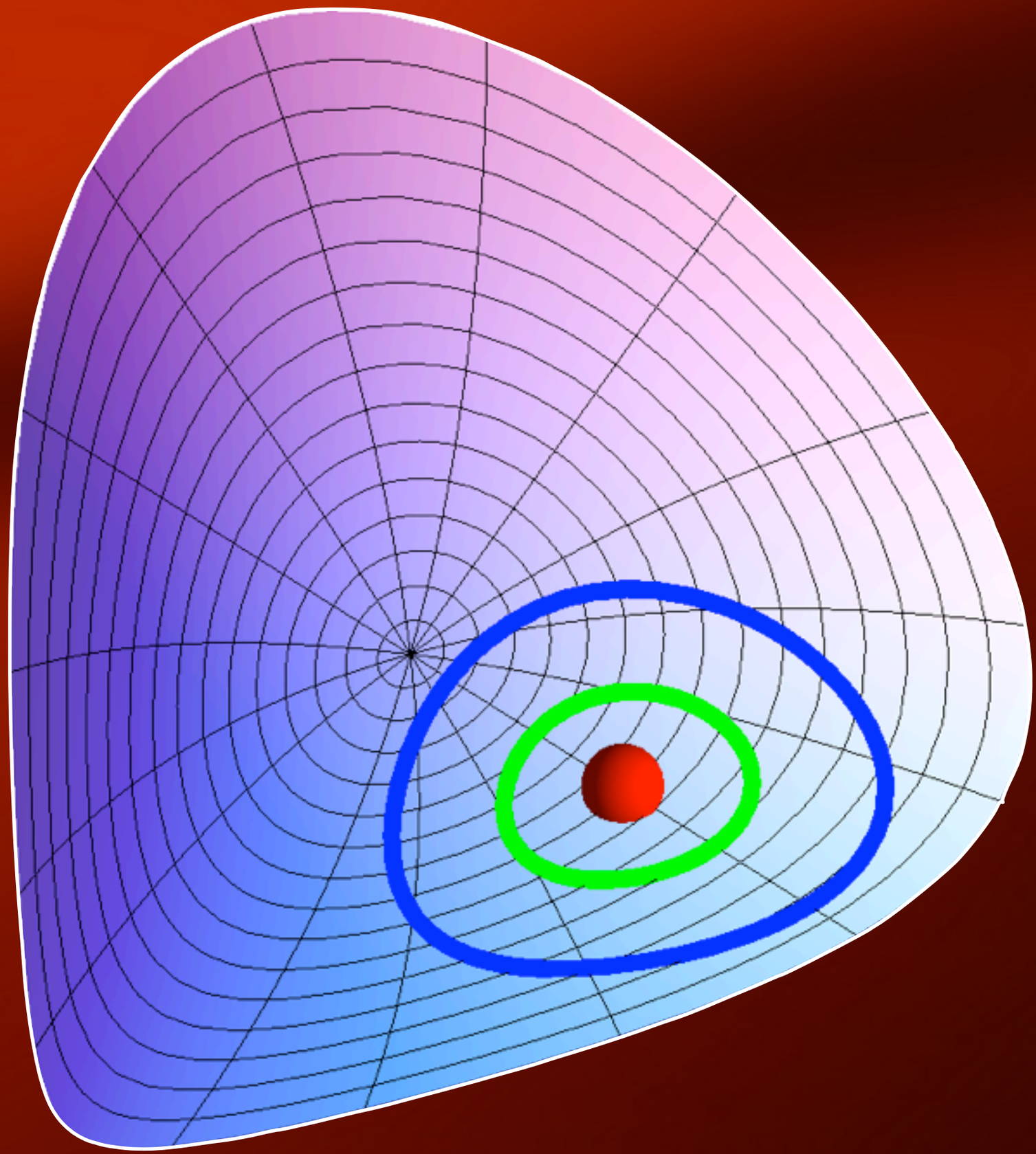

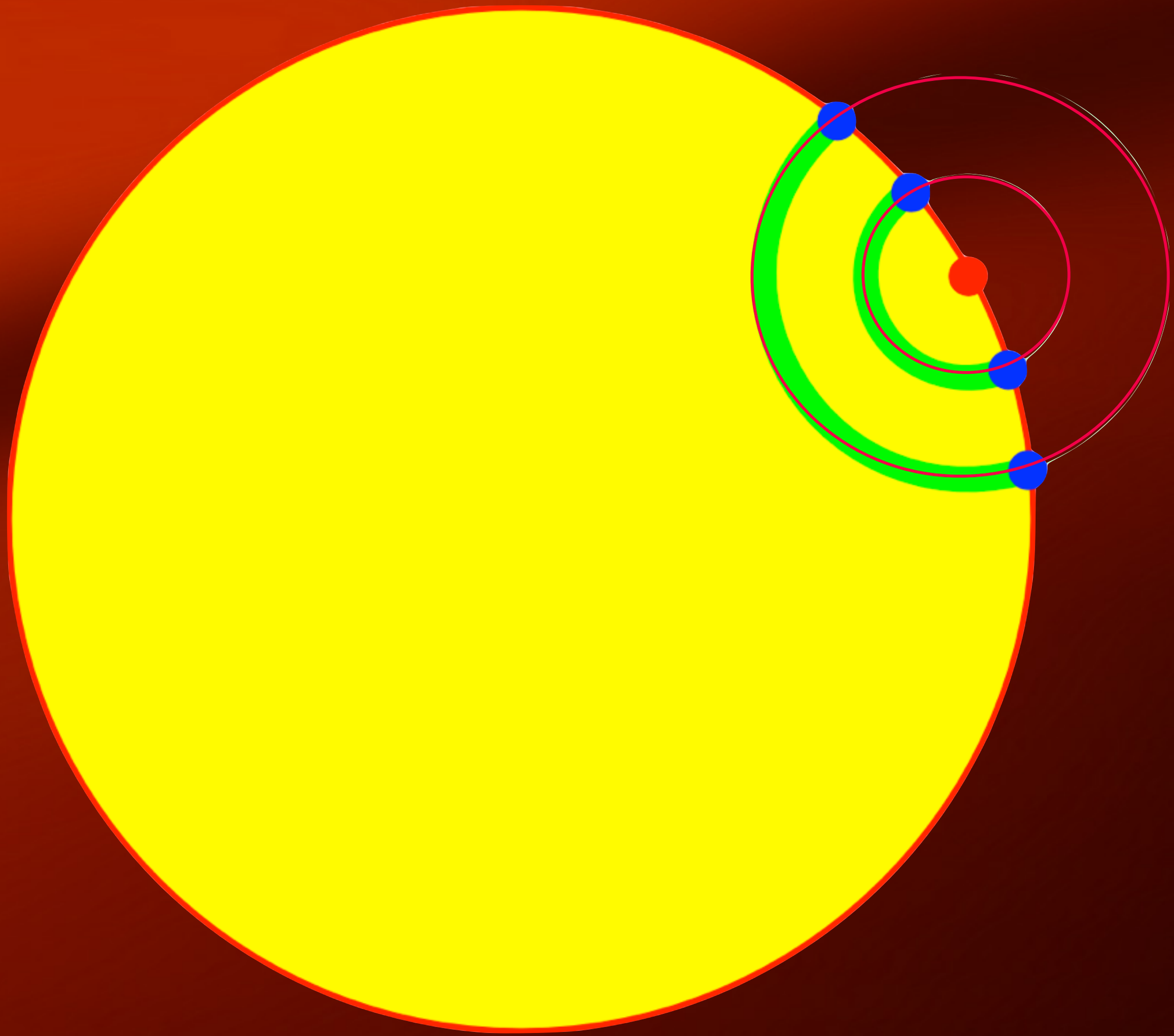

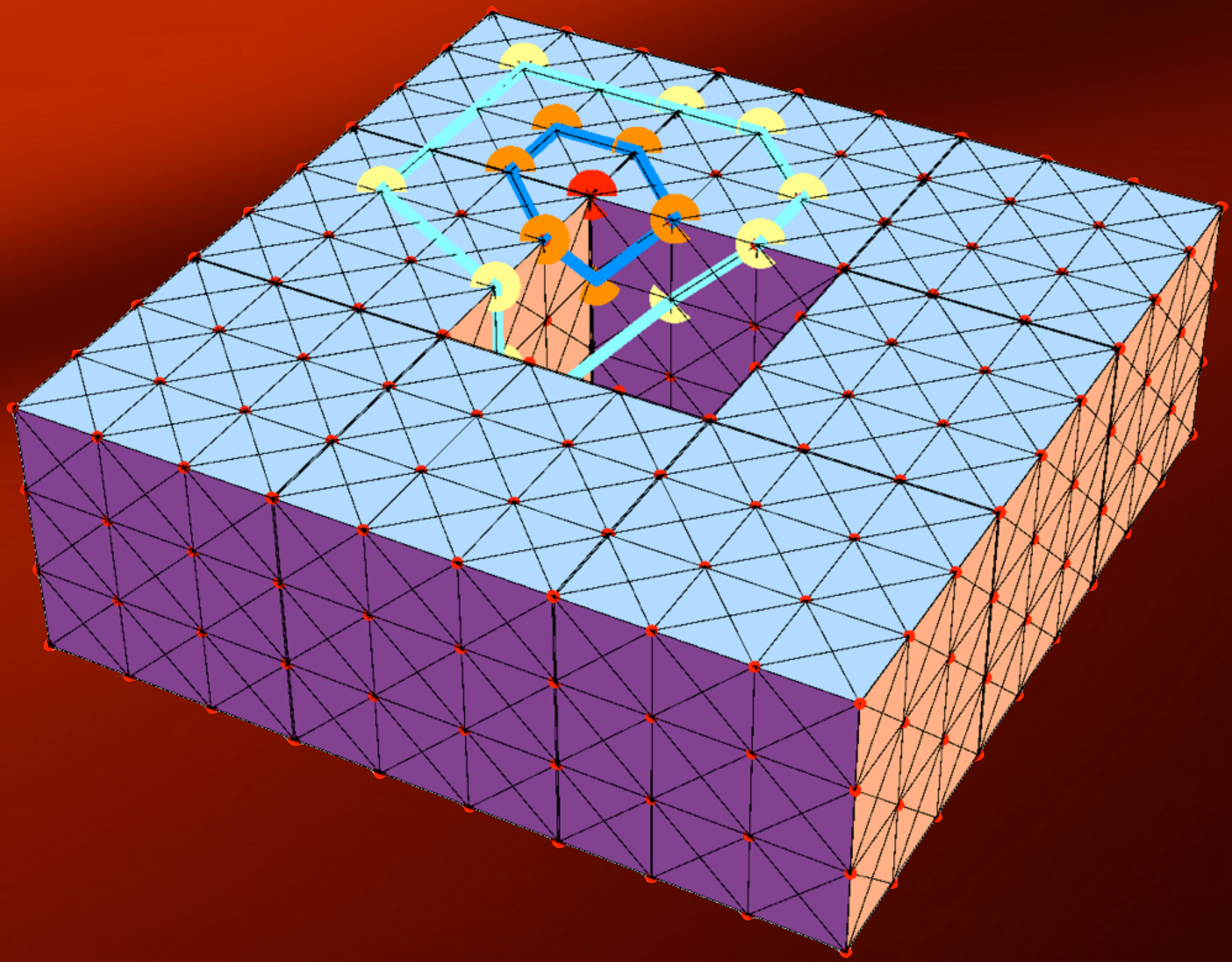

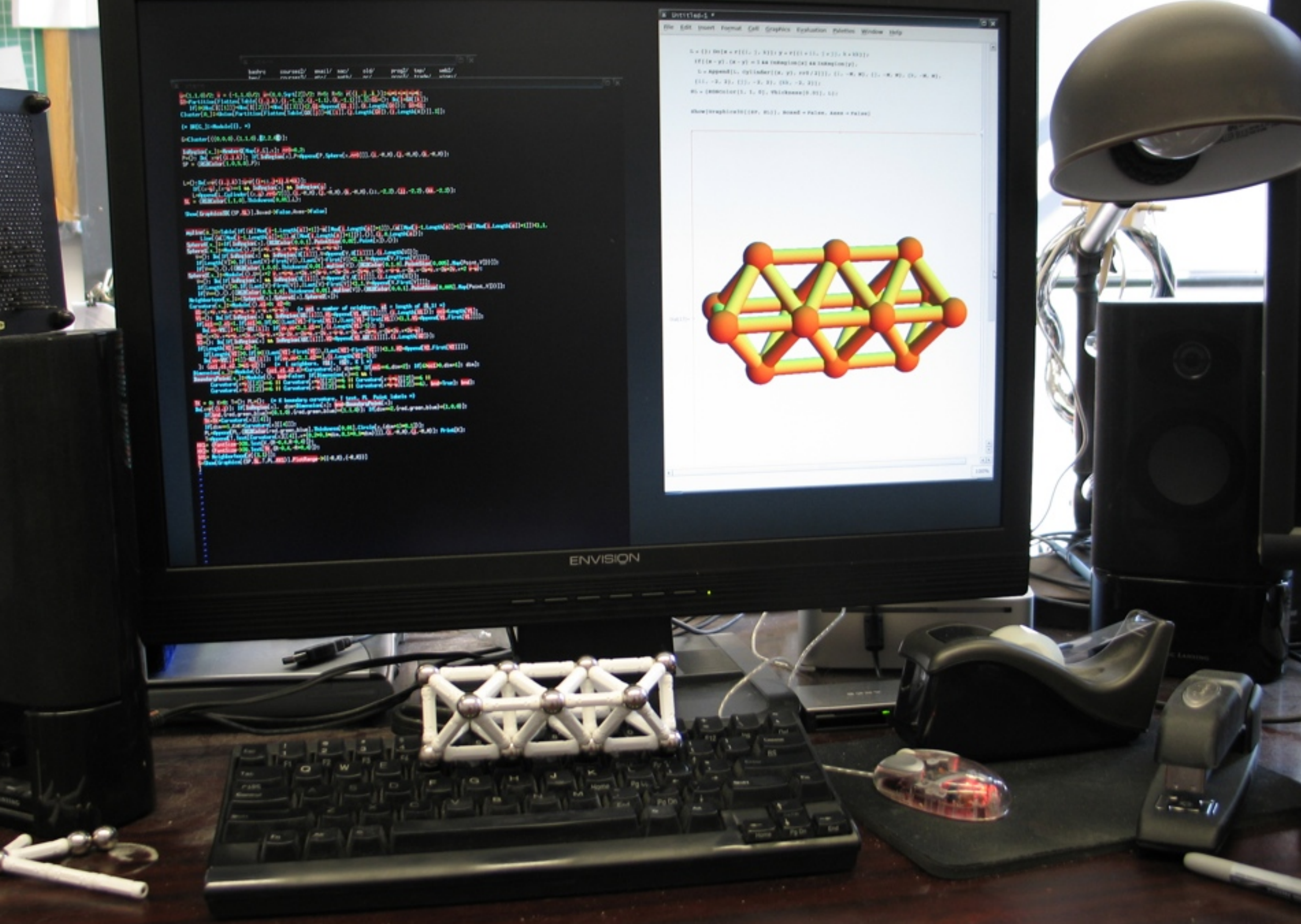
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ENVISION

Out[32]= {16385, 16386, 16387, 16388}

In[33]:= Triangles[{16485,16387}]

Out[33]= {}

In[34]:= InteriorP

Out[34]= {1, 17, 65, 66, 67, 68, 257, 258, 259, 260, 1000,

> 1026 4099, 4100, 16385, 16386, 16387, 1

Part 1 o st.

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lyhedr

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cylinder4.m cylinder5.png cylinder6

cylinder4.png cylinder6.m cylinder6

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{16388, 16385},

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6}, {19, 67},

, {4100, 16388},

257, 1028},

5}, {19, 66},

, {4100, 16387},

}, {1026, 18},

}, {16388, 260},

}, {1026, 19},

}, {16388, 257}}

4100.}, {1000., 65.},

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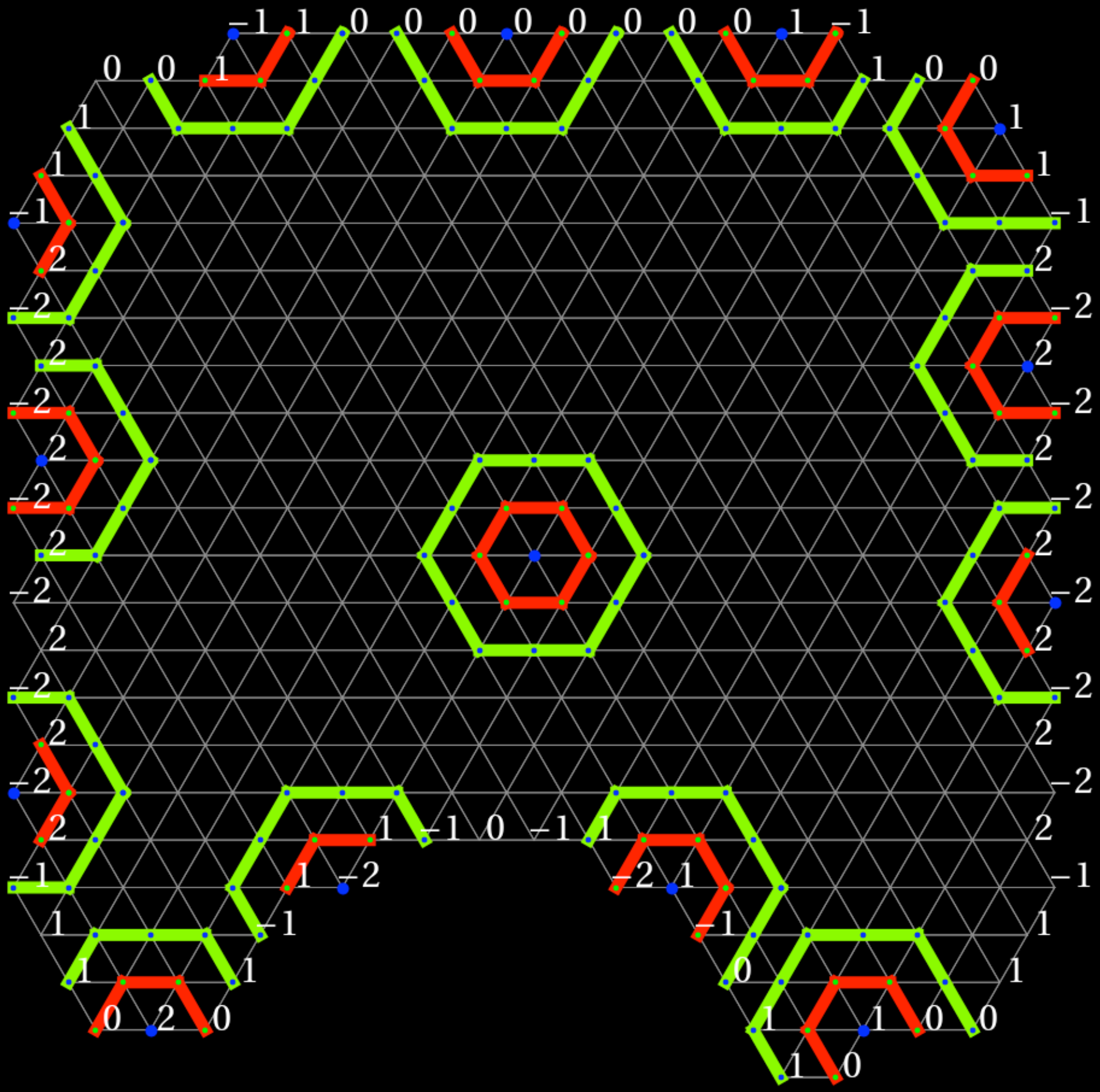
DELL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```
In[130]:= tri = {{1, 0}, {0, 1}, {-1, 1}, {-1, 0}, {0, -1}, {1, -1}}; (*tangent spaces*)
          connection[{p_, t_}] := Module[{}, If[BoundaryPoint[p + t], -t, t]]
          ExpMap[{p_, t_}] := {p + t, connection[{p + t, t}]}
          {p0, t0} = {{1, 1}, {1, -1}};
          orbit = NestList[ExpMap, {p0, t0}, 10];
          Orbit =
            Show[
              Graphics[
               {{Thickness[0.05], RGBColor[0, 0, 1],
                 Table[Point[r[orbit[[k, 1]]]], {k, Length[orbit]}],
                {PointSize[0.01], RGBColor[0.4, 0.6, 1],
                 Line[Table[r[orbit[[k, 1]]], {k, Length[orbit]}]]}}]];
          Show[GBSO, Orbit]
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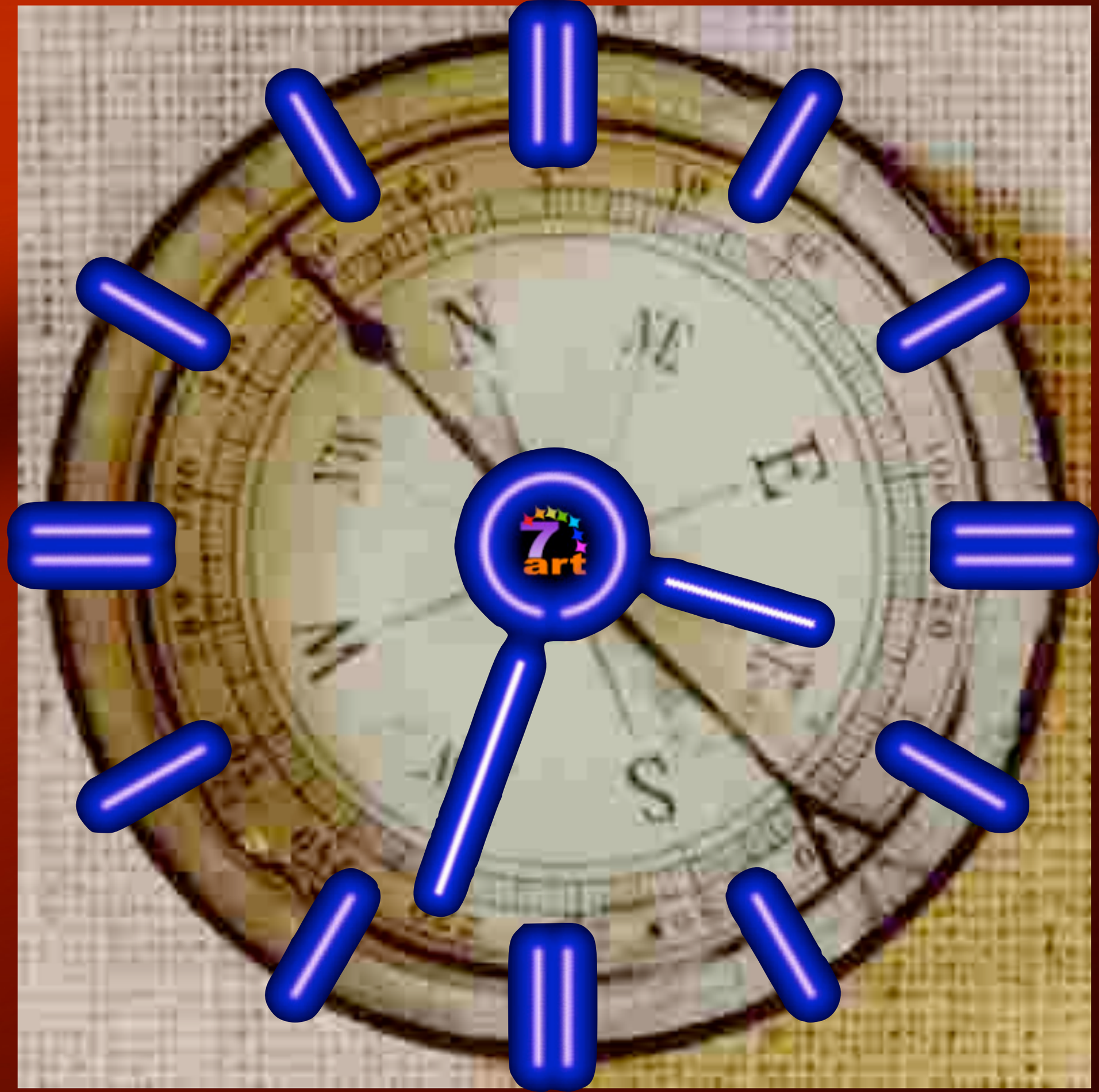
Out[131]=

Most recent problem

Spectra

$$A_{nm} = \cos(n^2 m\, \alpha + m\, \beta)$$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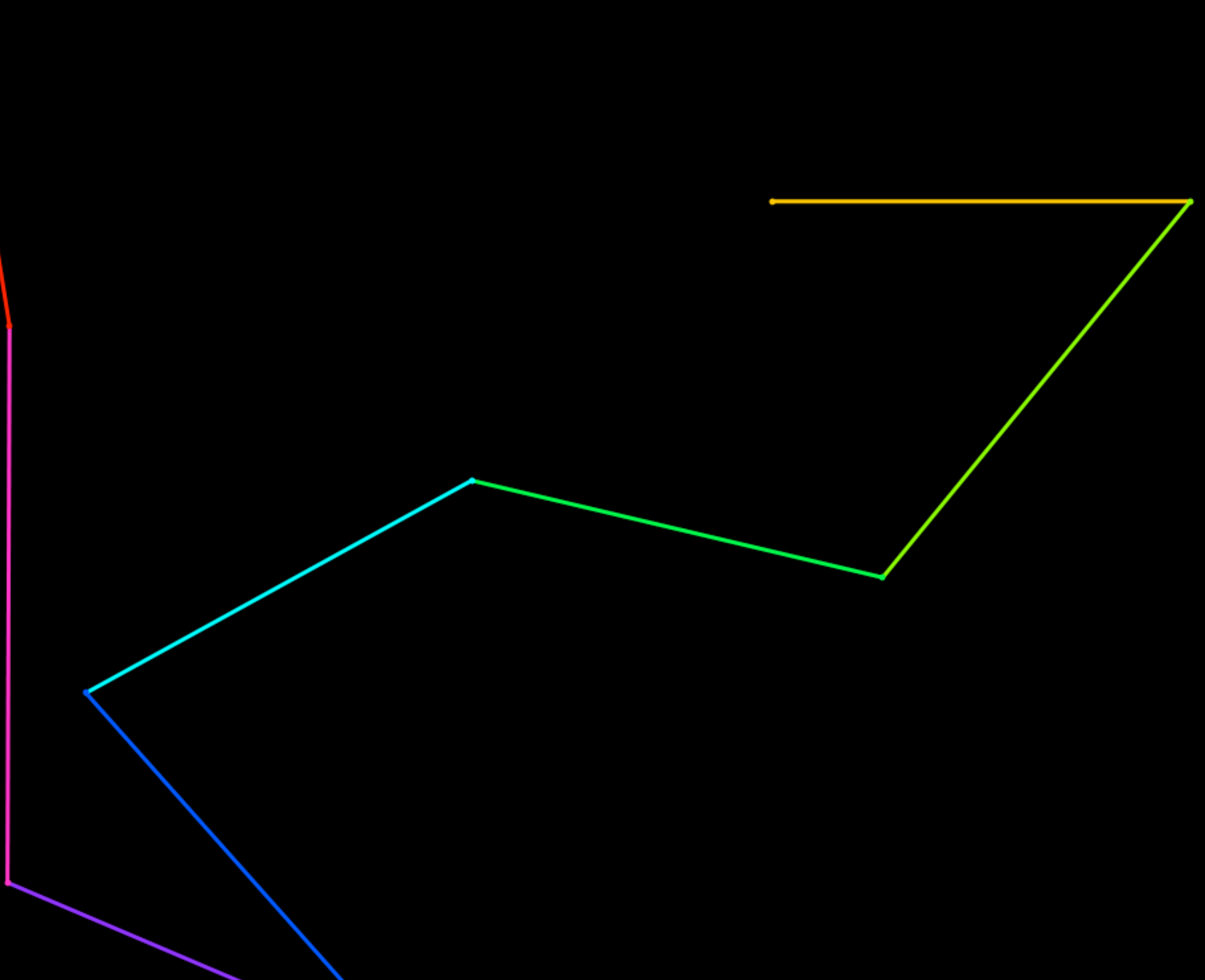
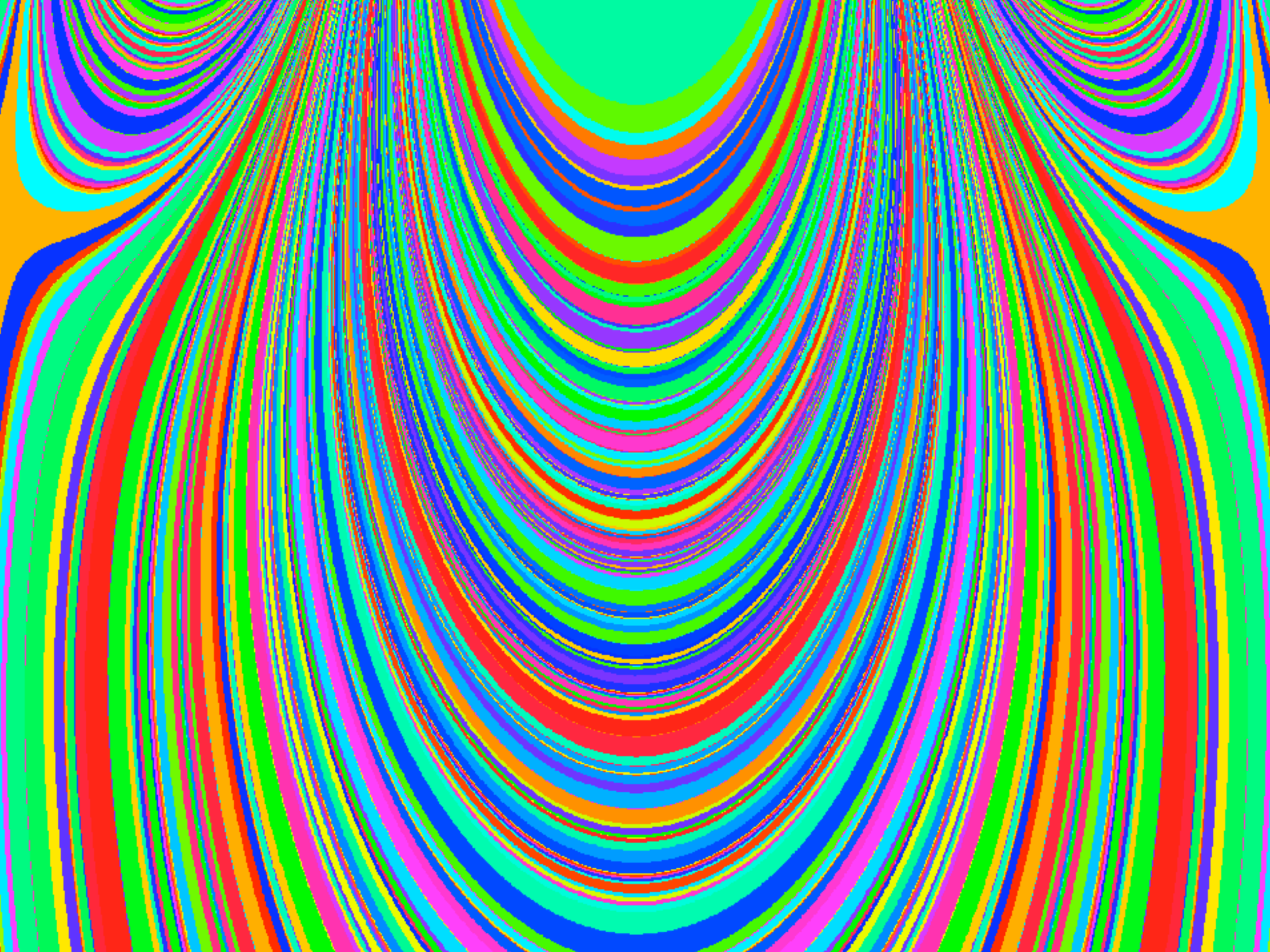
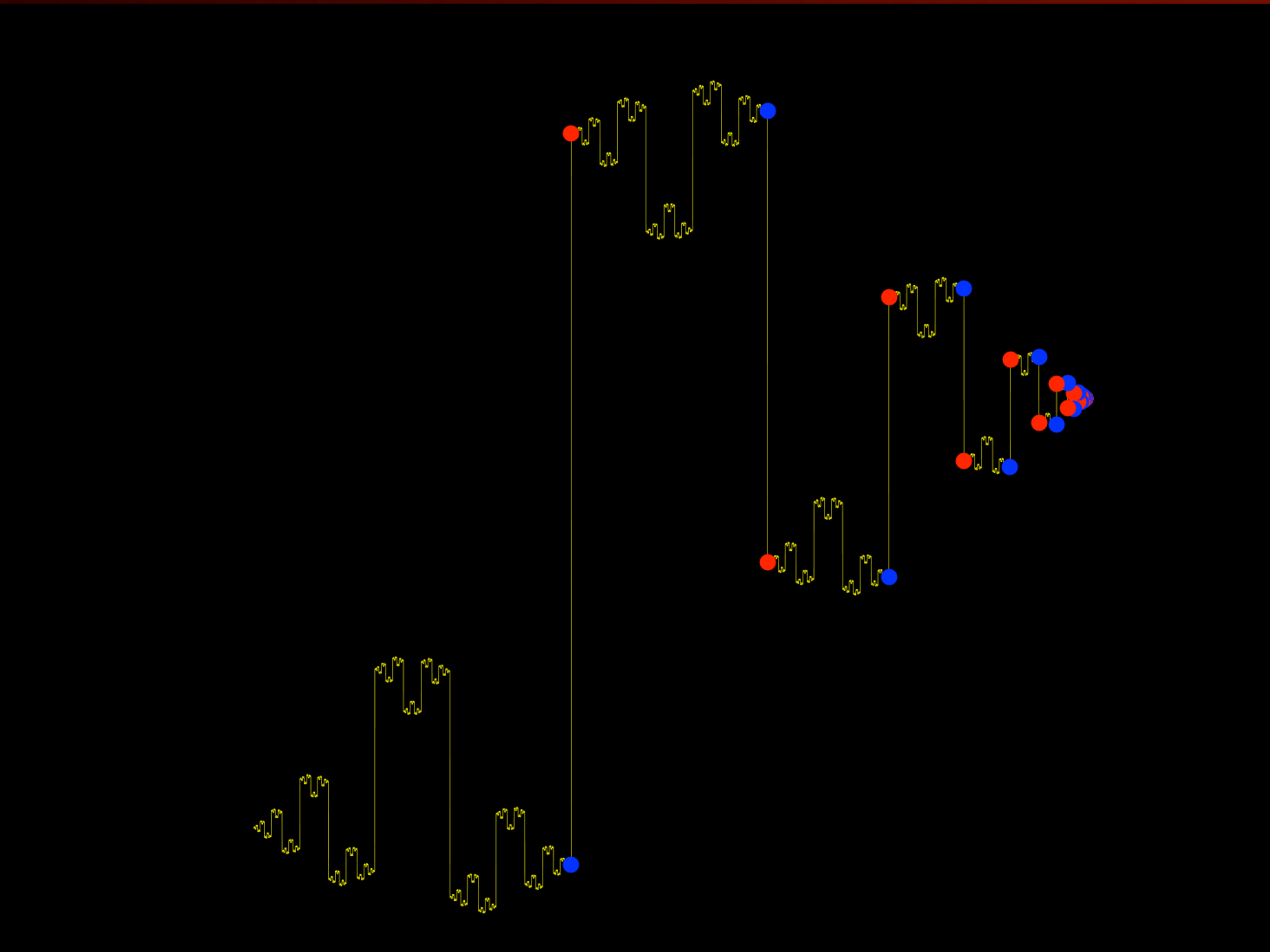


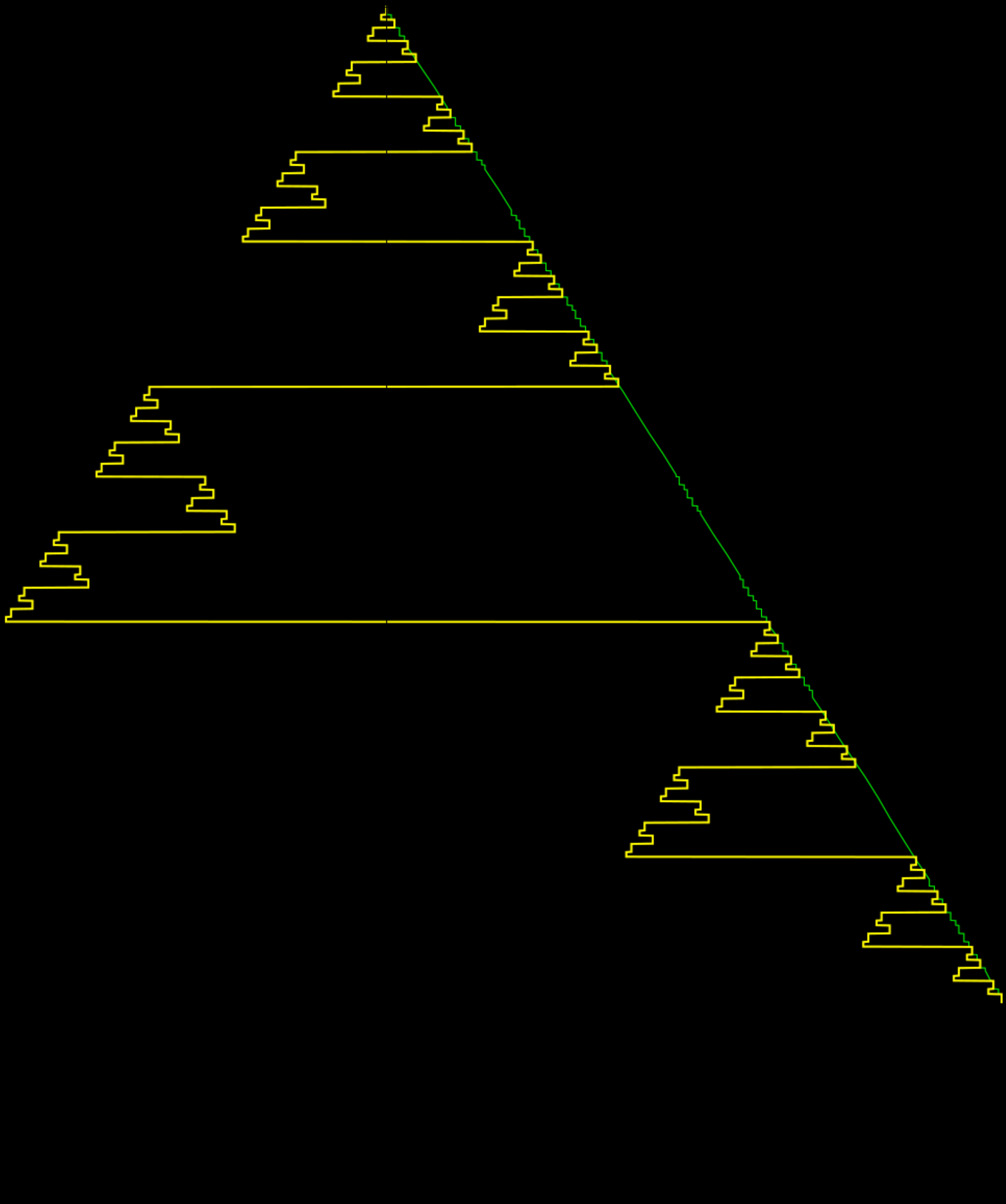
Curlicues

Theta function

$$f(a) = \sum_{n=l} e^{i n^2 a}$$







More about risks:

- Unfortunately, most failures in research are not documented, except if it is connected with success.

Stanford Grad School of Business

"If you want to learn the secrets of success, it seems perfectly reasonable to study successful people and organizations. But the research of Jerker Denrell, an associate professor of organizational behavior, suggests that studying successes without also looking at failures tends to create a misleading — if not entirely wrong — picture of what it takes to succeed."

Example: Cantor

Risky research Area:

Transfinite numbers
Foundation of mathematics
Cardinality
Fractals

Under Attack by traditional mathemematics: Weierstrass, Kronecker

Cantor had several nervous breakdowns and died 1918 in a mental instituation in Halle an der Saale in Germany

Apropos:

The Black Theorem

whoever finds it, becomes mad.

Most logicians
however remained
sane

Other risks: Germaine

1776 –1831

Risk as a women to go into Math.

Her parents forbid her to do math
Was as a pseudonym M. Le Blanc at the Ecole Polytechnique since women were not allowed to attend.

Mathematicians like Lagrange, Gauss supported her.

Part II

Teaching

Take Risks

Convocation 2010

II) In Teaching

- Technology
- Copy right
- Lecture
- Presentations
- Dogmas

Technology

- Benefits and risks of technology in the classroom

Pitfalls in teaching and learning calculus

Oliver Knill

5/20/2005, working draft

Abstract

Students studying calculus often make the same mistakes. Similarly, teachers teaching calculus have patterns of mistakes. It is much easier to tell how things should **not** be done then how things should be done. I collect in this document some "no-go's". This is a living document and is expected to be updated and adapted in the future.

General teacher mistakes

Lack of preparation. Even routine calculus problems need to be rehearsed.

Examples: a teacher takes a random 3x3 matrix and goes onto the task to find the eigenvalues of this matrix. Row reduction leads to mess, the characteristic polynomial has no apparent root.

Improvisation. Rely on improvisation skills for lectures.

Example: In a multivariable calculus course, an arc length computation which does not work like for a Lissajou curve $\vec{r}(t) = (\cos(5t), \sin(7t))$.

Difficulty. Assign too difficult problems as homework.

Example: Find the polytop with 12 edges with fixed surface area and maximal volume using Lagrange extremization.

Polititical correctness Use politically incorrect problems or jokes.

Example: show slides with sexist joke. Also politically biased statements can be tricky. There are students of almost any political orientation in the classroom.

Lecture too long. The flow of lectures at the college is interrupted. Students come too late to the next class. Everybody has to wait.

Example: the teacher discusses with students after class in the class room, while students of the next class have to wait. The next class gets delayed.

Too late. Come too late to class. After cleaning the black board, collecting homework.

Example: At Harvard, classes start 7 minutes after the hour.

No interaction. Have no interaction or activities during class. Students turn off.

Example: Tuesday-Thursday calculus classes at Harvard are 90 minutes. This is a long time to keep the attention span.

Wrong lecture. Cover an other topic than the other sections. The students can not do the homework and later do not know the material for the course wide exam.

Example: Basic definitions which are necessary for the homework are not introduced.

Outfit. Improper dressing can be a distraction. While in educational environments, almost everything goes, there are limits, like avoiding coming barefoot. Rule of thumb: have at least a shirt on ...

Example: For male teachers: check trousers after the bathroom. The range of acceptable clothing or hairstyle certainly also depends on the personality of the teacher and students are quite tolerant. But clothing issues should not become a distraction or an embarressment.

Untested technology. The use of technology unfamiliar to the teacher can eat away precious classroom time.

Example: it is annoying to watch somebody fiddling with the computer, the overhead projector or trying to fix a line of Mathematica code in front of the class.

Misuse of technology. Each technology has its own advantages. It is often difficult to transfer one to an other.

Examples: 1) make slides by scanning a handwritten paper and show it with the overhead projector. 2) take a PDF version of a text and pull it into a power point presentation 3) use the overhead projector to sketch a figure.

Exceptions. Focus too early on exceptions.

Example: "the infimum of a set is not always smaller then the supremum of a set". State exceptional examples too early: like examples, where $f_{xy} \neq f_{yx}$. For nonmathematicians, such counter examples may be amusing but have also a pathological touch.

Uninspiring. Showing lack of preparation and enthusiasm. Why should people at all come to class?

Example: A teacher copies his notes word by word onto the blackboard. Worse: a teacher copies problems from the book directly onto the blackboard.

Ignore student questions. A teacher brushes over a student question. Better: possibly repeat the question and answer carefully. If the question is not clear, restate it. If the answer is not known, refer to the next hour, or give it as a challenge to the class.

Example: Student: "Could you please explain the last step again". Teacher: "I'm sorry, we do not have time for that." or "You should have payed more attention to what I just sayd".

Mumble. Instead of useing loud and clear voice and speaking to the class, the teacher mumbles to the blackboard.

Example: A long computation is performed on the blackboard. The class sees only the back of the teacher. Worse, the teachers body covers the written part.

Giving away solutions. Providing full solutions to problems instead of hints to problems. the solution. Instead, one can give hints, still leaving the task of solving the problem to the student.

Example: Compute $\int_0^{2\pi} \sin^4(x)\, dx$. Hint 1: Use $\sin^2(x) - 1 = \cos^2(x)$ Hint 2: use this only for one $\sin^2$ and leave the other $\sin^2$. Hint 3: use then a trigonometric identity.

Mistakes by Course-head

Lack of guidance. Syllabus, homework problems, homework solutions, practice problems, quizzes are not available ahead of time.

Too much guidance. Too much advise like detailed prescribed lecture scripts can kill the innovation of the individual teacher. Some feel just becoming a narrator of a script. Sharing advise, tricks and experience is good but teaching is also a creative act.

Distributing the responsibility. Organization tasks can be shared with the section leaders but ultimately, the course head has the responsibility.

Use of CAs. CAs have about 15 hours per week. Some volunteer to do more and are happy to share more responsibility.

Change the syllabus. In service courses like calculus, there are some things which have to be taught and which other departments require to have included. While there is some variation of the syllabus possible, it should be fixed before the semester starts. The syllabus should have flexibility in the time frame like one or two hours to "catch up".

Examples: The homework assignment is only fixed a day before class. Because a lecture has to be tailored to make the homework useful, the section leaders can not prepared early enough.

Examples: Individual lecture-plans make often only sense for the teacher who prepares the lecture. They often do not mention things which are obvious. The most useless "lecture plan" is a list of the section titles which are covered in the book. Better: point out possible pitfalls, student questions, common misconceptions.

Examples: A section leader is assigned to proctor a midterm and does not show up. Because midterms can not be repeated easily (schedule, holidays, conflicts, lecture hall reservation), this is a disaster.

Examples: CAs have to grade midterms or even the final exam. CAs have to take their own midterms and exams, usually just at the time of the calculus midterms or exams. There also seems to be a Harvard policy that undergraduates are not allowed to grade exams. This makes sense because some CAs will have to grade the exams of their own friends.

Examples: Some section falls behind and all other sections adapt to the pace of the slower section. It can happen that classroom time is spent with valuable discussion time and not everything can be covered. In such a case, one has to ask the students to read the rest in the book. It is better to anticipate that the hour does not suffice for all the material, reduce the complexity of the examples or ask students to preread.

Mathematical teacher mistakes

Ambiguous notation. Use ambiguous notation.

Example: let $\mathbf{v}$ and $\mathbf{w}$ be vectors in space. Define the parametrized surface $r(u,v) = u\mathbf{v} + v\mathbf{w}$. Even so the difference between vectors and real numbers is done by taking bold face letter, such features can get lost on the blackboard.

Uncommon notation. Use uncommon notation.

Example: let α, β, γ be points in the plane and let P, Q, R denote the line segments connecting them.

Unusual twists. Unusual orientation of coordinate system.

Example: use a left handed orientation e_1, e_3, e_2.

Incorrect definitions. Give incorrect definitions of mathematical concepts.

Example: like a vector is an object with length and orientation.

Overkill in rigor. Adapt the rigor to the class.

Example: a $\epsilon - \delta$ definition of continuity is ok for mathematicians and physisics, but not appreciated by biochem majors for example. Eulers definition x close to y, then $f(x)$ close to $f(y)$ is more intuitive.

Too difficult problems Give too difficult problems without a hint.

Example: Calculate $\int_0^{\pi/2} \log(\sin(x))\ dx$. There is an easy solution to this problem, but it is not easy to find. 99 percent of all students would get very frustrated when assigned this problem.

Incorrect theorems State incorrect theorems.

Example: all extrema of $f(x,y)$ under the constraint $g(x,y) = c$ are obtained at points, where $\nabla f = \lambda \nabla g$. (This is incorrectly stated as a theorem in many text books.)

Course assistant mistakes

Not coming to class. It is not only to see what material is covered, the CA should also get a feel, what how students cope.

Example: Real life example: A course assistant worked for the second year. Feeling he knows the material enough, fails to come to lectures. He got fired.

Not grading in time. Bringing homework back too late is the biggest turn off.

Example: Real life and worst case scenario: a course assistant does not grade for several weeks and is out of town. The papers pile up. It becomes impossible for one person to do it. The teaching fellows spend an afternoon grading the papers.

General student mistakes

Do not come to lectures.

It is possible to learn mathematics by reading the book. However, the brain does not keep the information as reliably. Having seen and heard the material makes it stick better. In a time, where distraction (phone, Internet, friends etc.) is tempting, it needs stamina to make up the learning time away from class.

Do not speak up. If something is not clear.

Most of the time, if something is not clear to one student, it is not clear to the entire class.

Copy homework from someone else.

Mathematics is doing. The process of struggling with a homework problem is important too.

Come unprepared to class.	The most effective use of class room time is to have already partly absorbed the material before hand.
Cheat during exams.	Sometimes, this happens unconsciously. A student uses a calculator in an exam, where none are allowed.

Mathematical student mistakes

Improper use of substitution.	**Example:** $\int_0^{3\pi/4} \sin^2(x)\cos(x)\ dx = \int_0^{\sin 3\pi/4} u^2\ du = \int_0^{1/\sqrt{2}} u^2\ du$, where $u = \sin(x), du = \cos(x)\ dx$.
Improper handling of indefinite integrals.	**Example:** $\int_{-\pi}^{\pi} 1/x\ dx = 0$ so that $\int_0^{\pi} 1/x\ dx = 0$.
Matrix algebra issues:	$(A+B)^2 = A^2 + 2AB + B^2$.
Wrong linearity of determinant:	$\det(2A) = 2\det(A)$.
Too linear Inappropriate linearity:	$\sqrt{x+y} = \sqrt{x} + \sqrt{y}, e^{x+y} = e^x + e^y, (x+y)^2 = x^2 + y^2$. $1/(x+y) = 1/x + 1/y$.
Too commutative Inappropriate commutativity of composition:	$\log\sqrt{x} = \sqrt{\log(x)}, \sin(5x) = 5\sin(x)$.
A sin. A student "sin" as a joke.	$\frac{\sin x}{x} = \sin$.
Inappropriate cancellations.	$((x+1)+5x^2)/(x+1) = 1 + 5x^2/(x+1)$. $\frac{3+x}{x} = 3 + x/x = 3 + 1 = 4$.
Unclear brackets.	**Example:** $3x/5 = 3/5x = 3/5x = 3/(5x)$.
Unit confusion.	**Example:** $1\$ = 100c = (10c)^2 = (\$0.1\$)^2 = 0.01\$ = 1c$. (source: Eric Schechter, 2004)
Division by zero.	**Example:** $x(x^2-1) = x$ implies $x^2 = 2$ and so $x = \pm\sqrt{2}$.
Square root errors	**A famous example:** $a = b$ implies $a^2 = ab$ so that $a^2 + a^2 = a^2 + ab$ or $2a^2 = a^2 + ab$. The manipulation $a^2 - 2ab = a^2 + ab - 2ab$ gives $2a^2 - 2ab = a^2 - ab$. Writing this as $2(a^2 - ab) = 1(a^2 - ab)$ and canceling $(a^2 - ab)$ from both sides gives $1 = 2$.
Signs in inequalities.	**Example:** $-a < -3$ implies $a < 3$.
Misconception about constants.	**Example:** $\frac{d}{dx}x^x = xx^{x-1}$.
Integration by parts. Forget one integral.	**Example:** $\int x\cos(x)\ dx = x\sin(x) - \sin(x)$.
Polar coordinates. The inversion formula for polar coordinates is not complete.	**Example:** Given the point $(-1,-1)$. Find the polar coordinates. We have $r = \sqrt{2}$ and $\theta = \arctan(-1/-1) = \arctan(1) = \pi/4$.
An SAT pitfall. True facts for integers are extrapolated to all real numbers.	**Example:** This is a common trap for SAT exams: because $0 \le 0^2, 1 \le 1^2, 2 \le 2^2, 3 \le 3^2$ one concludes $x \le x^2$.
Sloppiness about signs. Especially in connection with the chain rule.	**Example:** $\int dx/(1-x) = \log|1-x| + C$.

Literature:

- Eric Schechter, "The most common errors in undergraduate mathematics education" http://atlas.math.vanderbilt.edu/ schectex/commerrs
- http://tutorial.math.lamar.edu/AllBrowsers/CommonErrors/CalculusErrors.asp
- Andy Engelward, "do's and don'ts for Classroom style", talk at Bok Center Fall Teaching Orientation Sept. 14th, 2004

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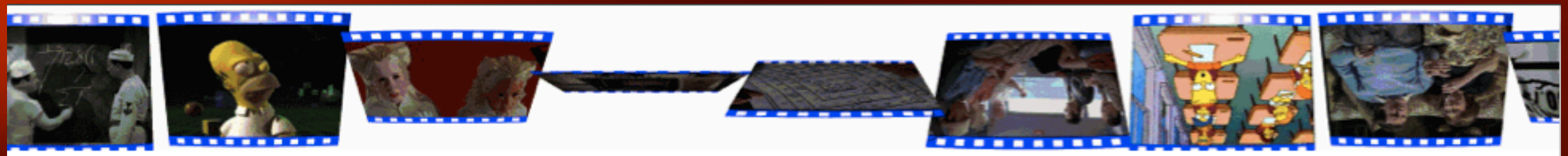


Mathematics in Movies

This is a collection of movie clips in which Mathematics appears. I'm collecting DVDs and VHS tapes of such movies. This is a working document to be extended over time. I started this page during spring break 2006. See also the page "Begin of lectures in college teaching" and "End of lectures in college teaching" and "Examples of good talks". To see the movies larger, to see it on the iphone or include it in a presentation, chose the quicktime ipod version, which are files with .m4v extension. (Media RSS link).

Date: March 2006 - August 2010

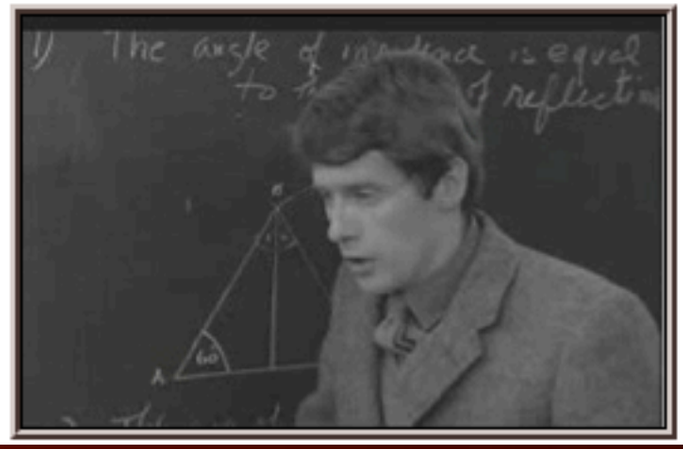
by:
Oliver Knill
Department of Mathematics
Harvard University

In July [IMDb link]

Theoretical and applied computation of a free fall problem (Thanks to Andrew Ranicki for the suggestion)

2000

Play the flash version (.swf). or watch the quicktime file (.m4v)



The Knack ... and How to Get It [IMDb link]

The angle of incidence is equal to the angle or reflection (Thanks to Andrew Ranicki for the suggestion)

1965

Play the flash version (.swf). or watch the quicktime file (.m4v)

Lecture

Level of Teaching

next slides recycled from
a talk of mine in

ICTCM Feb 15-18, 2006

Choice

The paradox of choice amplifies traditional dilemmas a curriculum has, also without technology. This happens on many levels, here are four:

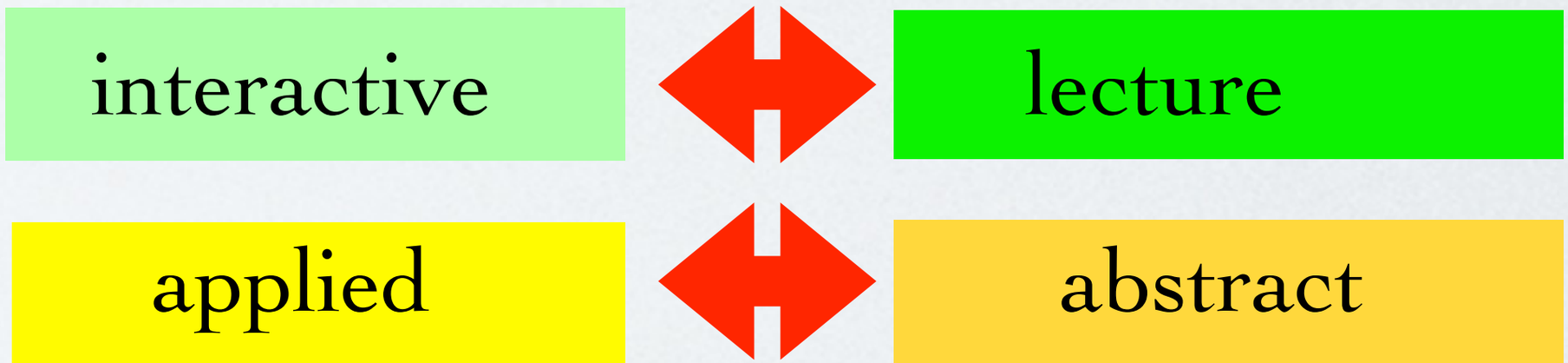
I PEDAGOGICAL LEVEL

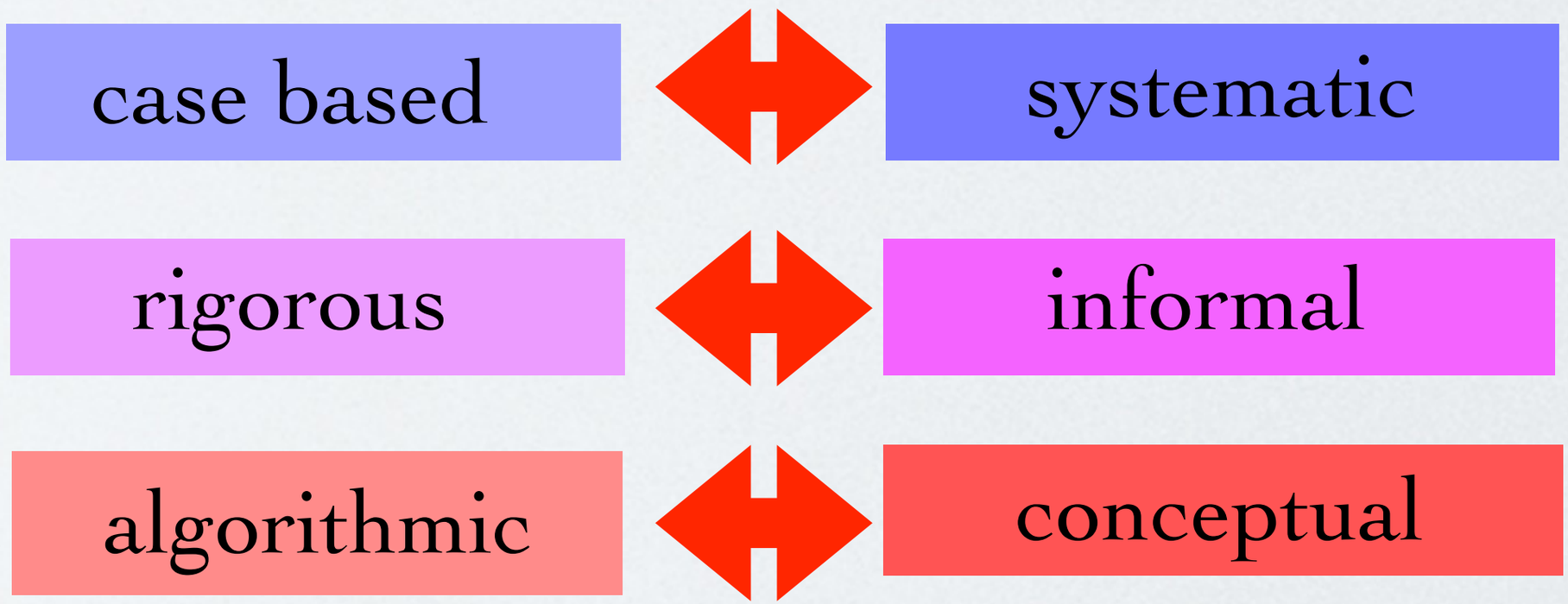
II PRESENTATION LEVEL

III OBJECTIVE LEVEL

IV TOOL LEVEL

Pedagogical Level





Presentation level

Objective Level

Visual
Geometric

Formal
Algebraic

Artistic
Entertaining

Social
Collaborative

Numerical
Algorithmic

Application
Practical

Humour
Fun

Historical
Cultural

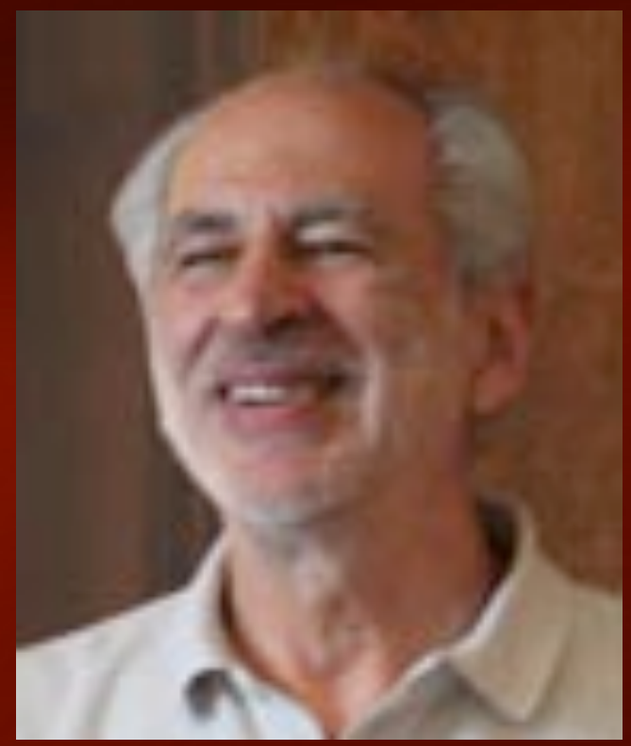
Challenge
Discovery

Inquiry
Exploratory

Tool Level

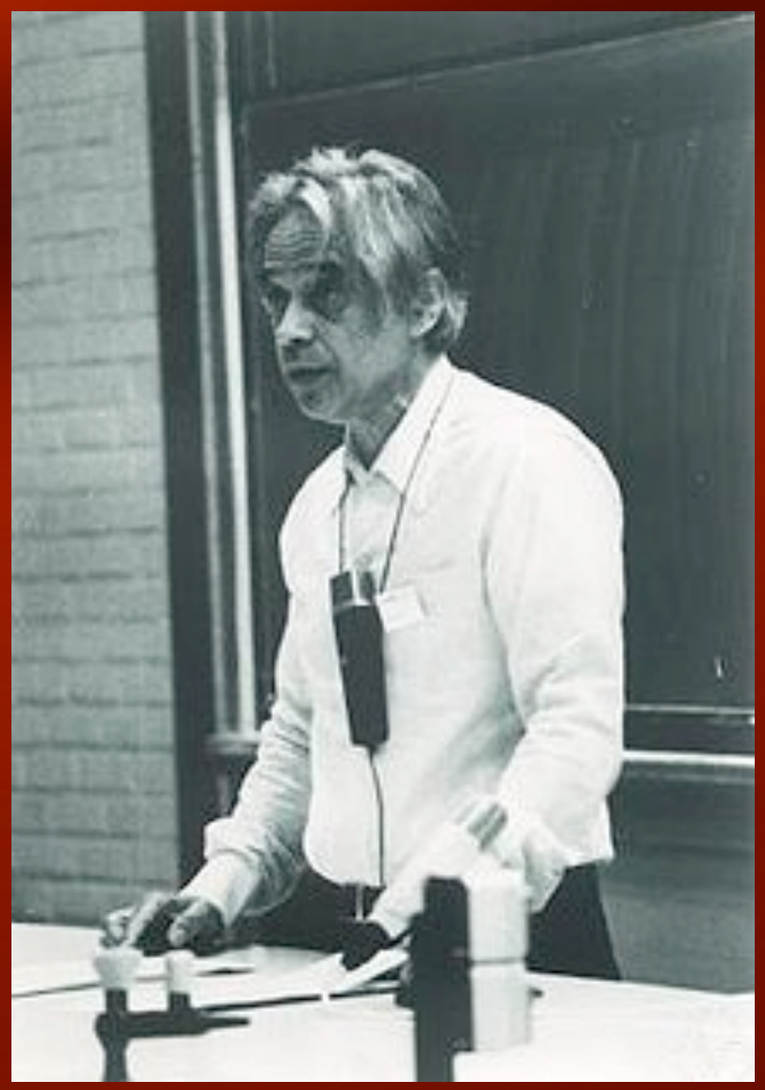
- Computer algebra systems
- Personal response systems
- Online tests
- Video podcasts
- Videos
- Teacher Wikis
- Interactive online tools
- Powerpoint lectures
- Games
- Demonstrations
- Email support
- Instant messaging
- Chat bots
- Course Blogs
- Projects
- Group work

An example by a local logician



- Gerald Sacks:
- in the middle of each class, a previously selected student would have to get up and tell a joke. The joke had to be short, funny, and inoffensive

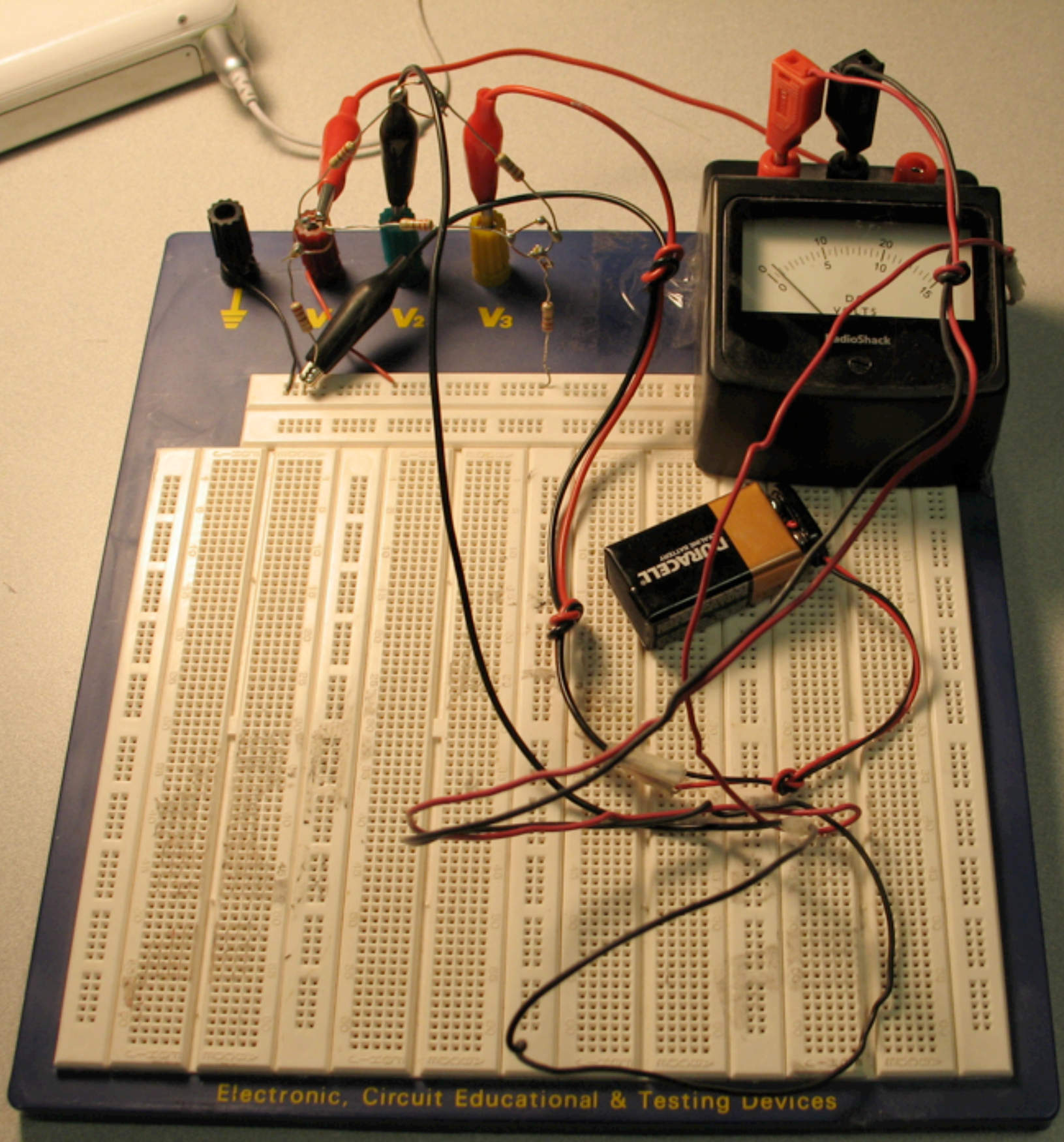
An episode told about teacher of mine:



in 1982

90 years

Demonstrations


V2
V3
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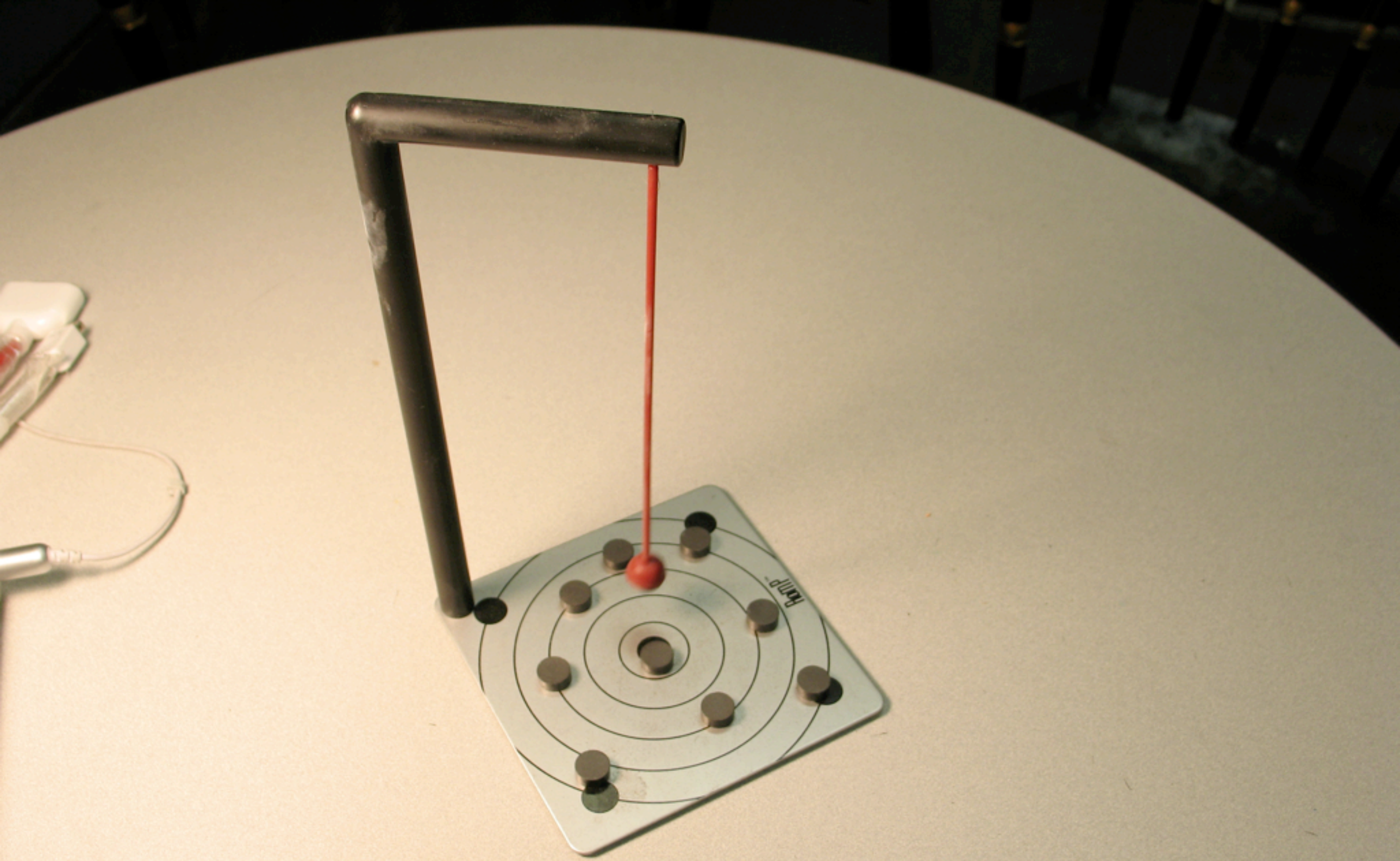
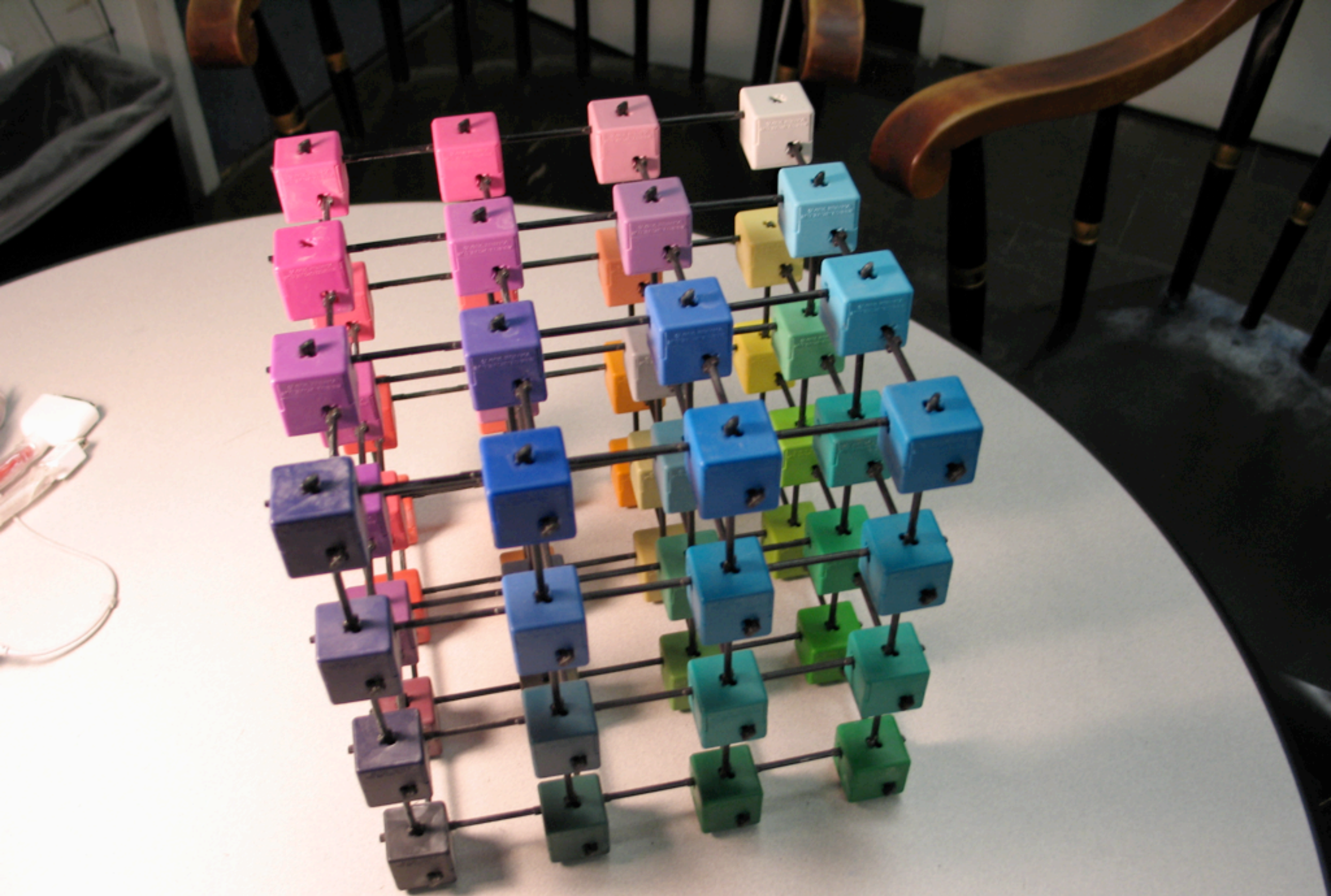
DURACELL
Electronic, Circuit Educational & Testing Devices


Hama

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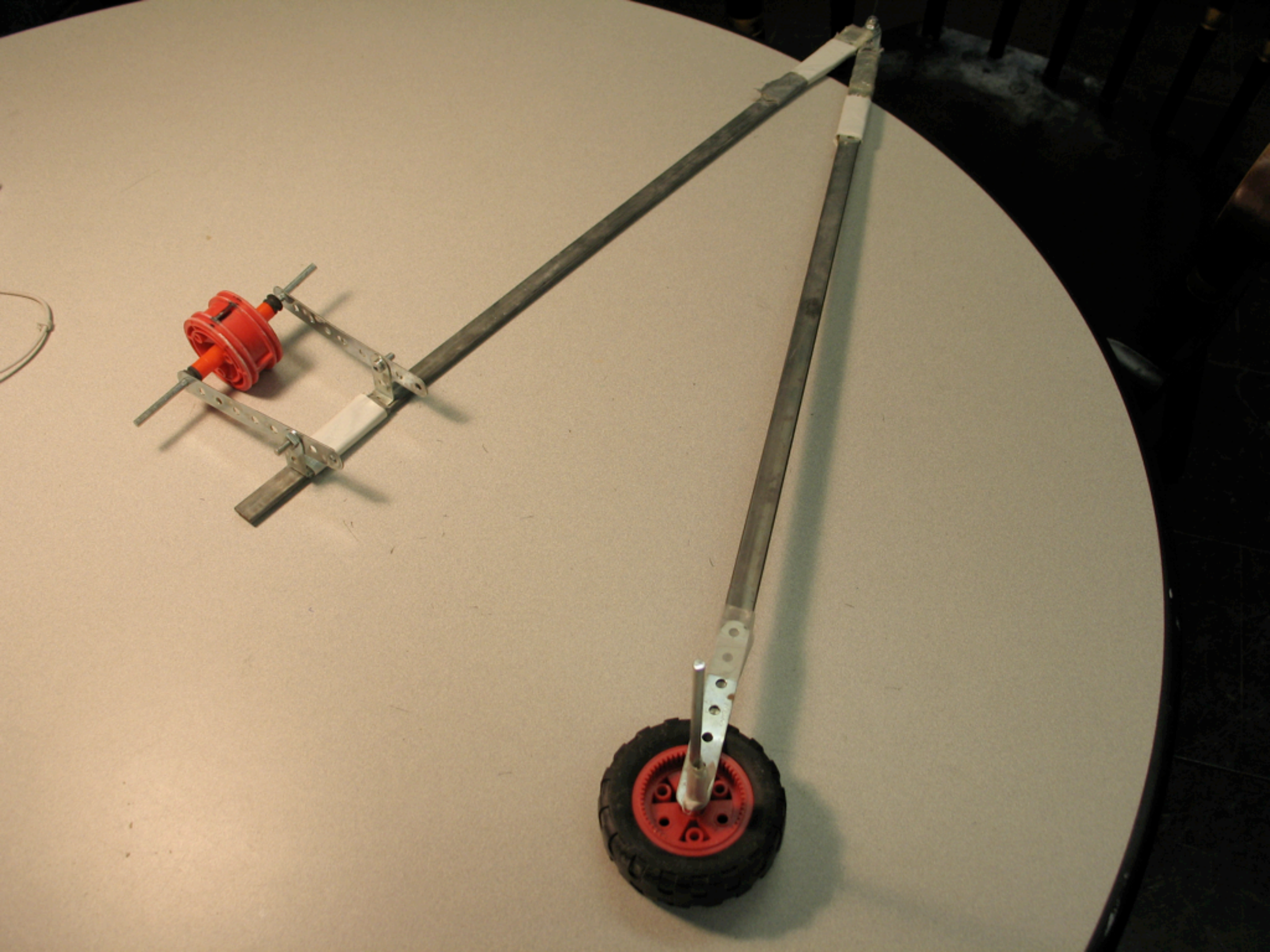

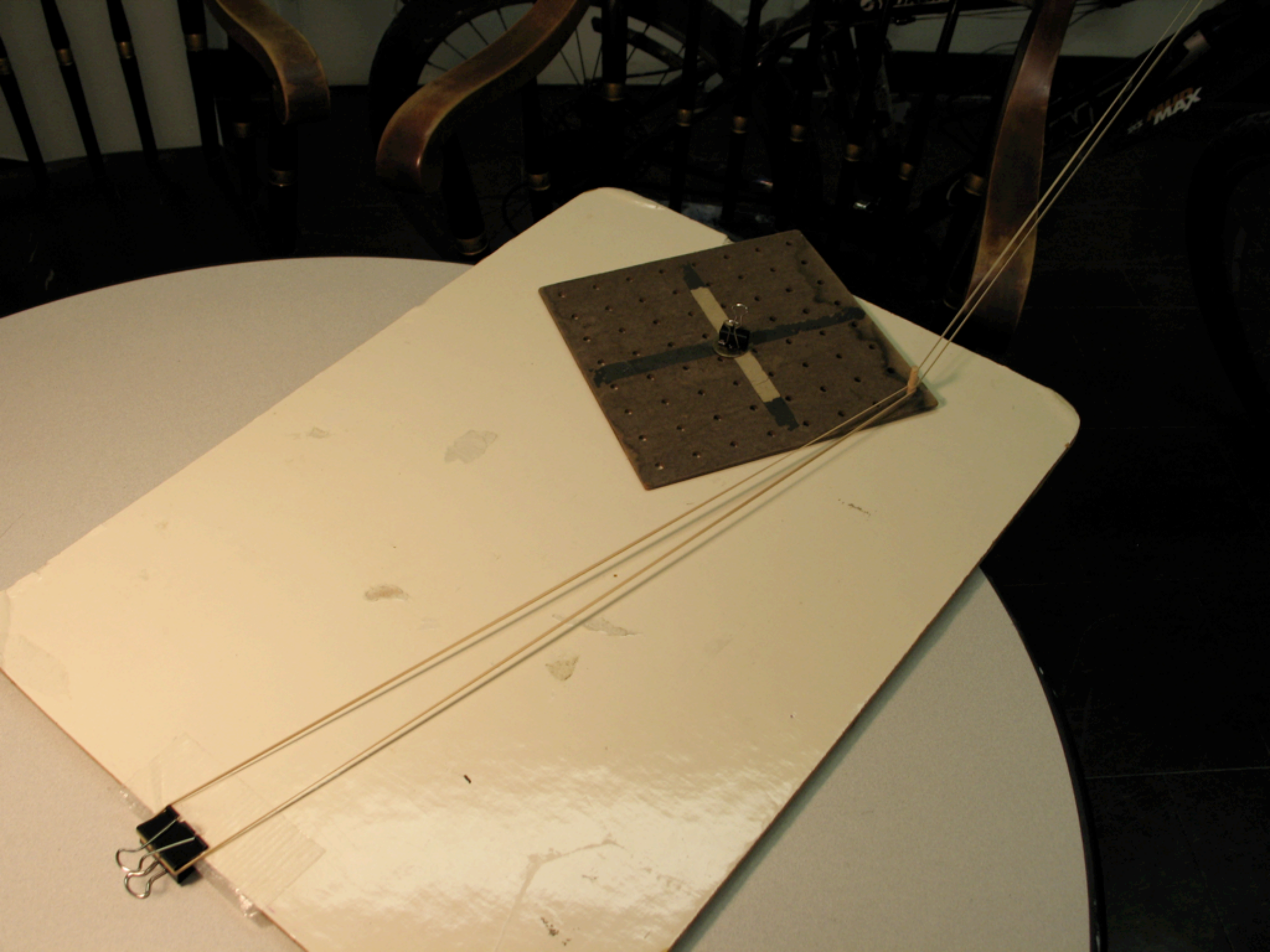

PRESS DOWN TO OPERATE


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FOR AGES 10 THROUGH ADULT

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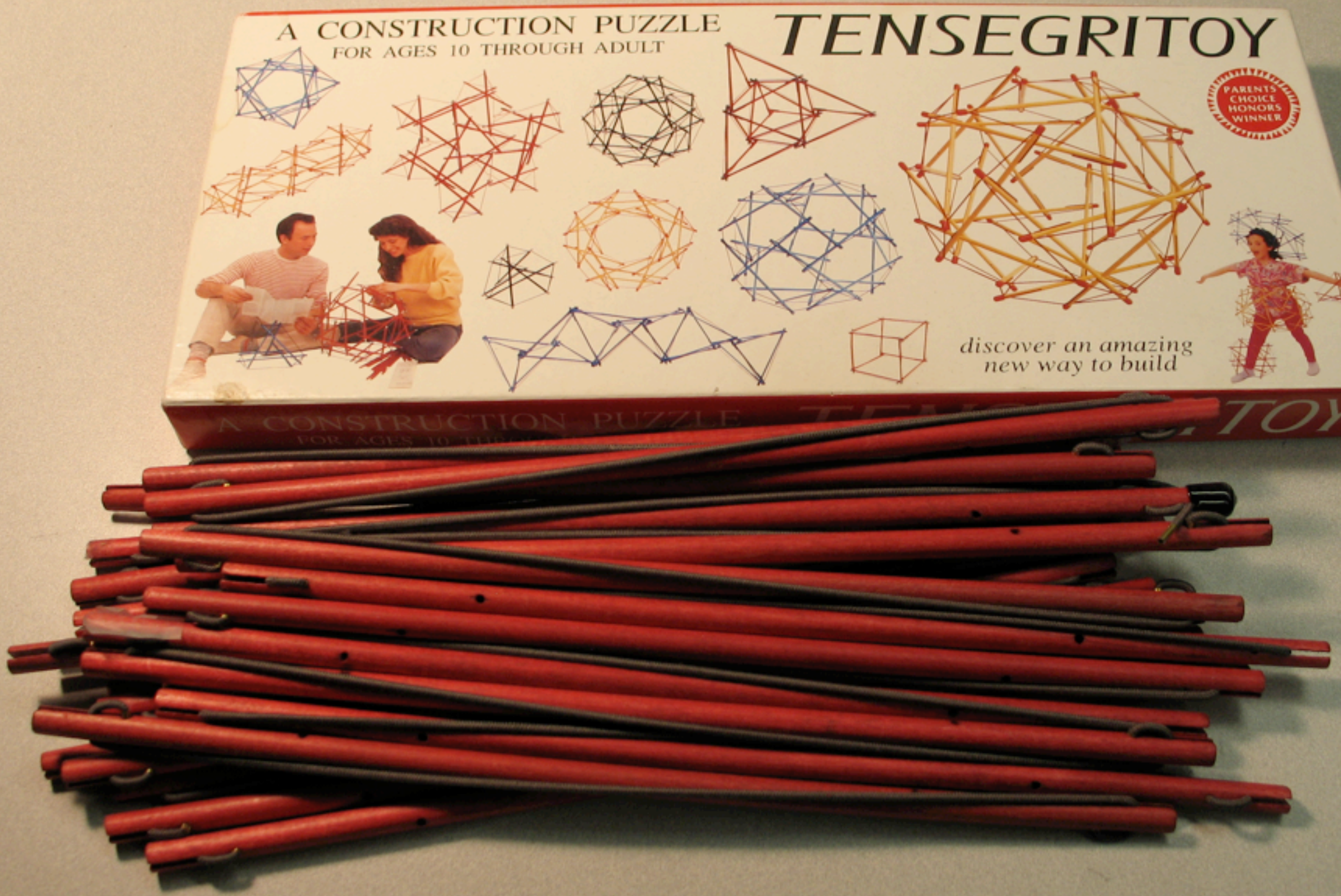
PARENTS CHOICE HONORS WINNER

discover an amazing new way to build



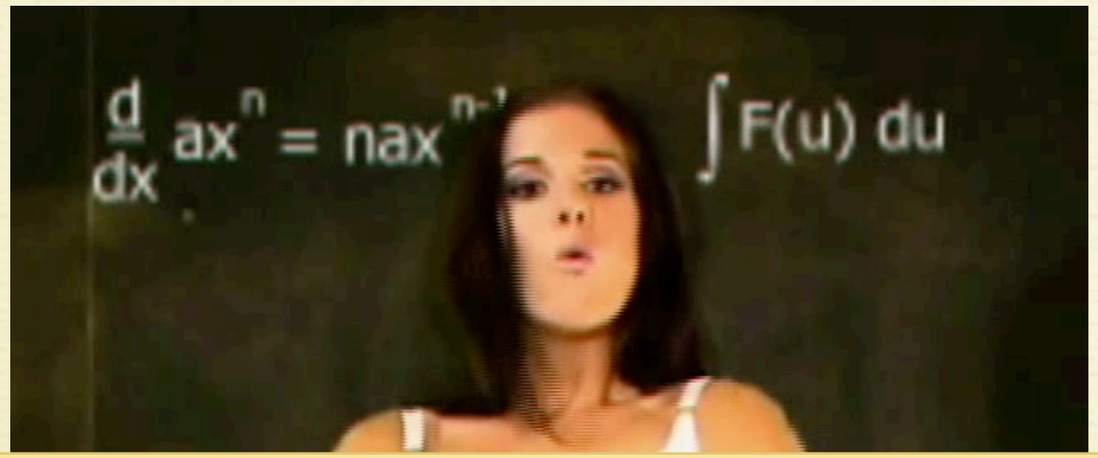
Multimedia

Here is a particularly risky part of a presentation.

Apropos integrals:

From 2006-2008, the first search entry for "Calculus" on google videos was

Calculus:



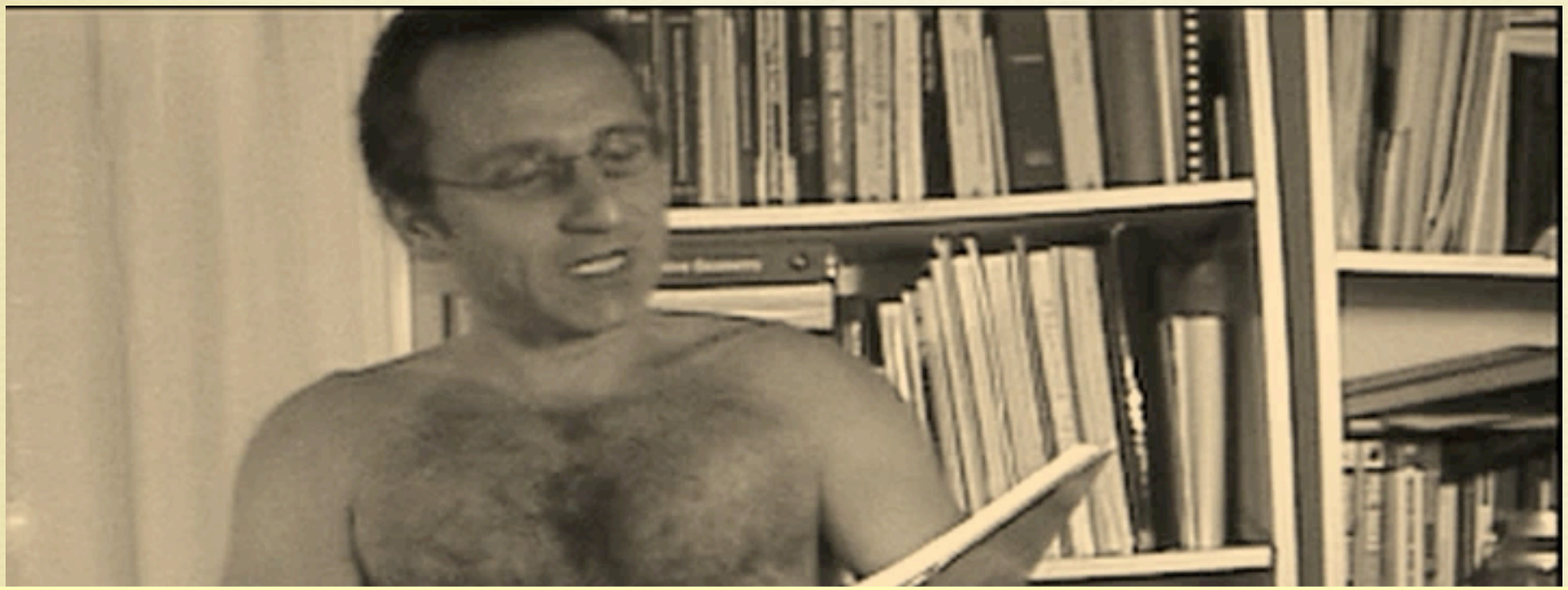
Censored

so, in 2006, I had a business idea:

Bikini Calculus for the other gender:

What is better
than calculus WITH
bikini. It is calculus
WITHOUT bikini!
Here is part of
the legendary test shot 2006

WITHOUT Bikini Calculus



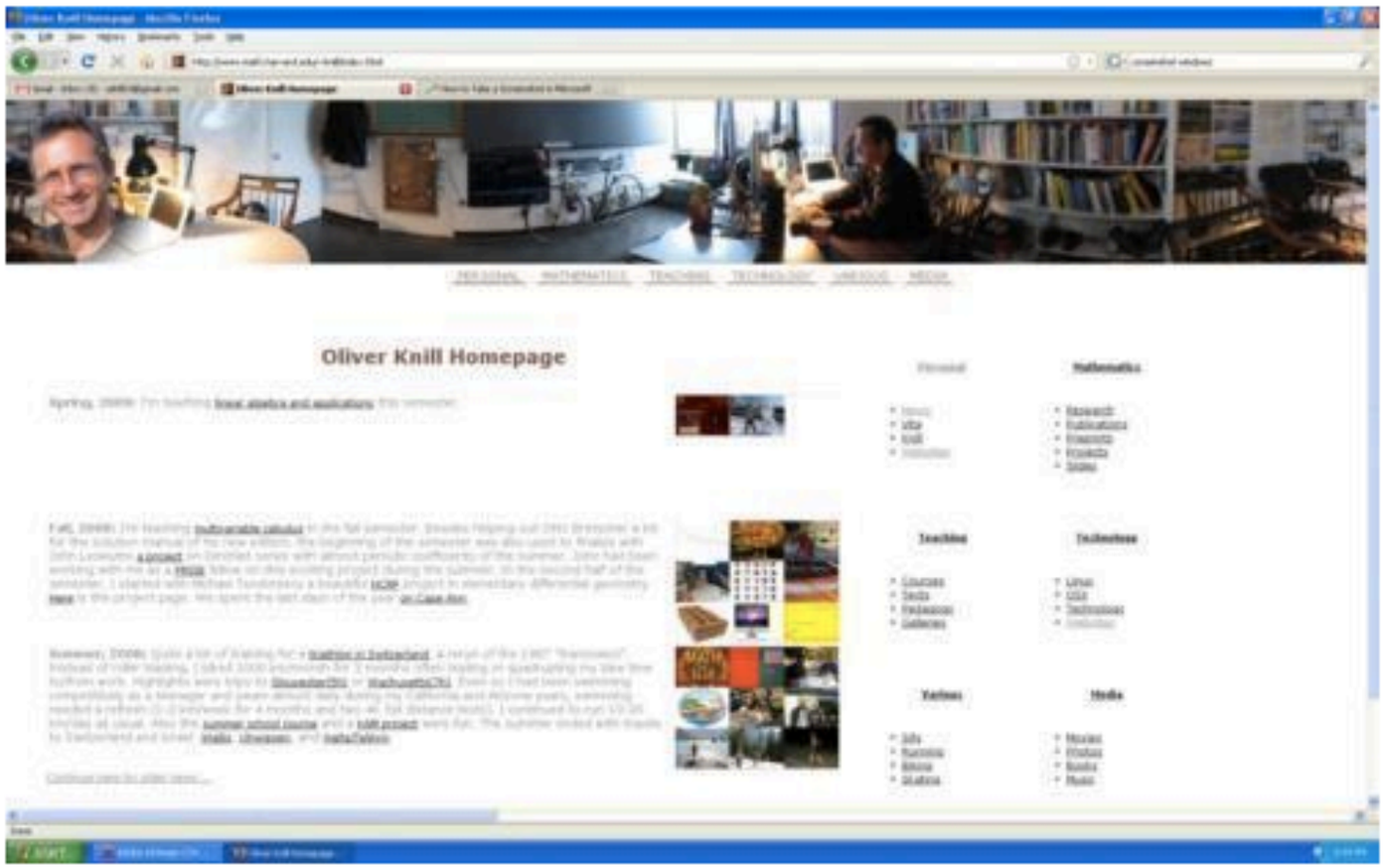
Censored

Lecture

Profs Online: From FYI to TMI

In an effort to reach students in an informal setting, some professors get personal

By LAURA C. SCHAFFER, CONTRIBUTING WRITER
Published: Wednesday, February 25, 2009



COURTESY JULIA B. HORNIG

Bookmark Oliver R. Knill's blog for all of your daily nipple flux and rollerblading video needs.

Last Word

- Take risks. If if things fail one can get a lot out of it.

Famous Last word

- Be aware that the previous statement could be a famous last word.

Sources and Credit:

- Theoni Pappas: Mathematical Scandals
- Krantz, A primer on mathematical writing
- Peter Wolf Breakhroughs in Mathematics
- Jose Ramirez, Work on Computer vision

The End