Symmetry breaking

Constructing a career in mathematics

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Mathematical Reviews (American Mathematical Society)

October 2020

The plan

- What do I do?
- Who am I?
- How did I get here?

The slides will be available

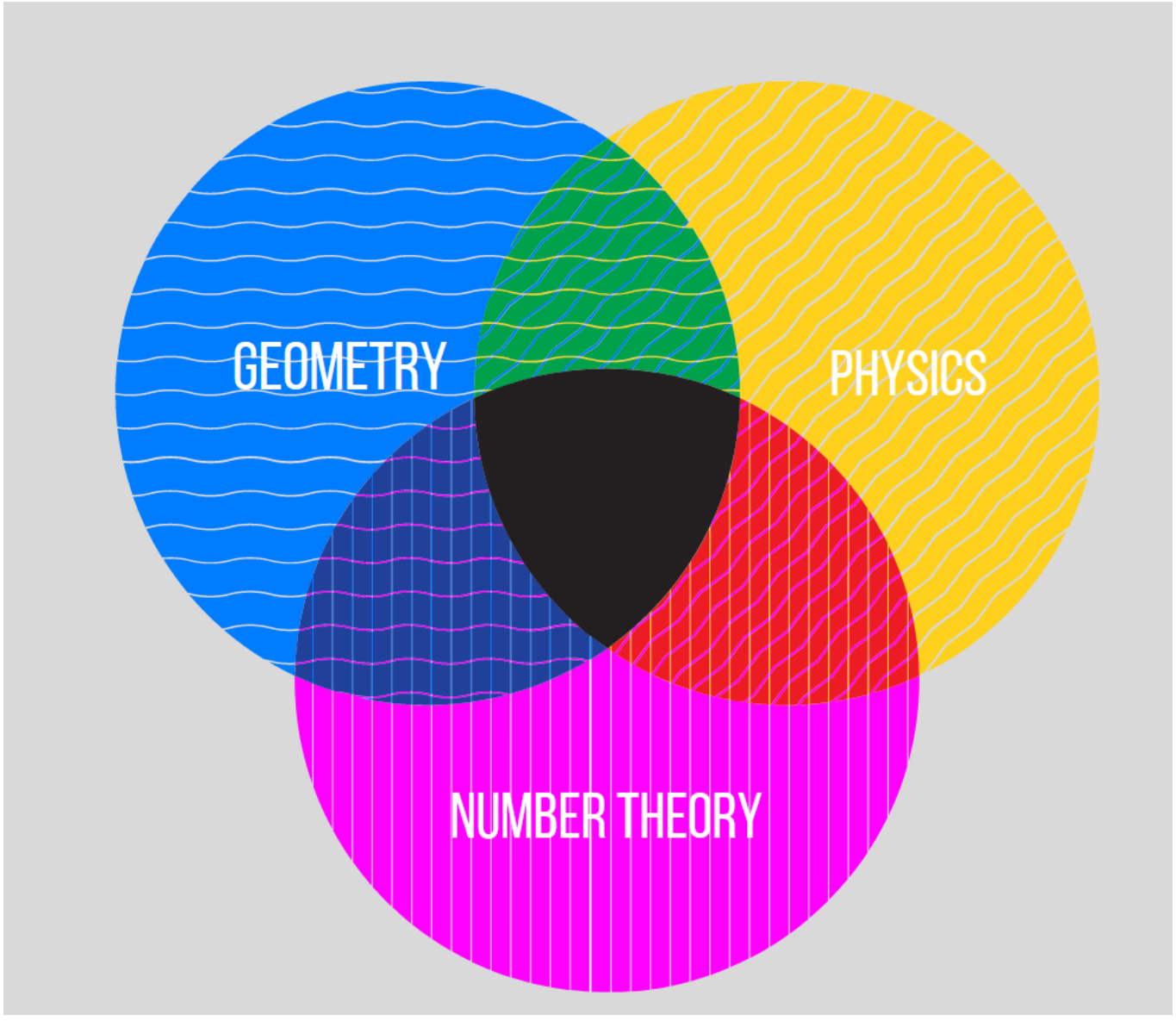
http://www-personal.umich.edu/~uaw/notes/

Swarthmore, 2003

- Honors major in math
- Honors minor in Latin
- Course minor in physics

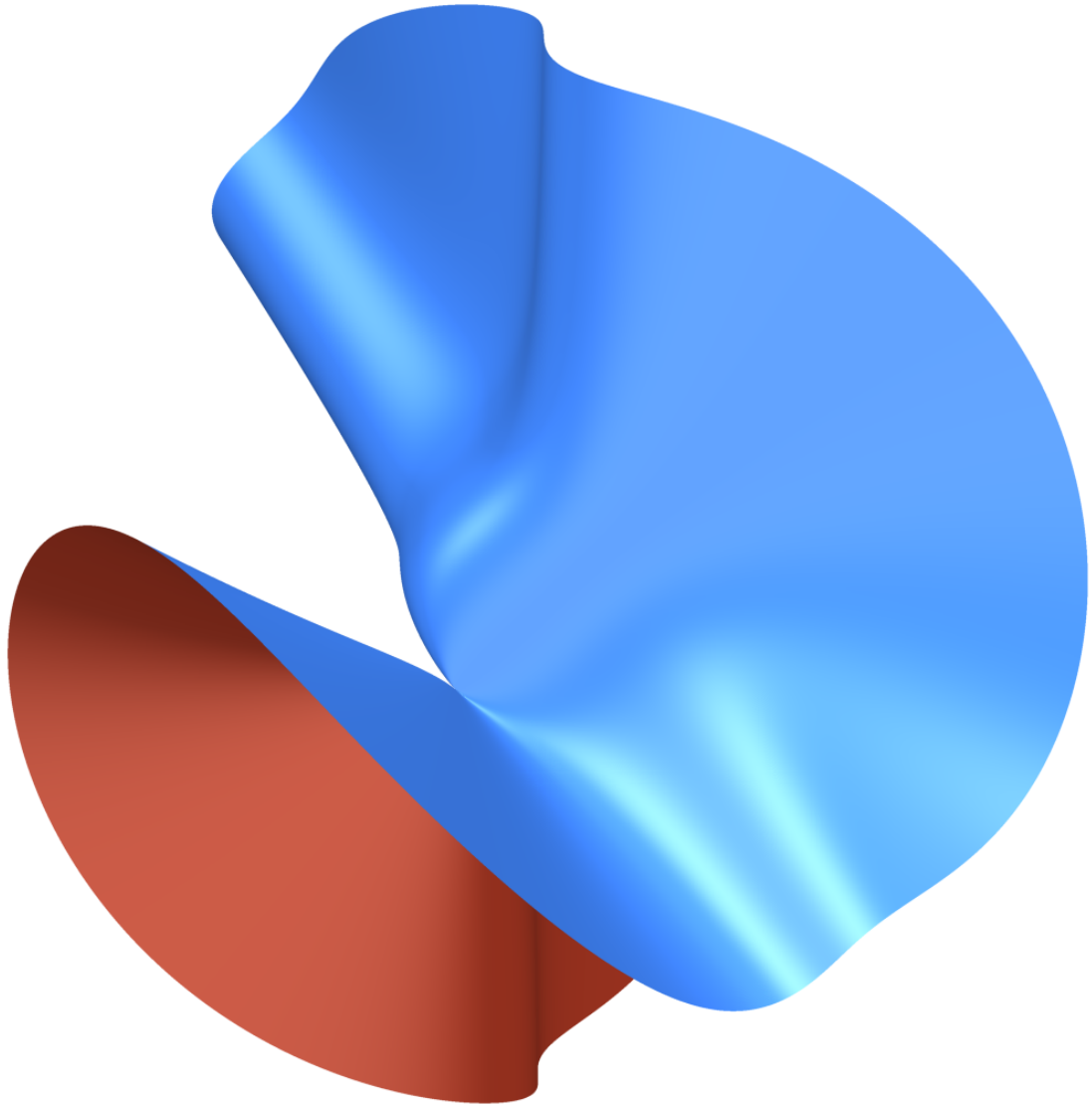
I still wear many hats!

Research



The big idea...

Use predictions about geometry made by physicists to gain mathematical insight.



Math Reviews

Associate Editor, Mathematical Reviews

- MathSciNet database (`https://mathscinet.ams.org/`)
- Part of the American Mathematical Society

Editorial responsibilities

01 History of math

12 Field theory

13 Commutative algebra

14 Algebraic geometry

51 Geometry (axiomatic treatments)

52 Convex and discrete geometry

55 Algebraic topology

Writing and editing

AMS Feature Column editor
https://www.ams.org/featurecolumn/

Monthly editorial board https://www.maa.org/press/periodicals/american-mathematical-monthly

Mathematical writing
http://www-personal.umich.edu/~uaw/notes/

Poetry and fiction http://yarntheory.net/

Shopping is hard! Let's do math.

Figure: Computer engineer and game developer Barbies

Two possible reactions

The false claim that femininity and math are incompatible can produce 2 reactions:

- "What if I'm bad at math?"

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  - Stereotype threat

Two possible reactions

The false claim that femininity and math are incompatible can produce 2 reactions:

- "What if I'm bad at math?"
  - Stereotype threat
- "What if I'm bad at being a girl?"

Unexpected confidence

Gender Identity *(non-binary, cis, trans, woman, gender non-conforming, gender fluid, etc.)*	boring but complicated

Low investment in womanhood can look like startling confidence. . .

Unsettling expectations

Figure: Quark art by Levi Qișin

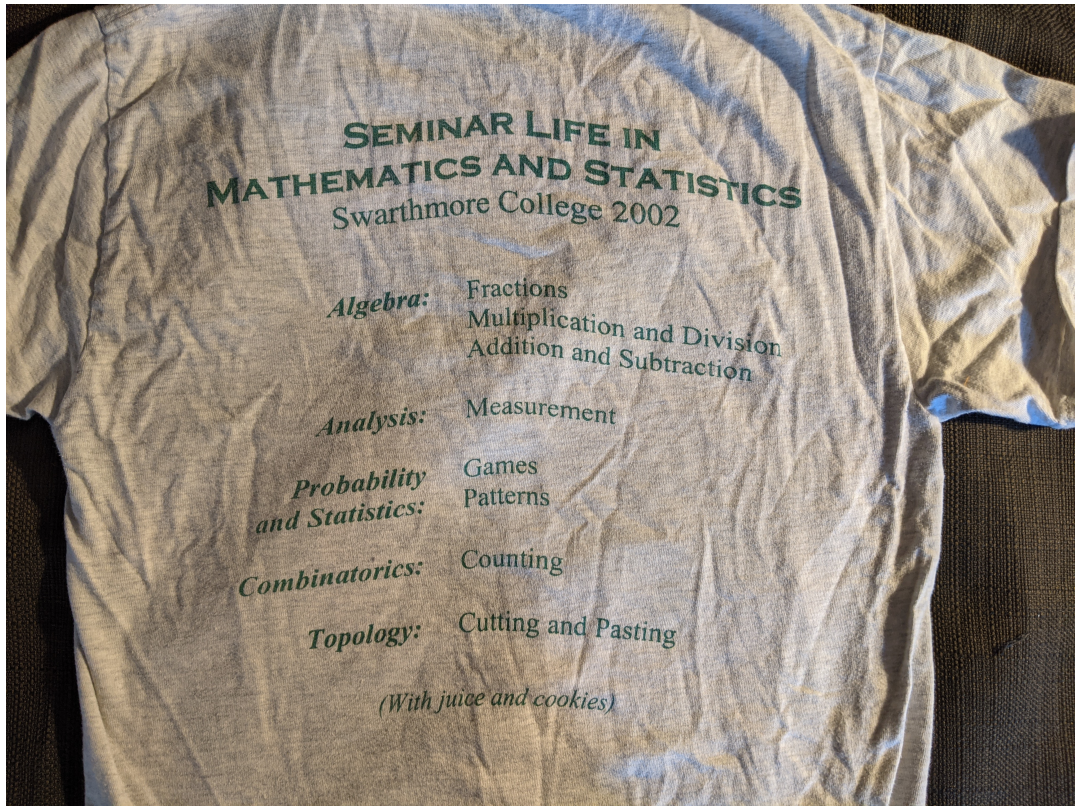
Other people may have gendered expectations of you.

Bisexual pride

Spouse!

- Brian and I started dating about a month before my freshman year at Swarthmore.
- He's an electrical engineer.

Algebraic topology vs. differential geometry



At Swarthmore, I took lots of classes with Tom Hunter and Janet Talvacchia.

The Math Forum

I worked for the Math Forum.

Schools with my initials

I went to graduate school at the University of Washington.

High-stakes exams all over again

UW's prelims felt like Honors exams, part II.

And then. . . ?

Choosing a PhD advisor is:

And then...?

Choosing a PhD advisor is:

- Very important

And then...?

Choosing a PhD advisor is:

- Very important
- Completely unstructured

Good advice

Janet Talvacchia: “Choose the person, not the mathematics.”

Careers belong to humans

Mathematics is made out of personal conversations and connections!

Meet Chuck

Figure: Charles F. Doran

- PhD, Harvard, 1999
- Algebraic geometry (and physics, and number theory...)

A collaborative approach

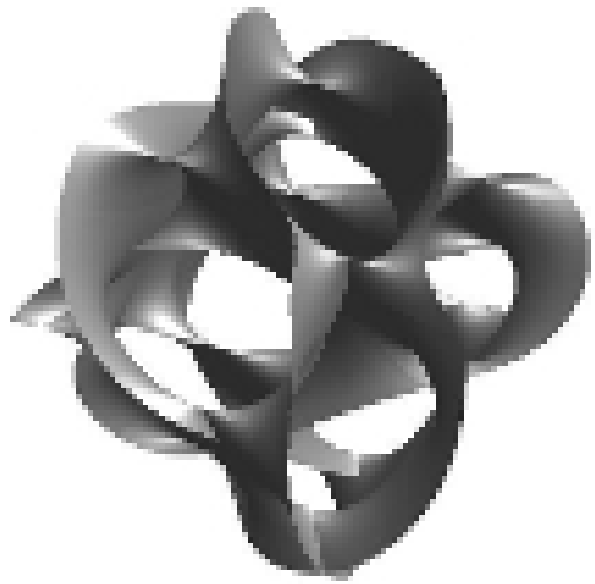
Chuck: "Let's write papers together."

Co-authors (by number of collaborations)

Bertin, Marie-José Brisbin, Abra Gail Clingher, Adrian Davis, Ryan Demeyer, Jeroen Doran, Charles F. Garbagnati, Alice Gewiss, Adam Harder, Andrew Hortsch, Ruthi Karp, Dagan Kelly, Tyler L. Lecacheux, Odile Lewis, Jacob Magyar, Christopher Mase, Makiko Moore, Daniel J. Movasati, Hossein Novosel'tsev, A. Yu. Ranganathan, Dhruv Riggins, Paul Salerno, Adriana Salgado, Cecília Skjorshammer, Dmitri Smith, Adam A. Sperber, Steven I. Stein, William A. Syryczuk, Alexa Voight, John Michael

Mirror symmetry

My dissertation was inspired by constructions in mirror symmetry (on the algebraic geometry side).



Triumphs of Twentieth-Century Physics

- General relativity

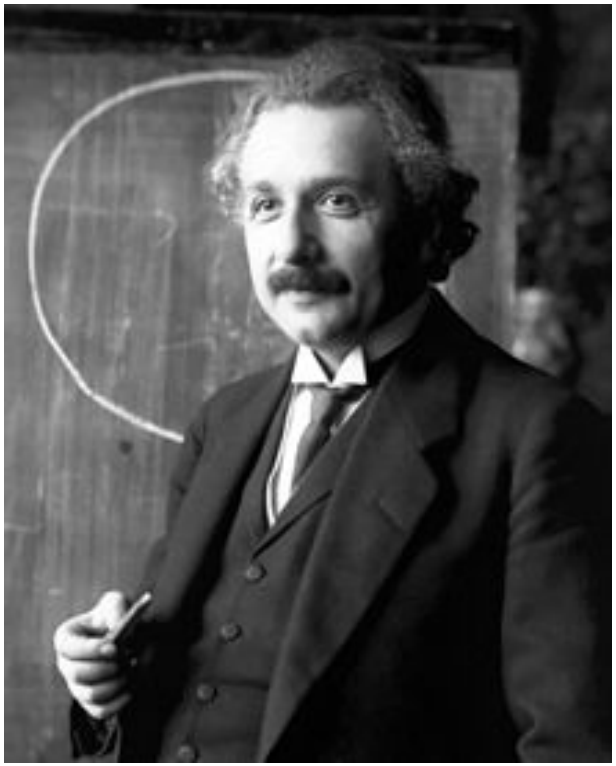


Figure: Albert Einstein

- Quantum mechanics

Figure: Fermilab

Where's the Theory of Everything?

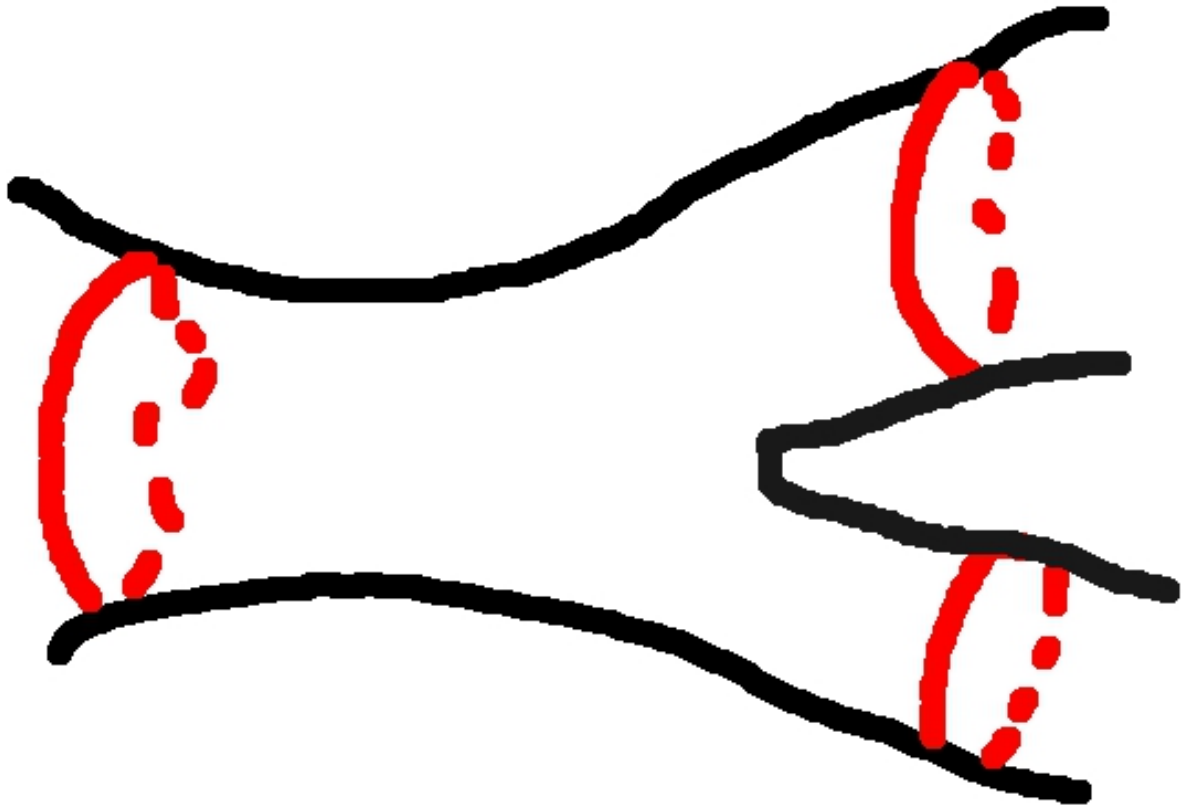
Can we build a theory of quantum gravity?

Challenge

Quantum fluctuations in "empty" space create infinite energy!

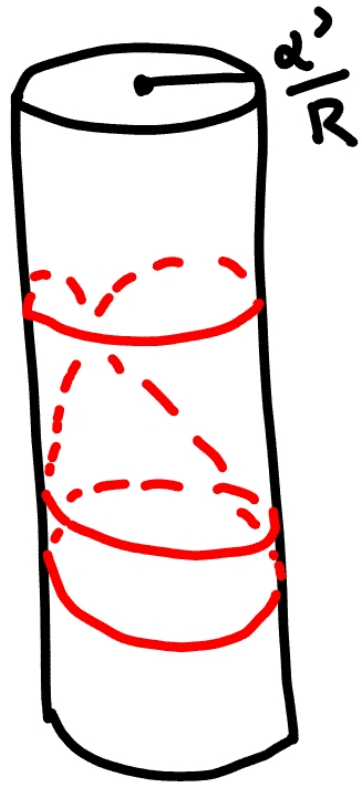
Are Strings the Answer?

String Theory proposes that "fundamental" particles are strings.



Extra Dimensions

For string theory to work as a consistent theory of quantum mechanics, it must allow the strings to vibrate in extra, compact dimensions.



Building a Model

Locally, space-time should look like

$$M_{3,1} \times V.$$

- $M_{3,1}$ is four-dimensional space-time
- V is a d-dimensional complex manifold
- Physicists require $d = 3$ (6 real dimensions)
- V is a Calabi-Yau manifold

A mathematical ancestor

The Yau in Calabi-Yau manifold is one of C. Doran's PhD advisors.

Figure: Shing-Tung Yau

The existential challenge of graduate school

Martin A. Schwartz, *The importance of stupidity in scientific research*

> *The crucial lesson was that the scope of things I didn't know wasn't merely vast; it was, for all practical purposes, infinite. That realization, instead of being discouraging, was liberating. If our ignorance is infinite, the only possible course of action is to muddle through as best we can.*

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`https://jcs.biologists.org/content/121/11/1771`

Many ways of doing mathematics

My strengths as a researcher include...

- Drawing together disparate sources

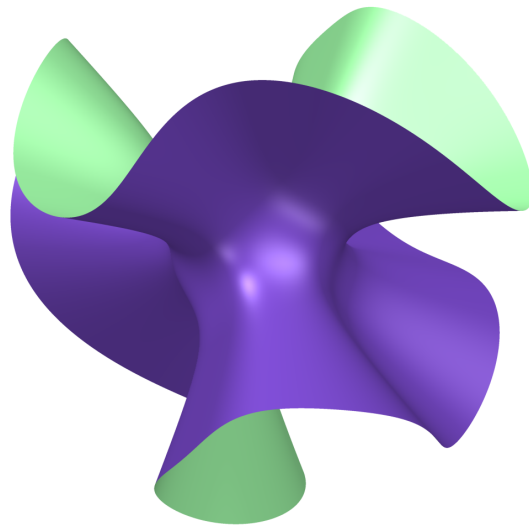
Many ways of doing mathematics

My strengths as a researcher include...

- Drawing together disparate sources
- Coding.

A dissertation takes shape

My dissertation was on K3 surfaces, four-dimensional Calabi-Yau manifolds.



Northward ho?

2008

Chuck starts job at University of Alberta (Edmonton, Canada).

The best-laid plans...

I stayed in Seattle, with a plan. Either:

- Tenure-track job at small liberal arts college
- Postdoc in Alberta

Welcome to the Great Recession

- Big financial hit to universities

Welcome to the Great Recession

- Big financial hit to universities
- Stimulus bill sent funds to NSF.

Teaching and Research Postdoctoral Fellowship

In May 2009, I was offered a postdoc at Harvey Mudd College.

Figure: Claremont, California

All the mentoring

Figure: UW, Dagan Karp, Talithia Williams

Not pictured: Ray Levy, Andy Bernoff, ...

A fortuitous meeting

Dagan invited me to speak at SACNAS 2010, where I met Adriana Salerno, a number theorist.

Two physicists and a number theorist

Figure: Philip Candelas

Figure: Xenia de la Ossa

Figure: Fernando Rodriguez Villegas

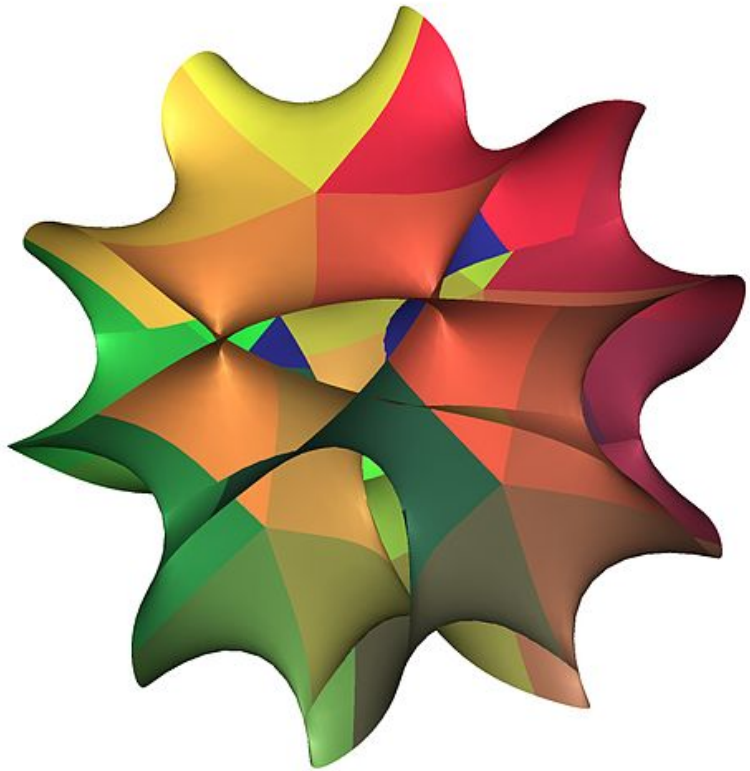
Fernando Rodriguez Villegas was Adriana's PhD advisor.

Counting solutions

How many solutions are there to

$$x_0^5 + x_1^5 + x_2^5 + x_3^5 + x_4^5 \equiv 0 \pmod{p}$$

?



The mirror matters

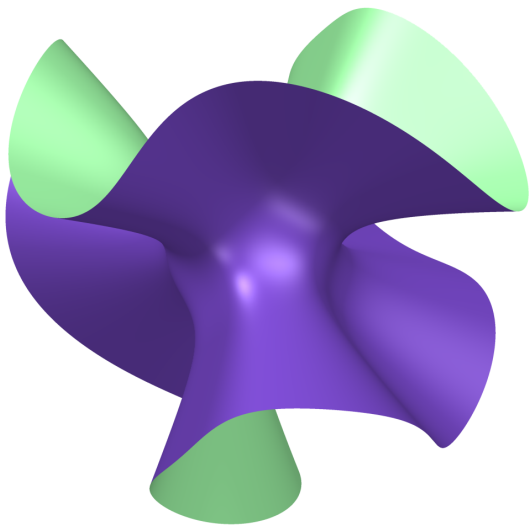
Candelas, de la Ossa, and Rodriguez Villegas showed that the number of solutions is related to the number of solutions for the mirror manifold.

Some interesting examples

Family	Equation
F_4 (Fermat/Dwork)	$x_0^4 + x_1^4 + x_2^4 + x_3^4$
F_2L_2	$x_0^4 + x_1^4 + x_2^3x_3 + x_3^3x_2$
F_1L_3 (Klein-Mukai)	$x_0^4 + x_1^3x_2 + x_2^3x_3 + x_3^3x_1$
L_2L_2	$x_0^3x_1 + x_1^3x_0 + x_2^3x_3 + x_3^3x_2$
L_4	$x_0^3x_1 + x_1^3x_2 + x_2^3x_3 + x_3^3x_0$

A physical prediction

If the mirrors have similar properties, the original manifolds have similar properties!



Moving north

In 2011, I started a tenure-track job at the University of Wisconsin-Eau Claire.

Figure: Eau Claire, Wisconsin

A culture of undergraduate research

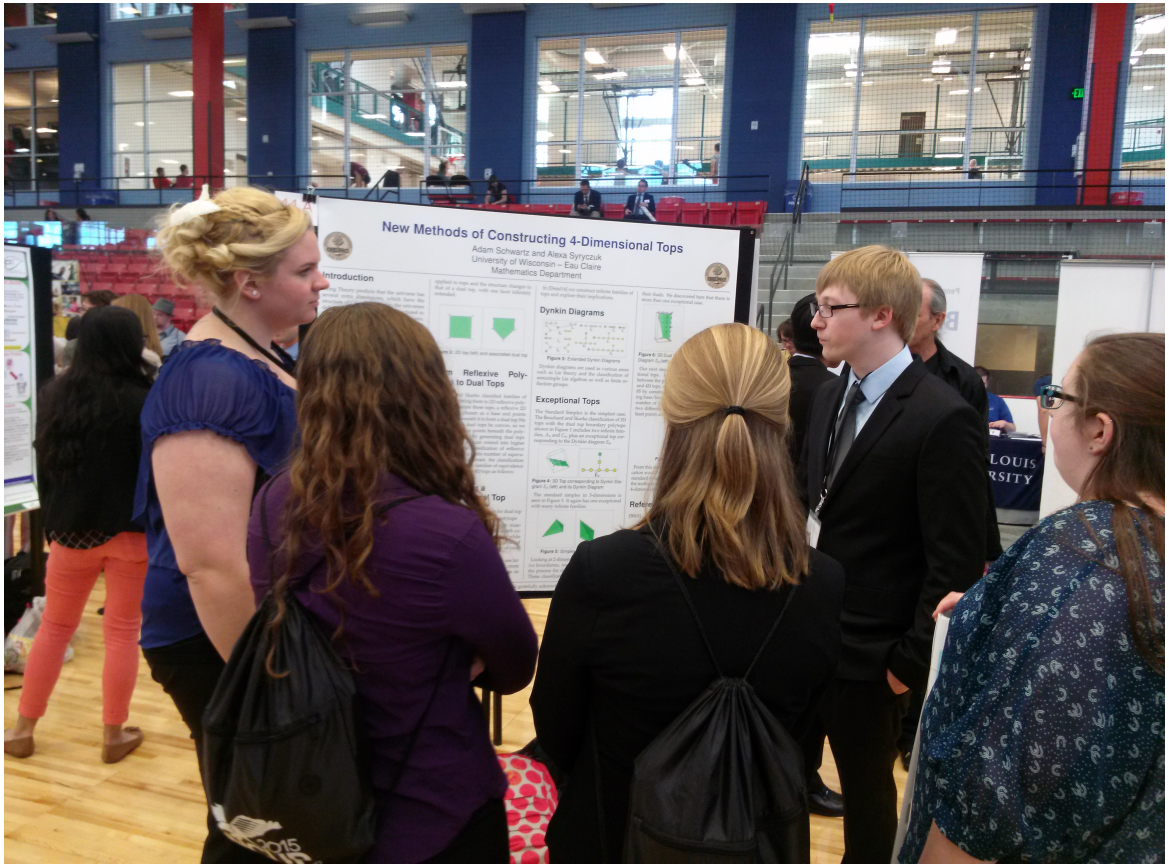


Figure: Adam Schwartz and Alexa Syryczuk describe their research

Teaching all the things

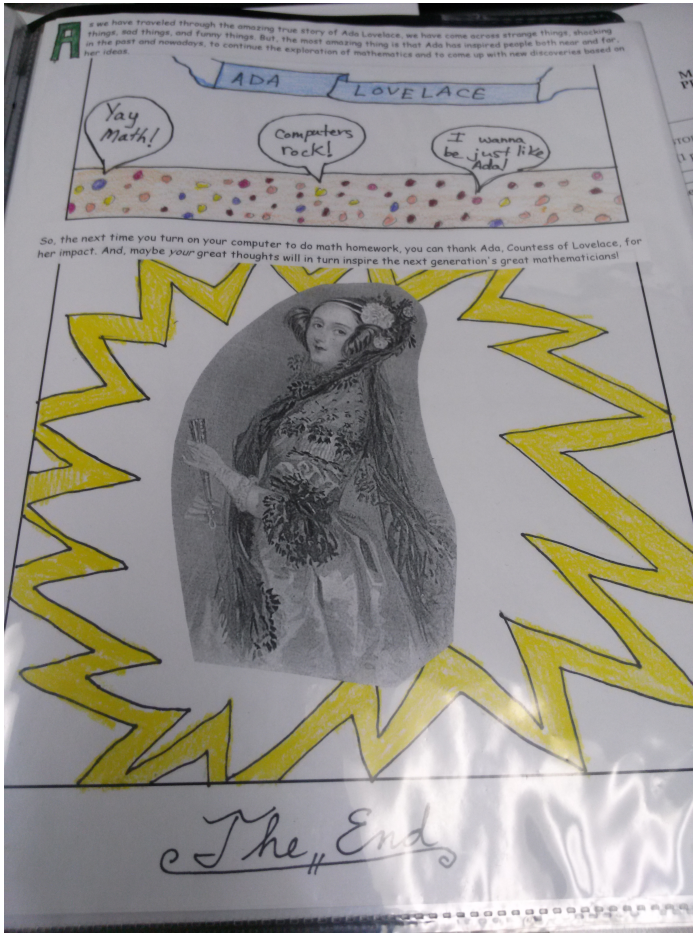


Figure: Student project

In my five years at UWEC, I taught (multiple sections of) 14 different courses.

The hyper-square

BIRS and AIM collaboration grants

Tyler Kelly, Charles Doran, Steven Sperber, Ursula Whitcher, John Voight, Adriana Salerno

The definition of tenure

2015 Wisconsin legislature removed tenure from state law.

2016 University of Wisconsin Board of Regents wrote new "tenure" description with weakened protections.

The two-body problem

Solutions aren't always permanent

Figure: A Cray-1 supercomputer

An intriguing advertisement

Math Reviews advertised for. . .

An intriguing advertisement

Math Reviews advertised for...

- A skilled writer

An intriguing advertisement

Math Reviews advertised for...

- A skilled writer
- With a background in algebraic geometry or group theory

An intriguing advertisement

Math Reviews advertised for...

- A skilled writer
- With a background in algebraic geometry or group theory
- And significant experience beyond the PhD.

All paths to victory

There are many ways and opportunities to communicate mathematics!

Sometimes you know a physicist

Figure: UW, BF, Kendall M. Mahn