Title: Designing solutions for communicating science (Scientists are designers too)

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Abstract: "A well constructed theory is in some respects undoubtedly an artistic production." - Sir Ernest Rutherford

"Design is the synthesis of form and content."-Paul Rand

On the surface, the scientific method (primarily analytic) and design methodologies (primarily synthetic) seem to be quite different processes but there is considerable overlap and communicating science involves a blend of both. Scientists tend to use a scientific approach when
communicating science but there are benefits to using a designer's approach. Communicating science always requires finding solutions to difficult, ill-defined problems but employing design frameworks can help.

One such framework is "design thinking", a powerful approach to problem solving that is rarely explicitly used in science or science communication. Design thinking consists of a set of analytic and
synthetic steps, although not a purely linear sequence, involving various modes of thought and processes. Design thinking is user-centered, collaborative, experimental, and has a bias toward action. This colloquium will present a design-thinking framework that can be useful in communicating science and examine how it differs from a typical scientific approach to problem solving.

Although the colloquium will focus primarily on outreach-type communication, we shall also consider applying the framework to writing scientific papers. In the end we'll find that scientists are designers
too, but that reframing the intellectual toolkits on hand can be useful for scientists when communicating science.

Designing solutions for communicating science

(Scientists are designers too)

David Harris
at the Perimeter Institute for Theoretical Physics
June 19, 2013

@physicsdavid

Where we're headed in this colloquium

- All about how to do better science communication using design thinking

Theory

- Some definitions
- Solving problems in science communication
- Models of problem solving
- What is design and "design thinking"?

Where we're headed in this colloquium

Applications

- Lessons and examples of unsuccessful and successful science communication in physics
- Why people get hung up on the Higgs mechanism and special relativity
- Why the Higgs announcement was both appropriate and not
- Writing scientific papers

Context: How most scicomm projects are conducted by scientists

1. Have a great idea of something to do

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4. Find an audience

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1. Have a great idea of something to do
2. Find the resources to make it happen
3. Prepare for the project instantiation
4. Find an audience
5. Execute the project

(Strictly linear process)

Is this an optimal approach?

DEFINITIONS

Design

- is a synthesis of form and content
- is a process for solving problems
- is a general field without explicit subject matter in general
- is part art and part science

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Graphic Design

- is a subfield of design concerning the application of general design principles to communication through layout, typography, and imagery
- is one of many subfields including industrial design, architectural design, fashion design, product design, systems design, etc.

Design Thinking

- Is a multi-stage process for solving problems in the design field combined with a set of modes of thinking

Scicomm as problem solving

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Scicomm as problem solving

- All strategic scicomm projects should have some sort of goal.
- Anything with a goal can be posed as a problem to be solved.

Examples of scicomm problems

- Goal: Convince an audience of the validity of some science
- Goal: Teach some concepts in science
- Goal: Increase awareness of science
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- **Simple** problems: Both the problem and the solution are known (*Eigenstates of a quantum system—has theoretical confirmation*)
- **Complex** problems: The problem is known but the solution is not known (*Predicting masses of new particles from a parameterized particle physics theory—needs experimental confirmation*)
- **“Wicked”** problems: The problem is not well-defined and the solution is not known. (*Quantum gravity—experimental tests not yet understood*)

Properties of wicked problems

As originally applied to planning and architecture – Horst Rittel, (mathematician/designer), 1972

1. Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution.
2. Wicked problems have no stopping rules.
3. Solutions to wicked problems cannot be true or false, only good or bad.
4. In solving wicked problems there is no exhaustive list of admissible operations.
5. For every wicked problem there is always more than one possible explanation, with explanations depending on the *Weltanschauung* of the designer.

Properties of wicked problems (cont.)

6. Every wicked problem is a symptom of another, "higher level", problem.
7. No formulation and solution of a wicked problem has a definitive test.
8. Solving a wicked problem is a "one shot" operation, with no room for trial and error.
9. Every wicked problem is unique.
10. The wicked problem solver has no right to be wrong—they are fully responsible for their actions.

Communication is a wicked problem

- The science of science communication is in its infancy so we don't have much evidence to go on.
- Wicked problems: e.g. giving a public lecture, writing a popular science book, making a video, creating a game

"Design is combining form and content. We need both. Too much form becomes abstract. Too much content becomes unreadable." – Paul Rand

Design problems are "indeterminate" or "wicked" because design has no subject matter of its own apart from what a designer conceives it to be.

- Buchanan, 1992

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- Communication is also a design problem.
- Communication problems involve subject content+psychology+sociology+rhetoric+…

MODELS OF SCICOMM

Science of scicomm

- Ideally we'd use the data to inform our methodology BUT the science of scicomm is immature and not many concrete results are known
- So instead, let's think about some of the existing models for problem solving and see whether they fit for our purposes

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- **Ad hoc methods** (most common): experience tells us that these tend to neglect best practice and evidence

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- **Information deficit model** (very common): assumes that conveying information will bring an audience on side
- **Scientific method**: Assumes a well-defined problem with a testable solution, evidence based. Communication as experiment (some sci education problems)
- **Design thinking**: Used for ill-defined problems with many factors and "fuzzy" solutions, where evidence is not present (most scicomm)

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- Defn: attributes public skepticism or hostility to a lack of understanding, resulting from a lack of information.

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- Examples where it has failed: anthropogenic global warming, BSE cases, GMO issue, nuclear anything, political support for basic research, SSC

ON DESIGN

What design isn't

"When Einstein realized, "Dear me, this universe with its wonders all adds up to $E=mc^2$?," he did not stop to think whether this concept would sell better set in Futura or *Antikva*?"

- Kari Piippo

Defining design

"Design is the method of putting form and content together. Design, just as art, has multiple definitions; there is no single definition. Design can be art. Design can be aesthetics. Design is so simple, that's why it is so complicated."

- Paul Rand, 2001

A more formal definition

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- Ralph and Wand, 2009

Defining theoretical physics

Theoretical physics (n):

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~~manifested by some *agent*~~,

~~intended to accomplish *goals*~~,

~~in a particular *environment*~~,

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SCIENCE VS. DESIGN: A DIFFERENCE IN WORLDVIEWS

"The scientific method is a pattern of problem-solving behavior employed in finding out the nature of what exists, whereas the design method is a pattern of behavior employed in inventing things of value which do not yet exist. Science is analytic: design is constructive."

- Gregory, S A (1966) ed. *The Design Method*, Butterworth, London UK

“The natural sciences are concerned with how things are… Design, on the other hand, is concerned with how things ought to be.”

- Simon, 1969

"Members of the scientific community, however, must be puzzled by the types of problems addressed by professional designers and by the patterns of reasoning they employ. While scientists share in the new liberal art of design thinking, they are also masters of specialized subject matters and their related methods….This creates one of the central problems of communication between scientists and designers, because the problems addressed by designers seldom fall solely within the boundaries of any one of these subject matters."

- Buchanan, 1992

Three cultures

	Science	Humanities	Design
Phenomenon of study	Natural world	Human experience	Artificial world
Primary methods	Controlled experiment Classification Analysis	Analogy Metaphor Evaluation	Modeling Pattern formation Synthesis
Primary values	Objectivity Rationality Neutrality Concern for 'truth'	Subjectivity Imagination Commitment Concern for 'justice'	Practicality Ingenuity Empathy Concern for 'appropriateness'

Adapted from:
Cross, N., Designerly Ways of Knowing (Board of International Research in Design), Sprinter Verlag, London, 2006

Differences in methods

Analysis	Synthesis
• Rational	• Emotional
• Logical	• Intuitive
• Deductive	• Inductive
• Solutions	• Paradigms, platforms
• "Thinking it through"	• Thinking through doing
• Single discipline	• Multiple disciplines
• Elegance	• Impact

DESIGN THINKING

"My view of the matter, for what it is worth, is that there is no such thing as a logical method of having new ideas, or a logical reconstruction of this process. My view may be expressed by saying that every discovery contains an 'irrational element,' or 'a creative intuition.'"

– Karl Popper

Design thinking process – two variants

(Note that these are not strictly linear)

Variant A

- Define
- Research
- Ideate
- Prototype
- Choose
- Implement
- Learn

Source: Wikipedia

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Variant B

- Empathize
- Define
- Ideate
- Prototype
- Test

Source: Stanford d.school

Design thinking mindsets

- Show don't tell
- Focus on human values
- Craft clarity
- Embrace experimentation
- Be mindful of process
- Bias toward action
- Radical collaboration

From the Stanford d.school

CASE STUDY: CONVEYING EMERGING CONCEPTS IN THEORETICAL PHYSICS

Define Research Ideate Prototype Choose Implement Learn

- Decide what issue you are trying to resolve. (*Convey the excitement of an emerging concept in theoretical physics.)*
- Agree on who the audience is. (*Science-interested general public.*)
- Prioritize this project in terms of urgency.
- Determine what will make this project successful. (*People come away from the experience excited and wanting to return for more.*)
- Establish a glossary of terms. (*Or at least figure out what jargon the audience knows or doesn't know.*)

Define **Research** Ideate Prototype Choose Implement Learn

- Review the history of the issue; remember any existing obstacles. (*Long history of public lectures; easy to go over the heads of an audience*)
- Collect examples of other attempts to solve the same issue. (*Public lectures, popular books, etc.*)
- Note the project supporters, investors, and critics. (*Institution; funders; scientific critics; general public skeptics*)
- Talk to your end-users, that brings you the most fruitful ideas for later design. (*Talk to some representative members of the audience about the topic.)*
- Take into account thought leaders' opinions. (*Ask your public information officer for advice.*)

Define Research **Ideate** Prototype Choose Implement Learn

- Identify the needs and motivations of your end-users – ask what they want to get out of it (e.g. usable knowledge, skills, interest) (*Primarily for entertainment.*)
- Generate as many ideas as possible to serve these identified needs. (*Lecture, book, educational kit, game, video, TV series, bus advertisements, etc.*)
- Log your brainstorming session.
- Do not judge or debate ideas. (*Don't laugh at bus advertisements yet.*)

Define Research Ideate **Prototype** Choose Implement Learn

- Combine, expand, and refine ideas.
- Create multiple drafts. (*Create rough outlines, sketches, storyboards*)
- Seek feedback from a diverse group of people, include your end users. (*Talk with intended audience about format as well as content.*)
- Present a selection of ideas to the client. (*Check that the approaches are acceptable to stakeholders.*)
- Reserve judgment and maintain neutrality.
- Create and present actual working prototype(s) (*Noting that prototypes shouldn't be polished final products.*)

Define Research Ideate Prototype **Choose** Implement Learn

- Review the objective. (*Check your ideas actually satisfy the original goal.*)
- Set aside emotion and ownership of ideas. (*Use the best ideas regardless of who came up with them.*)
- Avoid consensus thinking. (*Don't design by committee.*)
- Remember: the most practical solution isn't always the best. (*Don't just fall for the easiest or most familiar option.*)
- Select the powerful ideas. (*Choose your format and content.*)

Define Research Ideate Prototype Choose **Implement** Learn

- Make task descriptions.
- Plan tasks.
- Determine resources.
- Assign tasks.
- Execute.
- Deliver.

Define Research Ideate Prototype Choose Implement **Learn**

- Gather feedback from the audience.
- Determine if the solution met its goals.
- Discuss what could be improved.
- Measure success; collect data.
- Document.

"Prototype as if you know you're right, but test as if you know you're wrong."

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- Learn (*Ask for feedback; make the presentation available for review.*)

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- What should the take-home messages be? [Focus on human values]
- Will this fail catastrophically? [Embrace experimentation]

DESIGN AND THEORETICAL PHYSICS

Aside: How theoretical physics is like design

- Define → Choosing a scope/question

(not strictly linear)

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- Research → Literature review, discussions

(*not strictly linear*)

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- Choose → Test predictions of theory

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- Prototype → Model building, seminars, chats
- Choose → Test predictions of theory
- Implement → Write the paper
- Learn → Listen to colleagues' responses

(*not strictly linear*)

WHY USE A DESIGN METHODOLOGY FOR COMMUNICATION?

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- Making the methodology explicit makes it easier to follow and to be successful
- Allows for intuition in the process, where we don't have evidence

LESSONS AND EXAMPLES

Some lessons for theoretical physicists when communicating science

- Employ beginner's mind—empathize with your audience

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- Show don't tell—entertaining stories work

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- Show don't tell—entertaining stories work
- Create something tangible—don't just think
- Prototype and test—drafts and feedback are your friend—use pilot projects
- Collaborate radically—work with people from surprising fields

Example: Higgs mechanism

- Typical Higgs explanation: Standard Model tells us that particles should have no mass. Then use an analogy as to how that mass comes about.

Example: Higgs mechanism

- Typical Higgs explanation: Standard Model tells us that particles should have no mass. Then use an analogy as to how that mass comes about.
- But this misses the point of beginner's mind: Beginners don't see why we should start from no mass—our experience says that things have mass already. So we need an extra step to justify why we start at no mass or need a completely different framing.

Example: Special relativity

- Typical explanations assume Galilean relativity as a starting point, which is not always intuitive to beginners. Even a Galilean frame change can be confusing for a beginner.

Example: Special relativity

- Typical explanations assume Galilean relativity as a starting point, which is not always intuitive to beginners. Even a Galilean frame change can be confusing for a beginner.
- Whenever an explanation requires an evolution of thinking, make sure you start where the audience is. So we need to research that to begin with!

Example: Thought experiments

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- Are in the form of stories (good)
- Show rather than tell (good)
- Can be better than analogies as analogies break down in unsuspected ways in a beginner's mind
- But you have to start where the audience is
- Prototype and test your stories with real audience members if possible

The Crystal Goblet–Beatrice Warde, 1955

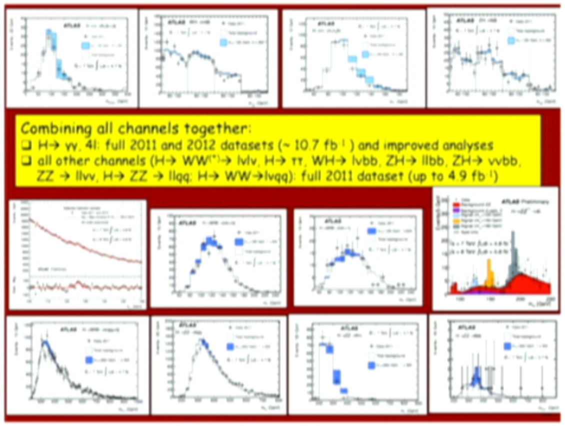
Excerpt from a lecture to the British Typographers' Guild

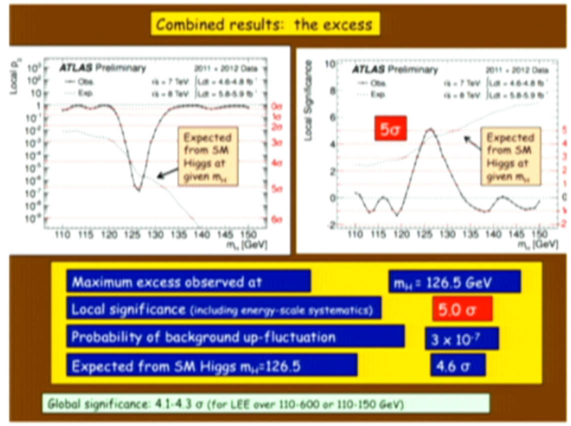
You have two goblets before you. One is of solid gold, wrought in the most exquisite patterns. The other is of crystal-clear glass, thin as a bubble, and as transparent. Pour and drink; and according to your choice of goblet, I shall know whether or not you are a connoisseur of wine. For if you have no feelings about wine one way or the other, you will want the sensation of drinking the stuff out of a vessel that may have cost thousands of pounds; but if you are a member of that vanishing tribe, the amateurs of fine vintages, you will choose the crystal, because everything about it is calculated to reveal rather than to hide the beautiful thing which it was meant to contain.

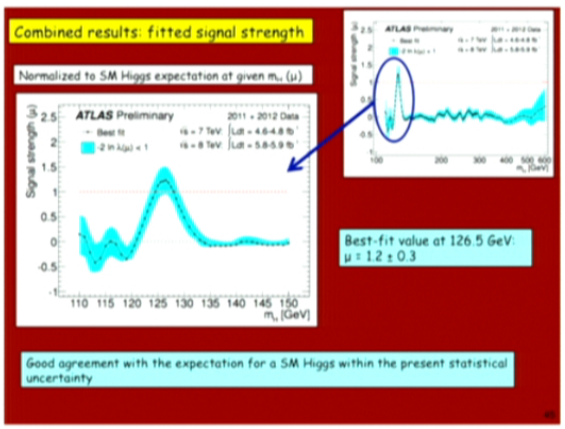
Application: Graphic design and aesthetics in science communication

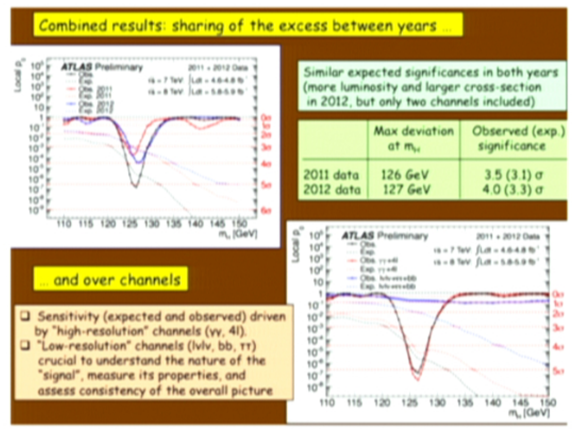
Design = form + content : for most science communication purposes, form should be effectively invisible and there to enhance the content. But some purposes might warrant more extravagant form, depending on your audience's sensibilities.

The Higgs Announcement and Comic Sans









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- MANY particle physics presentations use Comic Sans to the point where it is invisible in many cases.
- The high density of information on the slides is **really** bad for non-PP audiences but completely acceptable for PP audiences as they already have the language and experience to understand.
- The presentation was designed for particle physicists, not a wider audience. That might have been a mistake.

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- Our philosophy for graphic design (and the rest of the design) was to embody a set of adjectives, based on focus groups and interviews with our prospective audience, conducted at the very start of the process.
- Adjectives: clean, approachable, artful/stylish, approachable, alive, novel, engaging, credible.

WRITING SCIENTIFIC PAPERS

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- Note this implies a semi-open process.

CONCLUDING THOUGHTS

In a nutshell

Because we don't yet have strong, codified evidence for what works in science communication, we need something in the process to make up for that lack. Design thinking is one approach that has been proven to be effective in solving wicked problems.

Advice

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- Prototype and test more than you think you need to

Acknowledgments

- Jessica Beard (geochemist)
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- Phil Marshall (astrophysicist)
- Liz Neeley (science communicator)
- Matt Stone (designer)
- Unknown abstract reviewers (theoretical physicists)

"A well constructed theory is in some respects undoubtedly an artistic production."

– Sir Ernest Rutherford

"Design is the synthesis of form and content."

– Paul Rand

Designing solutions for communicating science

(Scientists are designers too)

David Harris
at the Perimeter Institute for Theoretical Physics

June 19, 2013

@physicsdavid

Science Communication at Perimeter

- Get involved with:
  - Educational Outreach
  - Publications
  - External Relations

PERIMETER INSTITUTE FOR THEORETICAL PHYSICS

Educational Outreach

BRAINSTEM

Your Future is Now Festival

September 30 – October 6, 2013

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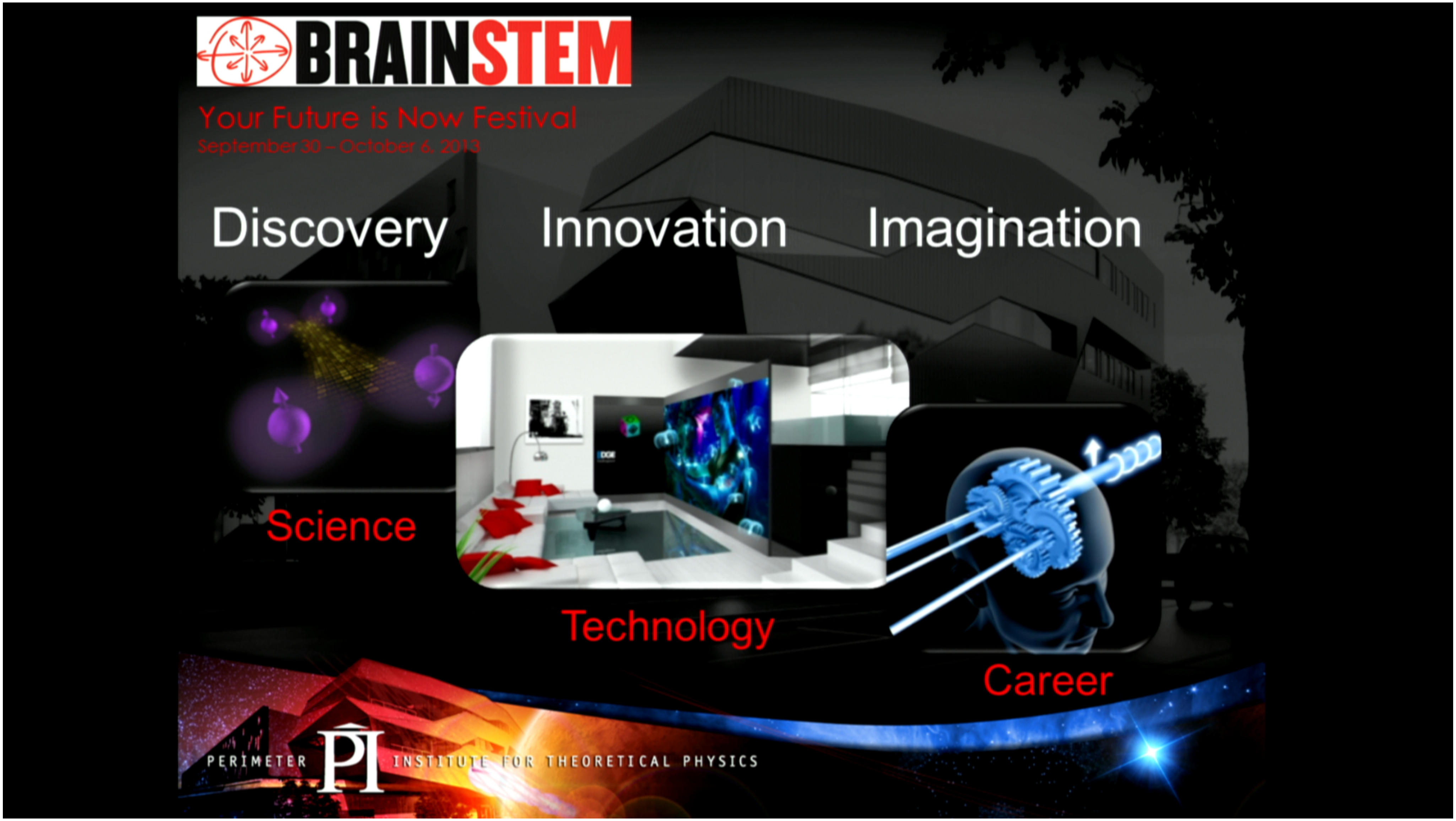
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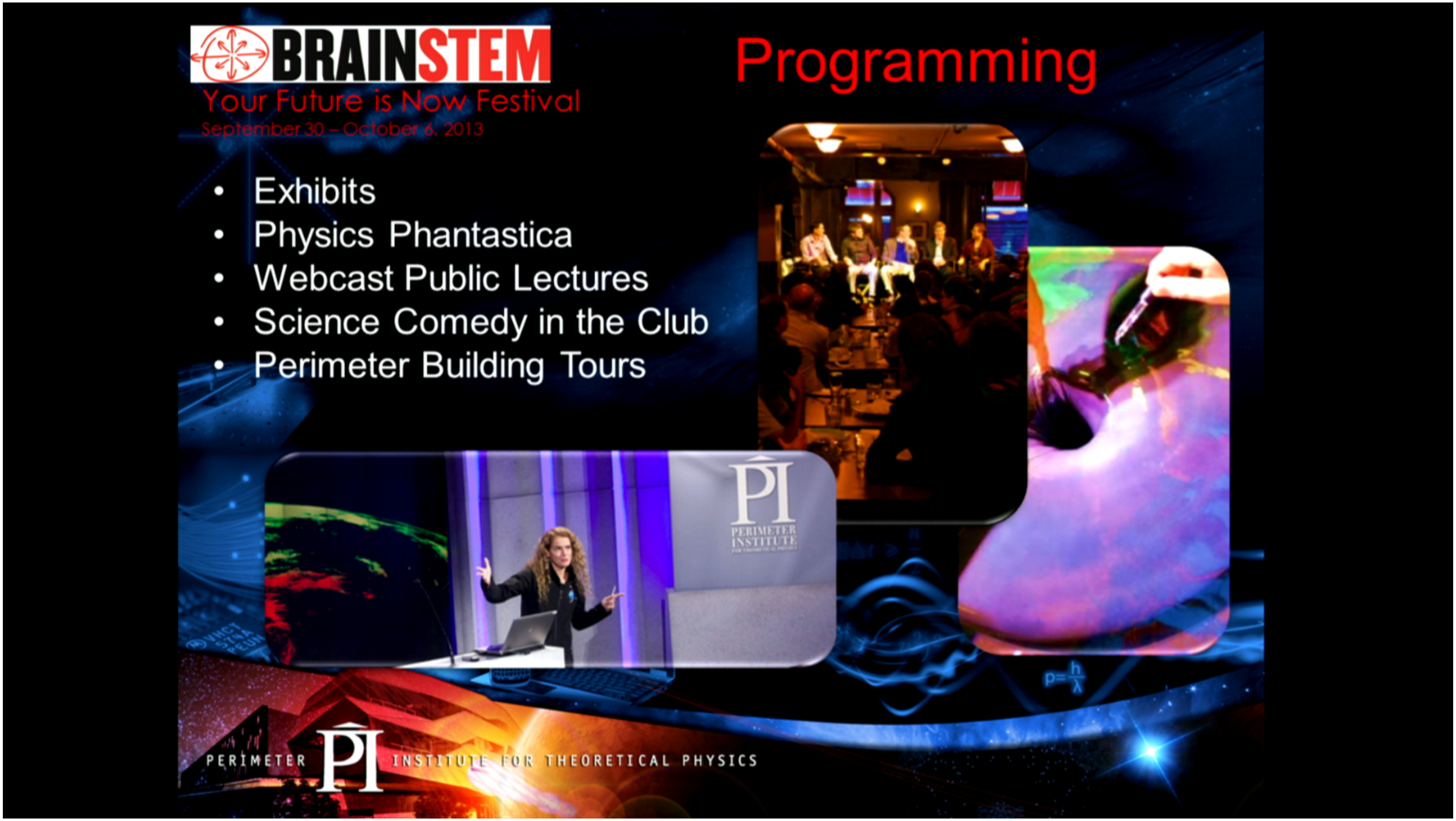
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• Perimeter Building Tours
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Getting Involved

- **Ask a Scientist**
  - Interact with high school students and the general public
  - Discuss what sparked your passion for science and what you are working on
- **Exhibit Host/Guide**
  - Discuss the science of Quantum Dots, Black Holes, Refraction (cloaking), etc.
- **Non-Scientific Opportunities**
  - Welcome to students, line control, direction guide, ticketing help

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fall 2012
inside the Perimeter
spring/summer 2013
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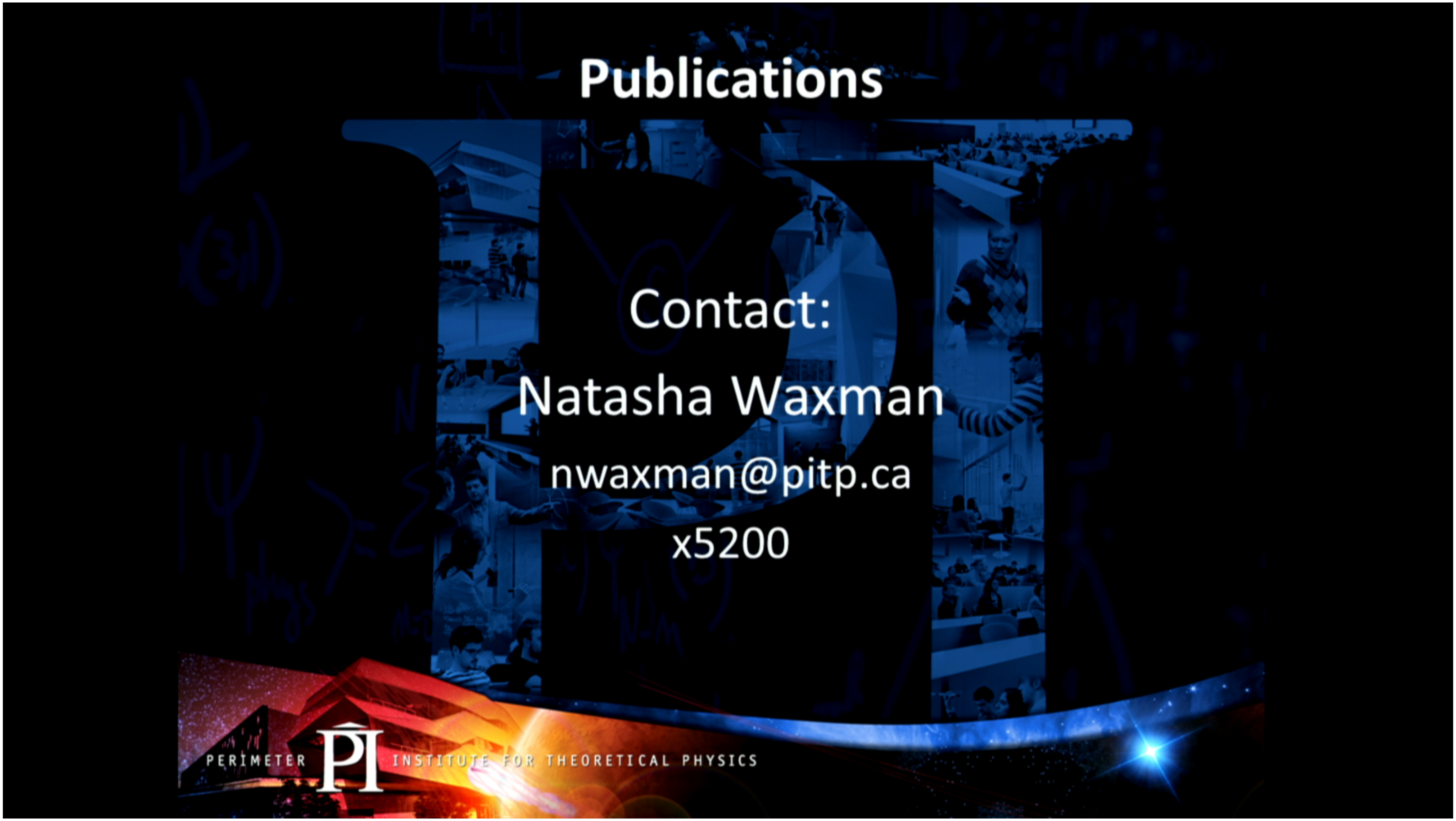
Publications
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External Relations

- Support with media engagement:
  - Building relationships with reporters
  - Understanding the nature of requests and expectations
  - Preparing for interviews
  - Getting your message across


THE GLOBE AND MAIL

Physicist's guiding star put universe at his feet

Master of the universes shakes up world of physics

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- Pirsa 12060017 - A Journalist's Perspective on Science Media with Ivan Semeniuk:
  - http://pirsa.org/displayFlash.php?id=12060017

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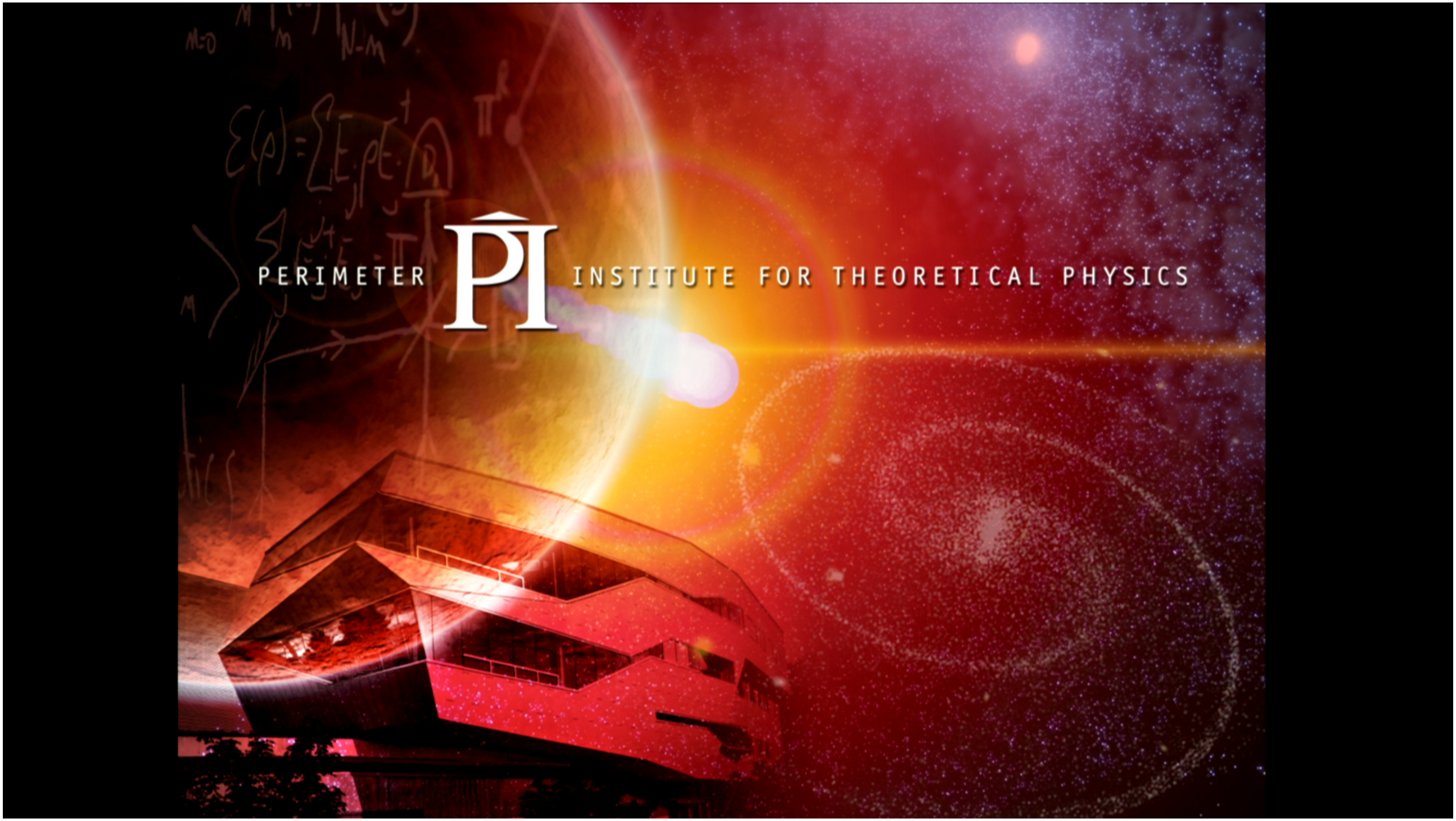
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