Title: Perspectives on Communicating Physics to the Public

Speakers: Matt Strassler, Tatiana Erukhimova

Series: Colloquium

Date: May 10, 2024 - 2:00 PM

URL: https://pirsa.org/24050022

Abstract: Presented as part of the SciComm Collider 2 workshop.
All PI Residents are invited.

A colloquium featuring 2 perspectives on science communication.

Tatiana Erukhimova - Making Physics Fun and Approachable
Matthew Strassler - The Challenge of Communicating Physics Accessibly, Clearly and Accurately

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Zoom link

Making Physics Fun and Accessible

Tatiana Erukhimova

Department of Physics & Astronomy


Think
DEEP


Amarillo
Lubbock
Wichita Falls
Abilene
Midland
Odessa
El Paso
San Angelo
Waco
Killeen
Temple
Round Rock
Austin
San Antonio
Dallas
Fort Worth
Arlington
Plano
Denton
Lewisville
Carrollton
Irving
Tyler
Longview
Texarkana
Houston
Pasadena
Sugar Land
Beaumont
Port Arthur
Galveston
Corpus Christi
Laredo
Victoria
College Station
Bryan
Huntsville
Texas


2018
CHILIFEST
Music Festival Snook, Texas
GUN SHOW
BELTWAY EAST
RT ON FAIRMONT
BOAT SHOW
nrg center

50+ professors

200+ hands-on science exhibits

NSF funded EvalFest project
24 Science Festivals in US
2015-2017

Would you recommend the Festival to others?

Physics Show

2007-current, 30000 attendees,
200 undergrads and grad students
~40 Shows per year

Mitchell Institute Physics Enhancement Program for High School Teachers (MIPEP)


DAD
AGGIES

Videos Liked

Power lights with a moving...

What happens if you overl...

Fuse #ice cubes to a st...

#ThankYou for all the ...

Shrink a #balloon with ...

Make a #banana ham...

#Phonebook #friction with...

Flying #toiletpaper #fun b...

Trap laser beams for inter...

Ready for a big #cloud?! T...

The #spinning#wheel defi...

SHE'S #SPINNING! Why?! ...

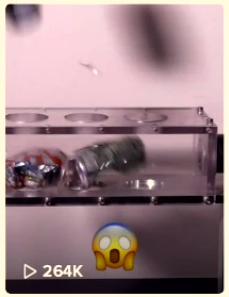
Lay #heavy#weight on ...

#DrTatiana stands on light ...

#DIY #Physics: Balance a ...

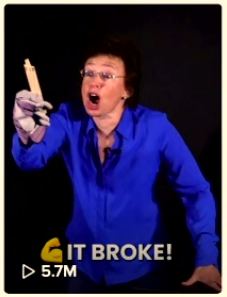
Create #fire from #air ...

#DrTatiana gets soaked b...



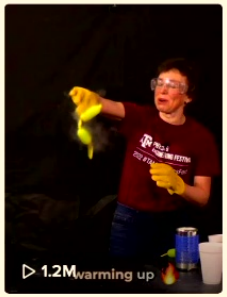
#Destroy cans with a ...

Sink or float #soda cans wi...



Break a ruler with ...

Shrink down and expand b...



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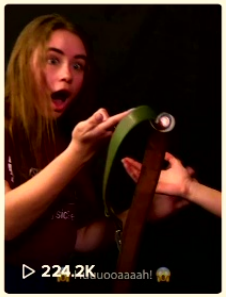
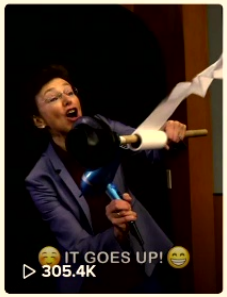


Ever wondered how ...



Make a mess & learn ...

TAMU Physics & Astronomy

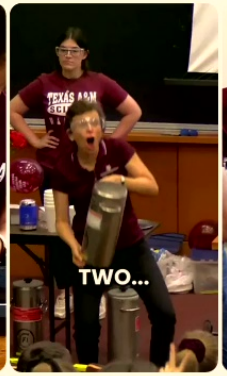
@tamuphysastr · 2.61M subscribers · 151 videos

The Department of Physics and Astronomy within Texas A&M University is home to int

Does the spinning wheel defy gravity? No! It obeys...
242M views

I AM FLYING! But how?! #shorts
50M views

Eggs can support A LOT of weight! #challenge #shorts
49M views

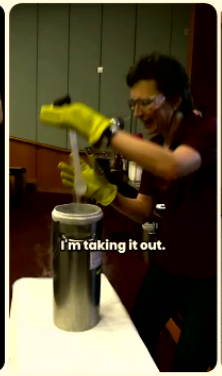


Ready for a big cloud?! These kids sure were! #physics...
41M views

Can a non-ma
be stopped by
30M views

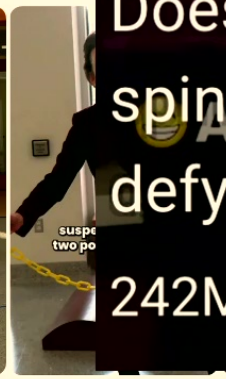
Erasers are like STONES!!
#shorts
27M views

Will the potato drop if I HIT the handle? LIKE THIS!? ...
26M views



Is oxygen magnetic? #shorts
25M views

Will they always meet in the middle??
#shorts
18M views



Can you ride a bike with square wheels? #viral...
17M views

It's a shaving cream volcano!
#shorts
17M views

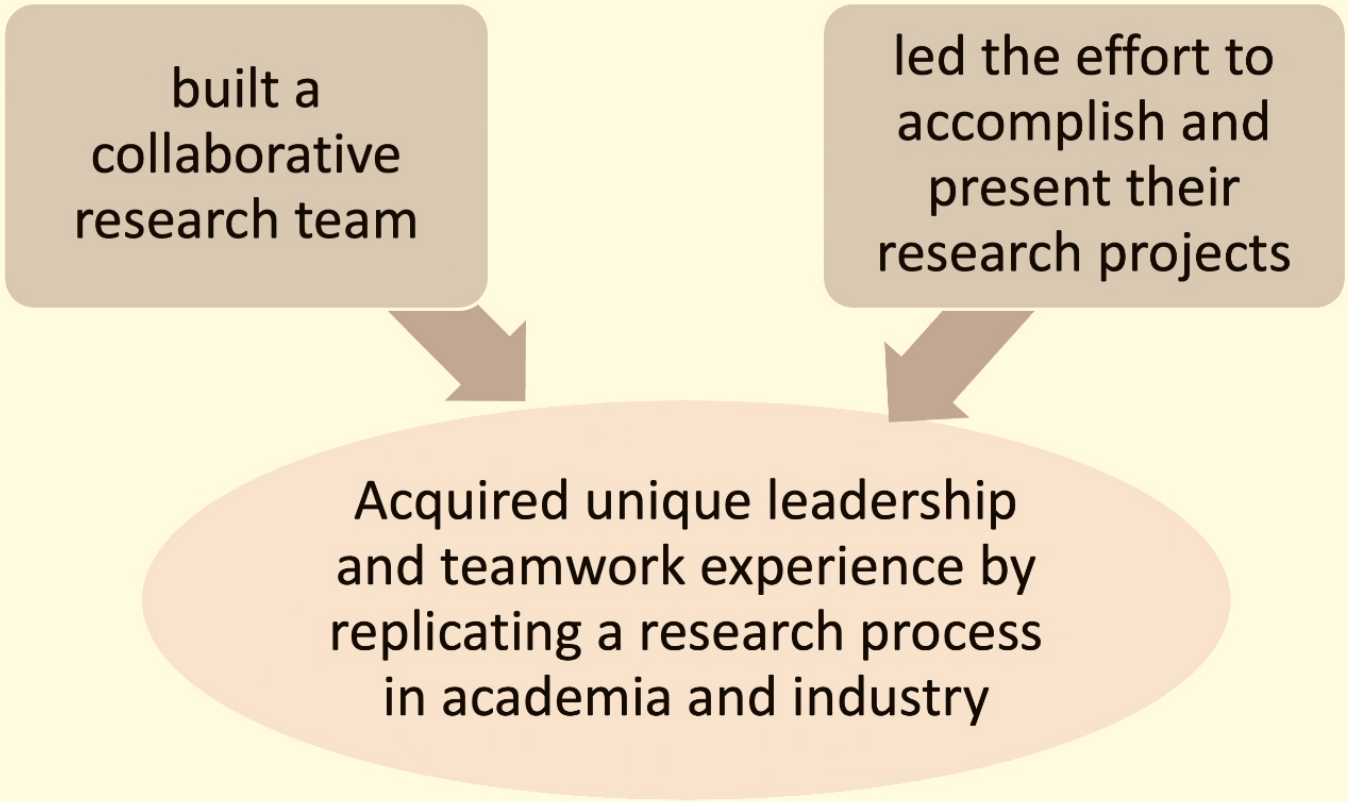

ORNINGS
SCHOOL MATTERS

Students work with peers and grad students on research, concept, design, and implementation of physics experiments

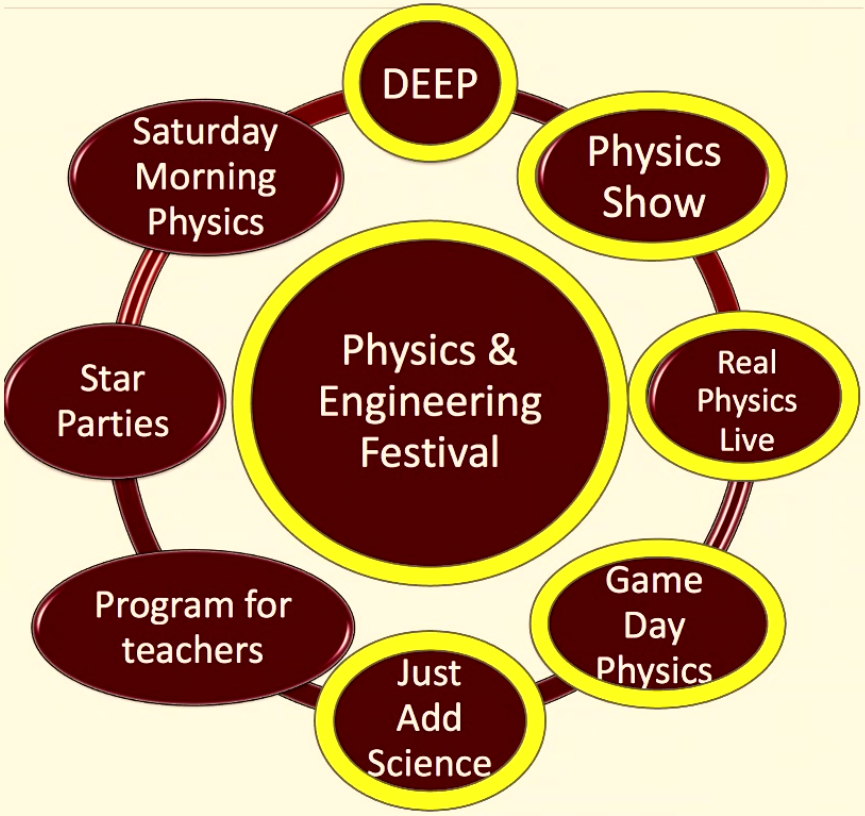
They present these exhibits during the Festival, Shows, Game Day Physics etc.

These demonstrations are used to enhance the undergraduate curriculum

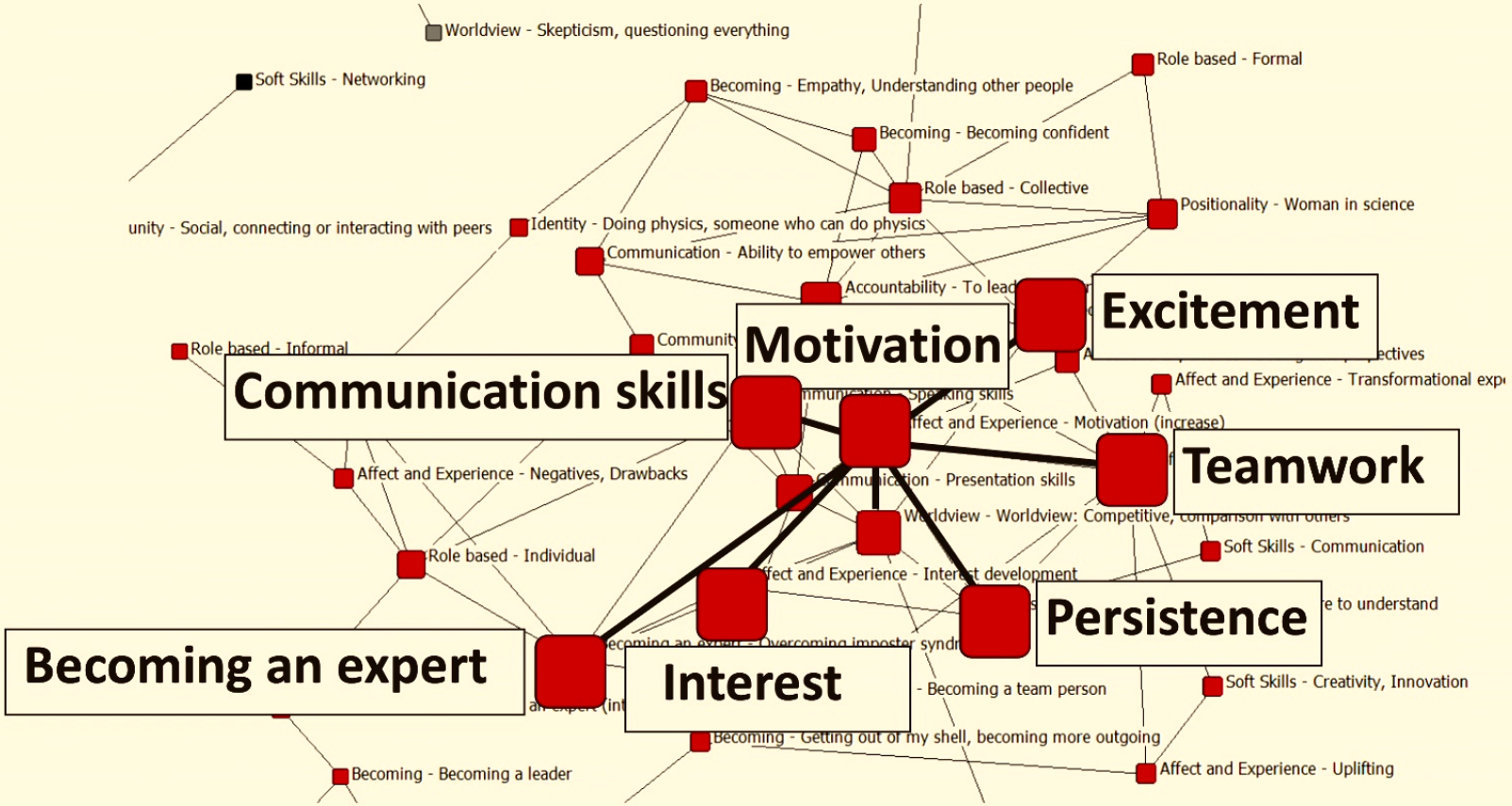
Graduate students (DEEP Mentors)



Physics & Astronomy Outreach



Semantic network map which shows the relationships between codes at the level of $p < 0.01$.



C. Rethman, J. Perry, J. P. Donaldson, D. Choi, and T. Erukhimova, Phys. Rev. Phys. Educ. Res. 17, 020110 (2021).

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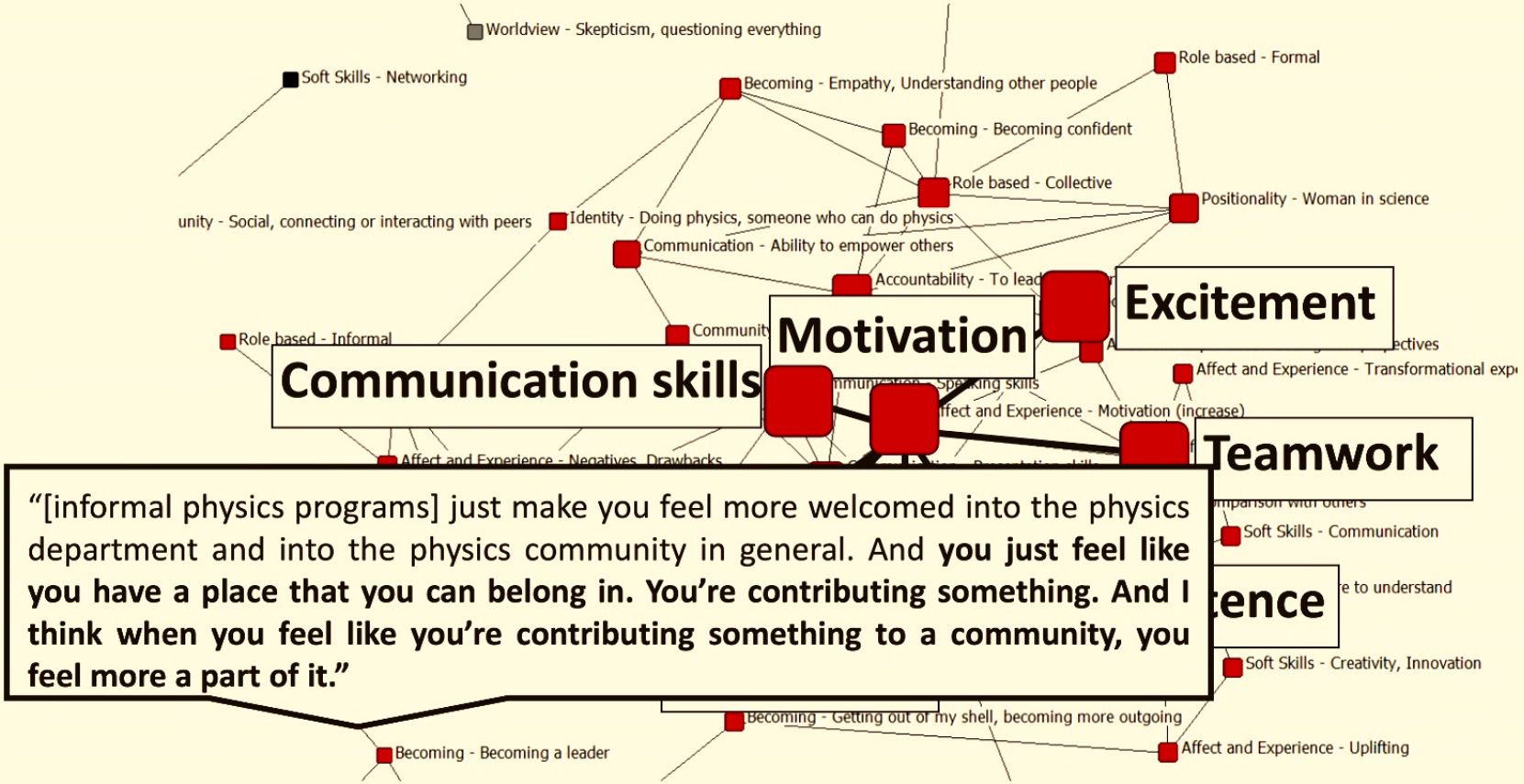


"[informal physics programs] just make you feel more welcomed into the physics department and into the physics community in general. And **you just feel like you have a place that you can belong in. You're contributing something. And I think when you feel like you're contributing something to a community, you feel more a part of it."**

C. Rethman, J. Perry, J. P. Donaldson, D. Choi, and T. Erukhimova, Phys. Rev. Phys. Educ. Res. 17, 020110 (2021).

Our mixed method study based on **self-reported data** showed that students who facilitated informal physics programs

- positively developed their physics identity experienced increased sense of belonging to the physics community;
- developed 21st century career skills: communication, teamwork and networking, design skills;
- female students experienced a statistically significant shift in their confidence of choice of major when comparing between prior to and after participating in the programs.
- all female students discussed positive effect on their interest and motivation with regards to the field of physics and the development of characteristics indicative of growth mindset. Majority of female students reported a positive impact on their confidence and self-efficacy, internal and external recognition, persistence, performance, and competency beliefs.
- creating demonstrations, working with peers to facilitate programs, engaging with a general audience promoted a greater breadth and depth of knowledge.

- Making physics accessible and enjoyable for people has to be a mission of every physics department. Every researcher can communicate physics to the public very effectively. You just need to create a proper format.

- Physics outreach is not only for the public. It is a unique experience and learning opportunity for students.

C. Rethman, J. Perry, J. P. Donaldson, D. Choi, and T. Erukhimova, Phys. Rev. Phys. Educ. Res. 17, 020110 (2021).

J. Randolph, J. Perry, J. P. Donaldson, C. Rethman, and T. Erukhimova, Phys. Rev. Phys. Educ. Res. 18, 020123 (2022).

C. Garrett, J. Perry, J. P. Donaldson, T. Erukhimova, PERC (2023)

THANK YOU

etanya@tamu.edu

https://physicsfestival.tamu.edu/

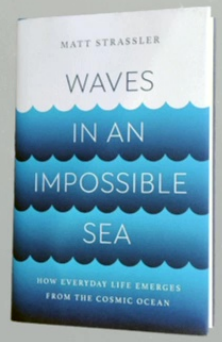
Physics, Words, and Metaphors

Some Thoughts on Science Communication

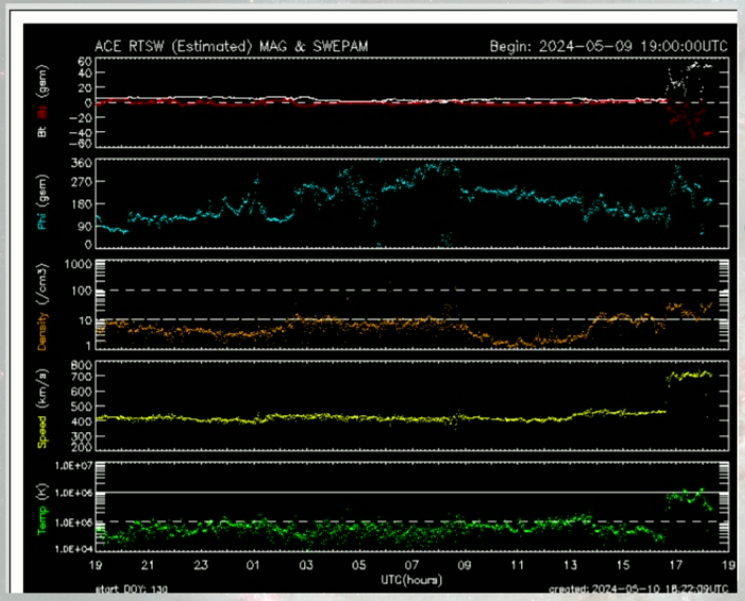
Matt Strassler

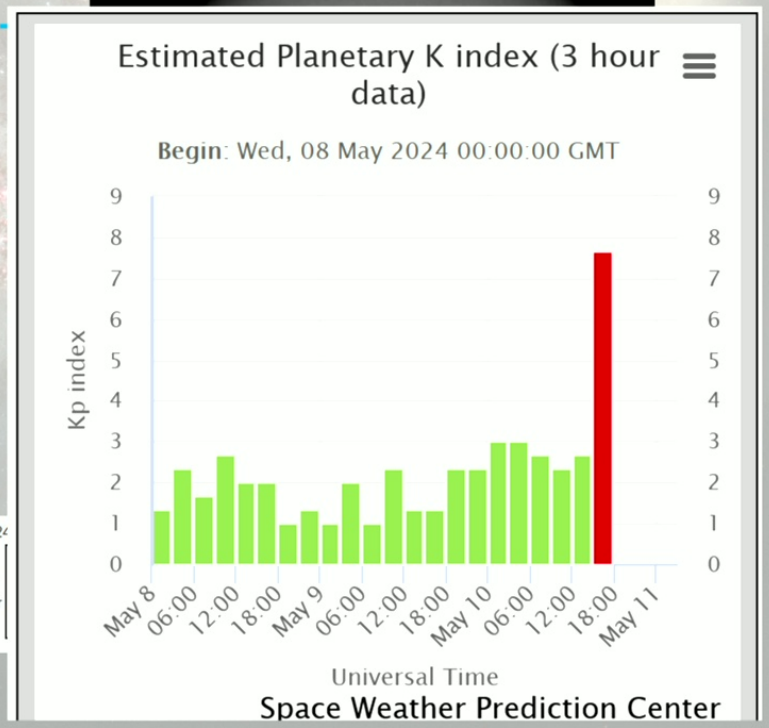
Harvard Physics

profmattstrassler.com



Aside: Auroras Ahead?





We Physicists Say Strange Things

- Explanations often (usually) involve compromise
  - But sometimes we don't tell the public that we're compromising
  - And sometimes we say things that are actually false
  - Moreover, some things we say contradict other things we say

Leads to cognitive dissonance: makes it difficult for non-experts to follow

Maybe contributes to distrust in science/scientists…?

Could we be clearer, more consistent?

Could we eliminate questions based on confusions we help create?

Today I'll point out a few examples that concern me…

My Own Approach

Guidelines that I try to write by:

- No statements, even if compromises, should be false
  - Should not contradict important facts
  - Should not need to be unlearned by future physicists
  - Should be defensible in front of scientific peers
- At all costs, try to avoid ambiguity in language
  - If words are inherently confusing, use others if possible
  - Make sure all definitions, if potentially ambiguous, are clear

Example: Higgs

Higgs field explanation

- as a sort of molasses, soup, or crowd [or… snow… ?!]
- gives mass to objects by impeding them / slowing them down

Lies outside my guidelines

- Contradicts important facts
  - Galileo's/Einstein's principle of relativity of motion
  - Newton's first and second laws
- Would need to be unlearned
  - Real action of Higgs field has nothing to do with motion at all
- Indefensible in front of scientific peers
  - Wrong about fields, about mass, about motion
  - There's simply nothing right about it!

"Why doesn't the Earth spiral into the Sun?"
"If the Higgs field exerts drag, why can't I feel it?"

“Mass”

Ambiguous/multiply-defined term:

- “As everyone knows, electrons have less mass than protons”
- “As everyone knows, mass increases with speed”

Obviously in contradiction…

- “rest mass”/”invariant mass”
- “relativistic mass” *[ill-defined but widely used]*
  - Similar issues for “gravitational mass” = “inertial mass”

- “Do photons have mass or not?”
- “Doesn’t the Higgs field have to do with gravity?”

Helpful to be explicit & clear about which “mass” is referred to?

- More overhead; but without it, confusion inevitable

“Matter” and Energy

- “The Cosmos is Made from Matter and Energy”

Also deeply problematic

- Matter **has** energy; it is not the opposite of energy
- Matter is a **substance**; energy is something that substances **have**
- “Ordinary matter, dark matter, dark energy”
  - Useful, common shorthand
  - Nevertheless, doesn’t actually support the above quote
    - Dark energy is not just “energy”; if it were, it wouldn’t “anti-gravitate”
    - Dark matter may not be “matter”; it just gravitates and clumps like matter

“Matter”

“The Cosmos is Made from Matter and Energy”

There are at least four definitions in particle physics, astronomy and cosmology!

All definitions agree that

- Atoms are matter
- Photons are not

Sure, but what about…

- Anti-protons?
- Neutrinos?
- Z bosons?
- Higgs bosons?
- Pions? Glueballs?
- Electrons in the first minutes of the Big Bang?
- Axion dark matter?

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Clear definition of “matter”, in context? – or avoid the term altogether?

Loose Language, Outdated Tropes

Interesting linguistics/history/psychology at work here

In our own conversations with one another, scientists speak loosely

- We often use words in contradictory ways – subtext establishes context
- This confuses young students for a while, but they catch on quickly

But best to keep loose language our of our public statements

Meanwhile we hang on to decades-old phrasing and viewpoints

We end up with a mix of jargon, confusing concepts and outdated tropes

- *Can't we can do better?*

“Electric Forces are Due to Photon Exchange”

This phrase had its historical role

More generally, same for the whole notion of “virtual particles”

But it mystifies something simple, something taught in first-year-physics!

“Electric Forces are Due to Photon Exchange”

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But it mystifies something simple, something taught in first-year-physics!

$$V(r) = \frac{e^{-mr}}{\mathbf{r}} = \int d^3p \; e^{i\mathbf{p}\cdot\mathbf{x}} \frac{1}{\mathbf{p}^2 + m^2}$$

For m=0, this is electrostatics…

Just a Fourier transform of a static field! Math trick, not physics.

What are Real and Virtual Particles?

Free field theory

$\hbar = c = 1$

- "Real particle": a **resonance** -- solution to *homogeneous* wave eq.

$$(\partial_t^2 - \partial_x^2 + m^2)\Phi(x,t) = 0 \Rightarrow E^2 - p^2 = m^2$$

- "Virtual particle": a **Green function**; solution to *inhomogeneous* wave eq.

$$(\partial_t^2 - \partial_x^2 + m^2)G(x,t;x',t') = i\delta(x-x')$$

$$\Rightarrow E^2 - p^2 = \text{ anything}$$

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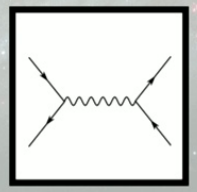

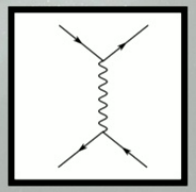

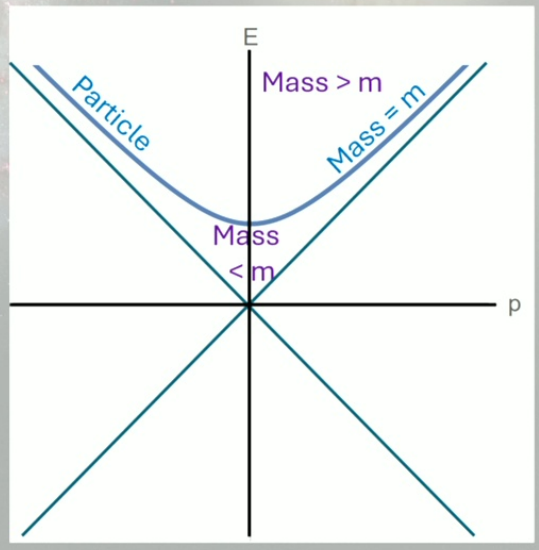

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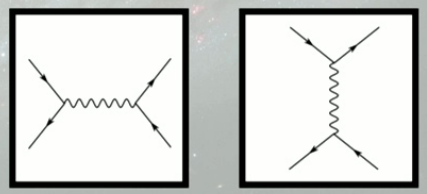
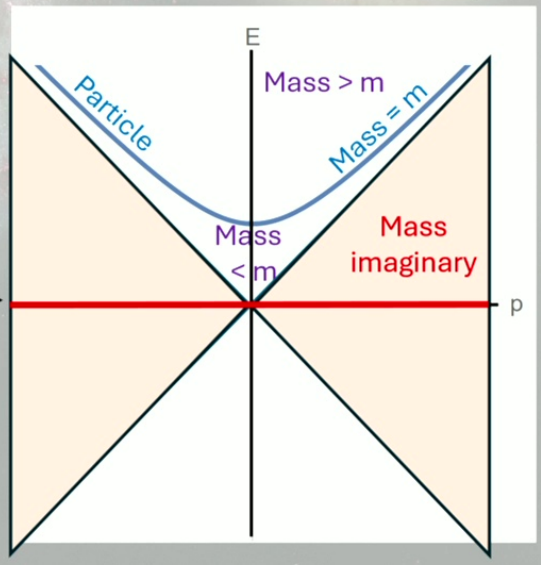
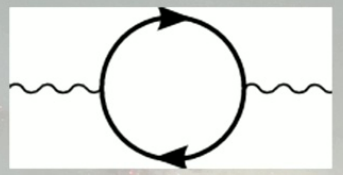
Here are the photons of electrostatics





Virtual Electron-Positron Pairs



- "A Photon Spends Part of its Life as an Electron-Positron Pair"
- "Uncertainty! Borrows Energy from the Vacuum for a Short Time"
  - But electron and positron have **mass > 0**…
    - So why doesn't this make the photon move slower than ***c***?
  - Isn't energy **conserved** in Feynman diagrams? It can't be borrowed…
- "Well, actually the Electron and Positron are Virtual Particles…"
  - But again, their masses can't both be real & positive

In truth, loop is a **zero-mass quantum fluctuation of the electron field**

Maybe We Could Say Fewer Strange Things?

The examples I gave are fundamental to particle/astro/cosmo physics

- Higgs
- Mass
- Matter
- “Hearing” the Universe
- Exchanging “Particles”
- Loops of “Particles”

And there are many more…

- Could we become more collectively sensitive to the pitfalls?
- Can’t we find metaphors/explanations that don’t contradict the math?
- Are there ways to work together to improve the situation?

Example: Higgs

Higgs field explanation

- as a sort of molasses, soup, or crowd [or… snow… ?!]
- gives mass to objects by impeding them / slowing them down

Lies outside my guidelines