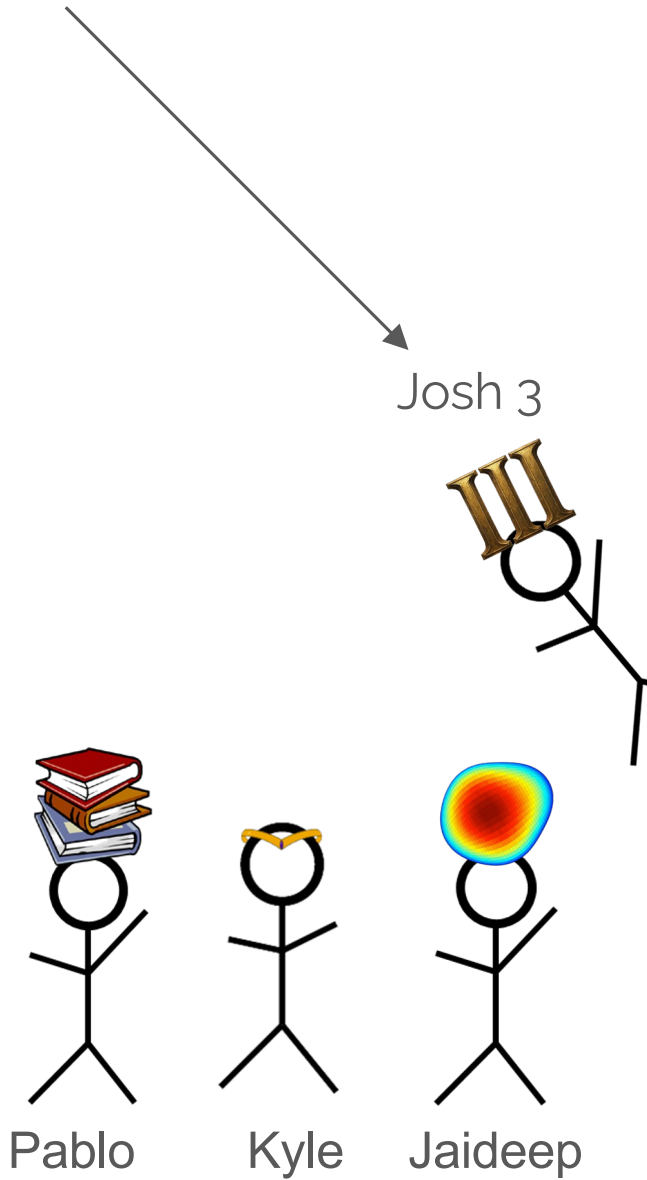
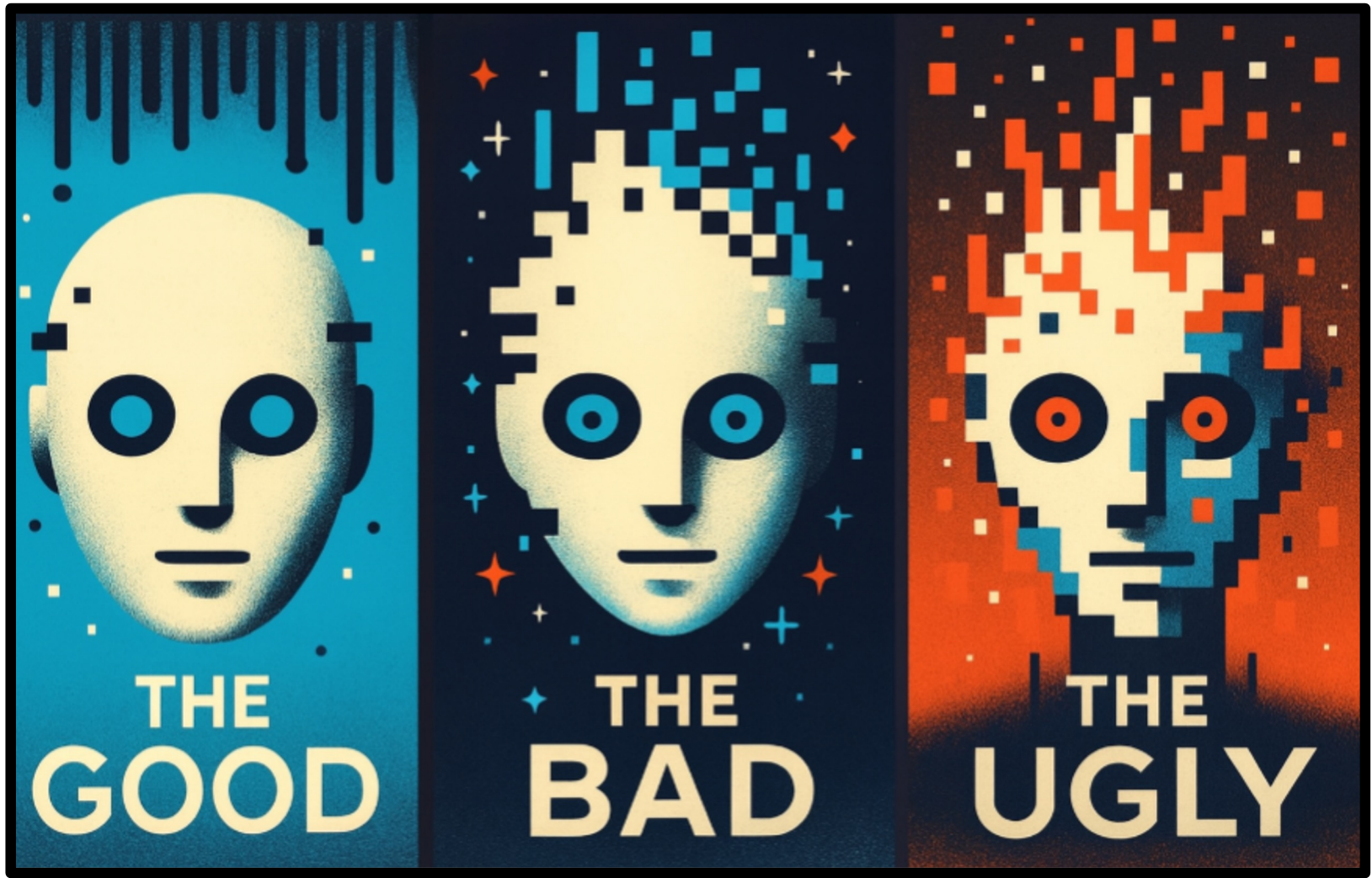


Generative AI in Higher Education: A Facilitated Discussion (w/ snacks and a special guest)



PA Colloquium, December 4, 2025, BPS 1415 @ 15:30

Core Message

Tools, in general, are only useful to the **skilled** user. No tool, enabled by no technology, exists without some caveat or limitation that the user should bear in mind.

“Let it do your chores, but not your thinking.”
- Maxwell (Yuchen) Cao (MSU PhD 2020)

Based on two previous events

(now an annual FRIB tradition)



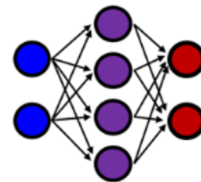
Watch on
YouTube

Outline

2024

What comes to mind?

How does it work?



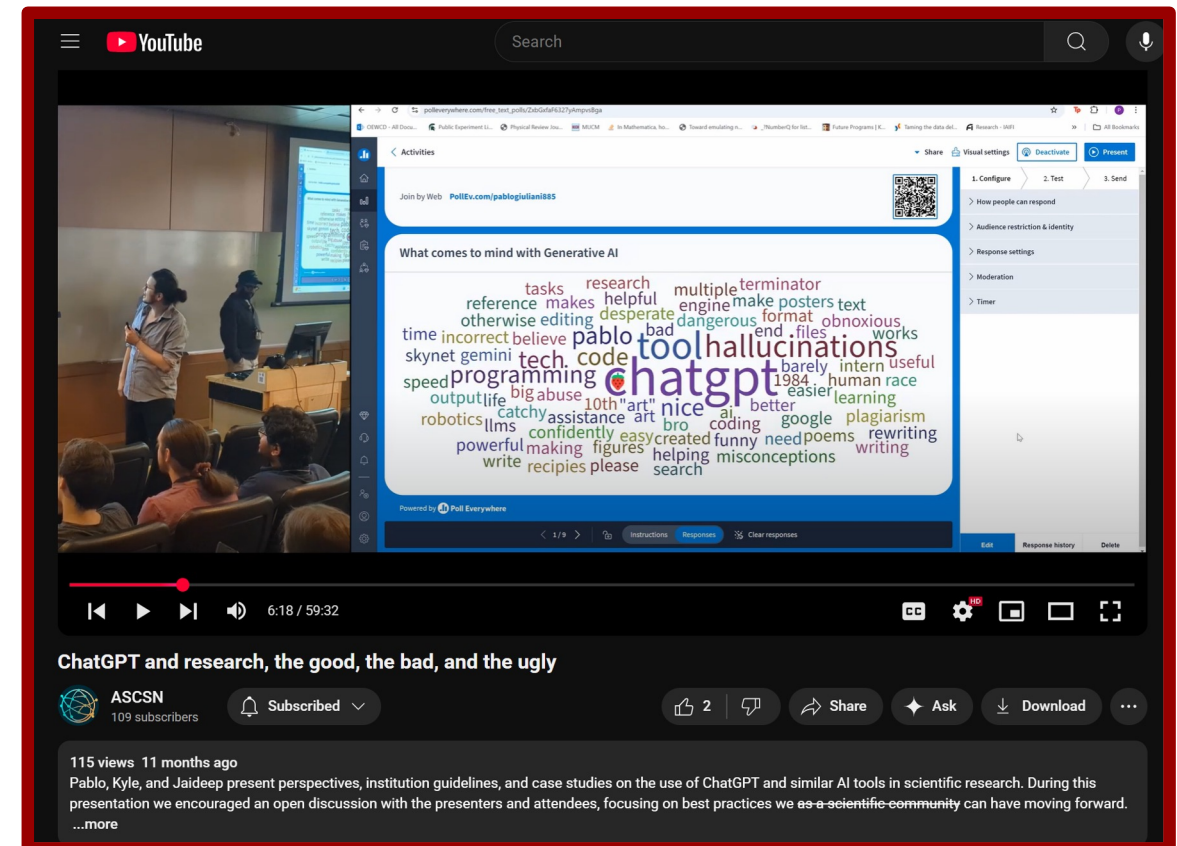
Current guidelines

MSU
Funding Agencies

Case studies



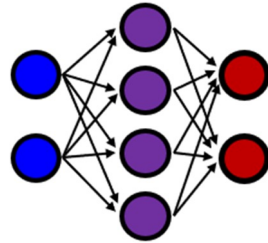
Going forward and open discussion



Outline

“Temperature of the room”...What comes to mind?

How does it work?



Scenarios and current guidelines

Case Study: Quantitative test

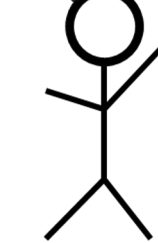
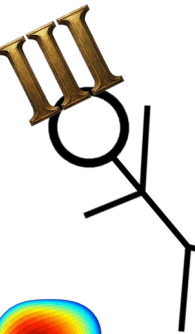
Going forward and open discussion

Extras: Application examples and additional considerations regarding ethics and accountability

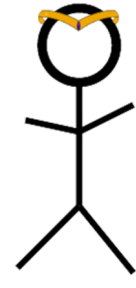


[Link to Slides](#)

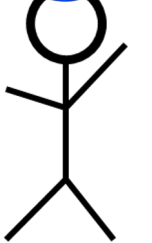
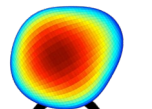
Josh 3



Pablo



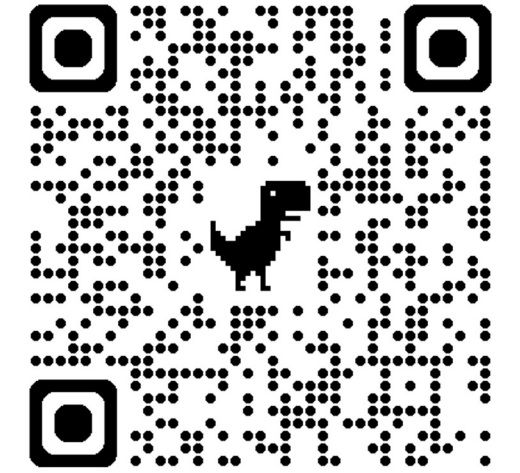
Kyle



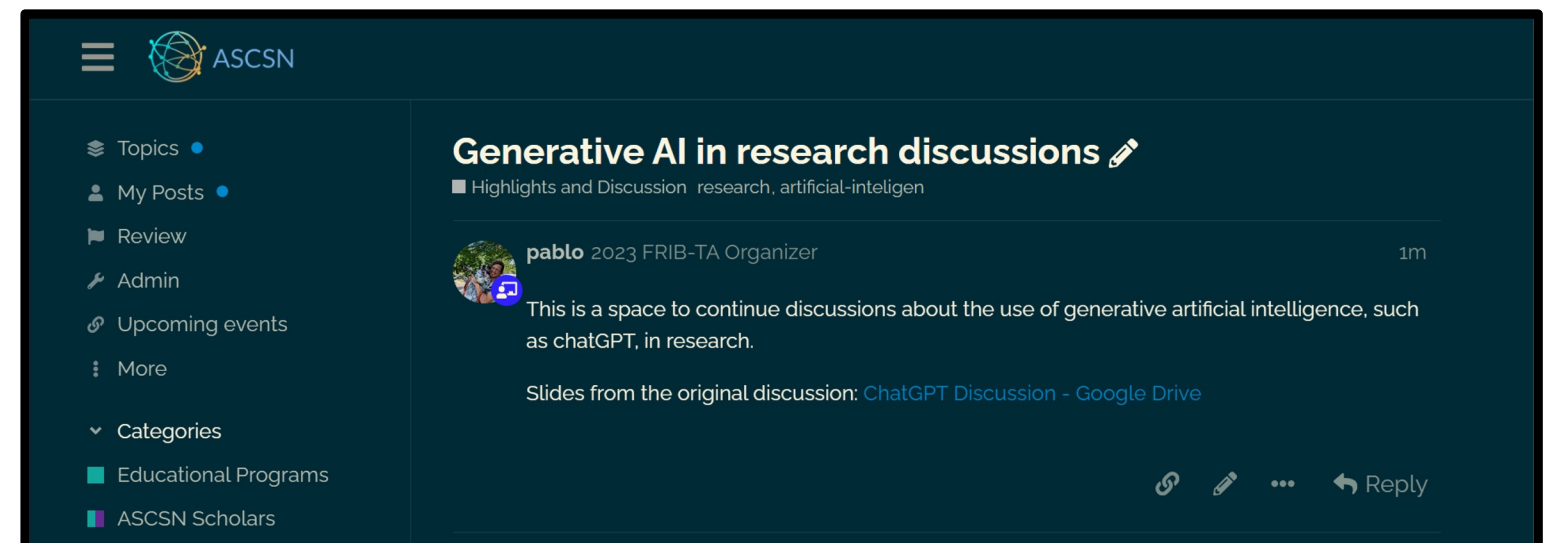
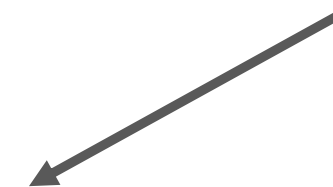
Jaideep

Objectives for today

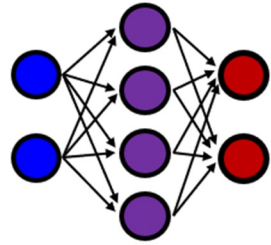
- Become aware of the tool(s) and current guidelines
- Become aware of how differently we all see/feel about the tool(s)
- Give initial push for open discussions about it (specially within research groups and classes)



Space to continue discussions



What comes to mind? (Poll Everywhere)



Gemini

Hello, Pablo
How can I help you today?

- Give me tips to stay in the present moment
- Design a custom cake for a good friend
- As a social trend expert, explain a term
- Create a futuristic image of a car

Humans review some saved chats to improve Google AI. To stop this for future chats, turn off Gemini Apps Activity. If this setting is on, don't enter info you wouldn't want reviewed or used. [How it works](#)

[Manage Activity](#) [Dismiss](#)

AI Claude 3

“ Claude, analyze this CSV of user engagement data and show me key trends.”



Write a report based on my data



Make me a personal webpage



What's in the news in Tokyo today?



Summarize a long document



Pablo

Message ChatGPT



Q0. Word Cloud



When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Reflexions about viewpoints

on August 30, 2021.^[14] In 2011, researchers retroactively estimated the annual impact of tetraethyl lead worldwide to be 1.1 million excess deaths, 322 million lost IQ points, 60+ million crimes, and 4% of worldwide GDP (around 2.4 trillion United States dollars per year).^[15]



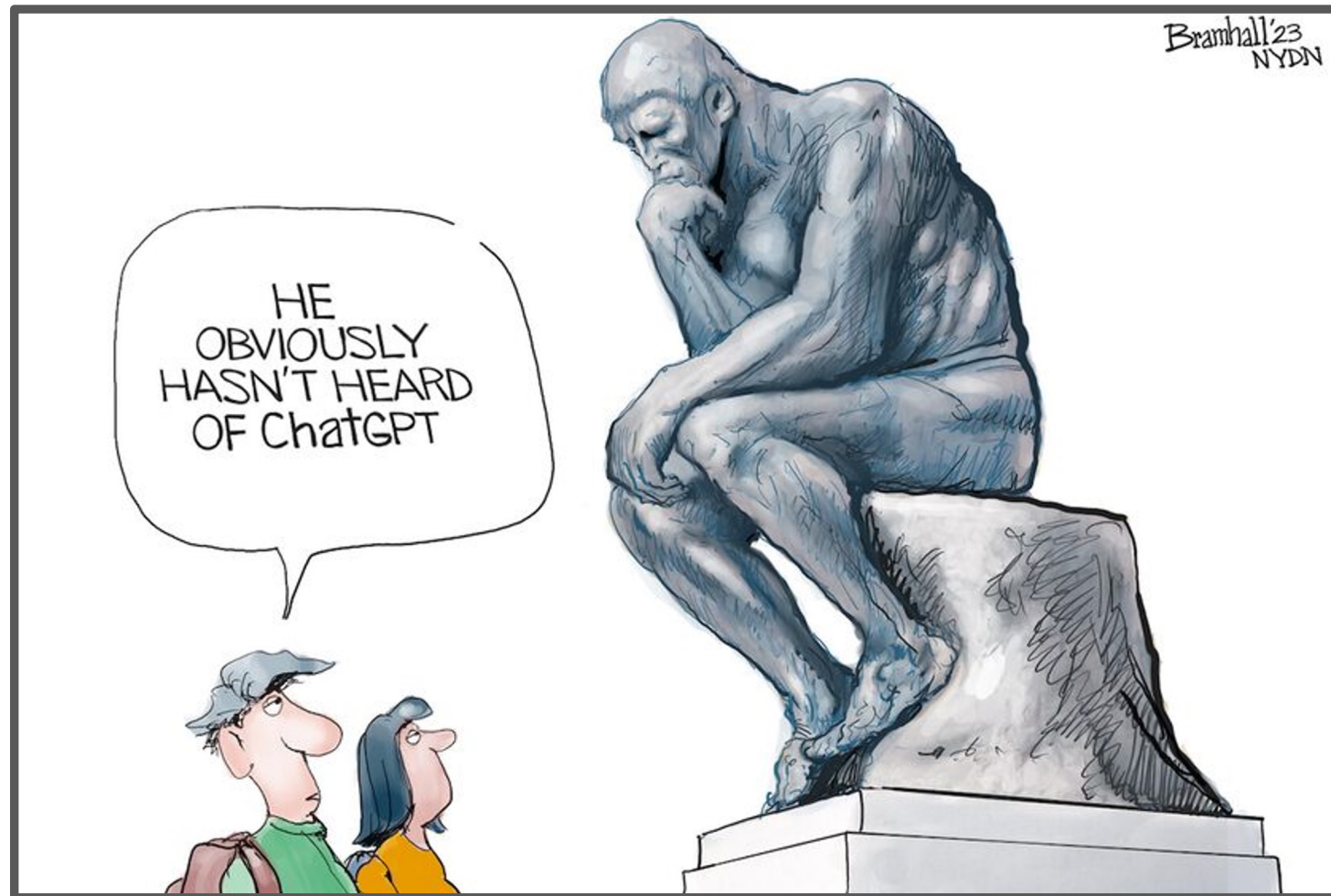
1889 anti-electricity Ad

Pablo



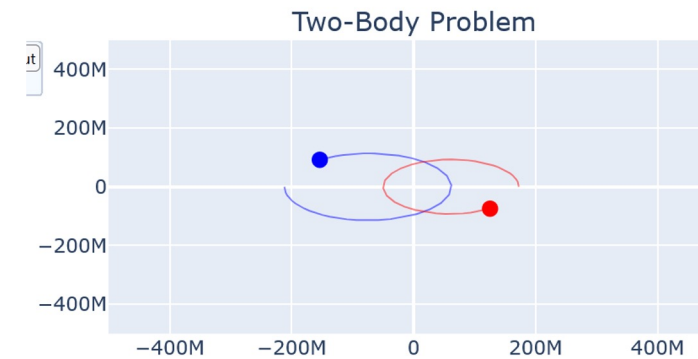
1954 pro Ethyl Gasoline Ad

Reflexions about viewpoints

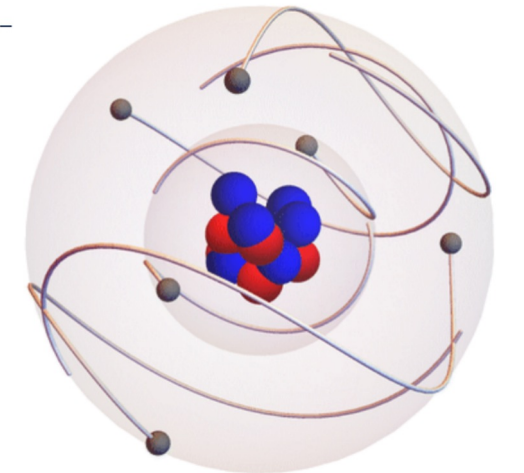


2023 Daily New York News
(Bill Bramhall)

Two-Body Problem and Effective Potential Animation



2024 Pablo saying stuff
(and usually being overly-excited)



How does it work?

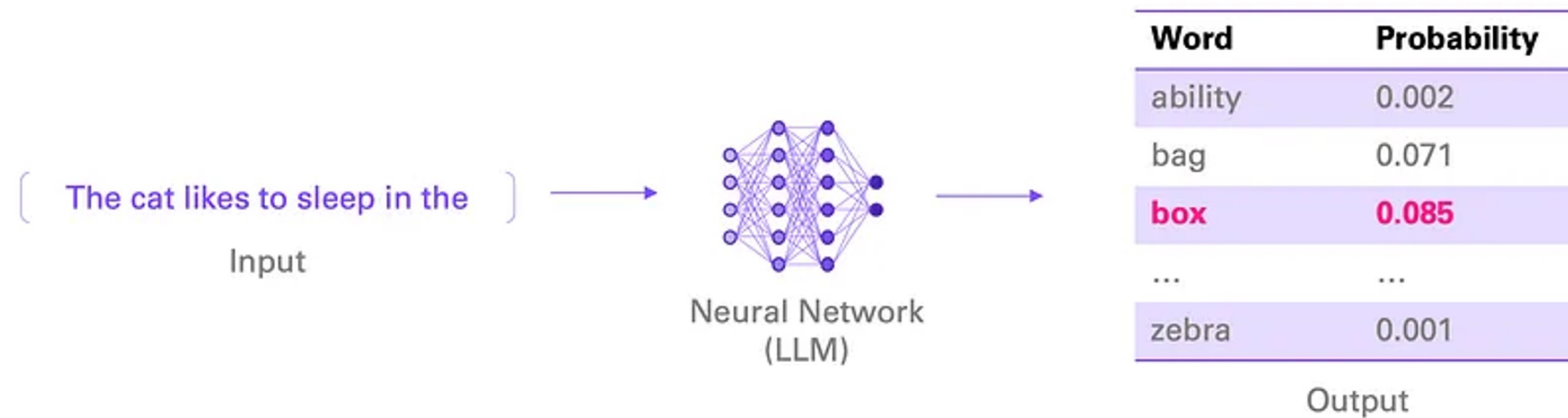
Language modeling

Imagine the following task: Predict the next word in a sequence

[The cat likes to sleep in the ___] → What **word** comes next?

Can we frame this as a ML problem? Yes, it's a classification task.

Now we have (say)
~50,000 classes (i.e.
words)



How does it work?

Phases of training LLMs (GPT-3 & 4)

1. Pretraining

Massive amounts of data from the internet + books + etc.

Question: What is the problem with that?

Answer: We get a model that can babble on about anything, but it's probably not **aligned** with what we want it to do.

2. Instruction Fine-tuning

Teaching the model to respond to instructions.

Model learns to respond to instructions.

→ Helps **alignment**

"Alignment" is a hugely important research topic

3. Reinforcement Learning from Human Feedback

Similar purpose to instruction tuning.

Helps produce output that is closer to what humans want or like.

New(-ish) Features

We've seen massive leaps in LLM performance on benchmarks spanning coding, creative writing, tool calling, and more

Frontier models are typically multimodal these days, allowing you to mix text, images, audio, and video in a prompt

Another point of improvement has been in the user experience and interface — think voice prompting and more natural text to speech — along with better programmatic interactions with other tools in agentic workflows

Search grounding has also helped improve overall reliability

Also New: Better Open-Source Models

If privacy is a concern, open source models that you can run locally are absolutely viable replacements for ChatGPT, Gemini, Claude, etc. if you have the resources

This opens up a world of possibilities for more intelligent domain-specific LLMs instead of relying on a one-size-fits-all model

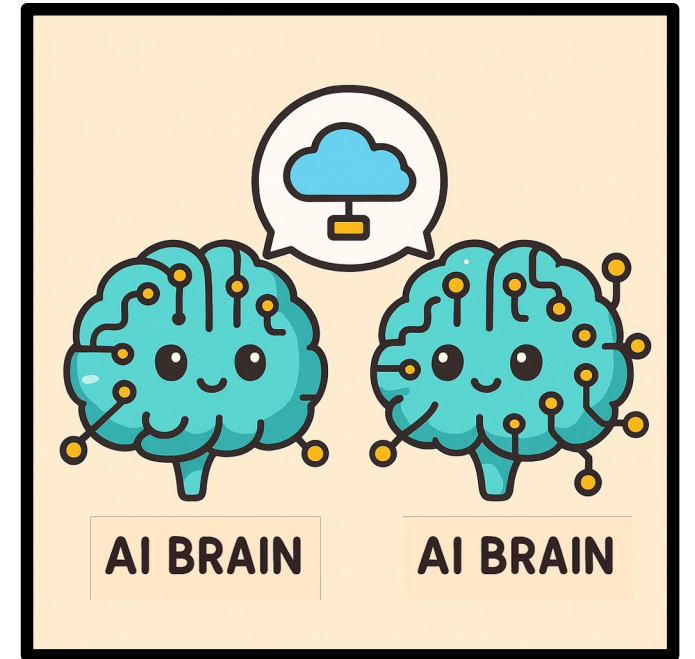
What do they think?



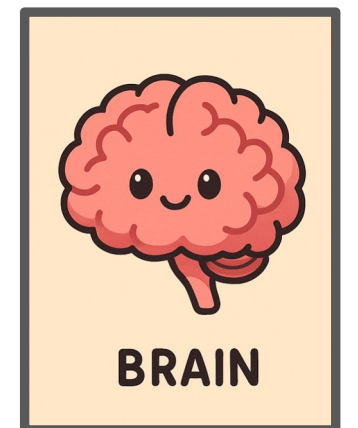
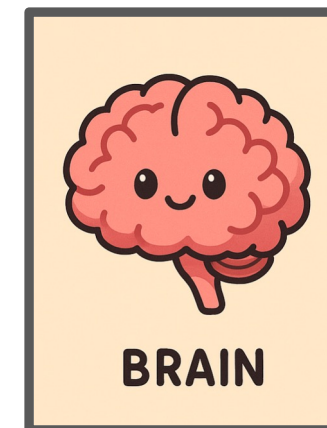
Watch
full
video



Kyle Godbey



What are your thoughts
on Generative AI,
research in nuclear
science, and ethics?



What do they think?



Watch
full
video

"Let's talk about those space missions"

"What if the AI isn't perfect and makes a mistake?"

"There is a genuine risk that if new generations rely too heavily on AI tools they might miss out on developing some foundational skills"

"We shouldn't stop using AI because of a bad outcome" [someone dying]

[On why not to use Gen. AI] *"The data they are trained isn't perfect ... it can reinforce existing inequalities"*

[On why not to use Gen. AI] *"It can create a false sense of security"*

"This is for informational purposes only, for medical advice or diagnosis consult a professional"

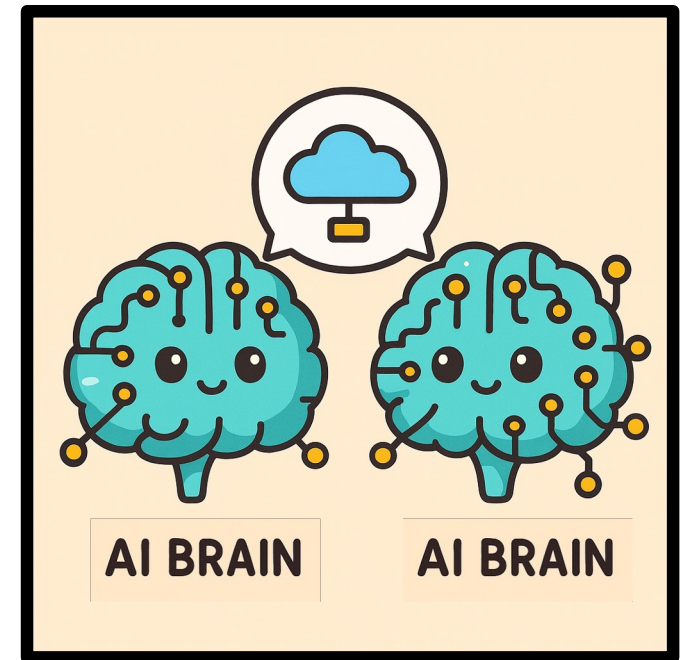
"it can help with streamline coding tasks, drafts parts of paper, and even reviewing and organizing grants"

"We need to be really careful on who has access to these technologies"

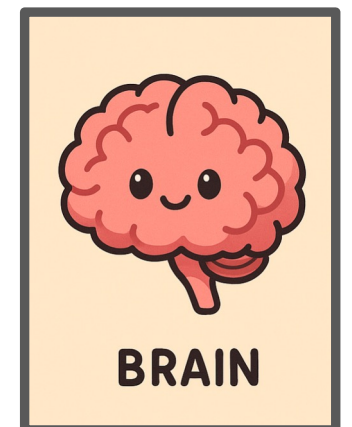
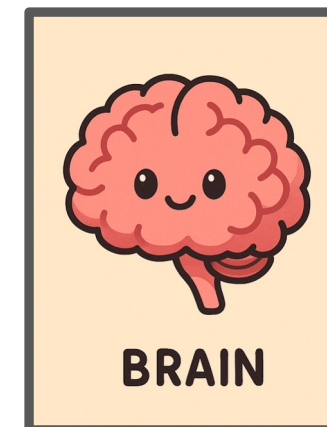
"Making sure it is in the right hands"

"The key is balance, we want to use AI as a tool, but not let it become a crutch"

[On who the right hands are] *"Would be those of highly trained scientists and researchers with a strong ethical compass"*

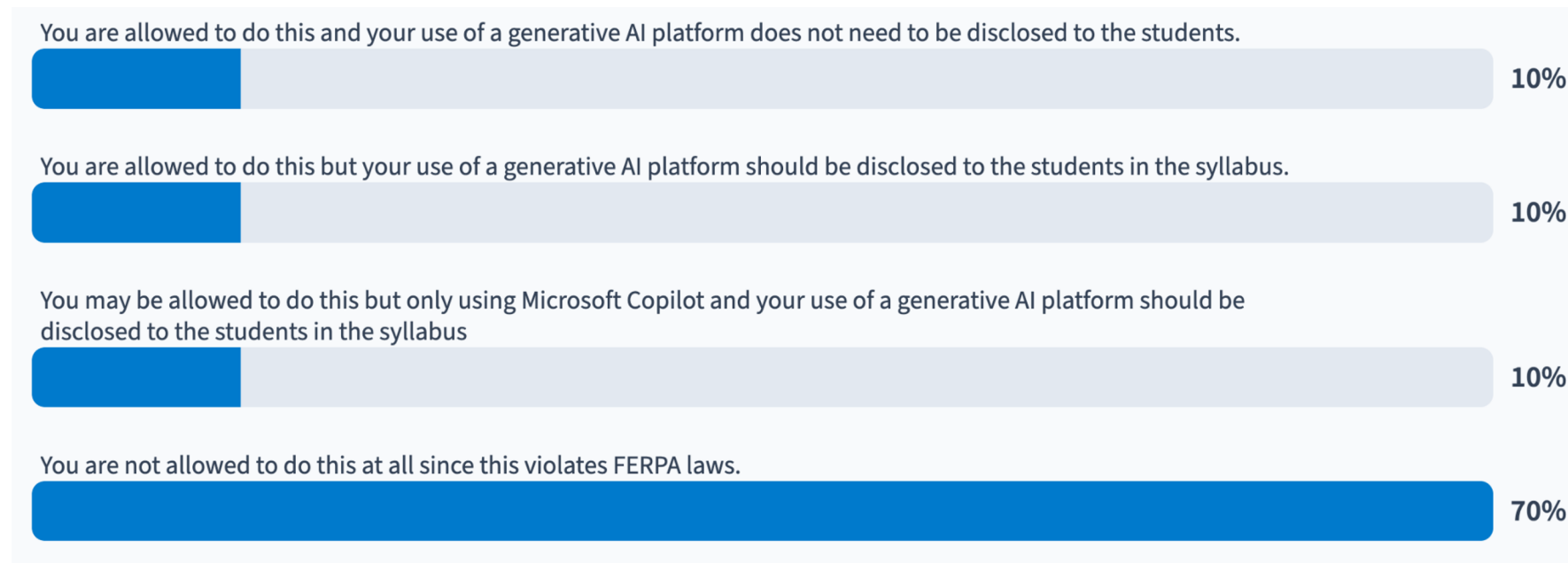


What are your thoughts on Generative AI, research in nuclear science, and ethics?



Current Guidelines (Poll Everywhere)

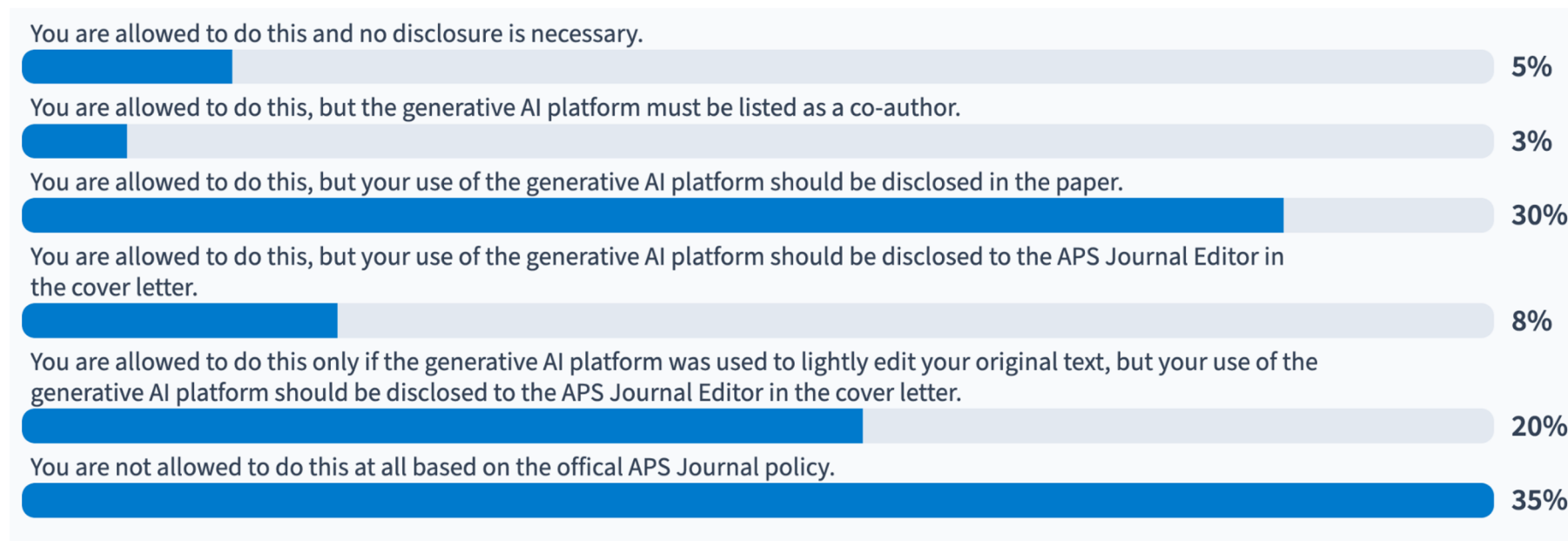
Q1. You ask a Generative AI platform to take your class roster along with all of their current assignment scores and then assign students into groups of three based on their strengths and weaknesses.



When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Current Guidelines (Poll Everywhere)

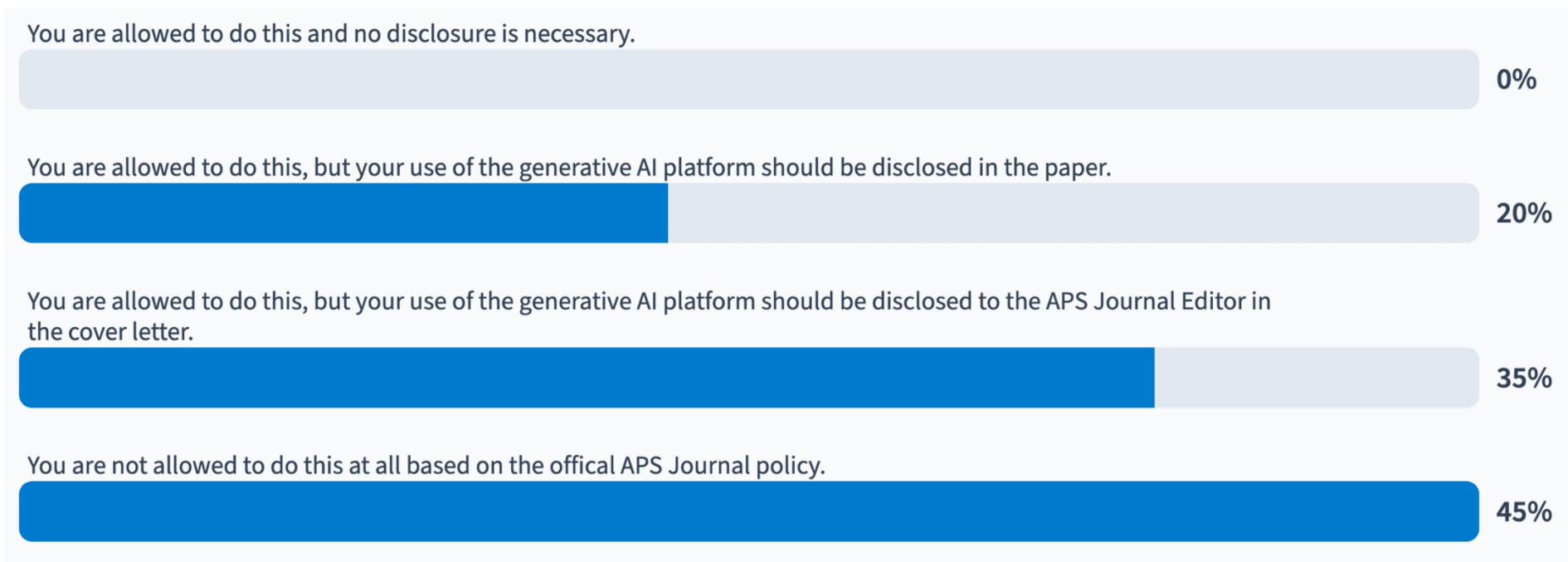
Q2. You submit a paper to an APS journal which contains text directly copied and pasted from a Generative AI platform.



When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Current Guidelines (Poll Everywhere)

Q3. You submit a paper to an APS journal which contains figures created by a generative AI platform.

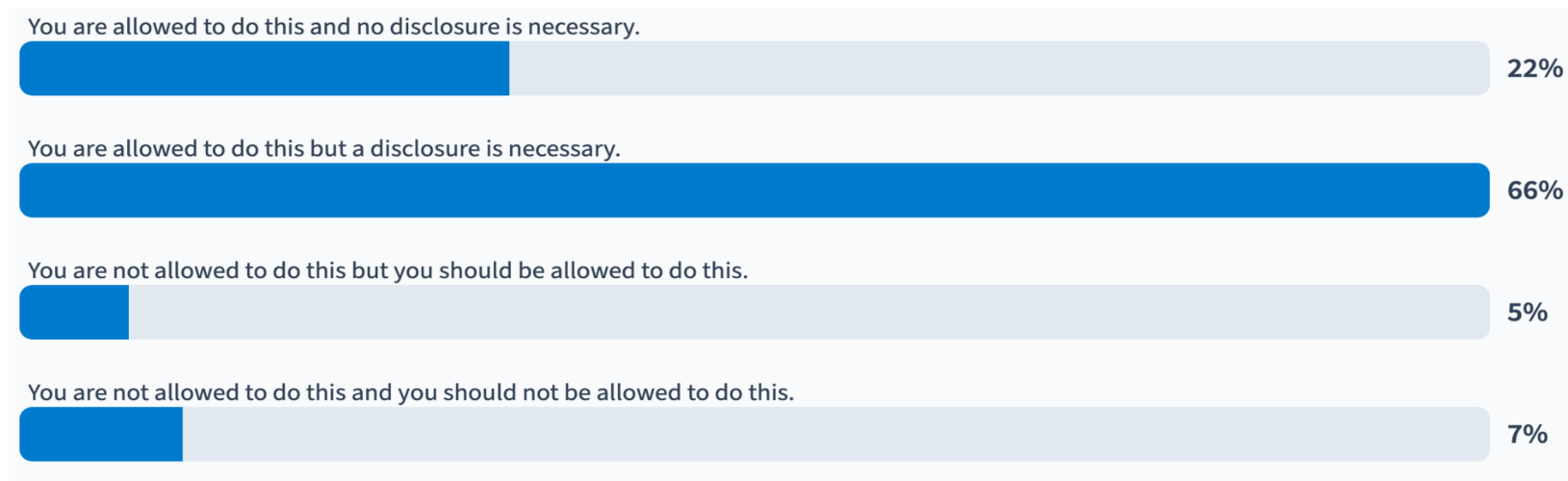


When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Current Guidelines (Poll Everywhere)

The course policy as set by the instructor is that you can use generative AI to do your HW, but you must disclose your use of generative AI in the form of the complete chat transcript along with your HW submission.

Q4. You use generative AI to define and clarify technical terms in your HW assignment.

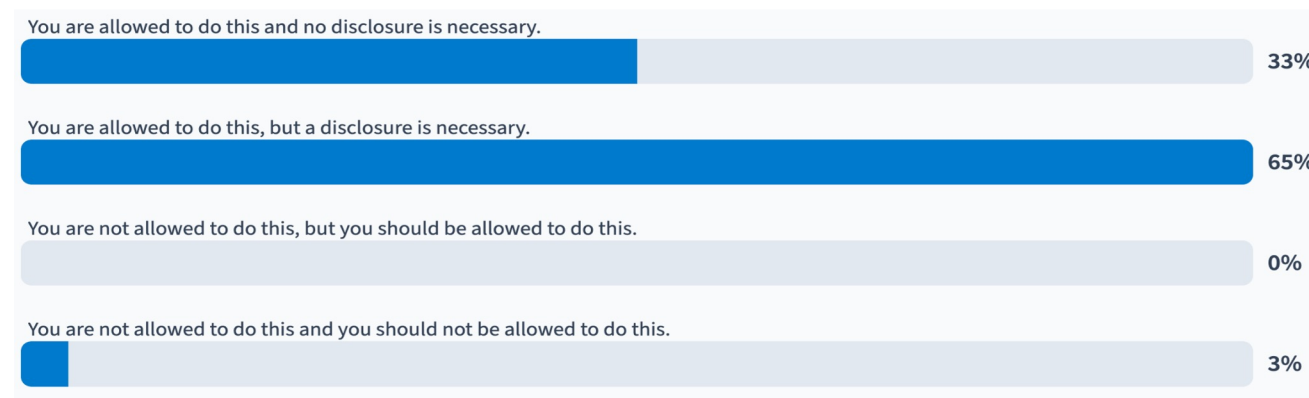


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Current Guidelines (Poll Everywhere)

The course policy as set by the instructor is that you can use generative AI to do your HW, but you must disclose your use of generative AI in the form of the complete chat transcript along with your HW submission.

Q5. You use generative AI to show you how to start a problem related to but not exactly the same as your HW problem assignment.

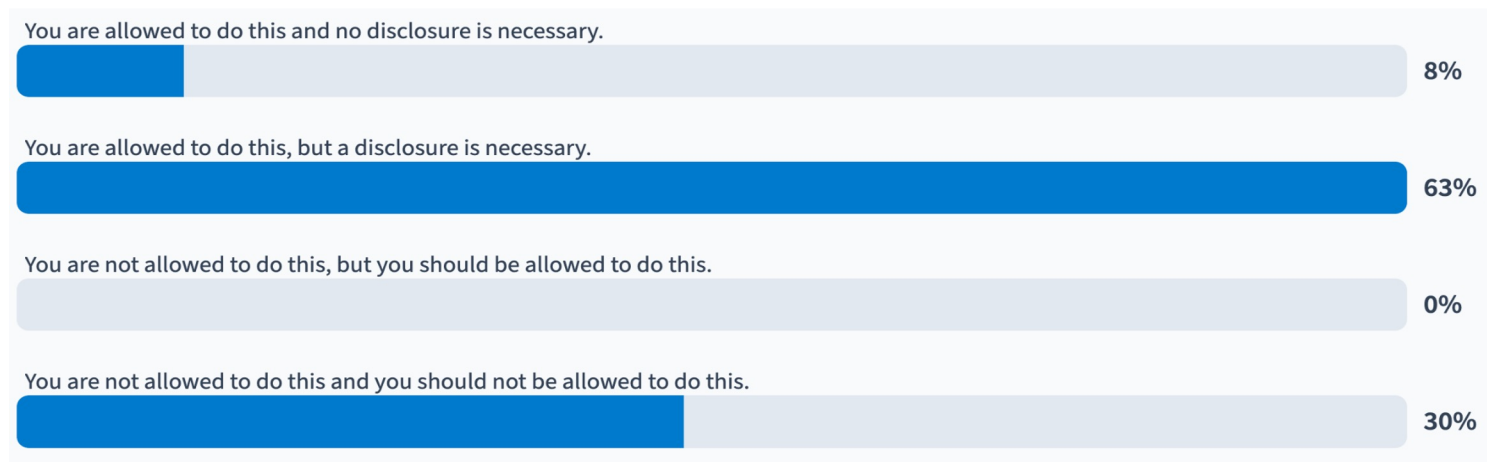


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Current Guidelines (Poll Everywhere)

The course policy as set by the instructor is that you can use generative AI to do your HW, but you must disclose your use of generative AI in the form of the complete chat transcript along with your HW submission.

Q6. You use generative AI to show you how to complete the exact HW assignment problem step-by-step.



When poll is active respond at:
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Current Guidelines (Poll Everywhere)

The course policy as set by the instructor is that you can use generative AI to do your HW, but you must disclose your use of generative AI in the form of the complete chat transcript along with your HW submission.

This was the official policy for my PHY 841 course in Spring 2024 and Spring 2025 with the additional stipulation that only the free (not paid) version accessible to all students is the only version that could be used.

~10 generative disclosures out of ~5000 individual submitted HW assignment problems = 0.2%

Q7: What are your initial thoughts about this disclosure rate?



A Selection of Guidelines (Still the Wild West)

MSU

1. [MSU subscriptions to generative AI platforms \(only Microsoft Copilot\)](#)
2. [General guidance as of August 12, 2025](#)
3. [Guidance for Research from Office of Research and Innovation](#)
4. **Most useful MSU resource: [MSU Ethics Institute](#)**

“AI tools should be documented, including their purposes, the rationale for their selection and the outcomes they intend to achieve. This documentation will facilitate accountability and continuous improvement.”

NSF: apparently no new guidance since Dec 2023 (but coming in 2025?): [link](#)

DOE: apparently no new guidance since Jun 2024: [link](#)

APS Journals: [link](#)

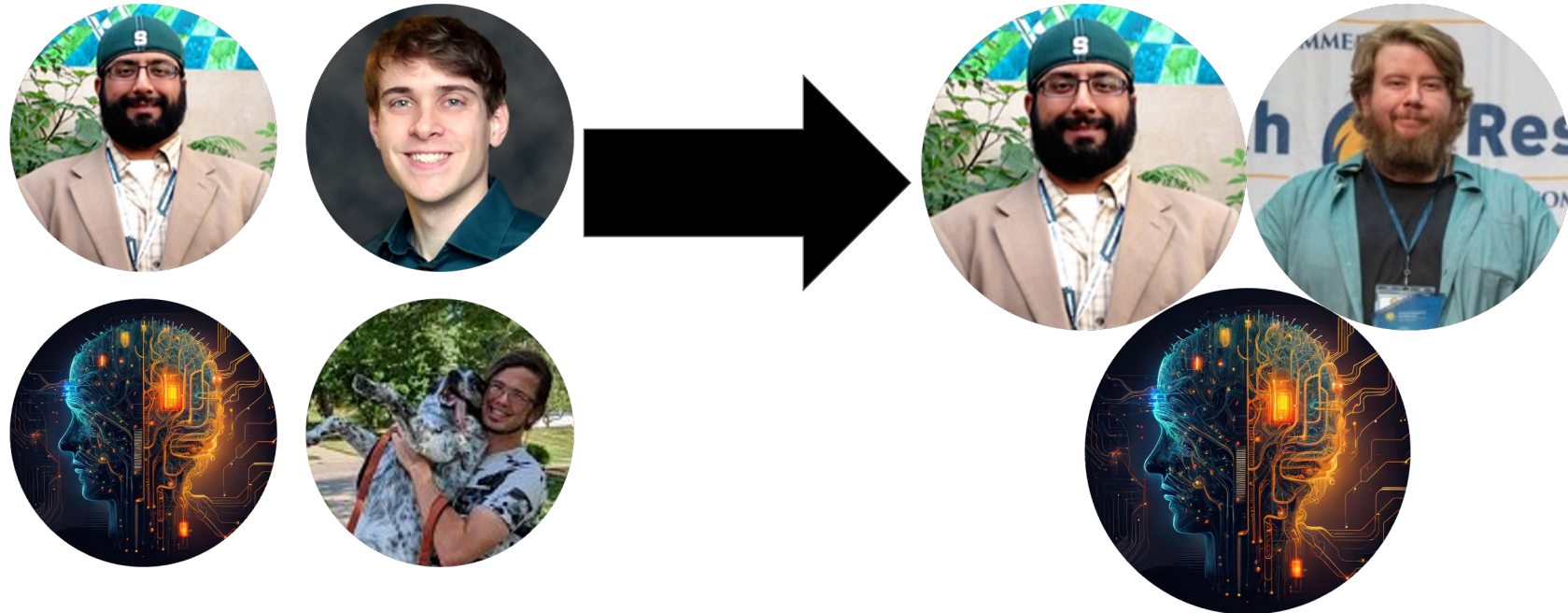
Should disclose allowed use (light text editing and/or basic image brightness modifications but no image creation) to Editor for both preparing the manuscript and for referee reports

Case Study: Motivation & Process



Quantitatively
testing them

Case Study: Motivation & Process



Case Study: Motivation & Process



Case Study: Motivation & Process

- Pick a collection of LLMs/AIs.
- Select a paper from each physicist.
- Write a report based on the given prompt.
- Physicists score each category based on prompt.

Read the attached paper. Respond to each of the following points as if you were an inquisitive student just starting out in the field of physics.

1. Summarize and discuss the key points of the paper in 250-500 words.
2. Can you think of 3 questions to ask the authors of the paper that is related to their analysis and/or proposed methods?
3. What kind of impact does this work have on the authors' field and broader physics community?






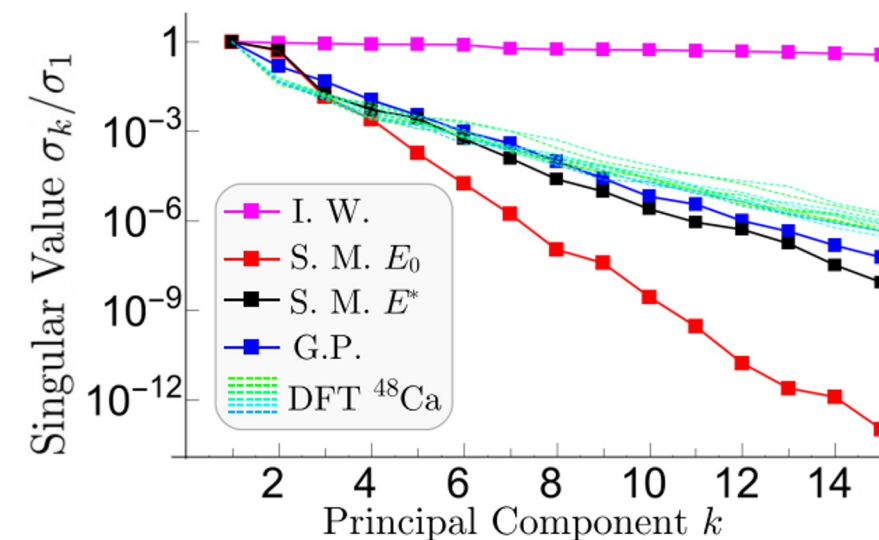
Training and projecting: A reduced basis method emulator for many-body physicsEdgard Bonilla ^{1,*,\dagger} Pablo Giuliani ^{2,3,*,\ddagger} Kyle Godbey ^{2,\S} and Dean Lee ^{2,4,\|}¹*Department of Physics, Stanford University, Stanford, California 94305, USA*²*Facility for Rare Isotope Beams, Michigan State University, East Lansing, Michigan 48824, USA*³*Department of Statistics and Probability, Michigan State University, East Lansing, Michigan 48824, USA*⁴*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA* (Received 18 March 2022; revised 14 May 2022; accepted 25 October 2022; published 17 November 2022)

FIG. 1. Decay of the singular values σ_k for a set of solutions of the infinite well (I.W. in magenta), the single channel two-body scattering with a Minnesota potential [37] with fixed energy (S.M.

Response 3:

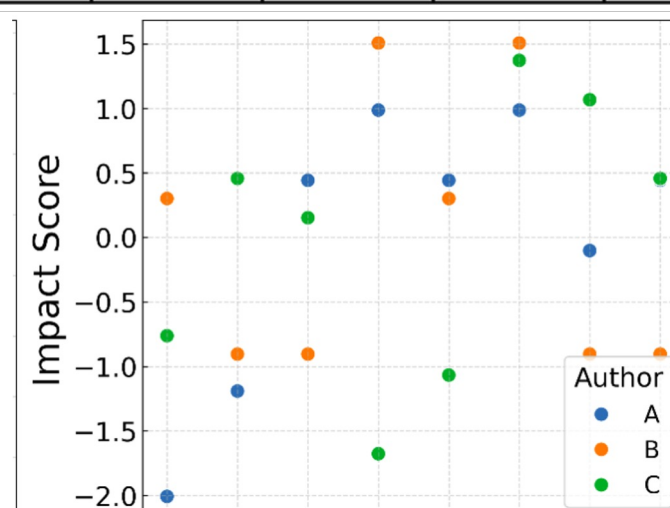
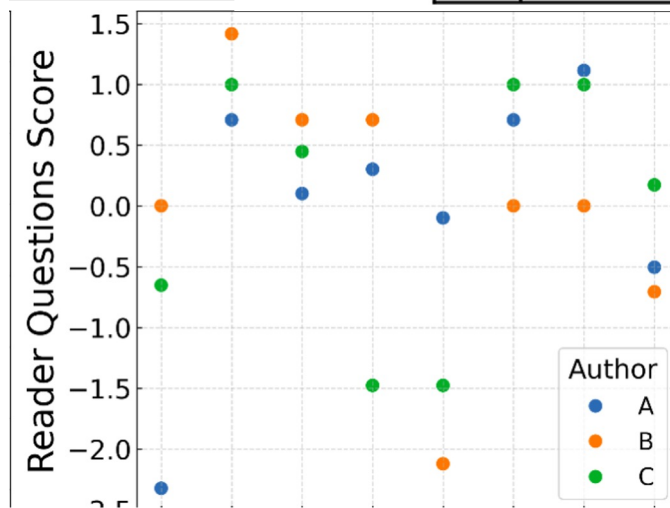
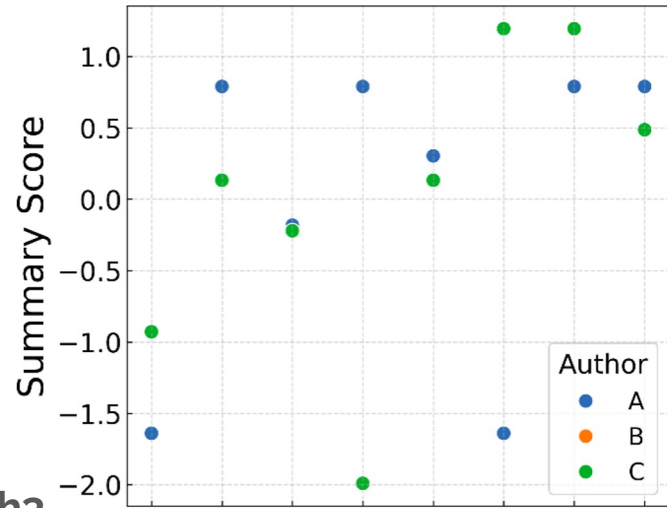
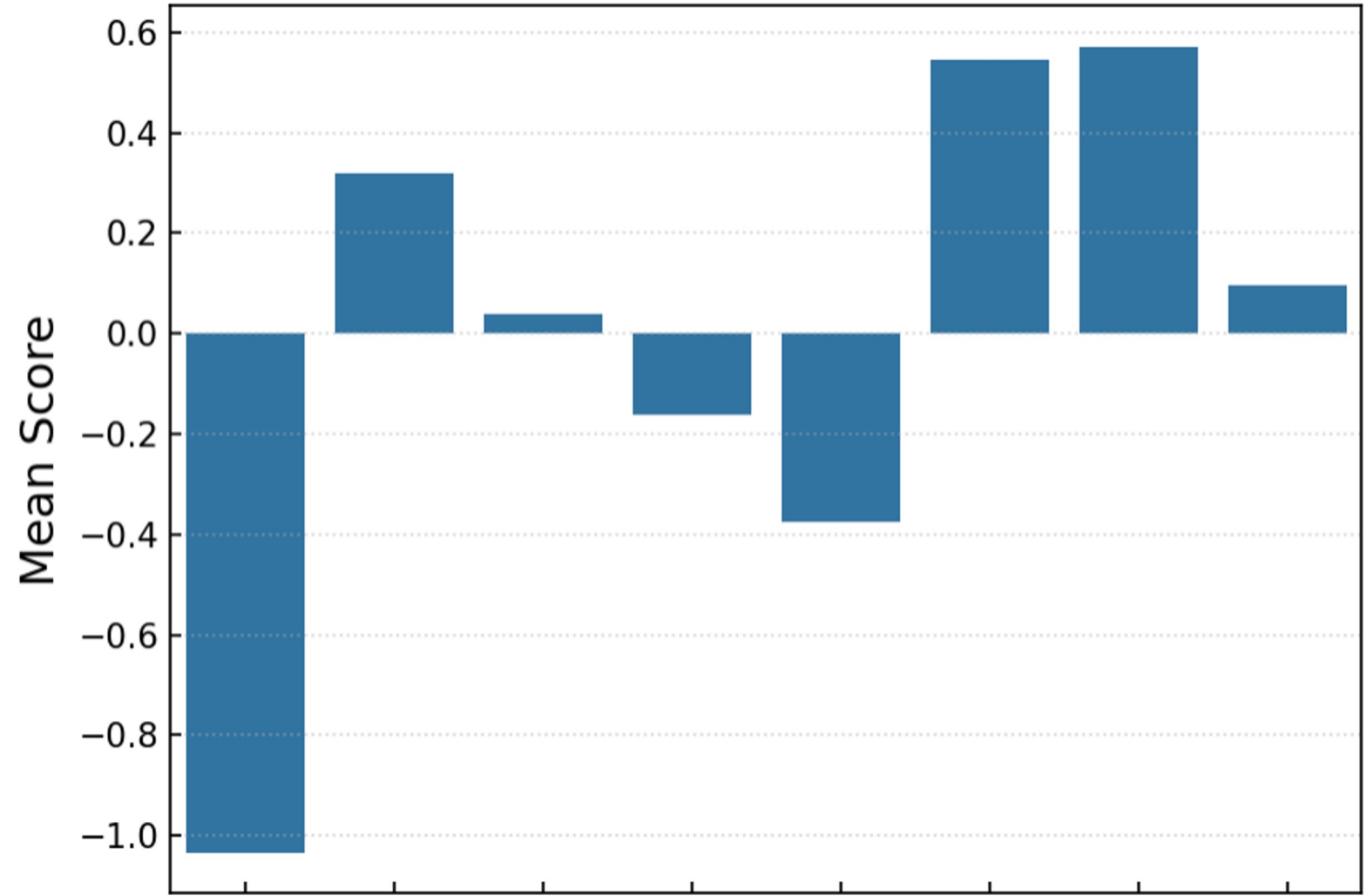
1. Could you elaborate on **how robust PCA is as a diagnostic for RBM applicability?** Are there specific **thresholds or criteria that predict failure cases?**

Response 4:

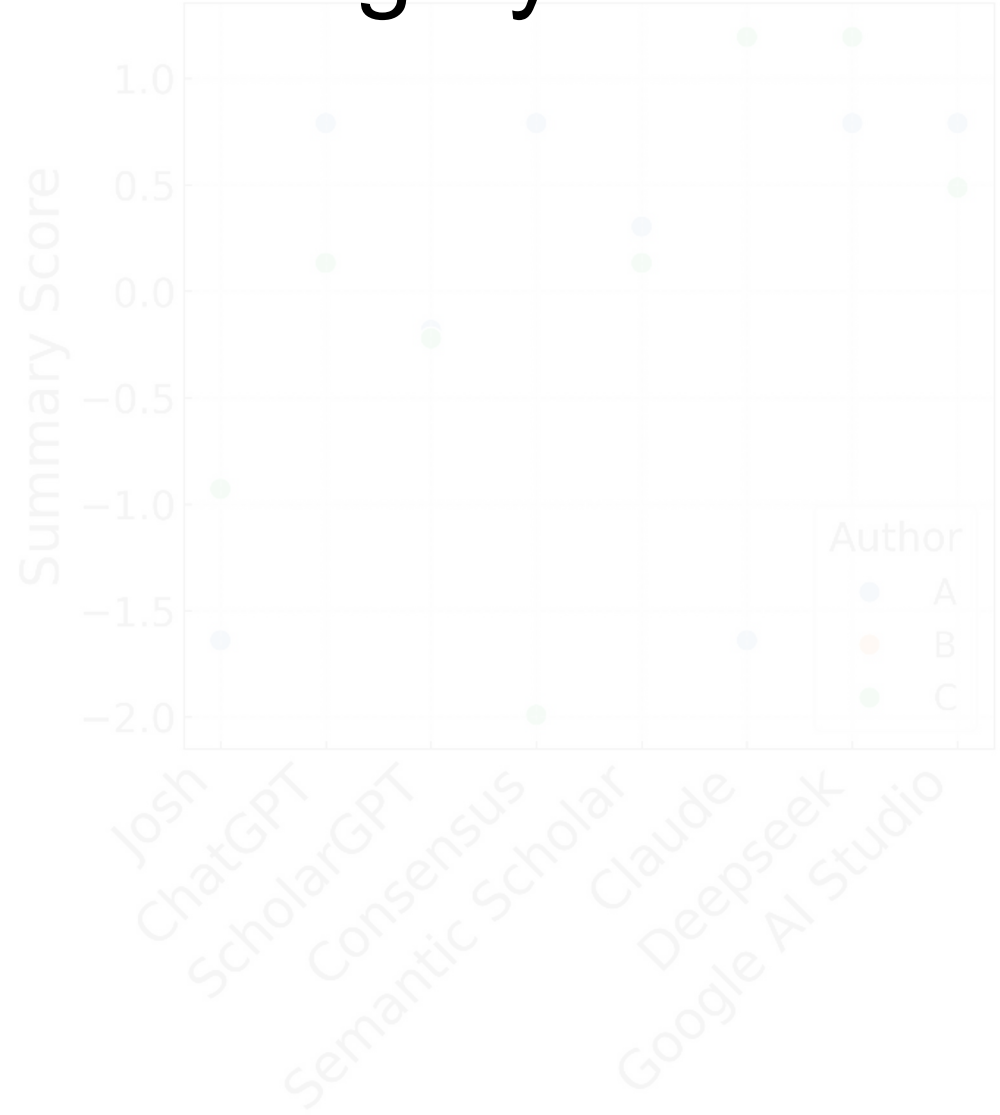
1. **How does the choice of training points** (the parameter values for the high-fidelity solutions) **affect the accuracy and generalizability of the RBM emulator**, especially in **high-dimensional parameter spaces?**

Case Study: Category Results

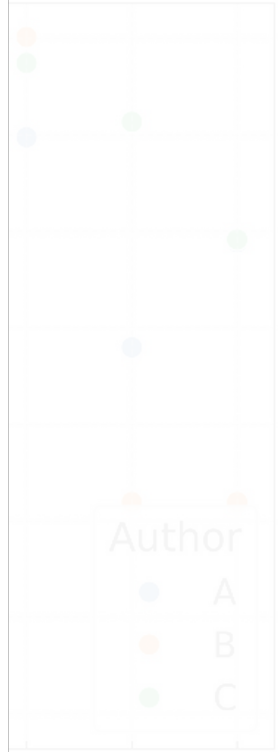
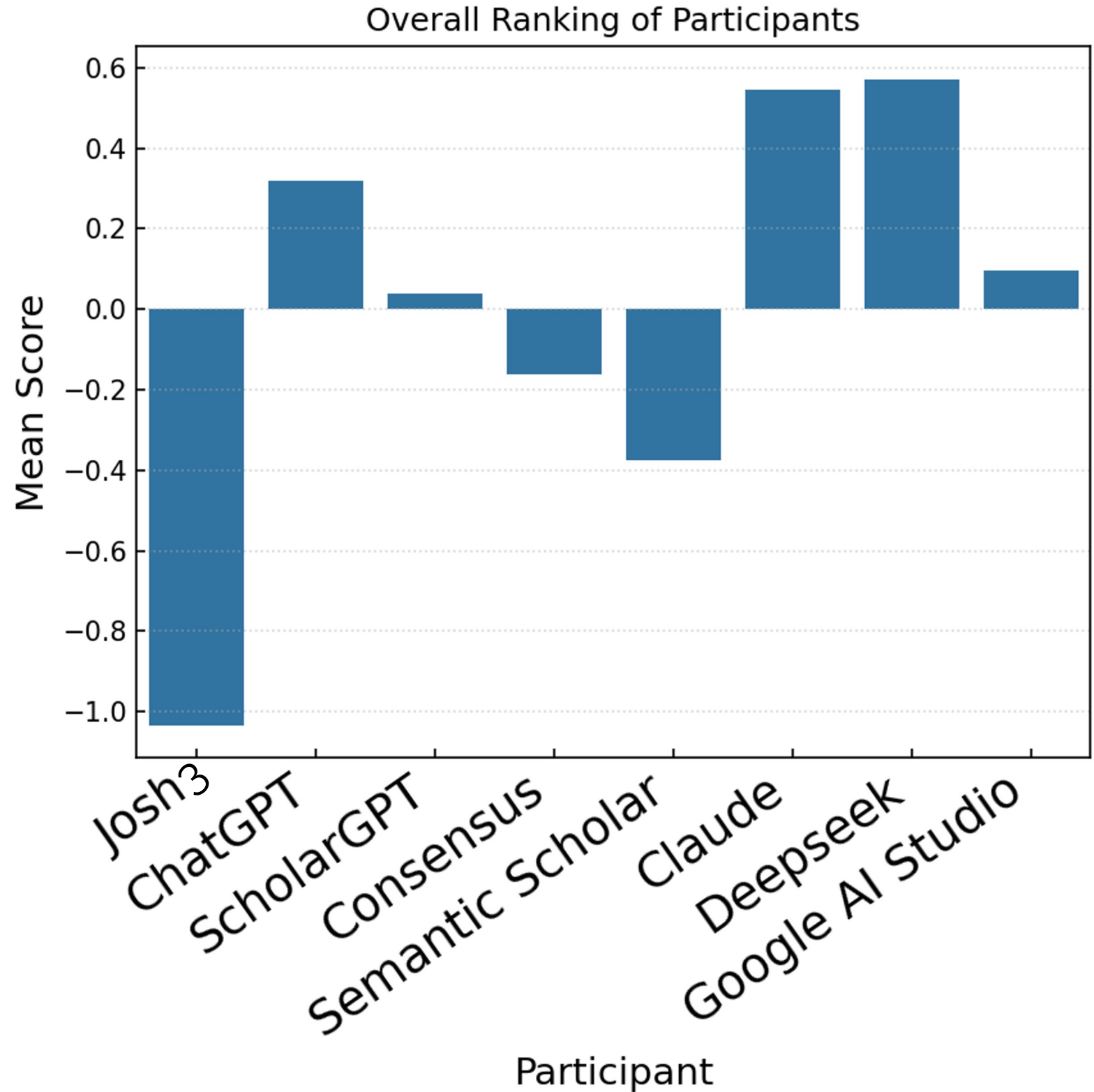
Overall Ranking of Participants



Case Study: Category Results



Reader Questions Score



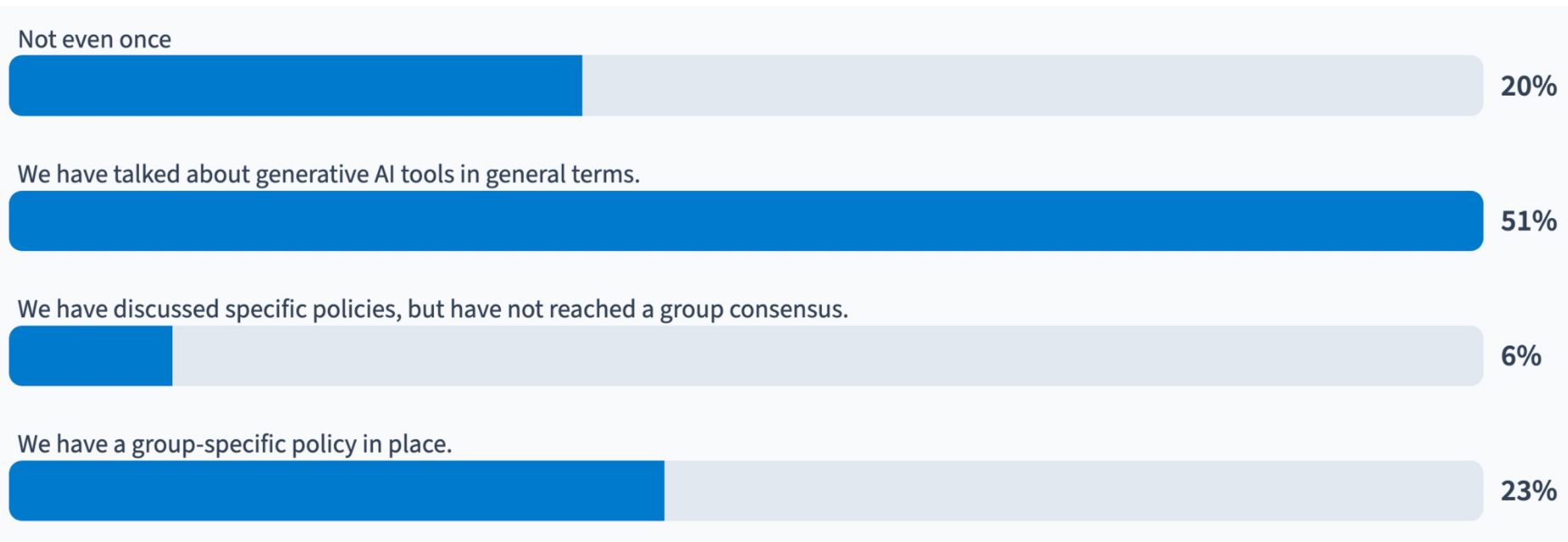
Core Message

Tools, in general, are only useful to the **skilled** user. No tool, enabled by no technology, exists without some caveat or limitation that the user should bear in mind.

“Let it do your chores, but not your thinking.”
- Maxwell (Yuchen) Cao (MSU PhD 2020)

Final Polls before discussion

Q8. Has there been a discussion about the use of generative AI for research within your research group?

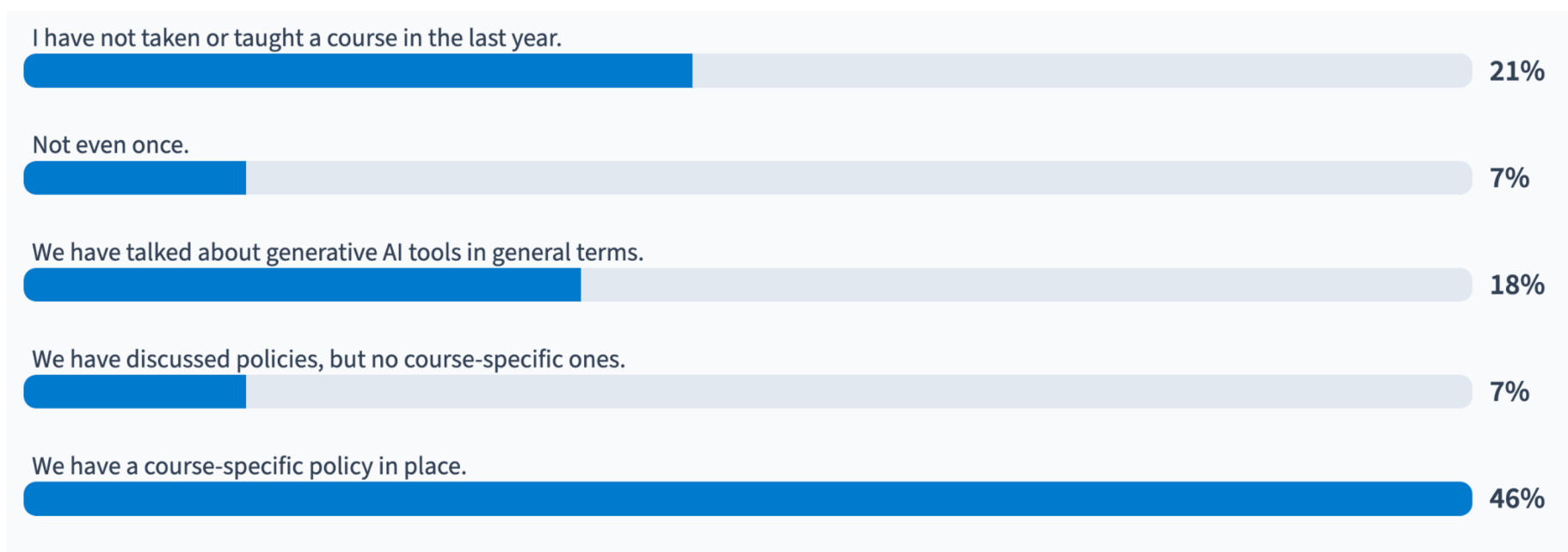


See slide 65 for one example of a group-specific policy (Spinlab-JTS)

When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Final Polls before discussion

Q9. Have you discussed the use of generative AI in courses within the last year (either as an instructor, TA, or student)?



When poll is active respond at:
<https://pollev.com/jaideepsingh305>

Open questions for discussion

When using Gen. AI, are we expanding human creativity—
or outsourcing it?

Could generative AI impact the process
of how we understand something?

Who is responsible when AI-generated
results lead to errors—or breakthroughs?

How do we maintain reproducibility and
transparency when using opaque
generative models?

How should we modify current curricula
and class formats based on all this?

Should research papers disclose if AI
contributed to the writing or analysis?
What about when it “just” helped
researchers understand ideas?

How does generative AI change the way
we teach and mentor the next generation
of scientists?

Could generative AI amplify systemic
inequalities by privileging well-resourced
labs with access to better Gen. models?

**Do you have the self-discipline and
self-confidence to use generative AI
in the “right” way?**



Joanna Maciejewska—Snakebitten is here. Get it!

@AuthorJMac

Follow



You know what the biggest problem with pushing all-things-AI is? Wrong direction.

I want AI to do my laundry and dishes so that I can do art and writing, not for AI to do my art and writing so that I can do my laundry and dishes.

7:50 AM · Mar 29, 2024 · **3.1M** Views

23.3K Reposts **1,207** Quotes **102.4K** Likes **3,644** Bookmarks

She is an independent author! Buy her books here:

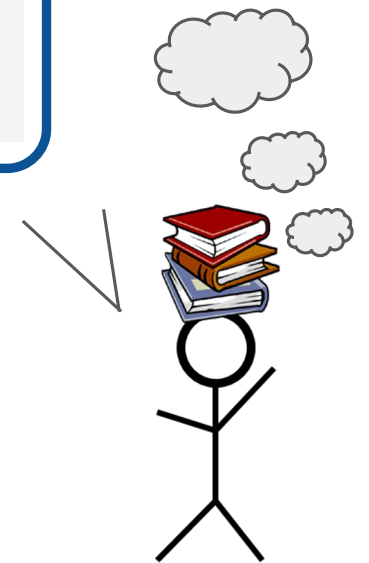
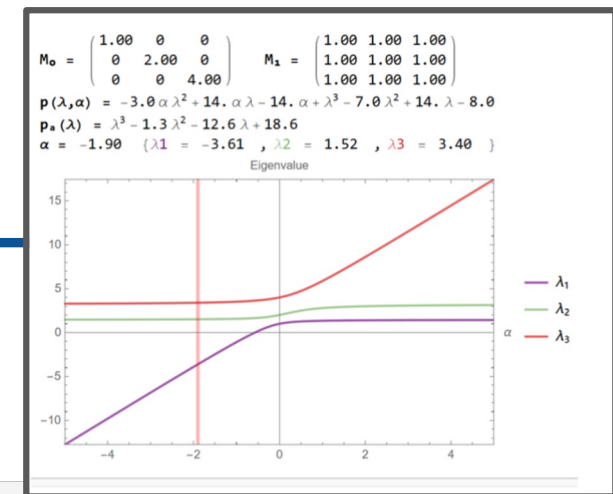
<https://authorjm.com/>

EXTRAS

Applications: Literature review

(on discussions of tracing the roots of parametrized polynomials and matrices)

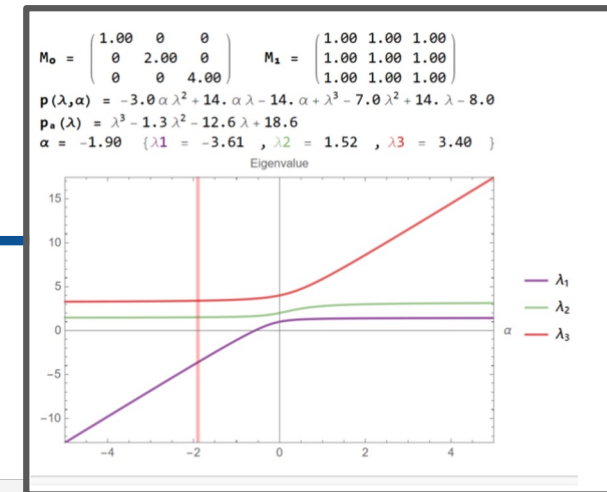
Do you know of any work/paper/resource of someone that already worked on this that I can read?



Applications: Literature review

(on discussions of tracing the roots of parametrized polynomials and matrices)

Do you know of any work/paper/resource of someone that already worked on this that I can read?



Below is a short “reading map” that connects exactly what you are doing (eigen-value trajectories of a parameter-dependent Hermitian/Symmetric matrix) to the established literature. The key bridge is that the equations you just verified are a special case of the **Pechukas–Yukawa equations**, a deterministic analogue of Dyson’s Coulomb gas.

	core idea	where to start
Pechukas (1983)	Maps the α -evolution of eigenvalues and eigenvectors of a <i>general</i> Hermitian family $H = H_0 + \alpha H_1$ to an n -body 1-D classical gas with inverse-cube forces.	<i>P. Pechukas, Phys. Rev. Lett. 51, 943 (1983)</i> “Distribution of Energies in the Irregular Spectrum”
Yukawa (1985)	Gives a Hamiltonian formulation and shows integrals of motion; the coupled ODEs are now called the Pechukas–Yukawa equations .	<i>T. Yukawa, Phys. Rev. Lett. 54, 1883 (1985)</i>
Zakrzewski & Delande (1991) <i>Haake group</i>	Applies the formalism to 2×2 and 3×3 random-matrix ensembles; discusses avoided crossings, “screening” and compares with numerical spectra.	<i>J. Zakrzewski and D. Delande, Phys. Rev. E 47, 1665 (1993)</i>



Applications: Literature review

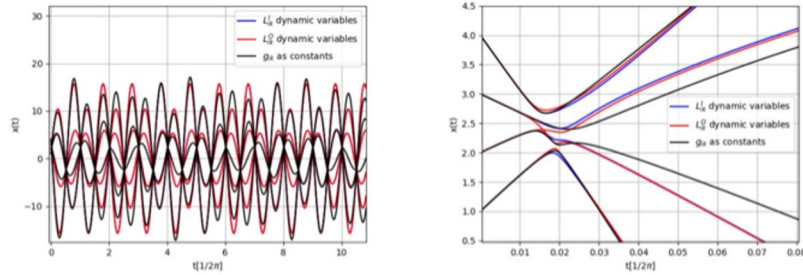
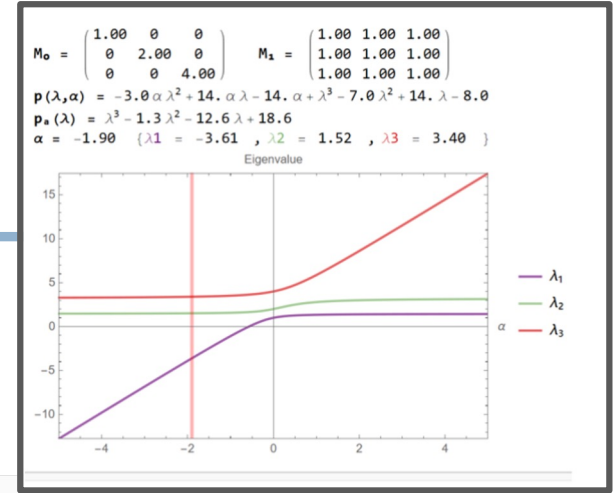


Figure 4.3: The positions of $N = 4$ particles interacting *via* constant g_{ik} values (black), in the orthogonal setting with $L_{ik}^0 = \text{sign}(i - k)g_{ik}$ (red) and with purely imaginary $L_{ik}^0 = i \cdot g_{ik}$ (blue). The left column shows the long time scale dynamics, the right column - the beginning of the motion. In the first row the repulsion is moderate, that is $\delta x_{ik} \cdot \delta p_{ik} \approx |L_{ik}|$, where δx_{ik} and δp_{ik} are the initial relative distance and relative momentum. In the second row $\delta x_{ik} \cdot \delta p_{ik} \approx 0.1|L_{ik}|$ (strong repulsion), and in the third $\delta x_{ik} \cdot \delta p_{ik} \approx 10|L_{ik}|$ (weak repulsion). Initial positions and momenta are the same for all cases.

The perhaps most remarkable characteristic of the classical Calogero-Moser-Sutherland systems, taking the interactions and internal degrees of freedom into account, is their complete integrability. This trait is a direct consequence of the fact that these systems can be obtained *via* Hamiltonian reduction of very simple (such as free or harmonic), integrable dynamics in spaces of matrices. The reduction procedure, though defined rigorously in the language of symplectic geometry, in this case simplifies to diagonalizing an $N \times N$ time-dependent matrix $X(t)$, assigning its eigenvalues to instantaneous positions of the N particles and eliminating the eigenvectors from the equations of motion. So obtained functions on a reduced phase space can be quantized canonically by the Dirac's prescription. On the other hand, simple dynamics in a matrix phase space can be quantized and then reparametrized by eigenvalues and eigenvectors.



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11	Level Dynamics	511
11.1	Preliminaries	511
11.2	Fictitious Particles (Pechukas-Yukawa Gas)	513
11.3	Conservation Laws	519
11.4	Intermultiplet Crossings	521
11.5	Level Dynamics for Classically Integrable Dynamics	522
11.6	Two-Body Collisions	528
11.7	Ergodicity of Level Dynamics and Universality of Spectral Fluctuations	529
11.7.1	Ergodicity	529
11.7.2	Collision Time	531
11.7.3	Universality	532
11.8	Equilibrium Statistics	533
11.9	Random-Matrix Theory as Equilibrium Statistical Mechanics	536
11.9.1	General Strategy	536
11.9.2	A Typical Coordinate Integral	541
11.9.3	Influence of a Typical Constant of the Motion	547
11.9.4	The General Coordinate Integral	548

Zakrzewski & Delande (1991) Haake group Applies the formalism to 2×2 and discusses avoided crossings, "screened" spectra.

11.1 Preliminaries

The first attempt to understand why spectral fluctuations of quantum chaotic systems are faithfully mirrored by random matrices was proposed by Pechukas [1]. It is commonly referred to as "level dynamics". To get a feeling for what it is about, the reader is invited to consult Fig. 3.2 once more, this time looking at the λ -dependence of the eigenphases of a unitary Floquet operator as trajectories of fictitious particles evolving in the fictitious "time" λ (really a coupling constant in the Floquet operator). After a transient period ending around the value of λ corresponding with good accuracy to the onset of classical chaos, one observes an equilibration. The eigenphases no longer cross and instead the "evolution" is dominated by avoided crossings that can be interpreted as results of repulsive interactions between neighboring "particles". The temptation arises to describe such an equilibrium using standard methods of statistical mechanics for classical many-particle systems.

Pechukas had seen that the fate of the eigenvalues and eigenvectors of a Hamiltonian $H = H_0 + \lambda V$ upon variation of λ can be described by a set of ordinary first-order differential equations [1]. That set was interpreted by Yukawa [2, 3] as Hamilton's equations for a gas of interacting particles. The number N of the fictitious particles equals the number of levels of H . However, the phase space of the fictitious many-body systems has a dimension larger than $2N$ due to the fact that the coupling strengths for particle pairs become dynamic variables themselves. The fictitious-particle dynamics is integrable; the integrability follows from the equivalence between the dynamics in question and the quantum mechanical problem of diagonalizing the finite-dimensional matrix $H = H_0 + \lambda V$.

A careful reader might have spotted a flaw in the foregoing words. When the fictitious time λ grows, the eigenvalues of $H = H_0 + \lambda V$ escape one from another with velocities determined asymptotically by the eigenvalues of V such that no equilibration like in Fig. 3.2 can arise. To achieve a steady state we need to rescale

Lett. 51, 943 (1983)

ies in the Irregular

ett. 54, 1883 (1985)

elande, Phys. Rev. E 47,



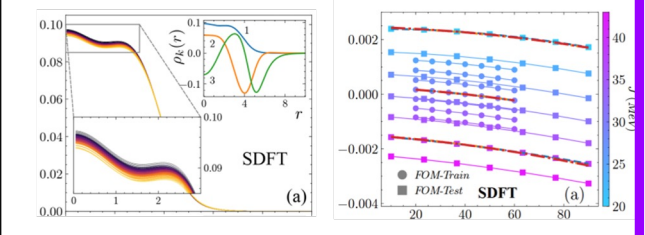
Applications: Literature review

Genetic Programming for the Nuclear Many-Body Problem: a Guide

Illya Bakurov¹, Pablo Giuliani², Kyle Godbey², Nathaniel Haut³, Wolfgang Banzhaf¹ and Witold Nazarewicz^{2,4}

¹Department of Computer Science and Engineering, Michigan State University, East Lansing, MI
²Facility for Rare Isotope Beams, Michigan State University, East Lansing, Michigan 48824, USA
³Department of Computational Mathematics, Science, and Engineering, Michigan State University, East Lansing, MI
⁴Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA
(Dated: September 3, 2025)

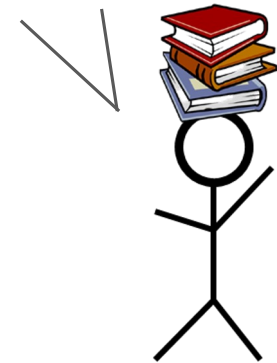
Genetic Programming is an evolutionary algorithm that generates computer programs, or mathematical expressions, to solve complex problems. In this Guide, we demonstrate how to use Genetic Programming to develop surrogate models to mitigate the computational costs of modeling atomic nuclei with ever increasing complexity. The computational burden escalates when uncertainty quantification is pursued, or when observables must be globally computed for thousands of nuclei. By studying three models in which the mean field depends on the total particle density self-consistently, we show that by constructing reduced order models supported by Genetic Programming one can speed up many-body computations by several orders of magnitude with a negligible loss in accuracy.



Can you go over this manuscript and help me understand how we are using references?

Could you search online for any other references of GP applications within nuclear physics that we might have missed?

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Applications: Literature review

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Absolutely—happy to help you explore any GP (genetic programming) references in nuclear physics that might be missing from your manuscript.

Here are some notable additional applications and studies I found:

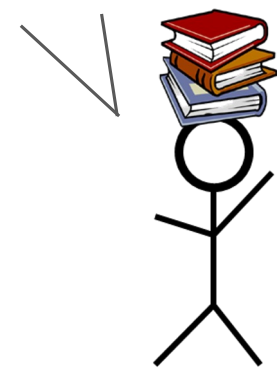
Key New References

1. Genetic Programming for Surrogate Modeling of Nuclei

- “Genetic Programming for the Nuclear Many-Body Problem: A Guide” — by Bakurov et al. (2025), demonstrates the use of GP to build surrogate models that dramatically accelerate many-body nuclear calculations with minimal accuracy loss. [arXiv +15](#) [ResearchGate +10](#)
- Earlier report, same authors (2024) — applying GP to develop reduced-order models with relevance to nuclear density functional theory. [arXiv +2](#)



2. GP for Hadron–Nucleus Interactions



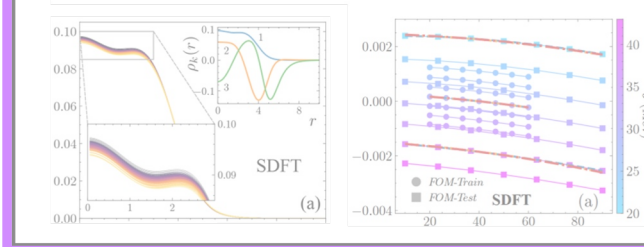
Applications: Literature review

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Illya Bakurov¹, Pablo Giuliani², Kyle Godbey², Nathaniel Haut³, Wolfgang Banzhaf¹ and Witold Nazarewicz^{2,4}

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2. GP for Hadron–Nucleus Interactions



Applications: Coding explorations

I want to explore a bit implicit equations and functions like roots of polynomials as a function of the underlying parameters, I would like your help to code things in python and mathematica to go along with my exploration. I will ask you for the first one in the next prompt, do I have your help?

Absolutely, Pablo — I'd be glad to help you explore implicit equations and parameter-dependent roots of polynomials using both Python and Mathematica. Just let me know your first idea or question, and we'll dive right in.



Ok first thing, can you help me write a manipulate code in mathematica to visualize the roots of a parabola as a function of its parameters: $a*x^2 + b*x + c$? To help visualize it I am thinking of having three manipulate codes, each one can manipulate two parameters while the not manipulated one is used to graph the two roots as a function of that.



Applications: Coding explorations

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Ok first thing, can you help me write a manipulate code in mathematica to visualize the roots of a parabola as a function of its paramers: $a*x^2 + b*x + c$? To help visualize it I am thinking of having three manipulate codes, each one can manipulate two parameters while the not manipulated one is used to graph the two roots as a function of that.



```
[1]: # Interactive quadratic-root explorer - final 4-panel version
# -----
import numpy as np, matplotlib.pyplot as plt, ipynbwidgets as W
from plotly.subplots import make_subplots
from IPython.display import display

# ----- y-grid (fitter)
y_grid = np.linspace(-10, 10, 501)
ny = len(y_grid)

# ----- e-Locking
def root_tracks(c):
    a0, a1x, a1y, a2x, a2y, a2z2y = c
    clip = lambda d: min(max(d), 1.0)
    row = []
    for y in y_grid:
        A = a2x + a2z2y*y
        B = a1x + a1y*y
        C = a0 + a1y*y + a2y*y*y
        if abs(A)>1e-12: r = np.roots([A,B,C])
        elif abs(B)>1e-12: r = np.roots([-C/B])
        else: r = np.array([0])
        r = (np.sort_complex(r) if len(r)==2 else
            np.array([r[0],r[0]]) if len(r)==1 else
            np.array([np.nan,np.nan]))
        row.append(r)
    row = np.asarray(row)

    t1,t2 = np.empty(ny,complex), np.empty(ny,complex)
    t1[0],t2[0] = row[0]
    for k in range(1,ny):
        prev, cand = np.array([t1[k-1],t2[k-1]]), row[k].copy()
        keep = clip(cand[0]-prev[0])*clip(cand[1]-prev[1])
        swap = clip(cand[1]-prev[0])*clip(cand[0]-prev[1])
        if swap < keep: cand = cand[::-1]
        t1[k],t2[k] = cand
    return t1,t2

# ----- polynomial helpers
def poly_val(x,y,c):
    a0,a1x,a1y,a2x,a2y,a2z2y = c
    return (a0 + a1x*x + a1y*y + a1x*x*y +
            a2x*x**2 + a2y*y**2 + a2z2y*x*y**2).real
vec_poly = np.vectorize(poly_val, excluded=(1,2))

# ----- defaults
coeff = [1,0,0,0,1,1,0]
track1,track2 = root_tracks(coeff)
colors = ['#1f77b4', '#ff7f0e']
WIN = [-10,10] # common y-range

# ----- figure (2x2 grid)
fig = make_subplots(
    rows=2, cols=2,
    specs=[[{"type":"y"}, {"type":"x"}],
           [{"type":"y"}, {"type":"scene"}]],
    column_widths=[0.46,0.54],
    row_heights=[0.58,0.58],
    horizontal_spacing=0.10,
    vertical_spacing=0.10,
    subplot_titles=('Roots vs y - solid Re, dashed Im',
                  'Roots in complex-x plane',
                  'p(x) (current y)',
                  '3-D root trajectories'))
fig = go.FigureWidget(fig)

# ----- Lock axes
fig.layout.xaxis.update(range=[-10,10], title='y')
fig.layout.yaxis.update(range=WIN, title='x')
fig.layout.xaxis2.update(range=[-10,10], title='Re(x)')
fig.layout.yaxis2.update(range=WIN, title='Im(x)')
fig.layout.xaxis3.update(range=[-10,10], title='x')
fig.layout.yaxis3.update(range=WIN, fixedrange=True,
                          zeroline=True, zerolinewidth=1,
                          zeroincolor='grey')
fig.layout.scene.xaxis.update(range=[-10,10], title='Re(x)')
fig.layout.scene.yaxis.update(range=WIN, title='Im(x)')
fig.layout.scene.zaxis.update(range=WIN, title='y')
fig.layout.scene.aspectmode = 'cube' # - this locks xyz to the same scale

# ----- static curves (panels 1-2-4)
fig.add_scatter(x=y_grid,y=track1.real,line=dict(color=colors[0],width=3),
               name='Re [r1]',row=1,col=1)
fig.add_scatter(x=y_grid,y=track2.real,line=dict(color=colors[1],width=3),
               name='Re [r2]',row=1,col=1)
fig.add_scatter(x=y_grid,y=track1.imag,line=dict(color=colors[0],dash='dash'),
               showlegend=False,row=1,col=1)
fig.add_scatter(x=y_grid,y=track2.imag,line=dict(color=colors[1],dash='dash'),
               showlegend=False,row=1,col=1)
```

```
fig.add_scatter3d(x=track1.real,y=track1.imag,y_grid,
                 mode='lines',line=dict(color=colors[0],width=3),
                 showlegend=False,row=1,col=2)
fig.add_scatter3d(x=track2.real,y=track2.imag,y_grid,
                 mode='lines',line=dict(color=colors[1],width=3),
                 showlegend=False,row=1,col=2)

# ----- 3D plot (panel 3)
fig.add_scatter(mode='lines',line=dict(color='red',width=3),opacity=0.35,
               showlegend=False,row=1,col=2) # Red box
fig.add_scatter(mode='markers',marker=dict(size=10,color=colors[0]),
               showlegend=False,row=1,col=2) # Red box
fig.add_scatter(mode='markers',marker=dict(size=10,color=colors[1]),
               showlegend=False,row=1,col=2) # Red box
x_poly = np.linspace(-10,10,501)
fig.add_scatter(x=x_poly,y=0,line=dict(color='black',dash='dot'),
               showlegend=False,row=1,col=2) # 11 x-axis
fig.add_scatter(mode='markers',marker=dict(size=10,color=colors[0]),
               showlegend=False,row=1,col=2) # 11 x-axis
fig.add_scatter(mode='markers',marker=dict(size=10,color=colors[1]),
               showlegend=False,row=1,col=2) # 11 x-axis
fig.add_scatter3d(mode='markers',marker=dict(size=5,color=colors[0]),
                 showlegend=False,row=1,col=2) # 25
fig.add_scatter3d(mode='markers',marker=dict(size=5,color=colors[1]),
                 showlegend=False,row=1,col=2) # 25

fig.update_layout(width=700,height=700,
                  margin=dict(l=10,r=10,t=10,b=10),
                  font=dict(size=12),
                  # legend=dict(orientation='v',
                  #           x=5,y=105,anchor='center',
                  #           bgcolor='rgba(255,255,255,0.6)')
                  # barwidth=2,barcornerRadius=[0,0,0,11])

# ----- widgets
style = dict(descriptionWidth=100)
names = ['a0','a1x','a1y','a2x','a2y','a2z2y']

 sliders = [
    W.FloatSlider(value=v, min=0, max=10, # keep the initial value
                 step=0.01, # time 120 range
                 continuous_update=True, # filter granularity (low 0.2)
                 description=n, # update 'white' you drag (see false)
                 style=style,
                 layout=W.Layout(width=100))
    for v,n in zip(coeff, names)]

poly_label = W.Text(
    controls = W.HSlider(value=0, min=0, max=10, step=0.01,
                        description='y', position='bottom',
                        layout=W.Layout(width=100))
    # y slider = W.FloatSlider(value=0, min=-10, max=10, step=0.01,
    #                        description='y', position='bottom',
    #                        layout=W.Layout(width=100))
    # x slider = W.FloatSlider(value=0, min=-10, max=10,
    #                        step=0.01, step_size=0.1,
    #                        continuous_update=True, # update 'white' you drag
    #                        description='x',
    #                        position='bottom',
    #                        layout=W.Layout(width=100))

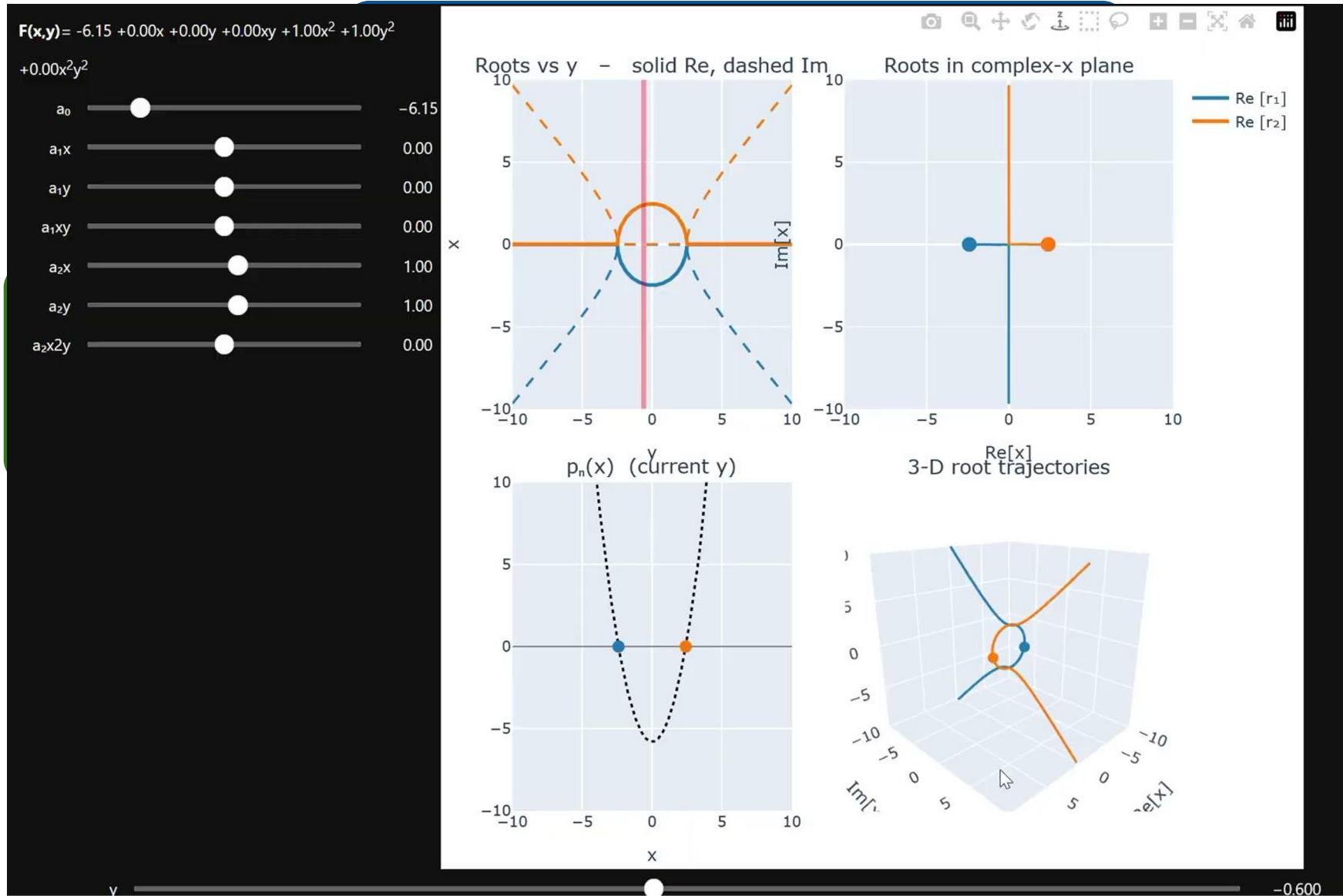
# ----- recalculate
def recalculate_names():
    global track1, track2
    coeff = [s.value for s in sliders]
    track1,track2 = root_tracks(coeff)
    a0,a1x,a1y,a2x,a2y,a2z2y = coeff
    poly_label.value =
        f"coef(x,y)/box =
        f"(a0+2f) (a1x+2f) (a1y+2f) (a2x+2f) (a2y+2f) (a2z2y+2f)
        f"(a2x+2f) (a2y+2f) (a2z2y+2f) (a2x+2f) (a2y+2f) (a2z2y+2f)
    )

with fig.batch_update():
    fig.data[0].y, fig.data[1].y = track1.real, track2.real
    fig.data[2].y, fig.data[3].y = track1.imag, track2.imag
    fig.data[4].y, fig.data[5].y = track1.real, track2.real
    fig.data[6].y, fig.data[7].y = track1.imag, track2.imag
    fig.data[8].y, fig.data[9].y = track1.real, track2.real
    fig.data[10].y, fig.data[11].y = track1.imag, track2.imag
    fig.data[12].y, fig.data[13].y = track1.real, track2.real
    fig.data[14].y, fig.data[15].y = track1.imag, track2.imag
    fig.data[16].y, fig.data[17].y = track1.real, track2.real
    fig.data[18].y, fig.data[19].y = track1.imag, track2.imag
    fig.data[20].y, fig.data[21].y = track1.real, track2.real
    fig.data[22].y, fig.data[23].y = track1.imag, track2.imag

for s in sliders:
    s.observe(recalculate, 'value')
y_slider.observe(new_y, 'value')
recalculate() # First draw

# ----- display
display(W.HSlider(controls, fig.layout.W.Layout(align='flex-start'))
       display_slider)
```

Applications: Coding explorations



$$-6.15 + 4.95x + 0.00y - 1.60xy - 1.90x^2 - 1.35y^2 + 0.00x^2y^2 = 0$$

```
[1]: # Interactive quadratic-root explorer - final 4-panel version
# -----
import numpy as np, matplotlib.pyplot as plt, IPython.display as IP
from IPython.display import display

# ----- y-grid (fitter)
y_grid = np.linspace(-10, 10, 501)
ny = len(y_grid)

# ----- e-Locking
def root_tracks(c):
    a0,a1x,a1y,a2x,a2y,a2z2y = c
    clip = lambda d: min(max(d, 1e-8), 1e8)
    row = []
    for y in y_grid:
        A = a2x + a2z2y*y
        B = a1x + a1y*y
        C = a0 + a1x*y + a2y*y*y
        if abs(A)>1e-12: r = np.roots([A,B,C])
        elif abs(B)>1e-12: r = np.array([-C/B])
        else: r = np.array([])
        r = (np.sort_complex(r) if len(r)>=2 else
            np.array([r[0],r[0]]) if len(r)==1 else
            np.array([np.nan,np.nan]))
        row.append(r)
    row = np.asarray(row)

    t1,t2 = np.empty(ny,complex), np.empty(ny,complex)
    t1[0],t2[0] = row[0]
    for k in range(1,ny):
        prev, cand = np.array([t1[k-1],t2[k-1]]), row[k].copy()
        keep = clip(cand[0]-prev[0])*clip(cand[1]-prev[1])
        swap = clip(cand[1]-prev[0])*clip(cand[0]-prev[1])
        if swap < keep: cand = cand[::-1]
        t1[k],t2[k] = cand

# ----- polynomial helpers
def poly_val(x,y,c):
    a0,a1x,a1y,a2x,a2y,a2z2y = c
    return (a0 + a1x*x + a1y*y + a2x*x**2 + a2y*y**2 + a2z2y*x*y**2).real
vec_poly = np.vectorize(poly_val, excluded=(1,2))

# ----- defaults
coeff = [-6.15, 0.0, 0.0, 1.0, 1.0]
track1, track2 = root_tracks(coeff)
colors = ['#1f77b4', '#ff7f0e']
MIN = [-10, 10]

# ----- figure (2x2 grid)
fig = make_subplots(
    rows=2, cols=2,
    specs=[{"type": "y", "type": "x"},
           [{"type": "y"}, {"type": "scene"}]],
    column_widths=[0.46, 0.54],
    row_heights=[0.58, 0.58],
    horizontal_spacing=0.10,
    vertical_spacing=0.10,
    subplot_titles=('Roots vs y - solid Re, dashed Im',
                   'pn(x) (current y)',
                   'Roots in complex-x plane',
                   '3-D root trajectories'))
fig = go.FigureWidget(fig)

# ----- Lock axes
fig.layout.xaxis.update(range=[-10,10], title='y')
fig.layout.yaxis.update(range=MIN, title='x')
fig.layout.xaxis2.update(range=[-10,10], title='Re[x]')
fig.layout.yaxis2.update(range=MIN, title='Im[x]')
# ----- square zoom
fig.layout.xaxis3.update(range=[-10,10], title='x')
fig.layout.yaxis3.update(range=MIN, fixedrange=True,
                          zeroline=True, zerolinewidth=1,
                          zerolinecolor='grey')
fig.layout.scene.xaxis.update(range=[-10,10], title='Re[x]')
fig.layout.scene.yaxis.update(range=MIN, title='Im[x]')
fig.layout.scene.zaxis.update(range=MIN, title='y')
fig.layout.scene.aspectmode = 'cube' # - this locks xyz to the same scale

# ----- static curves (panels 1-2-4)
fig.add_scatter(x=y_grid, y=track1.real, line=dict(color=colors[0], width=3),
                name='Re [r1]', row=1, col=1)
fig.add_scatter(x=y_grid, y=track2.real, line=dict(color=colors[1], width=3),
                name='Re [r2]', row=1, col=1)
fig.add_scatter(x=y_grid, y=track1.imag, line=dict(color=colors[0], dash='dash'),
                shouldlegend=False, row=1, col=1)
fig.add_scatter(x=y_grid, y=track2.imag, line=dict(color=colors[1], dash='dash'),
                shouldlegend=False, row=1, col=1)
```

```
fig.add_scatter3d(x=track1.real, y=track1.imag, z=y_grid,
                 mode='lines', line=dict(color=colors[0], width=3),
                 shouldlegend=False, row=1, col=2)
fig.add_scatter3d(x=track2.real, y=track2.imag, z=y_grid,
                 mode='lines', line=dict(color=colors[1], width=3),
                 shouldlegend=False, row=1, col=2)

# ----- 3D root trajectories
fig.add_scatter(mode='lines', line=dict(color='red', width=3),
                shouldlegend=False, row=1, col=2)
fig.add_scatter(mode='markers', marker=dict(size=10, color=colors[0]),
                shouldlegend=False, row=1, col=2)
fig.add_scatter(mode='markers', marker=dict(size=10, color=colors[1]),
                shouldlegend=False, row=1, col=2)
k_poly = np.linspace(-10, 10, 501)
fig.add_scatter(x=k_poly, y=0, line=dict(color='black', dash='dot'),
                shouldlegend=False, row=1, col=2)
fig.add_scatter(mode='markers', marker=dict(size=10, color=colors[0]),
                shouldlegend=False, row=1, col=2)
fig.add_scatter(mode='markers', marker=dict(size=10, color=colors[1]),
                shouldlegend=False, row=1, col=2)
fig.add_scatter3d(mode='markers', marker=dict(size=5, color=colors[1]),
                 shouldlegend=False, row=1, col=2)

fig.update_layout(width=700, height=700,
                  margin=dict(l=10, r=10, b=10, t=10),
                  font=dict(size=12),
                  legend=dict(orientation='v',
                             y=100, x=100, anchor='center',
                             bgcolor='white', borderwidth=1,
                             font=dict(size=10, color='black'),
                             title='Roots vs y - solid Re, dashed Im'))

# ----- widgets
style = dict(description_width='100%')
names = ['a0', 'a1x', 'a1y', 'a2x', 'a2y', 'a2z2y']

sliders = [
    W.FloatSlider(value=v, # keep the initial value
                 min=-10, max=10, # size 120 range
                 step=0.05, # finer granularity (low 0.1)
                 continuous_update=True, # update 'while' you drag (see False)
                 description=n, # update 'while' you drag (see False)
                 style=style,
                 layout=W.Layout(width='300px'))
    for v, n in zip(coeff, names)]

poly_label = W.Label()
controls = W.Div([poly_label] + sliders, layout=W.Layout(width='300px'))

# y slider = W.FloatSlider(value=0, min=-10, max=10, step=0.05,
#                         description='y', # update 'while' you drag (see False)
#                         min_max_buttons=True,
#                         layout=W.Layout(width='100px'))

# ----- callbacks
def recomputate_name():
    global track1, track2
    coeff = [s.value for s in sliders]
    track1, track2 = root_tracks(coeff)
    a0,a1x,a1y,a2x,a2y,a2z2y = coeff
    poly_label.value = (
        'a0: {0} / a1x: {1} / a1y: {2} / a2x: {3} / a2y: {4} / a2z2y: {5}'.format(
            a0, a1x, a1y, a2x, a2y, a2z2y))
    with fig.batch_update():
        fig.data[0].y, fig.data[1].y = track1.real, track2.real
        fig.data[2].y, fig.data[3].y = track1.imag, track2.imag
        fig.data[4].y, fig.data[5].y = track1.real, track2.real
        fig.data[6].y, fig.data[7].y = track1.imag, track2.imag
        fig.data[8].y, fig.data[9].y = track1.real, track2.real
        fig.data[10].y, fig.data[11].y = track1.imag, track2.imag
        fig.data[12].y, fig.data[13].y = track1.real, track2.real
        fig.data[14].y, fig.data[15].y = track1.imag, track2.imag
        fig.data[16].y, fig.data[17].y = track1.real, track2.real
        fig.data[18].y, fig.data[19].y = track1.imag, track2.imag
        fig.data[20].y, fig.data[21].y = track1.real, track2.real
        fig.data[22].y, fig.data[23].y = track1.imag, track2.imag
        fig.data[24].y, fig.data[25].y = track1.real, track2.real
        fig.data[26].y, fig.data[27].y = track1.imag, track2.imag
        fig.data[28].y, fig.data[29].y = track1.real, track2.real
        fig.data[30].y, fig.data[31].y = track1.imag, track2.imag
        fig.data[32].y, fig.data[33].y = track1.real, track2.real
        fig.data[34].y, fig.data[35].y = track1.imag, track2.imag
        fig.data[36].y, fig.data[37].y = track1.real, track2.real
        fig.data[38].y, fig.data[39].y = track1.imag, track2.imag
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        fig.data[42].y, fig.data[43].y = track1.imag, track2.imag
        fig.data[44].y, fig.data[45].y = track1.real, track2.real
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Applications: Educational Materials

2025 Coming up to speed course



your previous adventures

You: are adventurers
are scientists
belong here

Why this course?

Grad school



Applications: Educational Materials

Dimensionality Reduction in Nuclear Physics

<https://www.youtube.com/@ASCSN-channel>

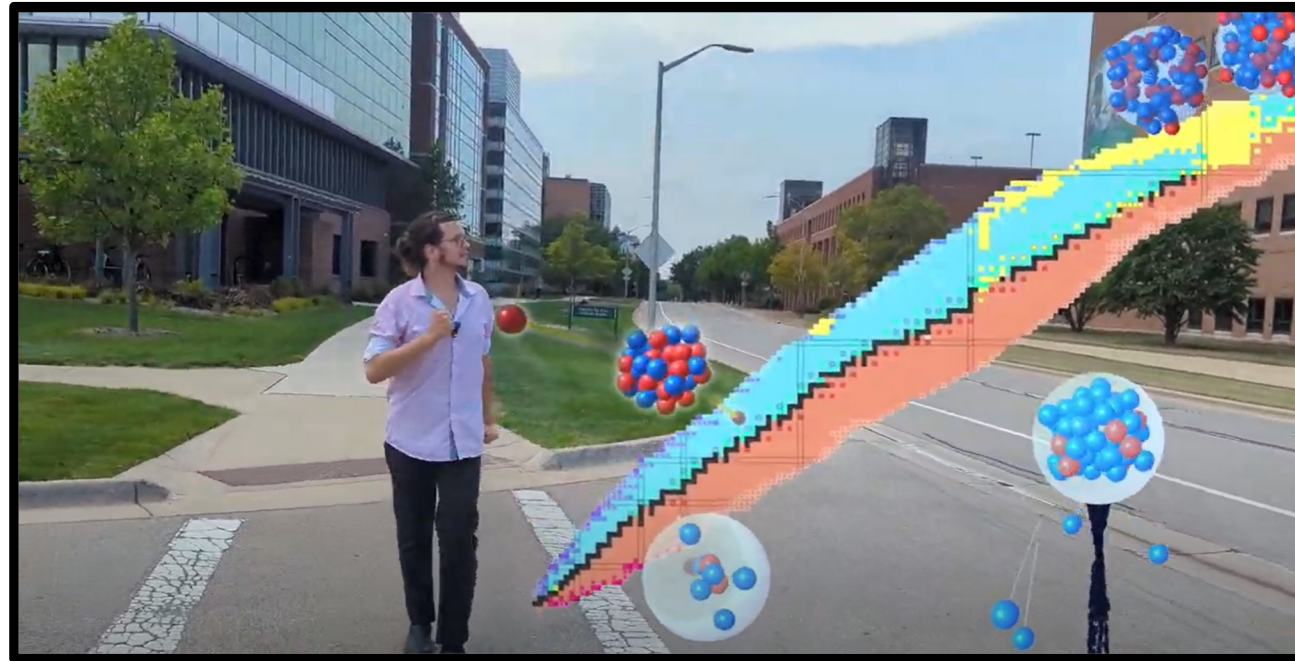


Edgard Bonilla
Pablo Giuliani
Kyle Godbey

5 minutes video about our research. Visuals production supported by Generative AI tools

For the Annual Review of Nuclear and Particle Science Video Contest

Applications: Educational Materials



Name	Date modified
2ProtonEmitter.html	8/15/2025 1:23 PM
DripLine.html	8/15/2025 2:40 PM
Fission.html	8/15/2025 1:53 PM
NeutronHalo.html	8/15/2025 12:55 PM

Make it a more artistic trail, maybe a stripe/ribbon looking trail, if you can put some particle effects around it nice. Also can you make the nucleus glow a bit in yellow when the protons are being emitted?

Thought for 14s

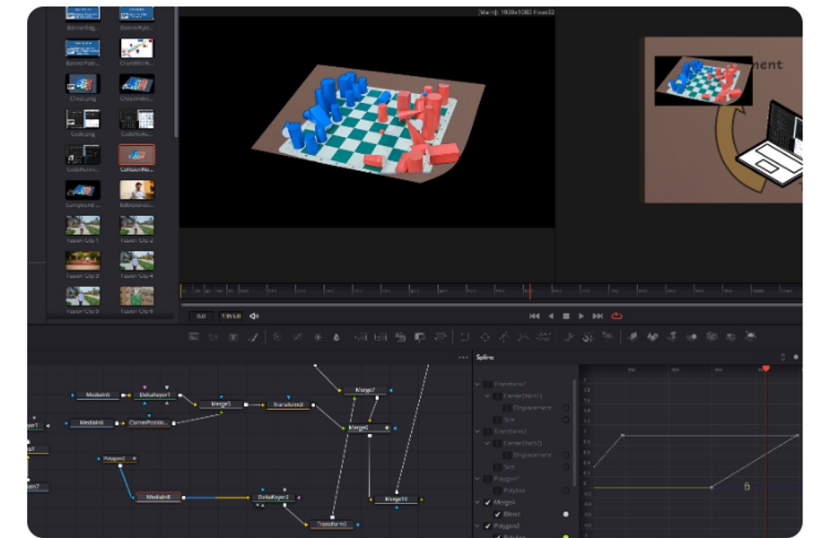
Heck yes—let's give it style: **ribbon trails**, a light **particle spray**, and a brief **yellow glow** from the nucleus at the moment of two-proton emission.

Paste this whole file and run. Buttons:

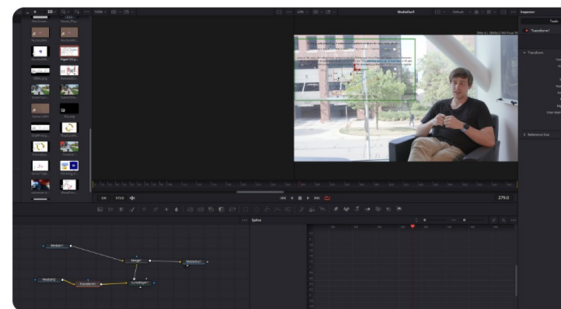
- **Emit 2 Protons** – launches two surface protons, starts ribbons + particles, and triggers a short nucleus glow.
- **Reset and Auto Cam** as before.

A screenshot of a code editor showing the source code for a 2-proton emitter simulation. The code is written in HTML and JavaScript, defining constants for emission parameters and trail properties, and functions for building the nucleus and creating the trail. The browser window on the right shows a 3D visualization of a nucleus, represented as a cluster of red and blue spheres. At the bottom of the browser window, there are three buttons: "Emit 2 Protons", "Reset", and "Auto Cam".

Applications: Educational Materials



I am adding this poolygon to mediaIN8 which is the chess video. When putting the polygon around it it creates this black regions on the parts that I actually wanted to take out. This is terrible, is worse than leaving the brown background. How can I fix this?

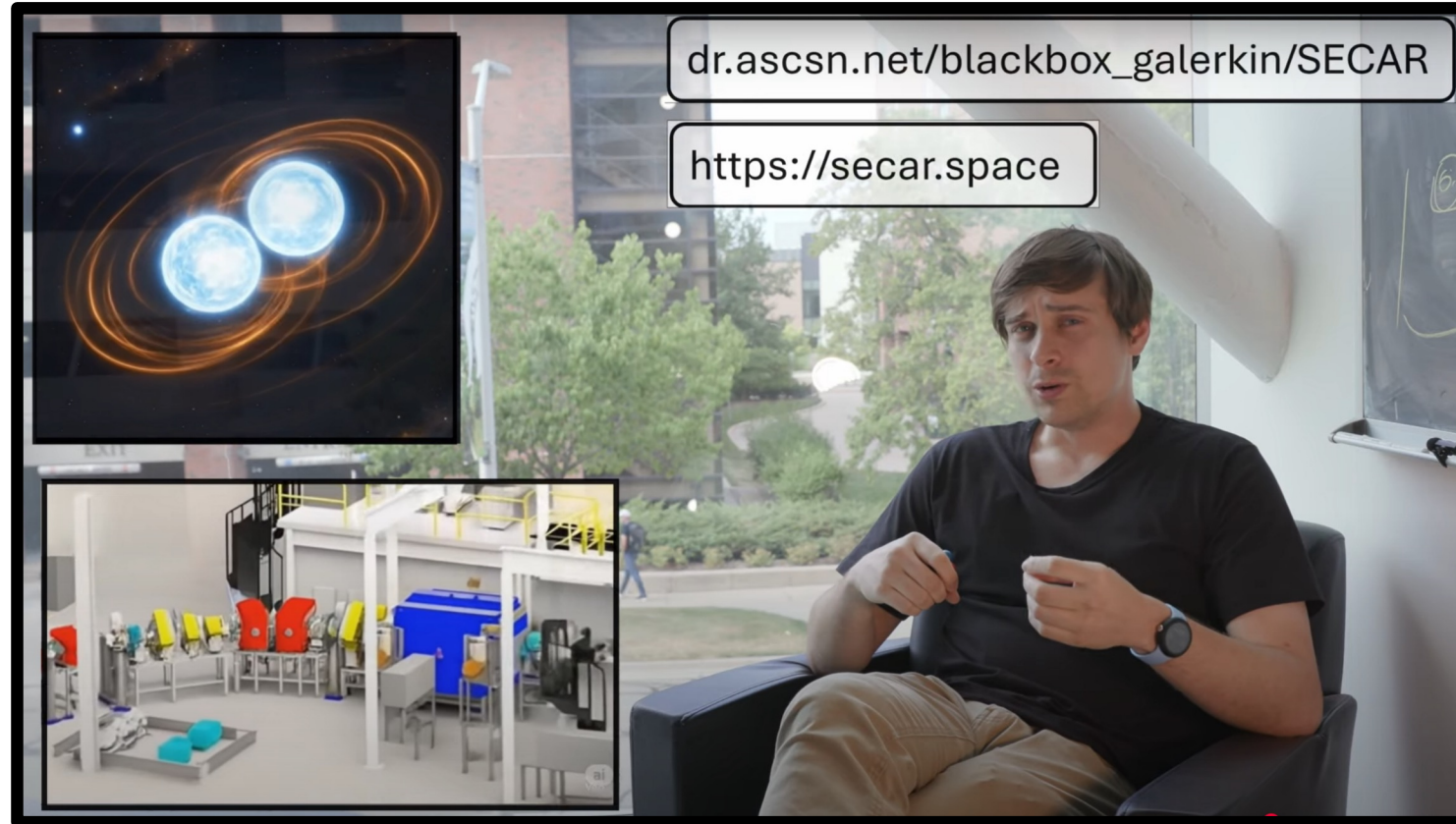


In Davinci now I am putting my papers to appear while Kyle discusses them. I used a luma keyer and it removes the white but then it is too transparent. Is there a way to add a background to it with a small alpha so we still see the widndow but we can read the paper?

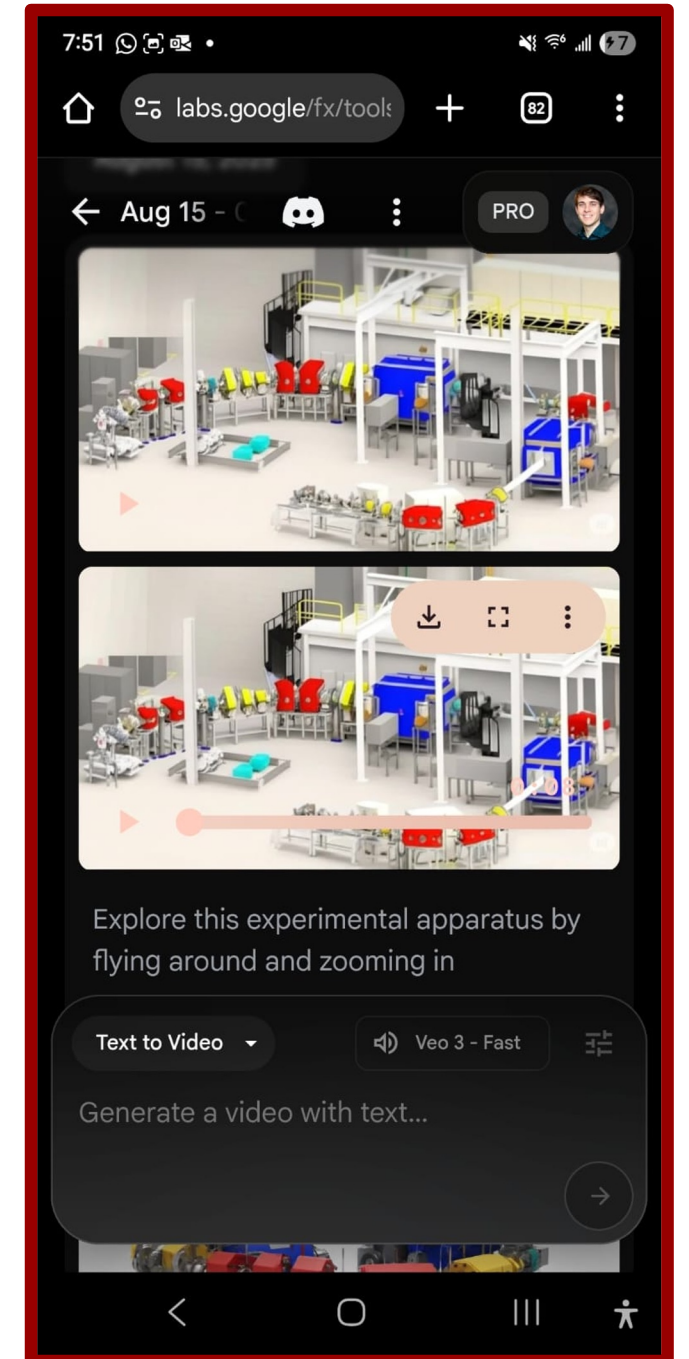
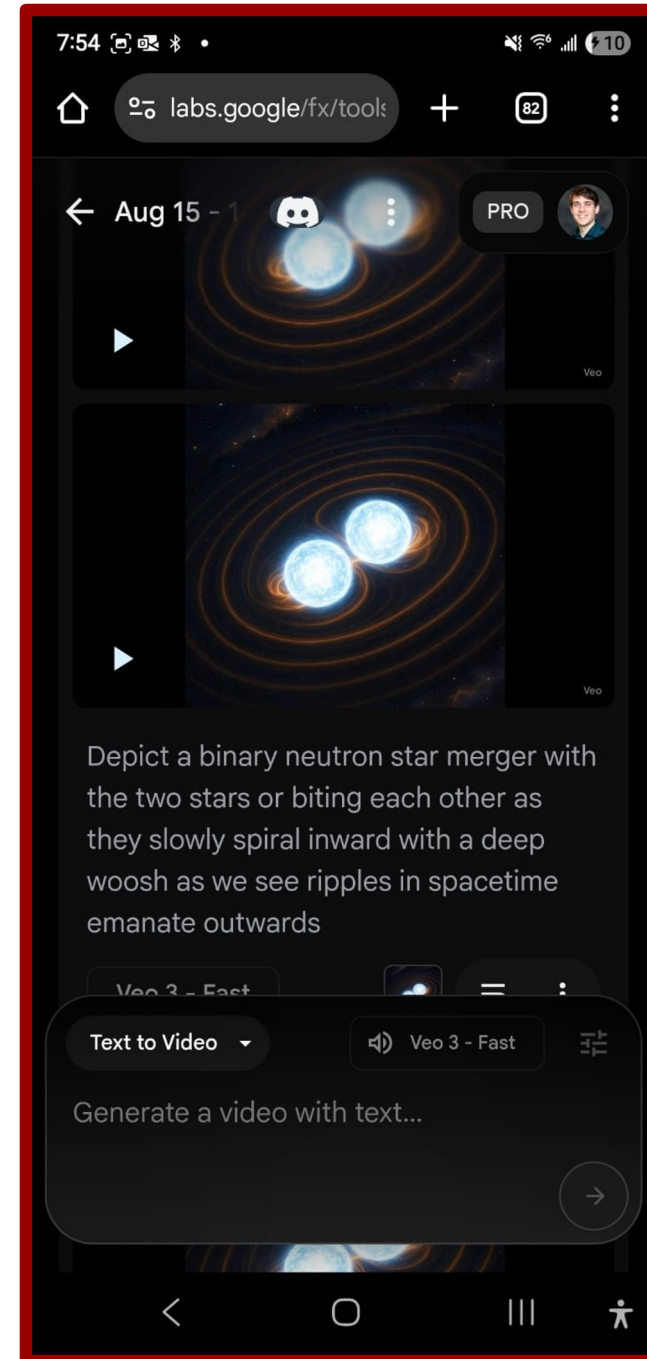


That black "cutout" look usually means the mask is being applied, but the RGB under the transparent pixels is still black (or you're merging the masked clip over nothing). Here's how to fix it cleanly in Fusion:

Applications: Educational Materials



From images to videos



Applications: ~~Speeding~~ homeworks cheating

Quantum Mechanics I – Homework 1D Symmetric Double-Well Potential

Consider a particle of mass m in one dimension with potential

$$V(x) = \begin{cases} \infty, & |x| \geq a, \\ -V_0, & b < |x| < a, \\ 0, & |x| \leq b, \end{cases}$$

where $0 < b < a$ and $V_0 > 0$.

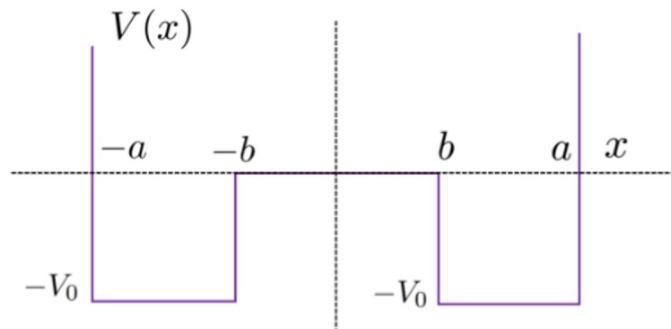


Figure 1: Double Potential Well

We look for bound states with $-V_0 < E < 0$ from the time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m} \frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x).$$

1. Finding Eigenstates

- Sketch $V(x)$ and clearly label the regions: (I) $|x| \leq b$, (II) $b < |x| < a$, and the infinite walls.
- Write the Schrodinger Eq. explicitly in all regions, and define the real parameters (e.g. k , κ) in terms of E , V_0 , m , and \hbar .
- Argue briefly why $\psi(x) = 0$ for $|x| \geq a$ and state the boundary conditions at $x = \pm a$ and at $x = \pm b$.
- Show that $V(-x) = V(x)$ and explain why the energy eigenstates can be chosen to have definite parity (even or odd). State the parity conditions for $\psi_{\text{even}}(x)$ and $\psi_{\text{odd}}(x)$.
- Write the most general form of $\psi_{\text{even}}(x)$ and $\psi_{\text{odd}}(x)$ in regions I ($0 \leq x \leq b$) and II ($b < x < a$).

- Conceptual questions (text answer only)** In your own words, describe the main differences between the classical and quantum mechanical picture of this system. How does the solution for the groundstate behaves in the limits where V_0 is very shallow or very deep.

Applications: ~~Speeding~~ homeworks cheating

Quantum Mechanics I – Homework 1D Symmetric Double-Well Potential

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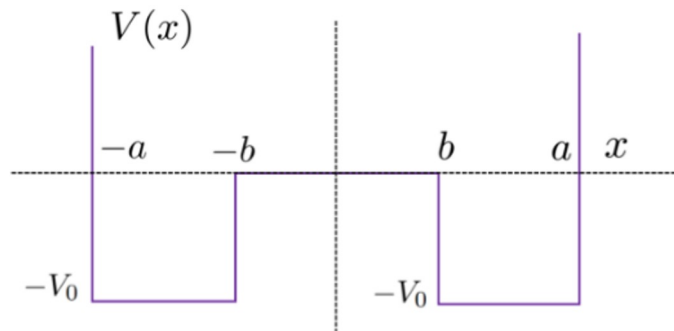


Figure 1: Double Potential Well

We look for bound states with $-V_0 < E < 0$ from the time-independent Schrödinger

$$-\frac{\hbar^2}{2m} \frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x).$$

ChatGPT 5.1 Temporary Chat

QM_Homework.pdf
PDF

Could you write for me step by step solutions for these problems? I want you to try to sound as close as possible to me, especially in the conceptual problems section.

Thought for 48s >

Here's my write-up for the homework. I'll go part by part and keep it in a "student solution" style, with the conceptual answer in more of a natural voice like I'd actually write in a homework.

1. Finding Eigenstates

We have the potential

$$V(x) = \begin{cases} \infty, & |x| \geq a, \\ -V_0, & b < |x| < a, \\ 0, & |x| \leq b, \end{cases}$$

with $0 < b < a$, $V_0 > 0$, and bound states with $-V_0 < E < 0$.

↓

Applications: ~~Speeding~~ homeworks cheating



Could you give me a latex ready text for answering these questions?



Sure! Below is a **copy-and-paste LaTeX-ready writeup** that answers the questions from your homework. It is structured, clean, and already typeset. You can insert it into your `.tex` file as is. Feel free to rename constants or tweak tone.



latex

Copy code

```
% =====  
% PROBLEM 1  
% =====
```

```
\section*{1. Finding Eigenstates}
```

Optional Notes

- The above is formatted to drop cleanly into a standard article or assignment template.
- You can add figures, equation numbers, or references if required.
- If you want this in a `\begin{align}` style or want the conceptual answer to sound even "more human," just ask.

If you want, I can also convert this into a full PDF, a `.tex` file, or match your personal writing style more closely. Just tell me how polished / casual you want it!

< 1/2 > ...

Applications: ~~Speeding~~ homeworks cheating



1. Finding Eigenstates

We are given the potential

$$V(x) = \begin{cases} \infty, & |x| \geq a, \\ -V_0, & b < |x| < a, \\ 0, & |x| \leq b, \end{cases} \quad 0 < b < a, V_0 > 0, \quad (1)$$

and we consider bound states with $-V_0 < E < 0$.

(a) Sketch and regions

The potential consists of infinite walls at $\pm a$, a negative constant region for $b < |x| < a$, and a central region of zero potential for $|x| \leq b$. We define:

$$\begin{aligned} \text{Region I: } & |x| \leq b, \quad V(x) = 0, \\ \text{Region II: } & b < |x| < a, \quad V(x) = -V_0, \\ \text{Outside: } & |x| \geq a, \quad V(x) = \infty. \end{aligned}$$

This looks like a symmetric double well with a bump at the center and infinite walls at the edges.

(b) Schrödinger equation in each region and parameters

The time-independent Schrödinger equation is

$$-\frac{\hbar^2}{2m}\psi''(x) + V(x)\psi(x) = E\psi(x). \quad (2)$$

Region I: ($|x| \leq b$, $V(x) = 0$)

$$-\frac{\hbar^2}{2m}\psi''(x) = E\psi(x) \quad \Rightarrow \quad \psi''(x) = \kappa^2\psi(x), \quad (3)$$

where

$$\kappa \equiv \sqrt{\frac{-2mE}{\hbar^2}} > 0. \quad (4)$$

Region II: ($b < |x| < a$, $V(x) = -V_0$)

$$-\frac{\hbar^2}{2m}\psi''(x) - V_0\psi(x) = E\psi(x) \quad \Rightarrow \quad \psi''(x) = -k^2\psi(x), \quad (5)$$

where

$$k \equiv \sqrt{\frac{2m(E + V_0)}{\hbar^2}} > 0. \quad (6)$$

Outside: $|x| \geq a$

The wavefunction must vanish, $\psi(x) = 0$.

(c) Boundary conditions

Since $V(x) = \infty$ for $|x| \geq a$, we must have

$$\psi(\pm a) = 0. \quad (7)$$

At $x = \pm b$, $V(x)$ is finite, so

$$\psi \text{ and } \psi' \text{ are continuous.} \quad (8)$$

(d) Symmetry and parity of eigenstates

The potential depends only on $|x|$, so it is even:

$$V(-x) = V(x). \quad (9)$$

Therefore, the Hamiltonian commutes with the parity operator, and energy eigenstates may be chosen to have definite parity:

$$\psi_{\text{even}}(-x) = +\psi_{\text{even}}(x), \quad (10)$$

$$\psi_{\text{odd}}(-x) = -\psi_{\text{odd}}(x). \quad (11)$$

At $x = 0$, this implies

$$\text{Even: } \psi'(0) = 0, \quad (12)$$

$$\text{Odd: } \psi(0) = 0. \quad (13)$$

(e) Wavefunctions for $x \geq 0$

We work only on $x \geq 0$ and extend by parity.

Region I ($0 \leq x \leq b$)

The general solution is

$$\psi_I(x) = C \cosh(\kappa x) + D \sinh(\kappa x). \quad (14)$$

Even parity ($\psi'(0) = 0$) implies $D = 0$:

$$\psi_I^{(\text{even})}(x) = A_e \cosh(\kappa x). \quad (15)$$

Odd parity ($\psi(0) = 0$) implies $C = 0$:

$$\psi_I^{(\text{odd})}(x) = A_o \sinh(\kappa x). \quad (16)$$

Region II ($b < x < a$)

The general solution is

$$\psi_{II}(x) = C \cos(kx) + D \sin(kx), \quad (17)$$

but we impose $\psi(a) = 0$ and write

$$\psi_{II}(x) = B \sin(k(a-x)). \quad (18)$$

Thus, for $b < x < a$:

$$\psi_{II}^{(\text{even})}(x) = B_e \sin(k(a-x)), \quad (19)$$

$$\psi_{II}^{(\text{odd})}(x) = B_o \sin(k(a-x)). \quad (20)$$

Matching at $x = b$ gives the quantization conditions for E .

2. Conceptual Discussion

(a) Classical vs. quantum picture

Classically, for $-V_0 < E < 0$, the particle has enough energy to move in the wells ($b < |x| < a$, where $E > V$), but not enough energy to enter the central region ($|x| \leq b$, where $E < V$). Thus, it is confined to either the left or right well and never penetrates the central region. There is no energy quantization: any energy in the range $(-V_0, 0)$ is allowed.

Quantum mechanically, the energy spectrum is discrete, and the wavefunction leaks into the classically forbidden central region via exponential decay. Because the potential is symmetric, eigenstates come in even/odd parity pairs. Physically, these correspond to symmetric and anti-symmetric superpositions of left- and right-localized states, with energy splitting determined by tunneling. The ground and first excited states form an almost-degenerate pair when tunneling is weak.

(b) Ground state behavior for shallow vs. deep V_0

Shallow well (V_0 small):

The bound state energy lies close to zero, so the barrier height $0 - E$ is small and the decay constant κ is small. The wavefunction spreads significantly into the central region, meaning strong tunneling between the two wells. The ground state is relatively delocalized, and the even/odd energy splitting is large.

Deep well (V_0 large):

The bound state energy lies far below zero, so the barrier height is large and κ is large. The wavefunction decays rapidly in the central region, tunneling is weak, and the two wells are almost independent. The even and odd states become nearly degenerate, with exponentially small splitting. The ground state is approximately a symmetric combination of two localized states.

Case Study: Jaideep tries to learn about intruder states

Step 0: Disclaimer, I don't have time to talk about:

- the ethical, environmental, and legal issues about how generative AI platforms were created and how they continue to evolve
- the usual, but vastly growing in sophistication, concerns regarding how internet firms, in general, but generative AI platforms, in particular, use/weaponize your data
- the equity issues regarding access to the evolving versions
- the erosive effect of using generative AI platforms on your ability to (1) grow as a creative and critical thinker and to (2) articulate your thought process and arguments in a logical and clear manner

Case Study: Jaideep tries to learn about intruder states

Step 1: Wikipedia to the rescue ?!?

☰ Intruder state

🌐 1 language ▾

Article [Talk](#)

[Read](#) [Edit](#) [View history](#) [Tools](#) ▾

From Wikipedia, the free encyclopedia

In [quantum](#) and [theoretical chemistry](#), an **intruder state** is a particular situation arising in [perturbative evaluations](#), where the energy of the perturbers is comparable in magnitude to the energy associated to the zero order wavefunction. In this case, a divergent behavior occurs, due to the nearly zero denominator in the expression of the perturbative correction.

Multi-reference wavefunction methods are not immune.^{[1][2]} There are ways to identify them.^{[3][4]} The natural orbitals of the perturbation expansion are a useful diagnostic for detecting intruder state effects.^[5] Sometimes what appears to be an intruder state is simply a change in basis.^{[1][6]}

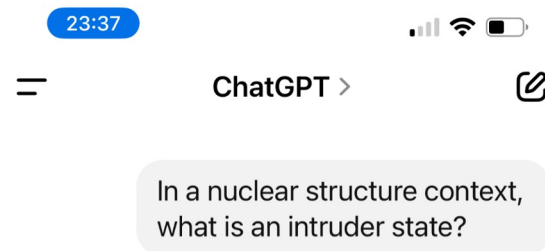
Citation styles for "Intruder state"

APA style

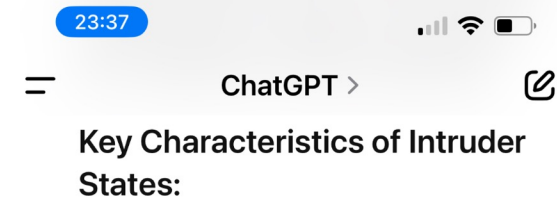
Wikipedia contributors. (2024, September 11). Intruder state. In *Wikipedia, The Free Encyclopedia*. Retrieved 04:11, September 12, 2024, from https://en.wikipedia.org/w/index.php?title=Intruder_state&oldid=1245192927

Case Study: Jaideep tries to learn about intruder states

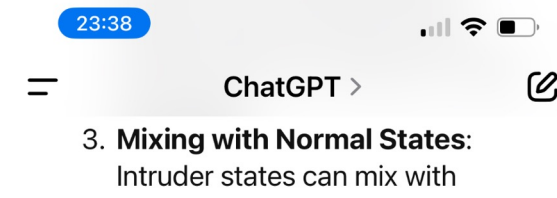
Step 2: ChatGPT to the rescue !?! (sounds correct to me...)



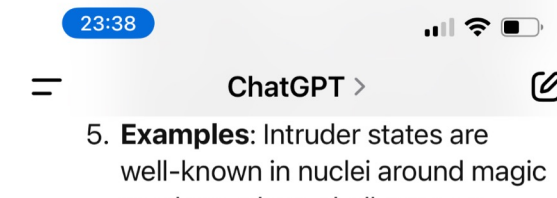
In nuclear structure physics, an **intruder state** refers to an energy state in a nucleus that arises due to the presence of configurations that do not follow the typical shell model ordering. These states are “intruders” because they belong to different major shells and can mix with normal configurations, leading to deviations from expected nuclear properties.



- 1. Different Major Shell Configuration:** Intruder states are often associated with nucleons (protons or neutrons) being excited across a shell gap into a higher energy orbital. For example, a neutron from the *sd* shell may be excited into the *fp* shell, which can lead to configurations that are not usually expected for that nucleus's ground state.
- 2. Low-Energy Appearance:** Despite originating from higher shell excitations, intruder states can appear at low energies in certain nuclei. This can occur when there is a deformation in the nucleus or a reorganization of single-particle energy levels, which lowers the energy of these excitations.



- 3. Mixing with Normal States:** Intruder states can mix with normal states (those that follow the shell model prediction) through configuration mixing, resulting in changes in the observed energy levels, electromagnetic transition rates, and other nuclear properties.
- 4. Shape Coexistence:** Intruder states are often associated with **shape coexistence** in nuclei, where different nuclear shapes (e.g., spherical, prolate, oblate) coexist at similar energies. The deformation or configuration associated with the intruder state often leads to an alternative shape that is different from the shape associated with the ground state.

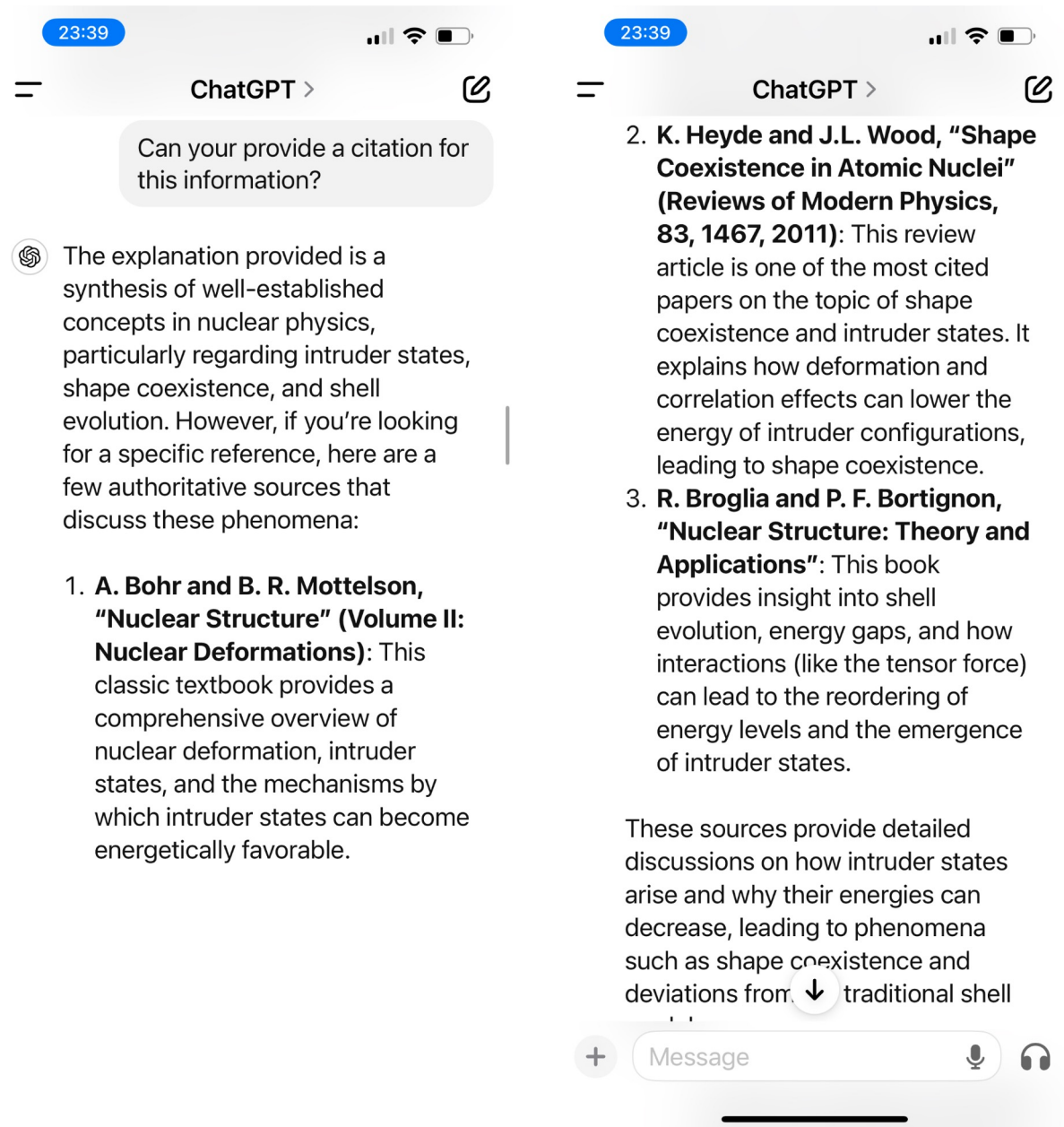


- 5. Examples:** Intruder states are well-known in nuclei around magic numbers where shell gaps are large, such as the “island of inversion” near neutron number $N = 20$ (e.g., in ^{32}Mg) and $N = 40$ (e.g., in ^{68}Ni). These nuclei exhibit properties that differ significantly from the predictions of the simple shell model, indicating the presence of intruder configurations.

(Full chat transcript in the backup slides, “GPT-4 architecture”)

Case Study: Jaideep tries to learn about intruder states

Step 3: Great, let's request "standard" references to dig deeper...



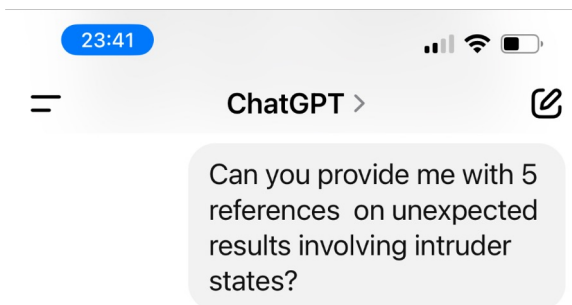
Bohr & Mottelson I & II:
"intruder state", "island of inversion" and
"shape coexistence" are not in the index?

Heyde & Wood:
Highly cited RMP with many mentions of
shape coexistence and intruder states

Broglia & Bortignon:
Frequent collaborators (>100 joint
publications), but this book simply does
not exist as far as I can tell...

Case Study: Jaideep tries to learn about intruder states

Step 4: Golly-gee-willikers, must be an honest mistake, let's try again...



3. **Cejnar, P., Jolie, J., & Casten, R. F. (2010). "Quantum Phase Transitions in the Shapes of Atomic Nuclei." *Reviews of Modern Physics*, 82(3), 2155-2212.**

• This review addresses quantum

Here are five references that discuss unexpected results involving intruder states in nuclear physics. These references cover various phenomena such as shape coexistence, shell evolution, and changes in nuclear structure that arise due to the presence of intruder states:

1. **Heyde, K., & Wood, J. L. (2011). "Shape Coexistence in Atomic Nuclei." *Reviews of Modern Physics*, 83(4), 1467-1521.**

• This review provides a

2. **Sorlin, O., & Porquet, M. G. (2008). "Nuclear Magic Numbers: New Features Far from Stability." *Progress in Particle and Nuclear Physics*, 61(2), 602-673.**

• This paper discusses the

4. **Gade, A., & Sorlin, O. (2016). "Nuclear Magic Numbers in the Disappearing Act." *Physics Today*, 69(8), 40-47.**

• This article explores the surprising disappearance or weakening of traditional magic numbers in certain isotopes due to the influence of intruder states. It provides examples where intruder states lead to unexpected ground-state deformations and changes in shell gaps, challenging long-held assumptions in nuclear physics.

5. **Lenzi, S. M., Nowacki, F., Poves,**

• deformations and changes in shell gaps, challenging long-held assumptions in nuclear physics.

5. **Lenzi, S. M., Nowacki, F., Poves, A., & Sieja, K. (2010). "Island of Inversion around $N = 40$." *Physical Review C*, 82(5), 054301.**

• This research paper focuses on the region around neutron number $N = 40$, where intruder states from the fp shell mix with normal configurations, leading to unexpected results. The authors provide a detailed shell-model analysis that explains the emergence of deformed ground states and the breakdown of the $N = 40$ magic number.

1. Real review article
2. Real review article
3. Real review article
4. According to one of the "authors" (Gade) of this "publication": **"Does not exist ... totally fake."**
5. Real PRC publication, but:
 - Wrong title in citation
 - **Main conclusion in summary is incorrect**

Case Study: Jaideep tries to learn about intruder states

- **The information may or may not be correct.** Not a big deal in my book. This is an old and conventional problem with trying to find information on the internet and “googling” stuff.
- **ChatGPT cannot tell you exactly where the information is coming from - it claims that it is just a “synthesis of well-established concepts.”** This is a bold claim that apparently cannot be verified using ChatGPT by itself. Not so bad, many websites just present information without any traceable sources. This is a “conventional” internet problem and you should always be skeptical and apply critical thinking skills when “doing your own research” on the internet.
- **When pressed on this issue, the citations ChatGPT gives you may or may not be (1) real and/or (2) relevant and/or (3) accurately represented.** Again - not great, but nothing new here relative to the “conventional” problems with trying to find information on the internet.

Rhetorical questions: In the old days, if a human did any of these things in a research context, then what kind of consequences might they suffer? If a human today says “don’t blame me, it is ChatGPT’s fault,” then who is to be held accountable?

Case Study: Jaideep tries to learn about intruder states

So what exactly I am worried/complaining about then?

I am concerned about issues regarding **intellectual honesty** and carrying out responsible and **reproducible research**. As scientists, we have an obligation to **give proper credit where it is due** (real and relevant citations) and making our work reproducible. One aspect of reproducibility is being able to **provide a “paper trail” showing how your original contribution was developed**.

A website can always be cited and, in principle, a human can be held accountable for wrong information. **Every version of a Wikipedia article can specifically be cited and accessed and again, in principle, a human can be held accountable for wrong information**. In both cases, acknowledgement for correct and useful information can also go to the human.

As far as I know, **even if ChatGPT gave 100% accurate responses,**

- **ChatGPT cannot be cited in a reproducible way** (unless you save the chat transcript)
- no human can be held accountable, and
- **the “paper trail” that the ChatGPT response is based on simply does not exist.**

Ethical Considerations for Generative AI in Research and education

1. Do you think that there are any ethical issues that one should consider before using generative AI for research? In class (as a teacher)? In class (as a student)
1. Do you think that there are any *NEW* ethical considerations posed by generative AI in the context of research and education outside of historical standards for professional ethics?
1. In one or two words, what are some of the ethical issues (if any) associated with using generative AI for research and education?

“New” Considerations: Accountability and Reproducibility

I am concerned about issues regarding **intellectual honesty** and carrying out responsible and **reproducible research**. As scientists, we have an obligation to **give proper credit where it is due** (real and relevant citations) and making our work reproducible. One aspect of reproducibility is being able to **provide a “paper trail” showing how your original contribution was developed**.

A website can always be cited and, in principle, a human can be held accountable for wrong information. **Every version of a Wikipedia article can specifically be cited and accessed and again, in principle, a human can be held accountable for wrong information.** In both cases, acknowledgement for correct and useful information can also go to the human.

As far as I know, **even if Generative AI gave 100% accurate responses,**

- **Generative AI cannot be cited in a reproducible way (unless you save the chat transcript)**
- **No human except the user can be held accountable, and**
- **It is not clear that a “paper trail” exists for a Generative AI response**

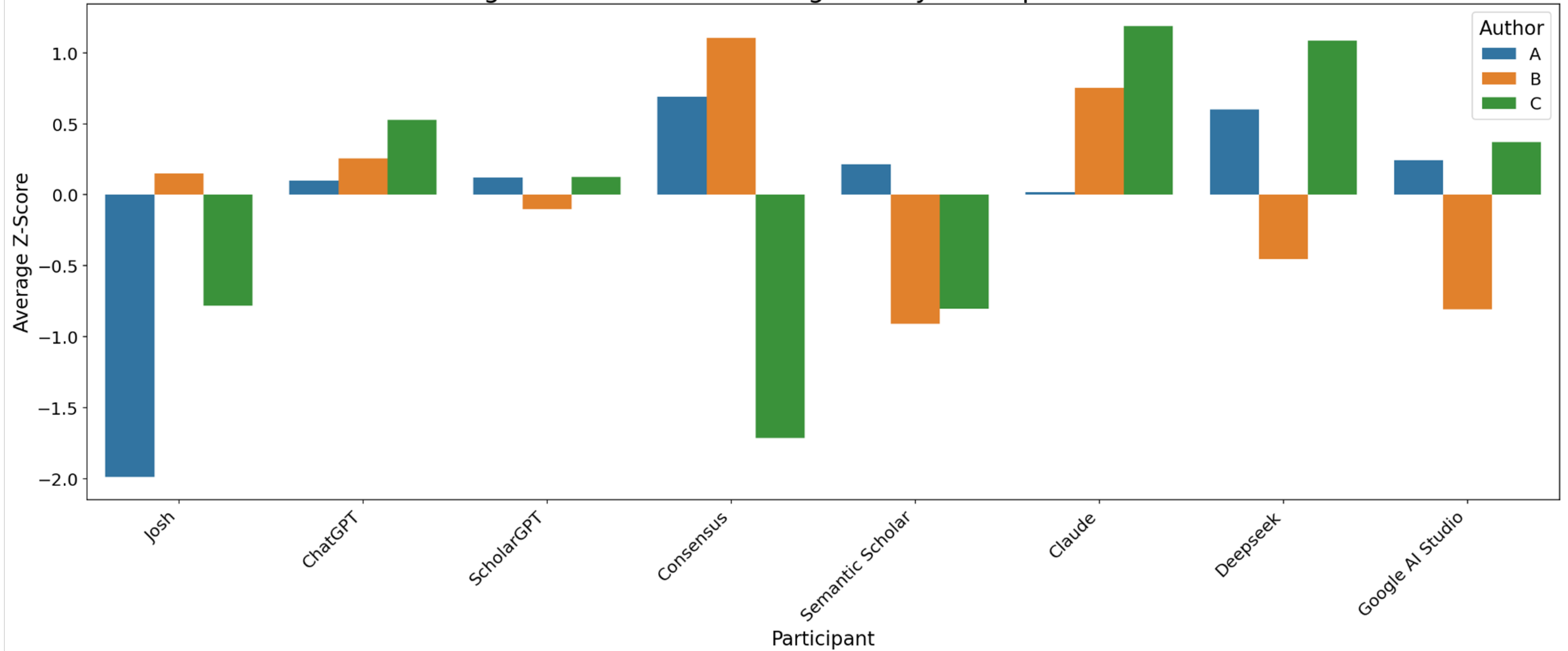
Going forward

1. Know the up-to-date professional guidelines from MSU, APS, NSF, DOE, and any other relevant organizations - this is the responsibility of each individual
2. Have on-going active, open, and honest conversations within your research groups about how generative AI platforms are used in a research context
3. **By default: disclose, disclose disclose! (the use of generative AI)**

Example of what we currently do in Spinlab (JTS Research Team):

- To the extent that generative AI is consistent with MSU/APS/NSF/DOE guidelines, team members can use it for **anything and everything**
- Any use of generative AI within the limited scope of Spinlab research activities **must be disclosed** in our electronic logbook (ELOG) including the **chat transcript of the interaction** which I view as following the spirit of our data management plan and conducting responsible & reproducible research
- **Active ongoing written discussion** about the ethical use of generative AI for Spinlab research activities

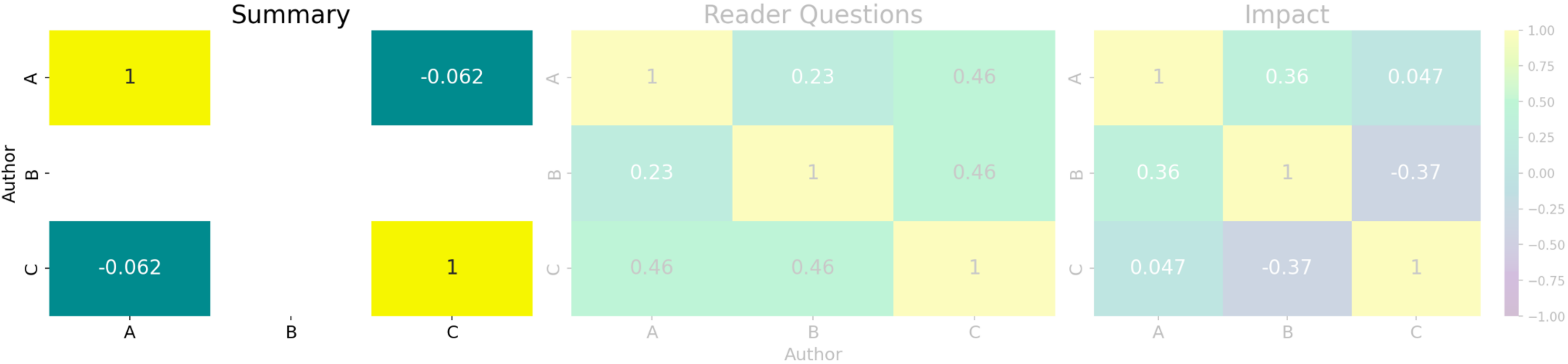
Average Score Across All Categories by Participant and Author



Case Study:
Extra Details

Correlation Explorations

Inter-Author Correlations Across Categories



Case Study:
Extra Details

Correlation Explorations

Inter-Author Correlations Across Categories



Case Study:
Extra Details

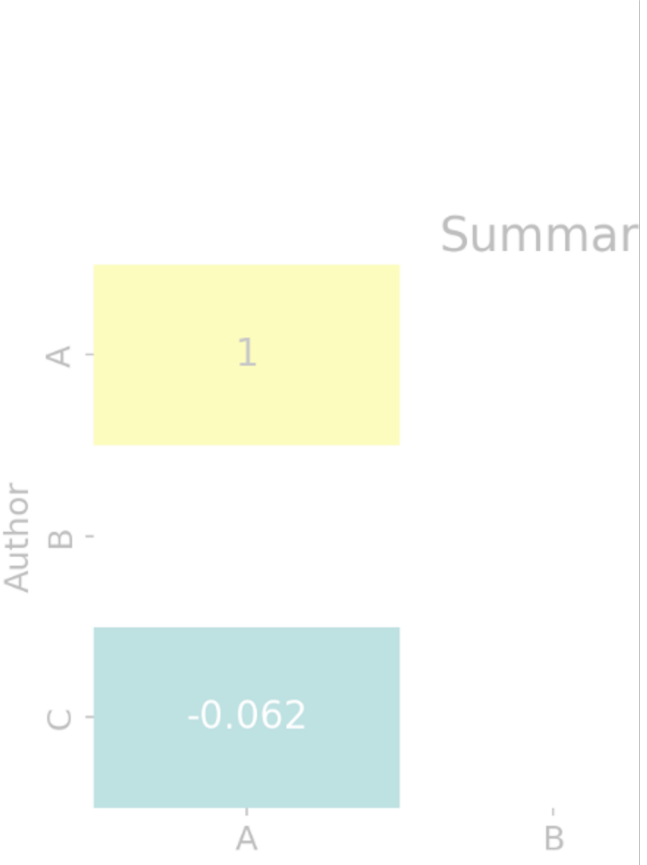
Correlation Explorations

Inter-Author Correlations Across Categories

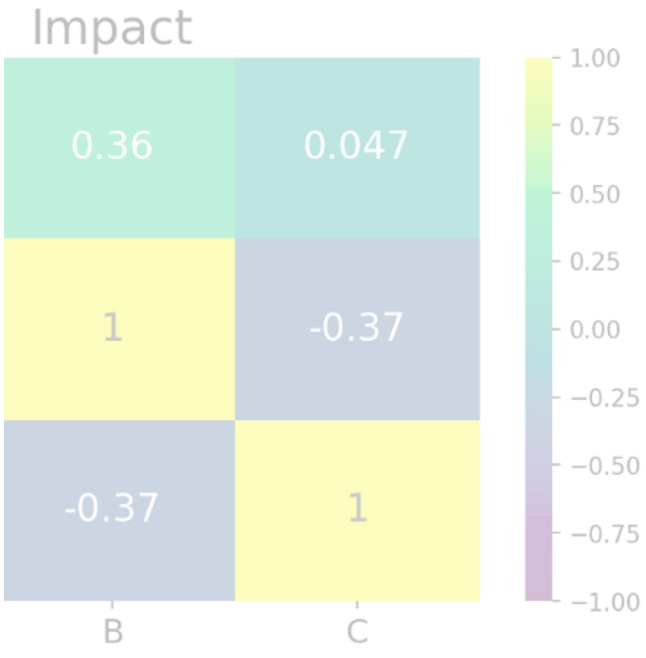
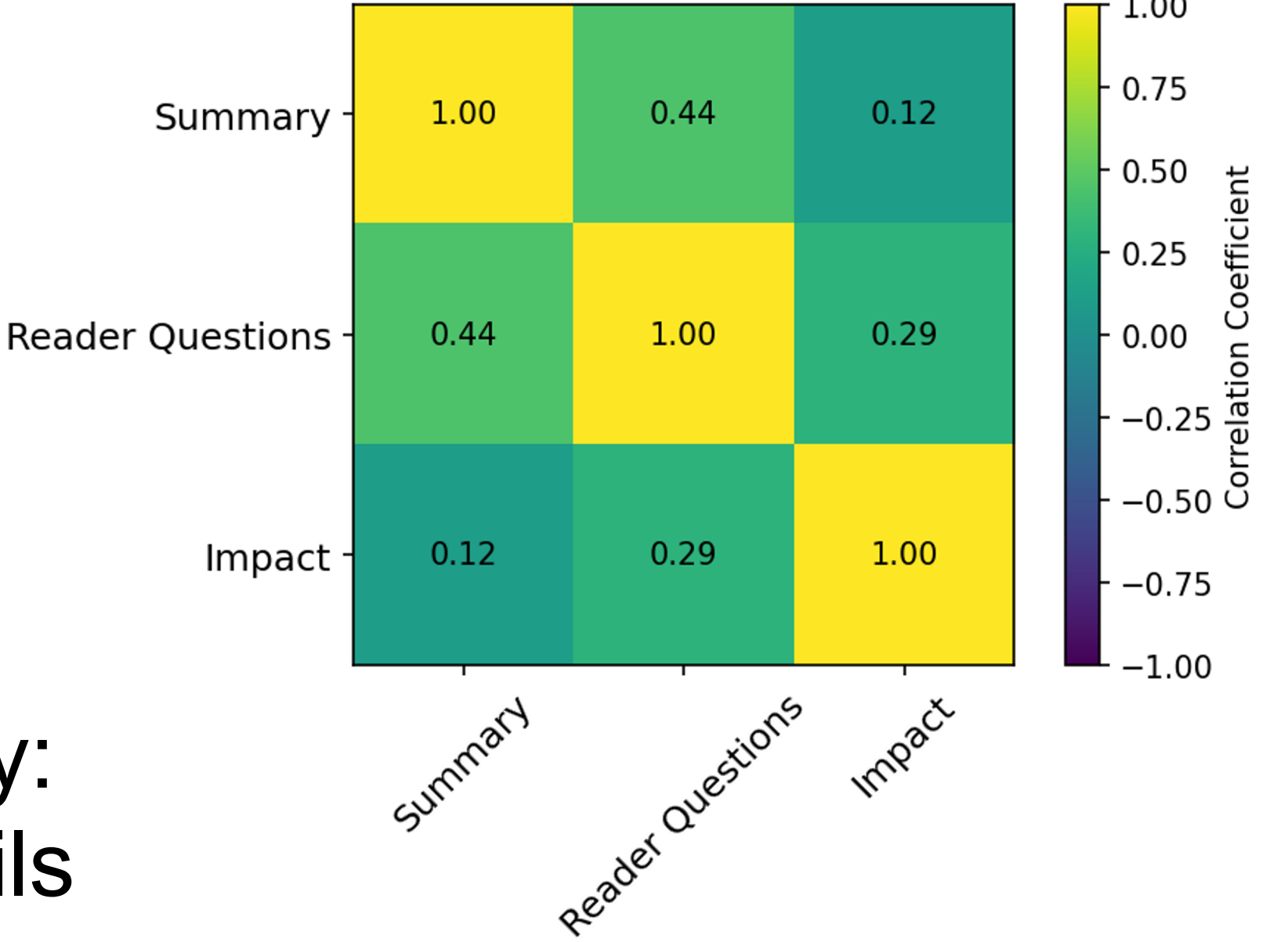


Case Study:
Extra Details

Correlation Explorations



Correlation Matrix of Average Scores by Category



Case Study:
Extra Details