

Theoretical Physics Research with Agentic AI

From Vibe Physics to Research Agents

Yi Wang, HKUST

Generated by Human + AI

May 20, 2026 Research Milestone

An OpenAI model has disproved a central conjecture in discrete geometry

[Read the proof ↗](#)

[Read the companion remarks ↗](#)



levent
@_alpoge_



hello there the jacobian conjecture is false thanx to my close friend akhil for asking about it and my other close friend fable for working during the world cup final

$((1+xy)^3 z + y^2 (1+xy) (4+3xy), y + 3x (1+xy)^2 z + 3xy^2 (4+3xy), 2x - 3x^2 y - x^3 z): \mathbb{C}^3 \rightarrow \mathbb{C}^3$, has jacobian determinant -2 , and sends $(0, 0, -1/4)$, $(1, -3/2, 13/2)$, and $(-1, 3/2, 13/2)$ to $(-1/4, 0, 0)$

5:19 AM · Jul 20, 2026 · **39.3M** Views



1.7K



8.4K



43K



11K



Ten Advances in Mathematics and Theoretical Computer Science

OpenAI

Abstract

We present a collection of results obtained by an internal OpenAI model, spanning mathematics and theoretical computer science:

1. **High-dimensional sphere packing.** The asymptotic strength of the Cohn–Elkies linear program is determined exactly. This gives an improved general packing bound in high dimensions and settles the corresponding Fourier sign-uncertainty problem asymptotically.
2. **Binary and spherical codes.** Classical upper bounds for fixed-distance binary and spherical codes are improved by exponential factors for all parameters. The spherical construction also recovers the sphere-packing exponent of Chapter 1.
3. **Non-sofic groups.** An explicit non-sofic group is constructed, resolving the question of whether every countable group admits finite permutation approximations. The argument uses property- (T) expanders and the binary Leavitt algebra.
4. **Connes’s rigidity conjecture.** Infinitely many pairwise nonisomorphic property- (T) groups are constructed with the same group von Neumann algebra, disproving Connes’s conjecture and answering a related finite-to-one question of Popa.
5. **Arithmetic circuit complexity.** For the permanent, division-free circuits require $\Omega(n^2 \log \log n)$ gates, while formulas require $\Omega(n^4 / \log n)$ leaves.
6. **Quantum parallel repetition.** Exponential parallel repetition is proved for every finite two-player entangled game, extending the classical repetition principle beyond previously treated special classes of quantum games.
7. **Closest vector problem.** A direct reduction from 3SAT gives $n^{1/400}$ -factor hardness for the Euclidean closest vector problem, with related consequences for binary decoding and other lattice norms.
8. **Ehrhart’s volume conjecture.** The sharp bound $(n+1)^n/n!$ is proved in every dimension for convex bodies whose barycenter is their only interior lattice point.
9. **Multicolor Ramsey numbers.** A superexponential lower bound proves $R_k(3) = k^{\Theta(k)}$.
10. **Compactness and degeneracy.** Separate bipartite graph constructions disprove two conjectures in extremal graph theory: the compactness conjecture of Erdős and Simonovits and a degeneracy conjecture of Erdős.

Research

01

Traditional

02

Vibe

03

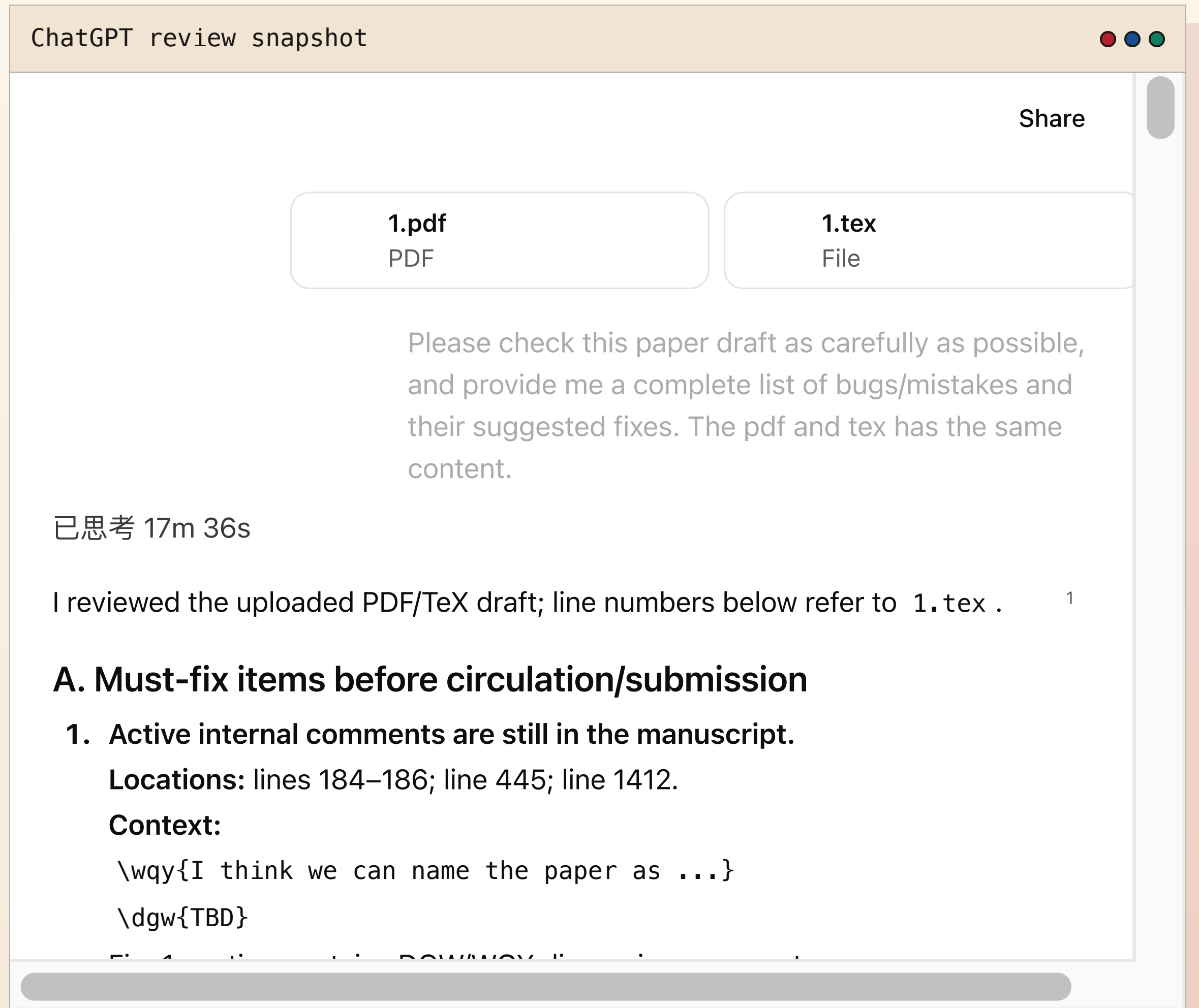
Research Agent

PART I

Vibe Physics

VIBE EXAMPLE 1

Paper draft review



VIBE EXAMPLE 2

Cosmological collider

Cosmological Collider: Strong Mixing

Cosmological Collider

Share

2606.18248v1(2).pdf

PDF

This paper lacks details of calculation. Fill-in details as much as you can, so that students with grad-school level math & physics can understand it smoothly. Generate .md and .pdf output for download & read

Thought for 23m 58s

Done. I generated expanded calculation notes based on the uploaded paper

2606.18248v1 .

Files:

•

Download the Markdown

•

Download the PDF

The notes include detailed derivations of the canonical normalization, equations of motion, Penrose diagram, fourth-order reduction, exact solution basis, initial

VIBE EXAMPLE 3

Planar unit-distance

by Xiao Ma

Erdős planar unit-distance

ChatGPT

Share

In this session, please do not use websearch

Let $P \subset \mathbb{R}^2$ be a finite set of distinct points. Define

$$\nu(P) = \left| \left\{ \{p, q\} \in \binom{P}{2} : \|p - q\| = 1 \right\} \right|$$

and, for each integer $n \geq 1$, $\nu(n) = \max_{\substack{P \subset \mathbb{R}^2 \\ |P|=n}} \nu(P)$.

Resolve Erdős's planar unit-distance problem completely: $\nu(n) \leq n^{1+O(1/\log \log n)}$ as $n \rightarrow \infty$? Equivalently, determine whether there exist absolute constants $C > 0$ and $N \in \mathbb{N}$ such that $\nu(n) \leq n^{1+C/\log \log n}$ for every integer $n \geq N$. Here $\log$ denotes the natural logarithm, and N may be taken large enough that $\log \log n > 0$. The hidden constant in $O(1/\log \log n)$ is absolute and independent of P and

VIBE EXAMPLE 4

Parisi

arXiv > cond-mat > arXiv:2606.03300

Search...
Help | Ad

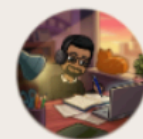
Condensed Matter > Statistical Mechanics

[Submitted on 2 Jun 2026]

A proof of an identity for the critical exponents of jamming

Giorgio Parisi, Francesco Zamponi

Within the full replica-symmetry-breaking (fullRSB) solution of dense hard spheres in infinite dimension, Charbonneau, Kurchan, Parisi, Urbani, and Zamponi (CKPUZ; J.Stat.Mech.P10009, 2014) introduced three critical exponents a , b , c governing the matching region of the fullRSB profile near the jamming transition. These exponents satisfy two scaling relations. The first, $b = (1 + c)/2$, was established analytically by the diffusion-drift balance in the scaling ansatz. The second, $a + b = 1$, was observed numerically to arbitrary precision but could not be proven. The exponents a, b, c of the scaling fullRSB ansatz are related to the physical exponents α, θ, κ that control the gap, force, and overlap distributions by the relations $\alpha = a/b$, $\theta = (c - a)/(b - c)$, $\kappa = c + 1$. Crucially, the relation $a + b = 1$ yields the scaling relations $\alpha = 1/(2 + \theta)$ and $\kappa = 2 - 2/(3 + \theta)$ predicted on independent grounds by the mechanical-marginal-stability arguments of Wyart and collaborators. Here, we give an analytic proof of the identity $a + b = 1$ from the scaling fullRSB equations. The proof was obtained through interaction with Claude (Sonnet 4.6 and Opus 4.7) and verified by us.



Emad @EMostaque



If Claude is good enough for Nobel Prize winners it is good enough for you

VIBE EXAMPLE 4

Parisi

Nonlinear ODE Solver with Shooting Method

Nonlinear ODE Solver with Shooting Method

Nonlinear ODE solver with shooting method

Created: 4/23/2026 19:52:17

Updated: 5/13/2026 11:17:12

Exported: 5/13/2026 19:56:40

Link: <https://claude.ai/chat/9f1ee878-e853-4647-9428-ea8fe16ef55b>

Prompt:

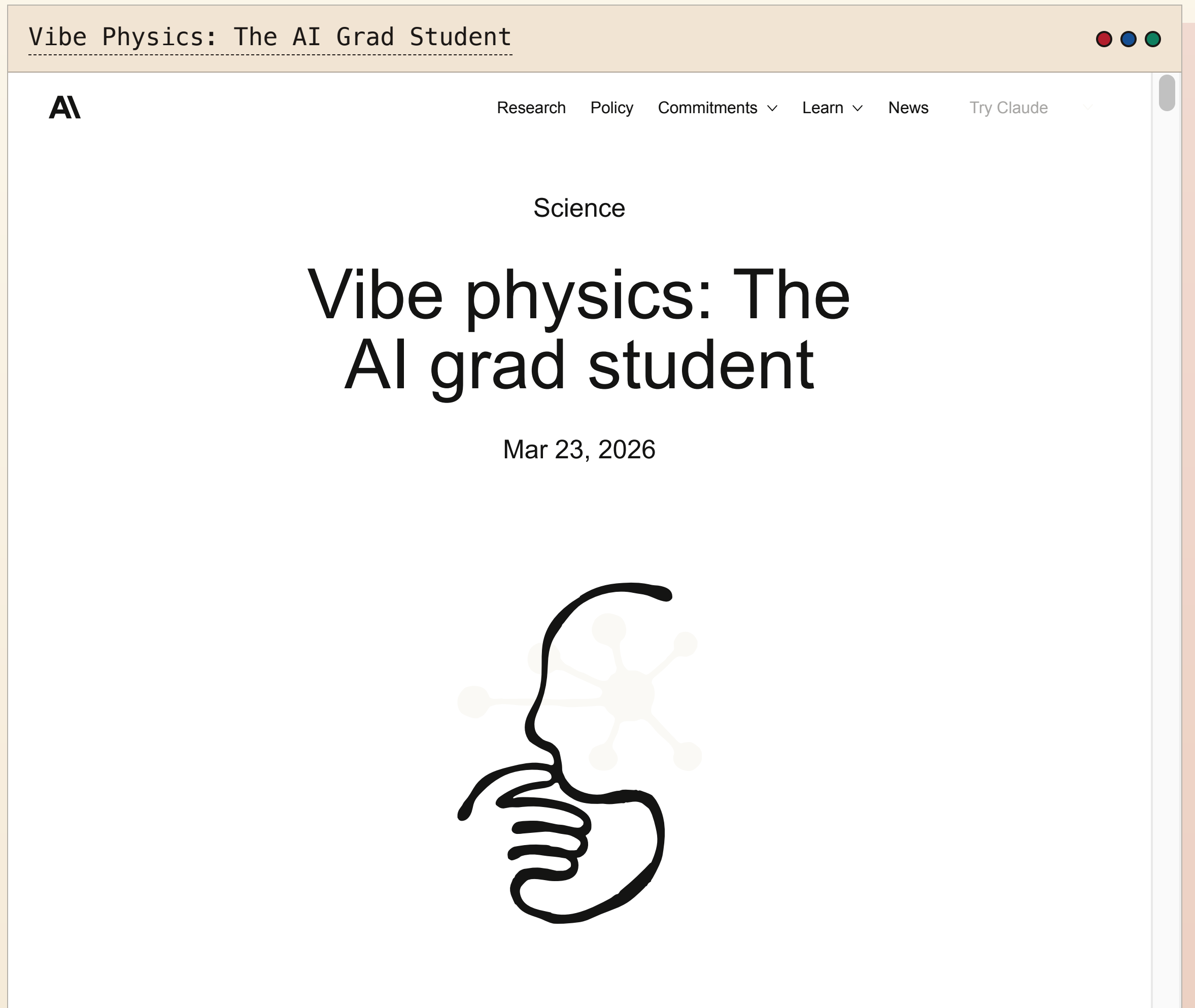
23/04/2026, 19:52:17

I would like to have a C++ code that solves the nonlinear equation

```
$$\label{eq:J} \frac{c}{2} J''(t) = t J'(t) \left(-\frac{1+c}{2} + c \tanh(-t) \right) + J(t) - \tanh(-t) + \frac{c^2}{4}
```

VIBE EXAMPLE 5

Schwartz



The car wash is only 100m
away from my house,
should I walk or drive?



**When asked what the speed of
sound was, Albert Einstein replied,**

**"I do not carry such information in my mind
since it is readily available in books... The
value of an education is not the learning of
facts, but the training of the mind to think."**

Meet **Fable 5**, our newest model for complex, long-running work. Tr
Included in your plan limits until Jun 22, then switch to usage o

how many r's in strawberry?

- **Fable 5's safety measures flagged this message for cybersecurity**
| Tip: You can configure model switch behavior in /config

*Worked for 9s

PART II

Vibe Physics → Research Agent

EXPLORER

CPARAMETER

ClaudeCode

Drafts

C_parameter_paper_v83.pdf

NLL_matched.pdf

C_parameter_paper_v82.pdf

C_parameter_paper_v82.tex

B_decomposition_fit.pdf

event2vssingular.pdf

nonsingular_zoom.pdf

cparam_full_distribution.pdf

BvsBns.pdf

C_parameter_paper_v81.pdf

C_parameter_paper_v81.tex

C_parameter_paper_v80.pdf

C_parameter_paper_v80.tex

C_parameter_paper_v79-lookinggood-...

C_parameter_paper_v61d.tex

C_parameter_paper_v61c.tex

PythonCode

FinalPDFs

Mathematica

Plots

pdfs

RegionsCheck

Paper

Mathematica code

pdfsv1Final

ultrafine_test

Data

OUTLINE

TIMELINE

can you check equation 12? i think the c...

Grep "cGM" (in /Users/schwartz/Claude/Cparameter/ClaudeCode/Drafts/C_parameter_paper_v8... 62 lines of output

Grep "C \equiv |C = |\equiv.*C" (in /Users/schwartz/Claude/Cparameter/ClaudeCode/Drafts... 1 line of output

Equation 12 (\label{eq:cGM-def} , line ~282) is:
$$c_{\rm GM} \equiv \frac{C}{6}$$
 The agent found **no convention conflicts** — the definition is used consistently throughout. Key checks:

- Text immediately after says the support is $0 < c_{\rm GM} < 1/8$ for $0 < C < 3/4$, which is arithmetically correct with the factor of 6 ✓
- Eq. A-from-F0 uses $F_0(C/6)$, matching the definition ✓
- All function arguments (m_0 , n_0 , f_0 , e_0 , p_0) use $c_{\rm GM}$ consistently ✓

What specific convention were you suspecting might be off? That might help narrow down where to look — for example, if you think the factor should be different (e.g., $C/3$ somewhere, or a different normalization in a different section).

Esc to focus or unfocus Claude

Ask befor... C_parameter_paper... /

C_parameter_paper_v81.pdf

ClaudeCode > Drafts > C_parameter_paper_v81.pdf

8 of 51 Automatic Zoom

- $C = 0$: Back-to-back two-jet events with all particles along a single axis ($\lambda_1 = 1, \lambda_2 = \lambda_3 = 0$).
- $C = 1$: Isotropic events with $\lambda_1 = \lambda_2 = \lambda_3 = 1/3$.

2.2 Three-parton kinematics

For a three-parton final state $\gamma^* \rightarrow q\bar{q}g$, momentum conservation in the center-of-mass frame gives $\mathbf{p}_1 + \mathbf{p}_2 + \mathbf{p}_3 = 0$, implying that the three momenta are coplanar. We define the energy fractions

$$x_i = \frac{2E_i}{Q} = \frac{2\mathbf{p}_i \cdot \mathbf{q}}{Q^2}, \quad (9)$$

where q^μ is the total four-momentum with $q^2 = Q^2$. Energy conservation gives $x_1 + x_2 + x_3 = 2$, with each $x_i \in (0, 1)$ for massless partons.

It is convenient to use the normalized invariant masses

$$s_{ij} = \frac{(p_i + p_j)^2}{Q^2} = \frac{2\mathbf{p}_i \cdot \mathbf{p}_j}{Q^2}, \quad (10)$$

which for massless partons satisfy $s_{ij} = 1 - x_k$ where $\{i, j, k\}$ is a permutation of $\{1, 2, 3\}$. The constraint $x_1 + x_2 + x_3 = 2$ becomes

$$s_{12} + s_{13} + s_{23} = 1. \quad (11)$$

For three massless partons, the C-parameter takes the form

$$C = \frac{6 s_{12} s_{13} s_{23}}{(1 - s_{12})(1 - s_{13})(1 - s_{23})} = \frac{6(1 - x_1)(1 - x_2)(1 - x_3)}{x_1 x_2 x_3}. \quad (12)$$

The second form uses the relations $1 - x_i = s_{jk}$ and $x_i = 1 - s_{jk} = s_{ij} + s_{ik}$.

2.3 The shoulder at $C = 3/4$

We now determine the maximum value of C for three-parton states. Maximizing Eq. (12) subject to the constraint (11) and positivity $s_{ij} > 0$, we use Lagrange multipliers:

$$\frac{\partial}{\partial s_{12}} [6 s_{12} s_{13} s_{23} - \lambda (s_{12} + s_{13} + s_{23} - 1)] = 0. \quad (13)$$

This gives $6 s_{13} s_{23} = \lambda$, and similarly for cyclic permutations. The solution is

$$s_{12} = s_{13} = s_{23} = \frac{1}{3}, \quad (14)$$

which corresponds to equal energy fractions $x_1 = x_2 = x_3 = 2/3$. At this *symmetric point*, the C-parameter achieves its maximum:

$$C_{\max}^{(3)} = \frac{6 \times (1/3)^3}{(2/3)^3} = \frac{6/27}{8/27} = \frac{6}{8} = \frac{3}{4} \equiv C_{\text{sh}} \quad (15)$$

8

arc-devSCROLL: 0/2000

154 + },
155 + {
156 + "equation_id": "eq_00103",
157 + "tex_line": 1608,
158 + "claim": "Canonical picture: Delta_a int dt H_int approximately equals -Delta_a(S-S0
) = -int d3x(Pi f - Pi0 f) approximately equals -i int d3x[Pi0 f, int dt H_int[Phi,Pi0]]."
159 + }
160 +],
161 + "claim_to_check": "Compare blind J13 derivations to source formulas eq_00082 and eq_0008
5-eq_00103. Classify each equation separately. Pay special attention to determinant signs, i fac
tors, one-half factors, branch sums, eta0- support, and whether broad decoupling or higher-order
claims need restricted scope."
162 + }
163 + }
164 +]
165 +}

Ran jq empty arc-tests/MWWWY_check_20260601_013452/calculate/mwwwy_check_20260601_013452/execute/
calculate.config.json && echo json-ok
json-ok

Ran packages/arc-paper/.venv/bin/python plugins/arc/skills/arc/workflows/scripts/calculate_runner.py
--help | head -n 80
usage: calculate_runner.py [-h] --config CONFIG [--json] [--dry-run]

... +5 lines (ctrl + t to view transcript)
--json
--dry-run

Explored
Search calc_j13|J13|eq_00103|eq_00082 in calculate.config.json

Ran packages/arc-paper/.venv/bin/python plugins/arc/skills/arc/workflows/scripts/calculate_runner.py
--config arc-tests/MWWWY_check_20260601_013452/calculate/mwwwy_check_20260601_013452/execute/
calculate.config.json --json --dry-run
{
"schema_version": "arc.workflow.calculate.result.v1",
... +21 lines (ctrl + t to view transcript)
}

Dry-run ok. Starting J13 consensus. This can take time; I will let runner work, no tight polling.

Waited for background terminal · packages/arc-paper/.venv/bin/python plugins/arc/skills/arc/workflows/
scripts/calculate_runner.py --config arc-tests/MWWWY_check_20260601_013452/calculate/
mwwwy_check_20260601_013452/execute/calculate.config.json --json

J13 still running after ~10 min, no output or errors. Continuing wait.

Waiting for background terminal (1h 35m 39s · esc to interrupt) · 1 background terminal running · /ps ...
packages/arc-paper/.venv/bin/python plugins/arc/skills/arc/workflows/scripts/calculate_runner.py...

Summarize recent commits

arc-dev · gpt-5.5 xhigh · Context 44% used · 5h 88% left · weekly 88% left · Tasks 6/6 · Fast off · Ma...

arc-dev [!]
SCROLL: 3/2000

Ran git status --short
M README.md
M packages/arc-llm/src/arc_llm/providers/claude_cli.py
... +3 lines (ctrl + t to view transcript)
?? plugins/arc/bin/
?? tests/test_arc_plugin_launcher.py

Explored
Search uvx|command\: \"uvx|args\: \[\\\"arc-mcp\\\"\\] in README.md

Implementation verified. I'll do final review pass myself because subagent spawn requires explicit user
request here.

Explored
Read SKILL.md (superpowers:requesting-code-review skill)

Ran git diff -- README.md packages/arc-llm/src/arc_llm/providers/claude_cli.py packages/arc-llm/tests/
test_providers.py plugins/arc/.mcp.json tests/test_arc_research_workflow_docs.py && git diff
--no-index -- /dev/null plugins/arc/bin/arc-mcp || true && git diff --no-index -- /dev/null tests/
... +1 lines
diff --git a/README.md b/README.md
index 9671bf6..e2c7879 100644
... +475 lines (ctrl + t to view transcript)
+ assert third.returncode == 0
+ assert calls.read_text(encoding="utf-8") == "badgoodgood"

Ran git diff --check
(no output)

Done. Install commands stay same:

/plugin marketplace add tririver/arc
/plugin install arc

Changed:

- plugins/arc/.mcp.json now runs bundled ./bin/arc-mcp, not uvx.
- plugins/arc/bin/arc-mcp added. It installs once into cache, reuses runtime, writes failure marker/
log, and does not retry failed installs unless ARC_MCP_INSTALL_RETRY=1.

- packages/arc-llm/src/arc_llm/providers/claude_cli.py no longer falls back to uvx.
- README/docs/tests updated.

Verified:

- Targeted tests: 7 passed
- Real launcher smoke: exit=0
- Package suite: 454 passed, 6 skipped
- git diff --check: clean

Known unrelated existing failures remain in full tests/test_arc_research_workflow_docs.py: 3 failures
around workflow doc length/color marker semantics/idea ranking order.

Worked for 7m 43s

Alt <Click> - group, Alt <Right-Click> - ungroup all

Zellij (default-session) Tab #1

Ctrl + <g> LOCK <p> PANE <t> TAB <n> RESIZE <m> MOVE <s> SEARCH <u> SESSION <Alt Shift q> QUIT


```
❯ arc-dev | MY FOCUS AND: | SCROLL: 0/969
• Explored
  ↳ Read planning-request.md

• Edited arc-tests/MWWWY_check_20260601_013452/calculate/mwwwy_check_20260601_013452/planning-request.md (+14 -0)
  95 - Requested plan action: before promoting more downstream dS/bootstrap checks, decide whether to continue
    from corrected accepted premises or require source revision and reparse.
  96 +
  97 +## J13 Split Handoff (2026-06-01T08:03:46Z)
  98 +- Current step: `J13`, status `blocked_for_user` / unresolved after three attempts. No source discrepanci
    es were identified.
  99 +- Consensus artifacts:
  100 + - State: `arc-tests/MWWWY_check_20260601_013452/calculate/mwwwy_check_20260601_013452/execute/calc_j13_
    20260601_013452/state.json`
  101 + - Attempt-3 reviewer: `attempt_batches/J13_attempt_003/loops/J13_attempt_003/rounds/round_001/reviews/r
    eviewer_001.json`
  102 + - Attempt-3 proposer outputs: `attempt_batches/J13_attempt_003/loops/J13_attempt_003/rounds/round_001/p
    roposer_outputs/proposer_001.json` and `proposer_002.json`
  103 +- Reviewer judgment: attempt 3 fixed the earlier decisive sign and normalization errors. Both proposers a
    gree on qualitative SK change-of-variables invariance, kernel Jacobian treatment, restricted dimensional-
    regularization local Jacobian decoupling, corrected free-action sign,  $\pi_0$  commutator normalization, a
    nd background-value subtraction.
  104 +- Remaining failure: the broad `J13` step is too large for formula-level acceptance. The outputs still do
    not reproduce the full  $\text{BD}/\epsilon$  rewriting, transformed source-functional identity, retarded/advanc
    ed second-order formulas, connected  $x,y$  master identity, and interaction-Hamiltonian commutator interpr
    etation.
  105 +- Main-agent decision: split `J13`; do not ask a human for a manual target-convention derivation. This is
    a planning granularity failure, not a scientific source discrepancy.
  106 +- Requested plan action: mark broad `J13` blocked/superseded and replace it with smaller ready checks:
  107 + - `J14`: `eq_00082` and `eq_00085`--`eq_00090` for path-integral change of variables, ghost determinant
    , BD initial state/ $\epsilon$ , and shifted fluctuation redefinition.
  108 + - `J15`: `eq_00091`--`eq_00099` for transformed source-functional identity, first-order SD, free IBP, c
    anonical commutator, and retarded/advanced first-order split.
  109 + - `J16`: `eq_00100`--`eq_00103` for second-order retarded/advanced identities, connected master identit
    y, and interaction-Hamiltonian interpretation.

• Working (1h 36m 55s • esc to interrupt)

> Summarize recent commits

arc-dev · gpt-5.5 xhigh · Context 51% used · 5h 88% left · weekly 88% left · Tasks 6/6 · Fast off · Main [defau...
```


What the Harness Can Do

The control layer that turns model capability into reliable technical work



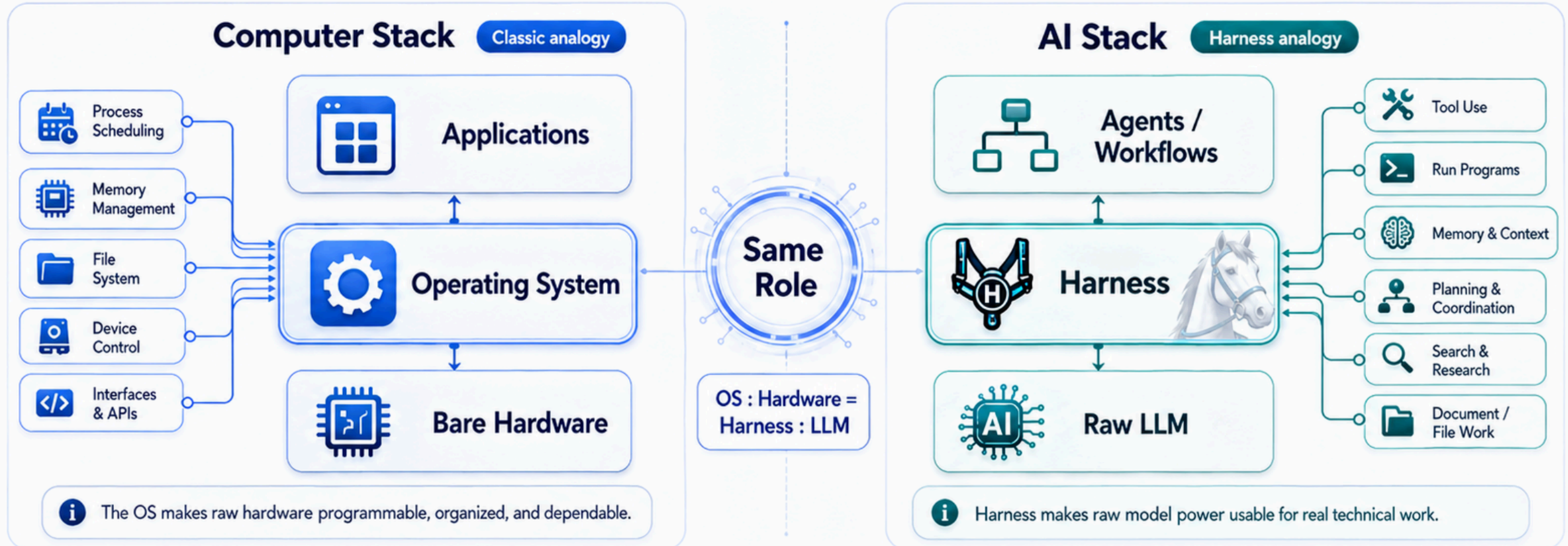
Example Use Cases



Harness connects model intelligence to tools, computation, memory, and reliable execution.

Harness Is to an LLM What an Operating System Is to Bare Hardware

Both are the control layer that turns raw capability into a usable, reliable working system



What the Middle Layer Adds



Abstraction
hide raw complexity



State
manage memory and context



Control
coordinate execution



Reliability
make work repeatable

Just as an operating system lets software use hardware, Harness lets agents and workflows use LLM intelligence.

Agent Skills

wang2-html/SKILL.md



wang2-html/SKILL.md

Wang2 HTML Slides

Create, convert, edit, review, internationalize, validate, and deliver reusable fixed-stage HTML slide decks.

name: wang2-html

description: Create, convert, edit, review, internationalize, validate, and deliver reusable fixed-stage HTML slide decks with shared themes, media, artifact frames, and webpage snapshots. Use for new presentations built from a topic, notes, research, or assets; PPTX-to-HTML conversion; existing Wang2 deck work; or maintenance of the kit itself.

1. Read the host project instructions and inspect the active modular deck.
2. Keep this kit reusable. Put active decks, facts, snapshots, rendered documents, and talk media in the host project.

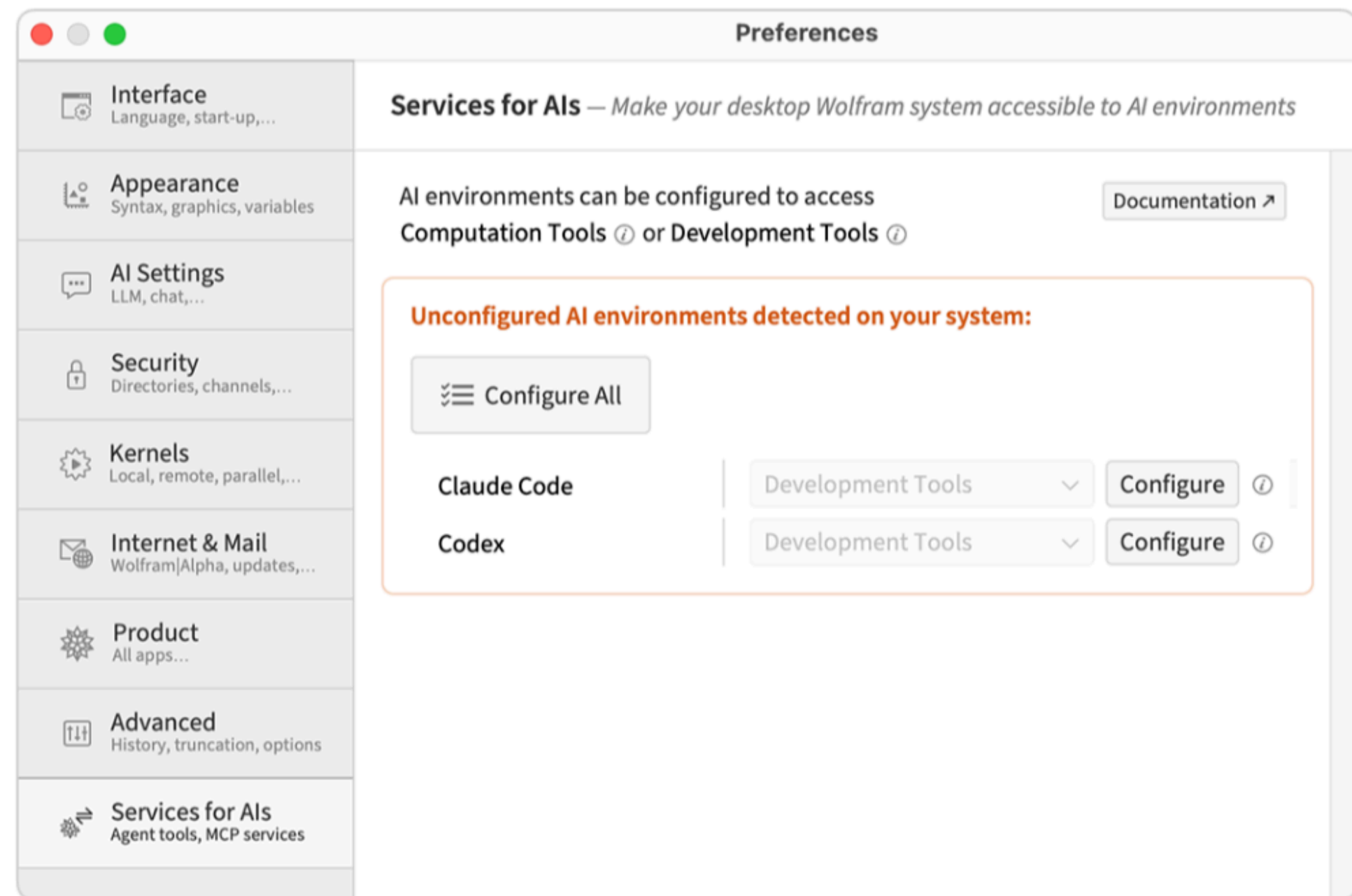
MCP

Model Context Protocol
-- use tools

Mathematica MCP

Configure your **Claude Code**, **Codex** to use your **Wolfram system** »

Clicking this takes you to the Services for AIs tab in the Preferences dialog:



MCP

Model Context Protocol
-- use tools

tririver/mathgr-py

PythonMCP serverTensor calculusGeneral relativityLocal README snapshot

MathGR-Py: A MCP/Python Port of MathGR for Tensor Calculus and General Relativity

mathgr is a Python/SymPy and MCP port of [tririver/MathGR](#), a symbolic toolkit for tensor calculus, general relativity, ADM/FRW decompositions, perturbation series, integration by parts, and TeX export.

The package has two user-facing interfaces:

- Python interface: normal Python/SymPy API for scripts, notebooks, tests, and direct human use.
- MCP interface: designed for Codex, Claude Code, and other coding agents. It accepts Python-like expression strings, auto-declares tensors and indices, and exposes tools such as `mathgr_compute`, `mathgr_parse`, and `mathgr_tex`.
Example agent call: `mathgr_compute("Simp(Dta(U('α'), D('β')) * f(U('β'))))")`.

Wolfram is not needed. The test suite translates upstream MathGR tests and notebook

Port the project [tririver/MathGR](https://github.com/tririver/MathGR) into python. Use SymPy for symbolic calculation. The name of the package is mathgr in Python.

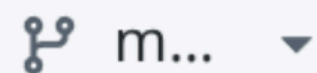
During the porting, you can use `/usr/local/bin/WolframScript` to run Mathematica. Test extensively during the porting. Make sure to include all test cases in MathGR, and write new test cases as usual in test driven development.

Port the components util, tensor, gr, decomp, ibp, frwadm, and anything depends on them. Make them fully functional. Make sure the output is identical compared to the Mathematica version.

Port all the examples in the `resources/examples/` as examples in python.

PART III

ARC: Agentic Research Copilot



4 Branches 6 Tags

Go to file



Code



ARC Dev docs: update installation remarks to include citation ...



0f231f9 · 2 days ago



181 Commits



.agents/plugins

Changed packaging system: easier to install...

5 days ago



.claude-plugin

Changed packaging system: easier to install...

5 days ago



packages

chore: release v0.9.3

2 days ago



plugins/arc

chore: release v0.9.3

2 days ago



scripts

feat: enhance output recovery and schema ...

2 days ago

ARC: An LLM-Native Agent Workflow for Theoretical Physics Research

Yanjiao Ma^{1,2}, Yi Wang^{1,2}, Xingkai Zhang^{1,2}

¹ Department of Physics, The Hong Kong University of Science and Technology,
Clear Water Bay, Kowloon, Hong Kong, P.R. China

² The HKUST Jockey Club Institute for Advanced Study,
The Hong Kong University of Science and Technology,
Clear Water Bay, Kowloon, Hong Kong, P.R. China

3.1

Design

ALC — Learning / 左



alc-ocr-proofread



alc-translate

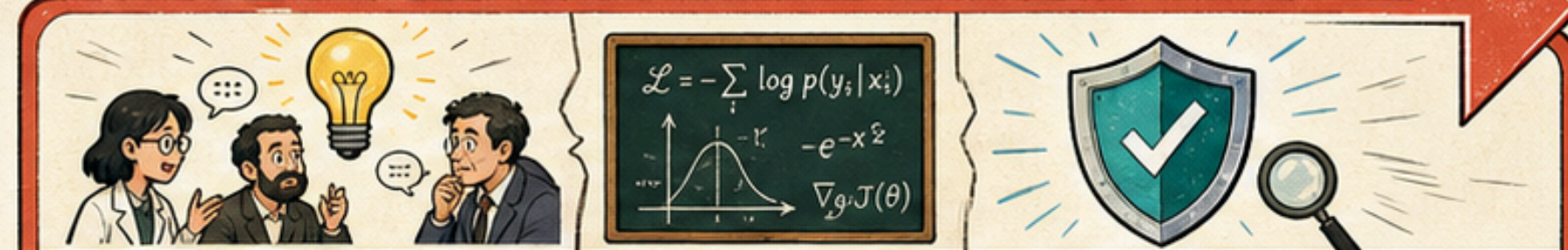


alc-render



alc-companion

ARC — Research / 右



arc-paper



arc-domain

AC FOUNDATION — Shared capabilities / 共同基础



ac-document



ac-jobs



ac-llm



ac-proposer-reviewer

3.2

Domain construction

Prompt input: Use ARC, for research field arXiv:0911.3380, recommend idea: tree-level calculations of scalar correlation function, with the internal propagating field a massive scalar.

**For human:
domain network**

**For human:
summaries if needed**

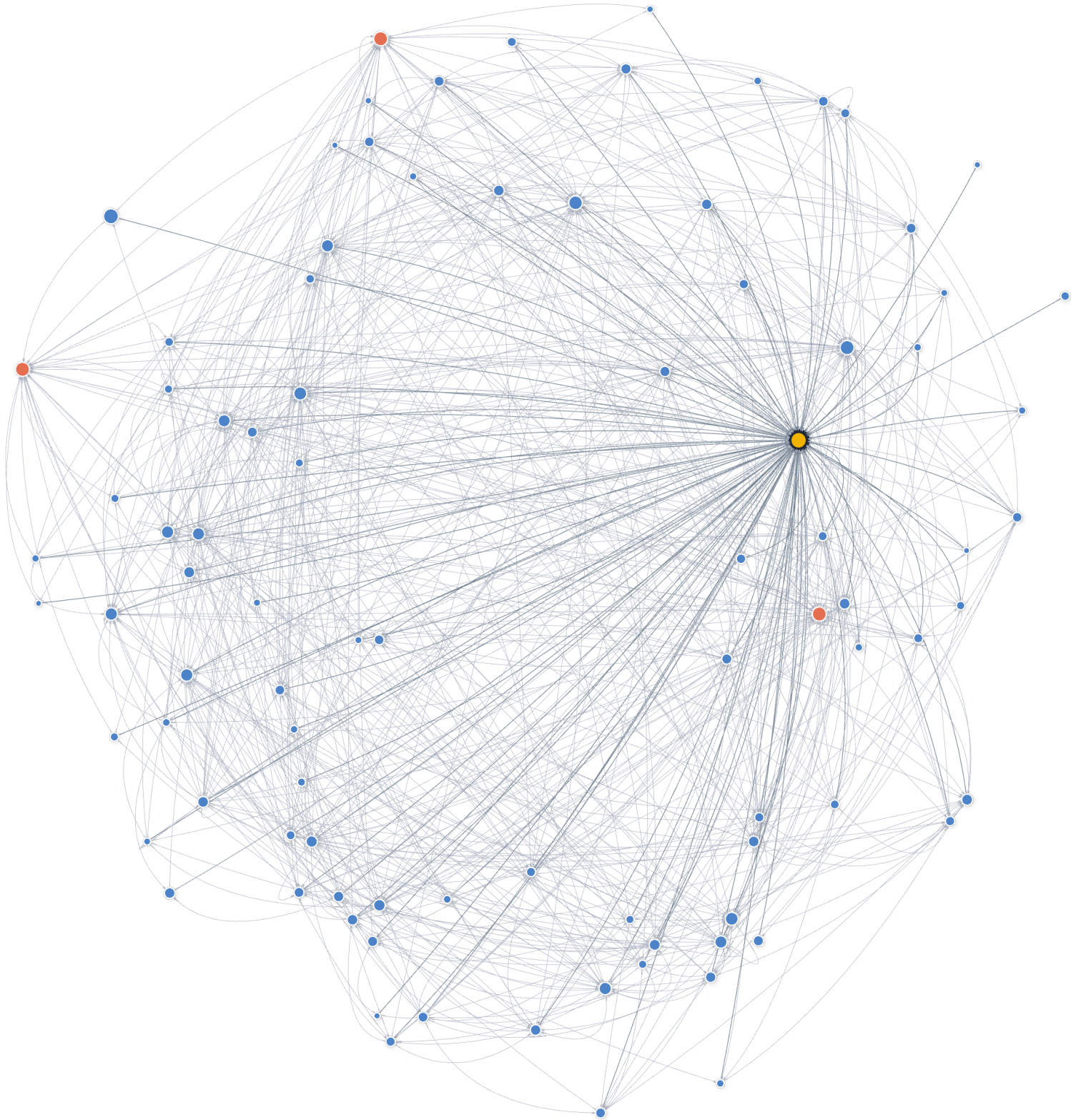
**For Agents: guide
research ideas**

ARC Domain Network

Foundation: arXiv:0911.3380 | Nodes: 92 | Edges: 752

Legend

- Selected foundation
- Parent foundation
- Domain paper
- Common reference



Click a node or row.

Role	Paper	Score
Foundation	Quasi-Single Field Inflation and Non-Gaussianities arXiv:0911.3380	
Parent	The Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems inspire:154280	
Parent	A New Inflationary Universe Scenario: A Possible Solution of the Horizon, Flatness, Homogeneity, Isotropy and Primordial Monopole Problems inspire:168781	
Parent	Non-Gaussian features of primordial fluctuations in single field inflationary models arXiv:astro-ph/0210603	
Domain	Non-Relativistic Cosmological Collider Signals arXiv:2605.20102	15.1333
Domain	Searching for Cosmological Collider in the Planck CMB Data II: collider templates and Modal analysis arXiv:2512.22085	13.4959
Domain	What Shape is the Inflationary Bispectrum? arXiv:2603.17004	12.3831
Domain	Cosmological Collider Searches beyond the Hubble Scale with Planck Data arXiv:2603.15728	12.3719
Domain	Loop integrals in de Sitter spacetime: The parity-split IBP system and d log-form differential equations arXiv:2604.14549	11.6333
Domain	Scalars at the Cosmological Collider: Full Shapes of Tree Diagrams and Bispectrum Searches using Planck Data arXiv:2604.07434	11.4582
Domain	Massive inflationary amplitudes: differential equations and complete solutions for general trees arXiv:2412.07843	11.2475
Domain	Split Representations and Bubble Resummation for Massive	9.9609



ARC PROVENANCE REPORT

How the Two HTML Reports Were Made

This page documents the workflow that produced `research_directions.html` and `full_shape_constraints.html`: what ARC is, how it was used, which prompts drove the work, what local artifacts were created, and what timing/token evidence is available.

2

HTML reports audited

145

2024+ citer records

9

full-shape papers reread

39

original figures reused

What ARC is

Exact prompts

Cost estimate

TOOLING

What ARC Is

ARC means Agent Research Copilot. In this workspace it is a cache-first research toolkit for theoretical-physics papers and research-domain construction. ARC is available on GitHub at github.com/trriver/arc.

ARC connects agent work to INSPIRE metadata/citations, arXiv identifiers, ar5iv/full-text sections, local paper caches, source downloads, equation/context search, LLM paper summaries, and report/export helpers.

ARC was used as both MCP tools and local workflow discipline: gather paper data first, cache it under the project dir, verify metadata, then synthesize reports from local artifacts instead of relying on memory.

How ARC Was Used Here

- Seed paper: `arXiv:0911.3380`.
- Initial ARC run fetched INSPIRE citer records and filtered `year >= 2024`.
- ARC metadata and summary artifacts separated arXiv records from non-arXiv records.
- For the focused full-shape report, ARC metadata verified nine paper titles/authors/arXiv IDs, while local PDFs/source archives supplied text, tables, and figures.
- ARC self-reflection files recorded outcomes and improvement notes.



ARC SYNTHESIS REPORT

Research Directions from Papers Citing arXiv:0911.3380 Since 2024

Seed: **Quasi-Single Field Inflation and Non-Gaussianities**, Chen, Xingang; Wang, Yi. This report distills the 2024+ citing literature into actionable research directions. Paper tables use ARC/INSPIRE metadata fields for titles, authors, years, citation counts, and arXiv identifiers.

145

2024+ citing records

130

arXiv records summarized

15

metadata-only non-arXiv records

7

research directions

How to read this report

The directions are not ranked. They are clusters where multiple recent citing papers converge on a shared technical bottleneck or opportunity. Each section gives a research summary, why the direction is timely, and a metadata-backed related-paper table.

- Metadata note:** Paper titles are taken from ARC/INSPIRE published metadata where available; they may differ slightly from current arXiv abstract-page titles. Citation counts are INSPIRE counts from the 2026-06-19 metadata snapshot.
- Evidence note:** ARC summaries for these papers often preserve caveats that some papers were abstract-only or section-limited. Treat this report as a direction-finding synthesis, not as formula-level validation.

Year distribution

Year	Records
2024	54
2025	64
2026	27

1. Build full-shape collider searches that combine CMB, LSS, and estimator systematics

3. Use multifield transfer, turns, and reheating as controlled signal engines

5. Make four-point and parity-sensitive observables first-class probes

2. Turn cosmological correlators into spectral, dispersive, and differential-equation data

4. Broaden the collider target space beyond simple massive scalar exchange

6. Propagate primordial collider features through nonlinear late-time structure

ARC FOCUSED REPORT

Observational Constraints on Cosmological Collider Shapes

Research direction: **Build full-shape collider searches that combine CMB, LSS, and estimator systematics.** This report reads the nine 2024+ papers in that direction and summarizes the explicit observational constraints on cosmological-collider-like shapes, using the papers' original figures where available.

9

papers read

39

original constraint figures

2.35 σ

strongest adjusted CMB bispectrum signal

1.7

tightest BOSS 95% limit on $A_{f_{NL}^{\alpha, \nu}}$

BOTTOM LINE

No robust detection; full-shape null tests are now systematics-limited

CMB bispectrum: Planck template and modal searches find several local 2–3 σ excursions, but look-elsewhere-adjusted significances remain modest. The strongest tabulated adjusted signal is the scalar-II collider template in Planck, $f_{NL}=467\pm140$, raw 3.34 σ , adjusted 2.35 σ .

LSS/BOSS: BOSS full-shape and power-spectrum analyses constrain collider amplitudes but do not detect oscillatory PNG. The tightest extended-collider limit is $A_{f_{NL}^{\alpha, \nu}} < 1.7$ at $(\alpha, \nu)=(-1, 4)$; the weakest is 1.7e5 at $(3.0, 0.1)$.

Estimator systematics: Planck trispectrum tests show no collider detection, with maximum baseline collider significance 1.6 σ . Lensing and simulation mismatches can shift some trispectrum amplitudes by several sigma, so null pipelines need aggressive systematics accounting.

Evidence note:

numerical values were extracted from paper text, TeX tables, and PDF text. Figures below are original source figures rendered or copied from each arXiv source archive and cited by arXiv ID plus paper figure number. Some grid-level f_{NL} constraints are figure-only in the source papers; those entries are explicitly marked.

Papers and metadata

CMB bispectrum templates

Shape reconstruction and estimator reach

Constraint map by shape family

Full tree shapes and chemical-potential shapes

LSS and BOSS limits



DEEP RESEARCH REPORT · ENGLISH HTML EDITION

Papers Citing arXiv:0911.3380 Since 2024

A structured English synthesis of post-2024 work citing Xingang Chen and Yi Wang, *Quasi-Single Field Inflation and Non-Gaussianities* (arXiv:0911.3380), with papers organized by research direction, bibliographic metadata, and relation to the original quasi-single-field program.

Scope note. This HTML report is generated from the completed Deep Research summary in the conversation. For the entry “Charged loops at the cosmological collider with chemical potential,” the provided source summary contained a DOI but no arXiv identifier; the table therefore does not invent one.

33
papers or preprints summarized

4
research directions

2024–2026
publication/preprint window covered

0911.3380
origin paper: quasi-single-field inflation



Deep Research on Papers Citing arXiv:0911.3380 Since 2024

A comprehensive summary of recent papers and research directions building upon the seminal work "Quasi-Single Field Inflation and Non-Gaussianities."

Introduction

The 2009 paper "Quasi-Single Field Inflation and Non-Gaussianities" (arXiv:0911.3380) by Xingang Chen and Yi Wang established a critical theoretical bridge between simple single-field inflation models and more complex multi-field scenarios. It introduced a framework where the inflaton field interacts with other massive fields, known as "isocurvatons," during the inflationary epoch. This interaction generates a unique and potentially large non-gaussian signature in the primordial density fluctuations, which are imprinted on the Cosmic Microwave Background (CMB). These non-gaussianities, specifically their shape and amplitude, serve as a powerful observational probe into the high-energy physics of the early universe.

This report provides a detailed analysis of the academic papers and preprints published since the beginning of 2024 that cite this foundational work. By examining these recent publications, we can identify the most active and promising research directions that are the direct intellectual descendants of the ideas first proposed in 0911.3380.

Papers Citing arXiv:0911.3380 Since January 2024

A search of academic databases has identified several recent publications that reference "Quasi-Single Field Inflation and Non-Gaussianities." These papers form the basis of our analysis of current research trends.

Published Journal Articles

Output for Agents

Domain Summary for arXiv:0911.3380

Tree-level scalar correlators with massive scalar exchange in quasi-single-field inflation

This domain is quasi-single-field inflation and its descendants: primordial scalar correlators are modified by an extra scalar with mass of order the Hubble scale, typically through mixing with the inflaton or curvature mode. The field was anchored by arXiv:0911.3380, which defined the core physics of Hubble-mass isocurvature modes generating intermediate-shape non-Gaussianity and potentially large trispectra. For doing calculations, the most useful starting point is arXiv:1703.10166, which turns the in-in formalism into practical Schwinger-Keldysh rules and shows how mixed propagators simplify tree-level exchange calculations. Later work broadens the toolkit: bootstrap and Mellin-space methods give analytic constraints and closed forms for exchange correlators; differential-equation and flow methods systematize general trees and numerics; recent papers extend to multiple exchanges, dynamical masses, boost breaking, and

3.3

Idea generation

Provide idea examples

Proposer-Reviewer loop



Ideas

Abbreviations:

IR=intent relevance, N=novelty, CN=confidence of novelty, SV=scientific value, PL=planning, WD=well-definedness, T=total.

domain_idea_001

Exact Collapsed Soft Indices for Strong-Transfer QSFI Exchange Trispectra

Round	IR	N	CN	SV	PL	WD	T
1	25	11	9	11	12	11	79
2	25	12	10	12	13	13	85
3	25	12	10	13	14	14	88
4	25	12	10	13	14	15	89
5	25	12	10	13	14	15	89

3.4

Plan-Calculation Loop

Work Note

Task

Proceed with ranked direction 1 from the ARC idea run:

Collapsed Phase of the Exact Strong-Mixing Primordial Trispectrum.

The scientific target is a tree-level, s -channel scalar four-point function in quasi-single-field inflation with a massive internal scalar and exact quadratic mixing. The concrete first-pass goal is not yet the full numerical phase scan. It is to derive a source-aware analytic setup for the calculation:

1. the Hamiltonian/flow inputs for the simplified exact-mixing model;
2. the collapsed-limit nonanalytic clock-frequency form that motivates fitting

$$\Delta\mathcal{T}(x) \sim x^\alpha \mathcal{A}_4 \cos(2\mu_{\text{eff}} \log x + \delta_4).$$

The later numerical target is the phase $\delta_4(\rho)$ after analytic-background subtraction on the slice

3.5

Companion generation

Companion generation

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目录

FEARFUL SYMMETRY

FEARFUL SYMMETRY

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FIGURE CREDITS

SYMMETRY AND DESIGN

In Search of Beauty

BEAUTY BEFORE TRUTH

TRAINING OUR EYES

INTRINSIC VERSUS EXTRINSIC BEAUTY

LIVING IN A DESIGNER UNIVERSE

THE MUSIC VERSUS THE LIBRETTO

LOCAL ORDINANCES VERSUS CONSTITUTIONAL PRINCIPLES

Symmetry and Simplicity

As a physicist, I am much enamored of the sentiment expressed by Einstein. While the vast majority of contemporary physicists are engaged in explaining specific phenomena, and rightly so, a small group, the intellectual descendants of Einstein, have become more ambitious. They have entered the forest of the night in search of the fundamental design of Nature and, in their limitless hubris, have claimed to have glimpsed it.

译者注

译者注: "黑夜的森林"出自威廉·布莱克《虎》中的 "In the forests of the night"; 该诗同段随后问 "Could frame thy fearful symmetry?", 亦是本书书名的出处。 [9]

Two great principles guide this search: symmetry and renormalizability. Renormalizability refers to how physical processes with different characteristic lengths are related to each other. While I will touch on renormalizability, my focus will be on symmetry as the unifying aesthetic viewpoint through which fundamental physicists look at Nature.

译文

作为一名物理学家, 我深深着迷于爱因斯坦所表达的这种情怀。尽管绝大多数当代物理学家都在致力于解释具体的现象——这当然无可厚非——但有一小群人, 作为爱因斯坦的智识后裔, 已经立下了更为宏大的志向。他们踏入了黑夜的森林, 去探寻自然的基本设计, 并在那无边的狂傲之中, 宣称已瞥见了它的真容。

译文

有两大原理指引着这一探寻: 对称性与可重整性。可重整性关乎不同特征尺度的物理过程如何彼此关联。尽管我会触及可重整性, 但我的重心将放在对称性上, 将其视为基础物理学家审视自然时那统一的美学视角。

译文

智识后裔走入黑夜的森林

“爱因斯坦的智识后裔”指继承一种研究取向的物理学家: 他们希望从大量现象中找出自然的基本设计。“黑夜的森林”则把尚未理解的自然比作难以辨路的未知领域。作者同时使用“无边的狂傲”“宣称”和“瞥见”, 为这幅探险图景加上自我警惕: 所谓“瞥见”表达理论家的宏大抱负; 一种基本设计能否成立, 仍取决于它能否形成明确、可检验的预测并经受实验检验。

+

译文

可重整性与重整化各自承担什么

可重整性是一种理论性质, 重整化则是处理量子场论计算的一套程序。对于可重整的理论, 在微扰展开与该理论适用的尺度范围内, 短距离计算产生的紫外发散能够系统地吸收到有限个参数的重新定义或有限个反项中; 用有限个实验输入确定这些参数后, 理论便能继续给出有限预测 [10]。重整化程序具体完成这种吸收, 并追踪参数随能量或长度尺度怎样变化。于是, 序言所说的“不同特征尺度如何彼此关联”, 可以落实为同一理论的参数和预测随观察尺度按规律变化。作者随后把重心放在对称性上, 把它作为寻找统一结构的美学视角

Zee, Fearful Symmetry + ARC companion

3.6

Lessons and Fun Stories

Lessons

Be LLM Native

Do not tell AI what to do.
Provide info

Skill-package separation

No software engineering for
skills yet (or ever?)

Peer review

A proposers-reviewer model
is helpful and reusable

Provide trust

prevent cheating is
important but not most
important

Provide service

create another agent to fill
forms if the main agent fails

Model vs harness

ChatGPT pro may
work better if more
intelligence needed

Fun Stories

Debug

Proposers-reviewer model no longer useful

Debug

No longer check equation by equation

Summary

Vibe Physics

Vibe Physics ->
Research Agent

ARC: Agentic Research
Copilot

github.com/tririver/arc

Discussion

AI is more relevant to physicists since 2026

Physicists should work with AI, at least more
than we used to work with Mathematica

Calculation becomes cheap, idea and checking
still expensive

Value of education: reshaped teaching
and learning