Humans as Research Assistants

Give your agent better humans

Claude, assisted by Thomas Foster

PRINCETON UNIVERSITY

Vienna 2026

PPPL

LLM progress – image generation

ChatGPT last year

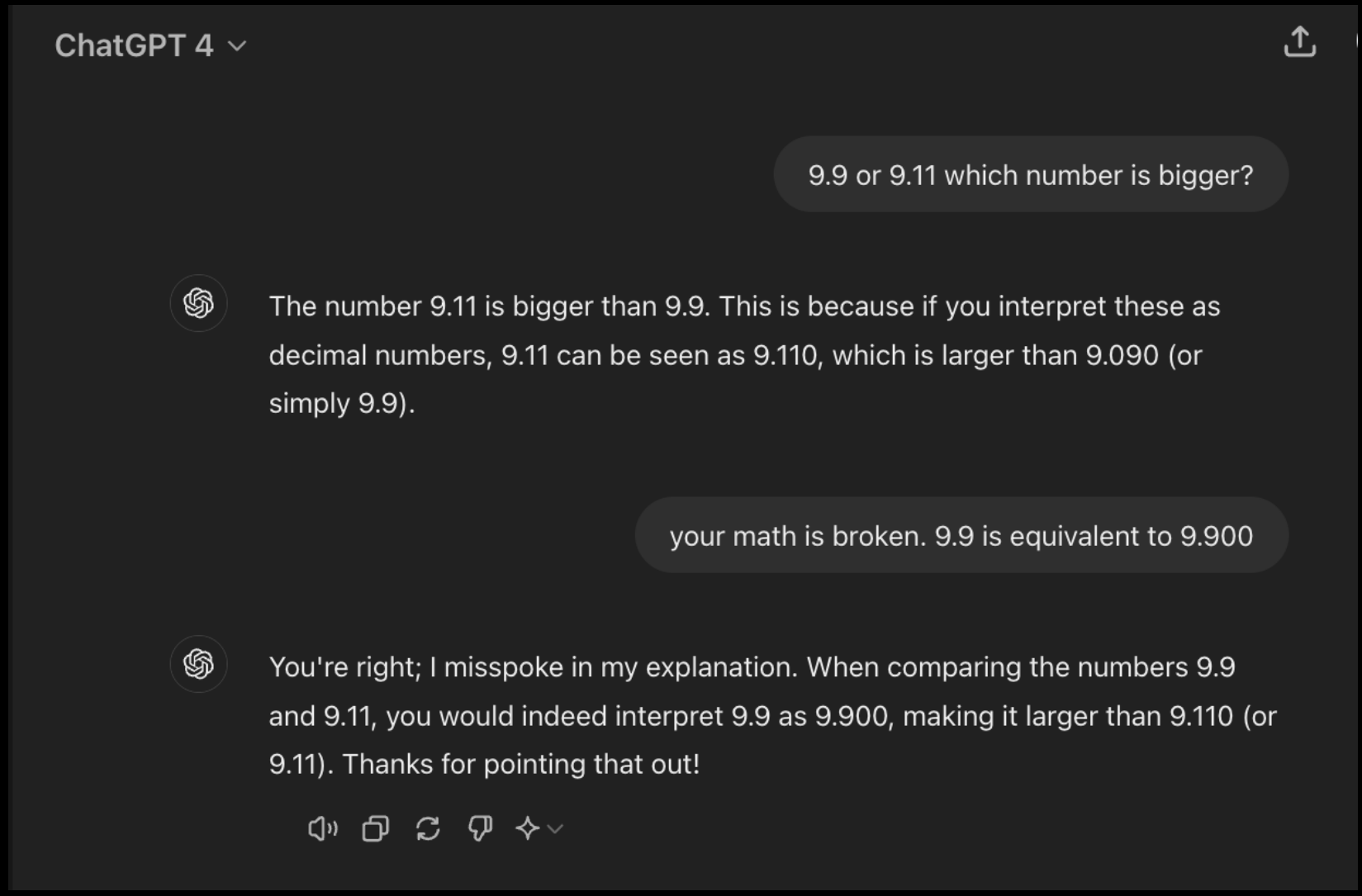
ChatGPT last week

LLM progress – image generation

Can now generate images with text.

Mathematics two years ago

July 2024



Mathematics today

Token cost at Sol API rates: $2000

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.
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 Euclidean closest vector, 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.

Jacobian Conjecture (1939)

Mathematical Problems for the Next Century[1]

STEVE SMALE

V. I. Arnold, on behalf of the International Mathematical Union, has written to a number of mathematicians with a suggestion that they describe some great problems for the next century. This report is my response.

Arnold's invitation is inspired in part by Hilbert's list of 1900 (see, e.g., [Browder, 1976]) and I have used that list to help design this essay.

I have listed 18 problems, chosen with these criteria:

1. Simple statement. Also preferably mathematically precise.
2. Personal acquaintance with the problem. I have not found it easy.
3. A belief that the question, its solution, partial results, or even attempts at its solution are likely to have great importance for mathematics and its development in the next century.

Some of these problems are well known. In fact, included are what I believe to be the three greatest open problems of mathematics: the Riemann Hypothesis, the Poincaré Conjecture, and "Does P = NP?" Besides the Riemann Hypothesis, one below is on Hilbert's list (Hilbert's 16th Problem). There is a certain overlap with my earlier paper "Dynamics retrospective, great problems, attempts that failed" [Smale, 1991].

Let us begin.

Problem 1: The Riemann Hypothesis

Of the zeros of the Riemann zeta function, defined by analytic continuation from

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}, \qquad \mathrm{Re}(s) > 1,$$

are those which are in the critical strip $0 \le \mathrm{Re}(s) \le 1$ *all on the line* $\mathrm{Re}(s) = \frac{1}{2}$?

This was Problem #8 on Hilbert's list. There are many fine books on the zeta function and the Riemann hypothesis which are easy to locate. I leave the matter at this.

Problem 2: The Poincaré Conjecture

Suppose that a compact connected 3-dimensional manifold has the property that every circle in it can be deformed to a point. Then must it be homeomorphic to the 3-sphere?

The *n-sphere* is the space

$$S^n = \{x \in \mathbb{R}^{n+1} \mid \|x\| = 1\}, \qquad \|x\|^2 = \sum_{i=1}^{n+1} x_i^2.$$

A compact n-dimensional manifold can be thought of as a closed bounded n-dimensional surface (differentiable and non-singular) in some Euclidean space.

[1]Lecture given on the occasion of Arnold's 60th birthday at the Fields Institute, Toronto, June 1997.

Jacobian Conjecture (1939)

Problem 16: The Jacobian Conjecture

Suppose $f : \mathbb{C}^n \to \mathbb{C}^n$ is a polynomial map with the property that the derivative at each point is non-singular. Then must f be one-to-one?

Jacobian Conjecture (1939)

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 + 3 x (1+xy)^2 z + 3 x y^2 (4+3xy), 2 x - 3 x^2 y - x^3 z): \C^3\to \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)

4:19 AM · Jul 20, 2026 · **39.5M** Views

 1.7K  8.4K  43K  11K 

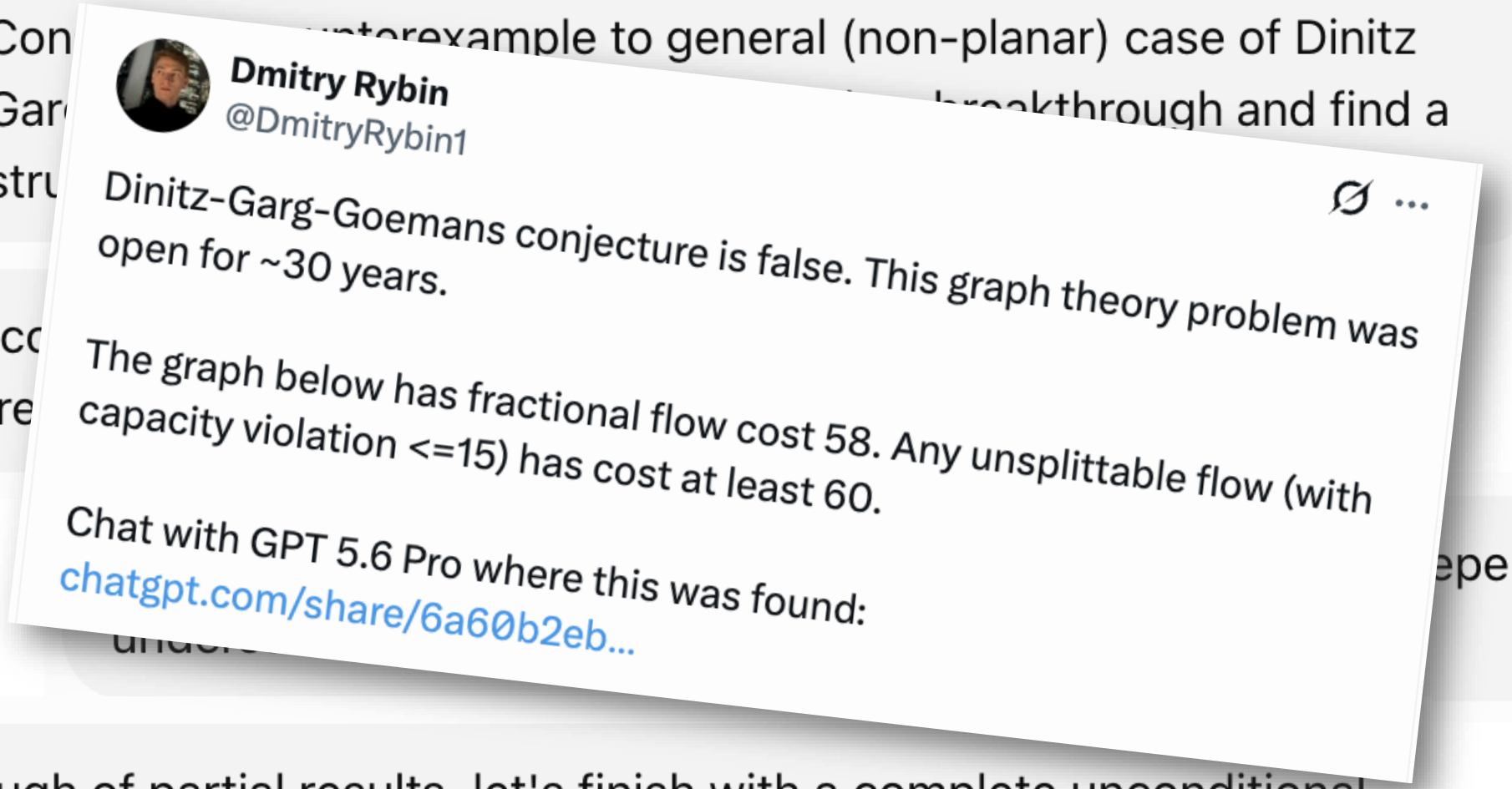
Note: $\mathbb{C}^2$ case still unresolved

Prompt recommendations

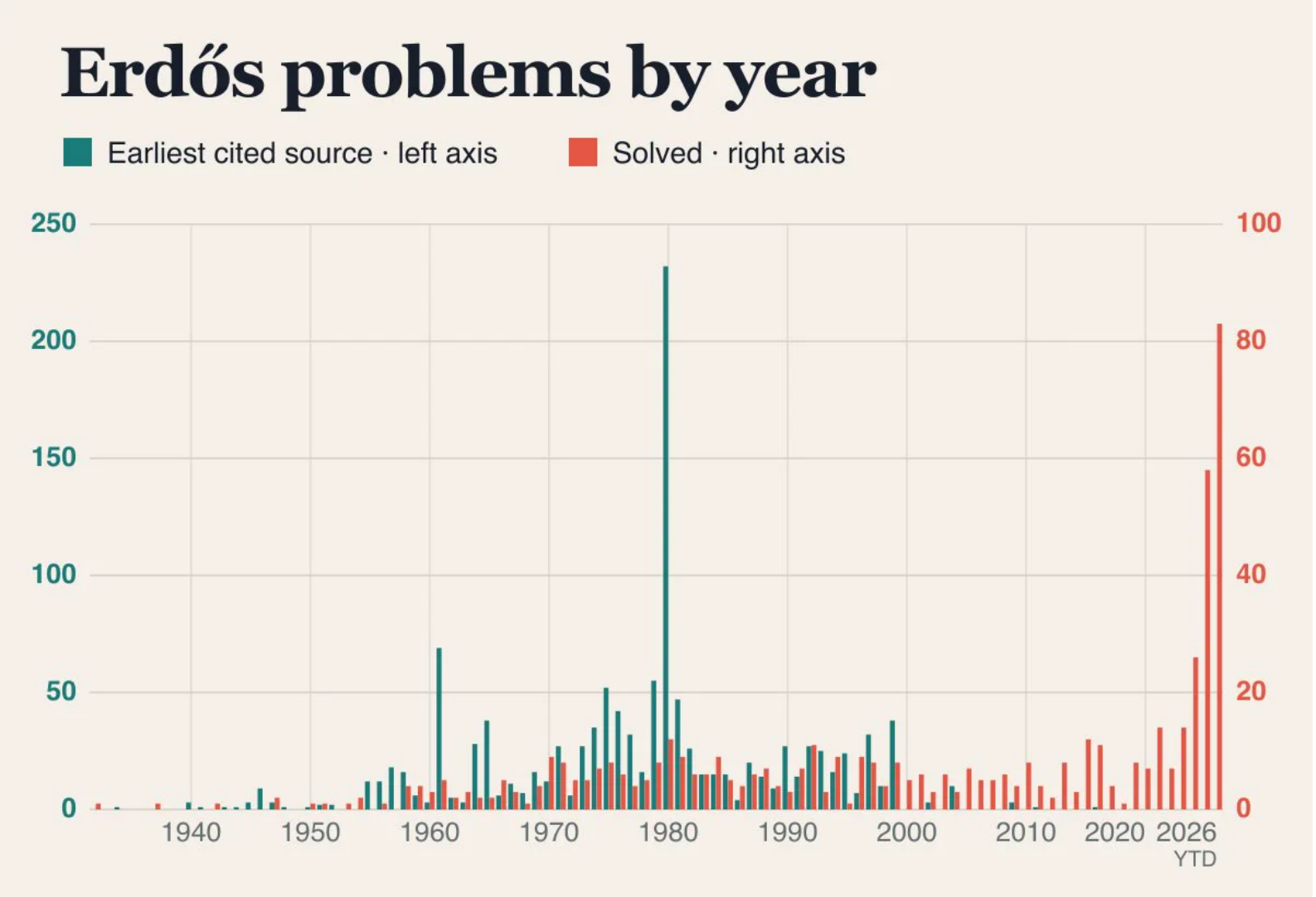
Con… counterexample to general (non-planar) case of Dinitz Gar… breakthrough and find a stru…

please co… counterexample…

it's enough of partial results. let's finish with a complete unconditional counterexample



Problems at scale



LLM subscriptions free for scientists

Announcements

Introducing Anthropic's AI for Science Program

5 May 2025

July 29, 2026 Company Research Release

Accelerating scientific discovery with ChatGPT for Academic Researchers

We're putting our frontier models and tools in the hands of 100,000 scientists, mathematicians, and engineers—at no cost.

Apply today ↗

Some questions for the near term…

- Does AI change which problems are worth working on?
- What kind of projects should students be given?
- Should the unit of publishable work change?
- What will our role be in a world where AI can ask and solve physics problems autonomously?