

How do you **trust** what your LLMs tell you?

- >>> Citation grounding, **RAG** and other ways
to make LLMs show their sources



Language models are not tuned for factual accuracy

- **ChatGPT in the Avianca Airlines Lawsuit (2023)**

A law firm representing a passenger used ChatGPT to draft a legal filing and included six completely fictional judicial precedents. The attorneys were sanctioned and fined **\$5,000** by the court for failing to check the accuracy of the citations.  Appen

- **Air Canada Chatbot Refund Policy (2024)**

An AI-powered customer service chatbot on Air Canada's website hallucinated a nonexistent bereavement fare policy for a passenger. When the airline refused to honor the chatbot's promise, a civil resolution tribunal ruled against Air Canada, forcing them to pay damages and compensation.  BizTech Magazine +1

- **Anthropic's Claude in a Copyright Dispute (2025)**

During ongoing litigation against music publishers, Anthropic submitted a legal filing that contained a fabricated case citation generated by its Claude model. The legal team apologized and attributed the error to a missed manual review.  Appen

- **Google Bard's Telescope Error (2023)**

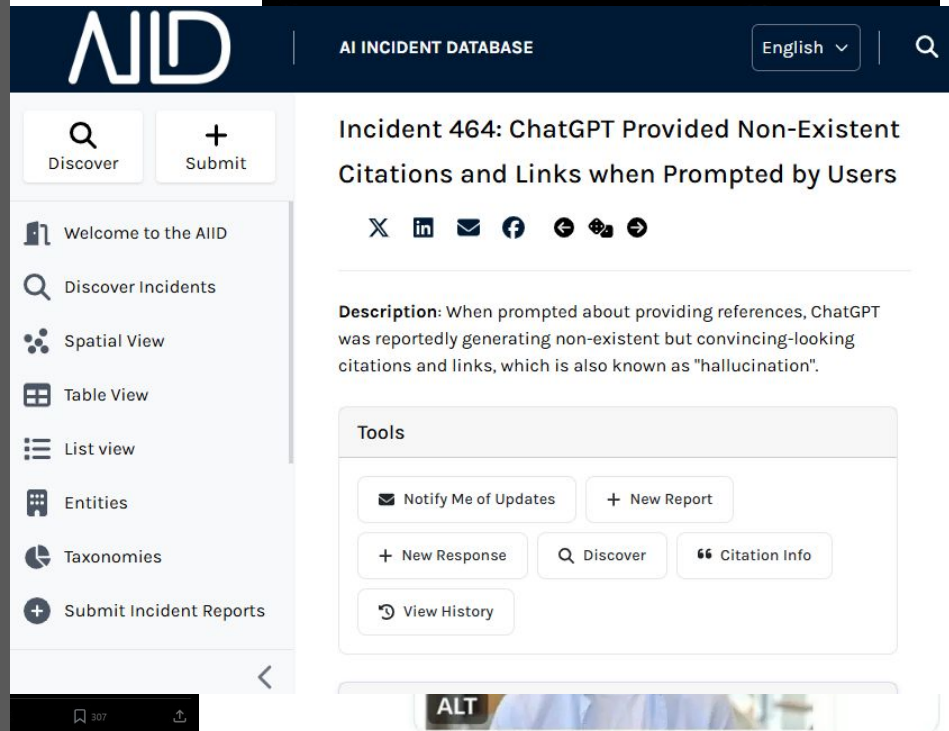
During a promotional launch, Google's Bard chatbot incorrectly claimed that the James Webb Space Telescope took the very first pictures of a planet outside our solar system (which were actually taken by the Very Large Telescope years prior). The factual error contributed to a drop in parent company Alphabet's market value.  Evidently AI +1

- **Deloitte Report Phantom Citations**

A corporate report generated using AI systems cited a completely phantom **\$300,000** government tax refund and non-existent regulatory guidelines.  Evidently AI

- **Meta's Galactica Withdrawal**

Meta released Galactica, an LLM trained on scientific literature, which quickly began generating authoritative-sounding but completely fabricated research papers, biased claims, and wrong formulas, forcing Meta to pull the model offline shortly after launch.  Dynamo AI



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These are the only fully correct ones!

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ry.social
discovered "thinking"

Follow

Follow

ess of writing a good
atGPT, I end up solving my
even needing to submit it.



Joanna Maciejewska

@AuthorJMac

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 · 3.2M Views

AIID

AI INCIDENT DATABASE

English



Discover



Submit



Welcome to the AIID



Discover Incidents



Spatial View



Table View



List view



Entities



Taxonomies



Submit Incident Reports

Incident 464: ChatGPT Provided Non-Existent Citations and Links when Prompted by Users



Description: When prompted about providing references, ChatGPT was reportedly generating non-existent but convincing-looking citations and links, which is also known as "hallucination".

Tools

Notify Me of Updates

+ New Report

+ New Response

Discover

Citation Info

View History

307



ALT

Ensuring factual & semantic accuracy of model outputs is
crucial for using them in scientific contexts

In theory, **factually grounding an LLM** is quite straightforward:

1. Feed the model context along with your question
2. Get the model to attribute parts of your context in its response
3. Verify that it's actually citing real (and correct) bits of the context.

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1a. Find the right literature

1b. Get the right information
from the relevant papers

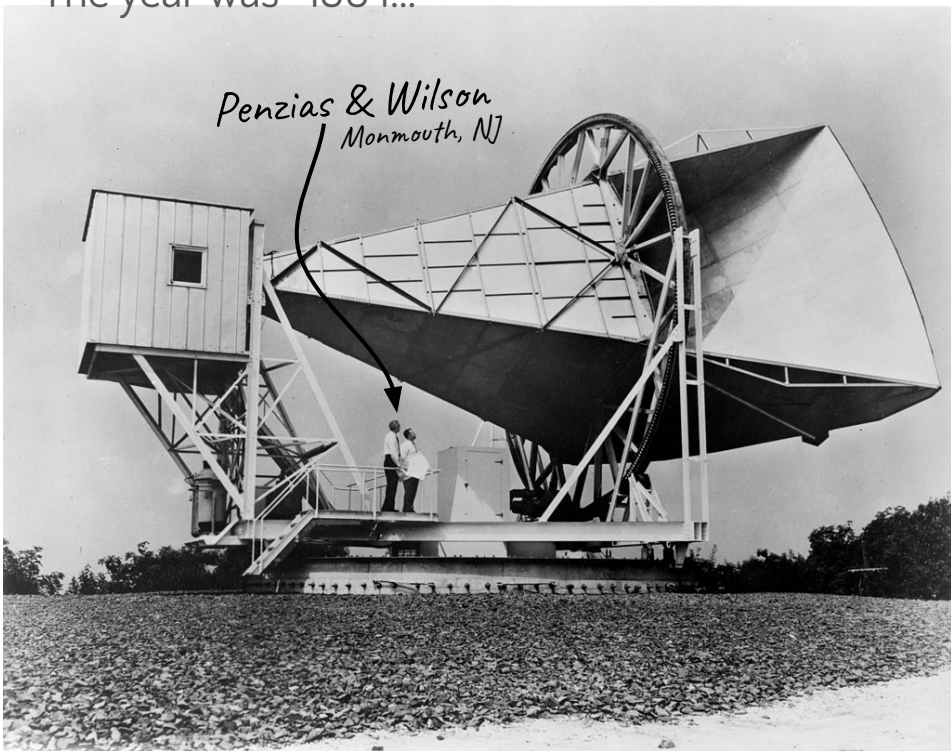
1a. Keeping track of the astronomy literature is difficult (but necessary!)



- > citing everything relevant
- > keeping track of new papers
- > exploring new areas and jargon
- > contextualizing new results with old
- > synthesizing results across many papers
- > finding the right reference for a specific statement is hard

The year was ~1964...

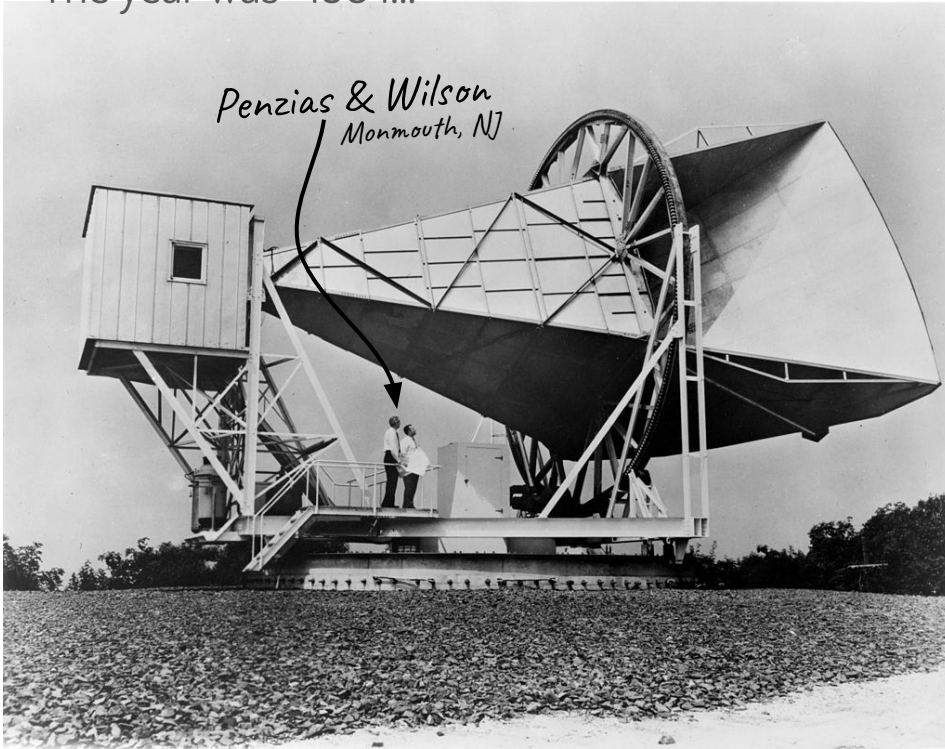
*Penzias & Wilson
Monmouth, NJ*



Penzias and Wilson at the telescope where they made their discovery (image from NASA)

The year was ~1964...

*Penzias & Wilson
Monmouth, NJ*

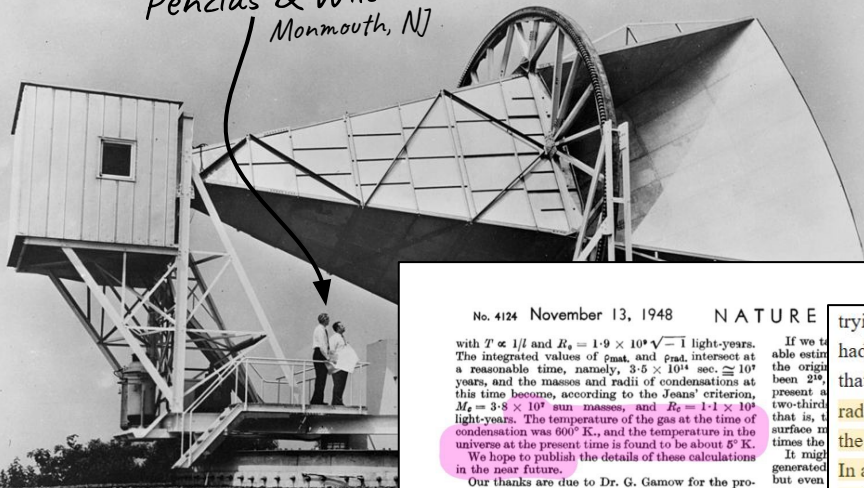


*Robert Dicke
Princeton, NJ*



The year was ~1964...

Penzias & Wilson
Monmouth, NJ



Robert Dicke
Princeton, NJ



No. 4124 November 13, 1948 NATURE

with $T \propto 1/l$ and $R_0 = 1.9 \times 10^4 \sqrt{-1}$ light-years. The integrated values of ρ_{mat} and ρ_{rad} intersect at a reasonable time, namely, 3.5×10^{14} sec. $\approx 10^9$ years, and the masses and radii of condensations at this time become, according to the Jeans' criterion, $M_J = 3.5 \times 10^4$ sun-masses, and $R_J = 1.1 \times 10^4$ light-years. The temperature of the gas at the time of condensation was 600° K., and the temperature in the universe at the present time is found to be about 5° K. We hope to publish the details of these calculations in the near future.

Our thanks are due to Dr. G. Gamow for the proposal of the topic and his constant encouragement during the process of error-hunting. We wish also to thank Dr. J. W. Follin, jun., for his kindness in performing the integrations required for the determination of α , on a Reeves Analogue Computer. The work described in this letter was supported by the United States Navy, Bureau of Ordnance, under Contract NOrd-7386.

RALPH A. ALPHER
ROBERT HERMAN

Applied Physics Laboratory,
Johns Hopkins University,
Silver Spring, Maryland.
Oct. 25.

¹ Gamow, G., *Phys. Rev.*, **70**, 572 (1946).

If we take the origin of time to be the time of the Big Bang, the surface of the universe at the present time is the surface of the universe at the present time.

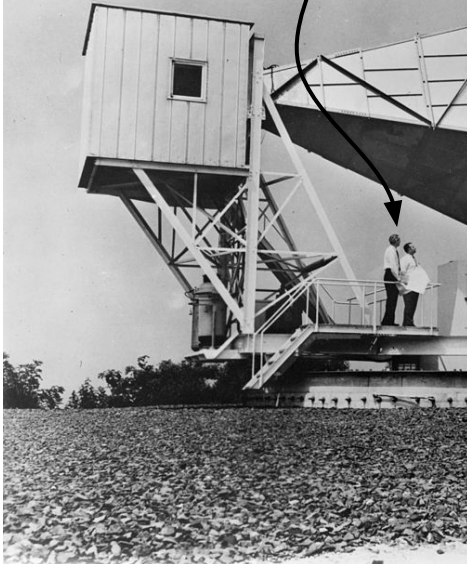
It might be expected that the surface of the universe at the present time is the surface of the universe at the present time. The noise that Penzias and Wilson were hearing was, of course, the noise that Gamow had postulated. They had found the edge of the universe, or at least the visible part of it, 90 billion trillion miles away. They were "seeing" the first photons—the most

trying so diligently to get rid of. The Princeton researchers were pursuing an idea that had been suggested in the 1940s by the Russian-born astrophysicist George Gamow: that if you looked deep enough into space you should find some cosmic background radiation left over from the Big Bang. Gamow calculated that by the time it had crossed the vastness of the cosmos the radiation would reach Earth in the form of microwaves. In a more recent paper he had even suggested an instrument that might do the job: the Bell antenna at Holmdel. Unfortunately, neither Penzias and Wilson, nor any of the Princeton team, had read Gamow's paper.

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Penzias & Wilson
Monmouth, NJ



That energy should still be around, they realized. But as the universe expanded, the primeval fireball would have cooled to a few kelvin above absolute zero — which, they calculated, would put the cosmic radiation in the microwave region of the electromagnetic spectrum. (The group did not know, or had forgotten, that the same calculation had been made 20 years earlier by the physicist George Gamow and his collaborators at George Washington University.)

Dr. Dicke assigned two graduate students — David Wilkinson, a gifted instrumentalist, and James Peebles, a theorist — to try to detect these microwaves. As the group was meeting to decide on a plan of action, the phone rang. It was Dr. Penzias. When Dr. Dicke hung up, he turned to his team. “Boys, we’ve just been scooped,” he said.

The two teams met and wrote a pair of papers, which were published back-to-back in the journal *Physical Review Letters*. The Bell Labs group described the radio noise, and the Princeton group proposed that it could be leftover heat from the Big Bang — “probably each side thinking, Well, what we’ve done is correct but the other may not be,” Dr. Wilson said.

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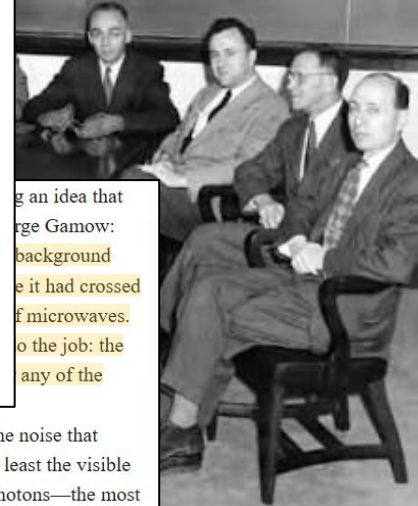
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to imagin was extra also escap of argon t argon. If argon of t is derive arrive at years, which differs by a factor of about 2 from the accepted estimates of geological ages. A correction to these results should be applied for the amount of argon in solution in the ocean; but it can easily be shown that this correction is of no importance.

Princeton team, had read Gamow's paper.

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Dicke
Princeton, NJ



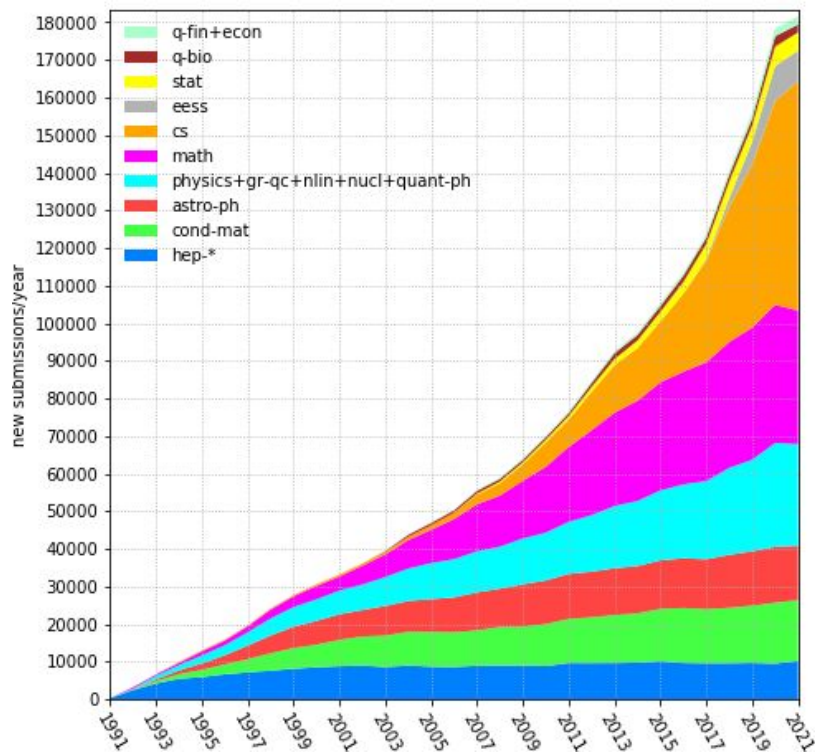
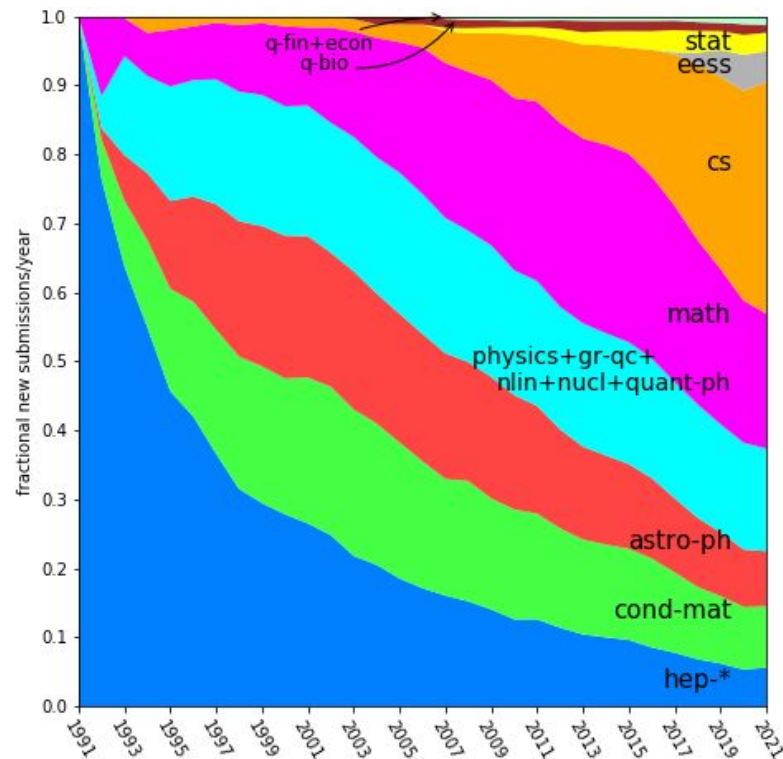
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Keeping track of this literature is difficult (but necessary!)

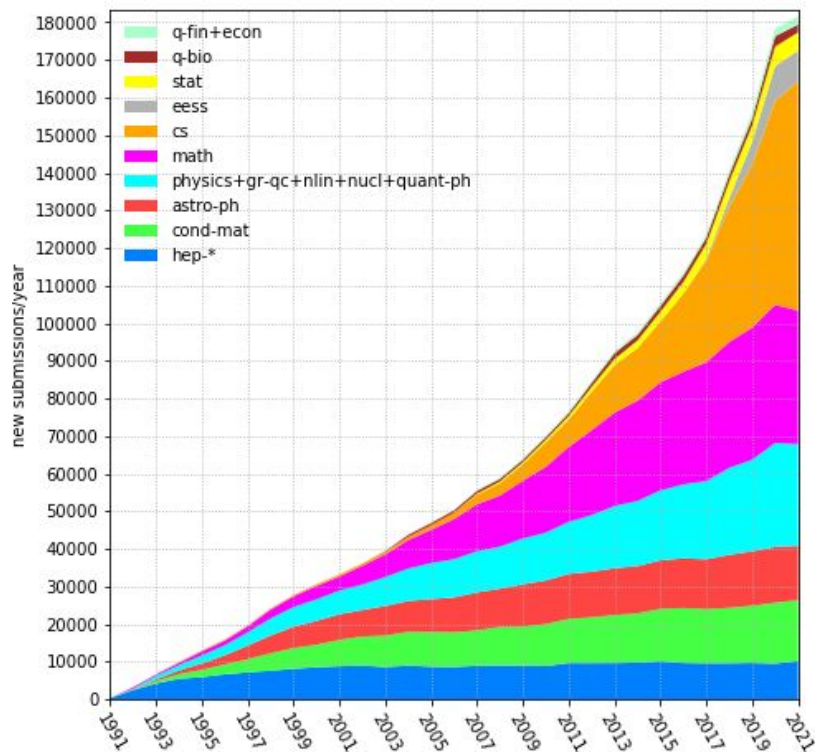
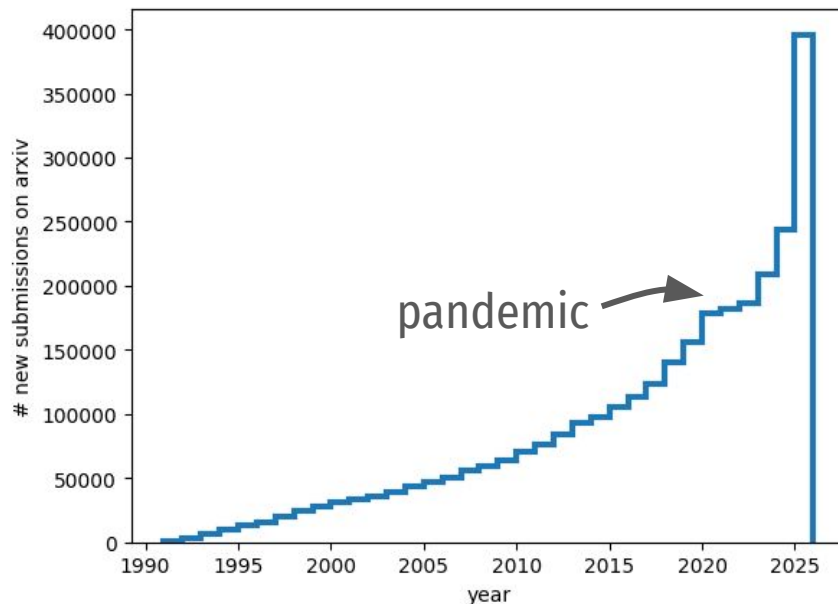


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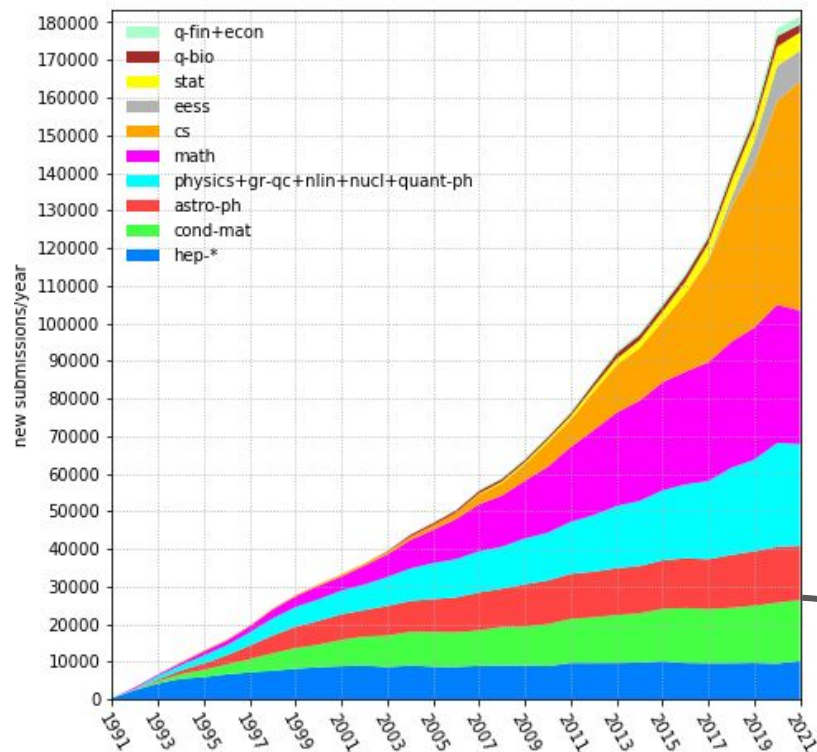
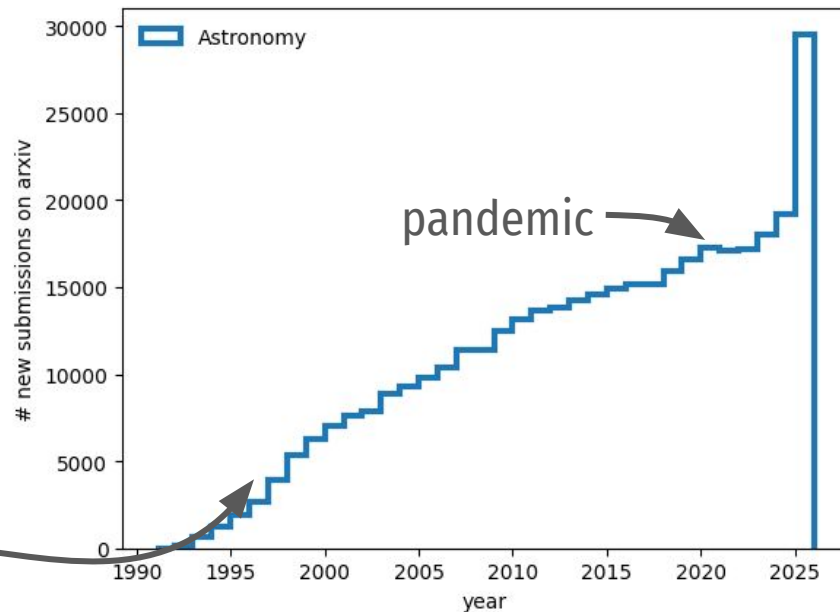
Like our universe, the literature is expanding at an accelerating rate



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Like our universe, the literature is expanding at an accelerating rate



How do we find relevant papers?

Ask your cat/dog/parrot/lizard person/plant <

Keyword searches <

Author + friends-of-friends (+date?) <

Word of mouth / conferences like this <

Citation graphs <

Matching meaning beyond keywords (semantic search) <

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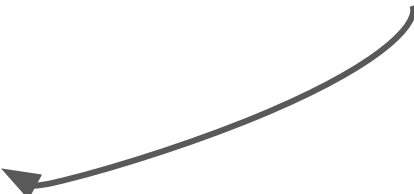
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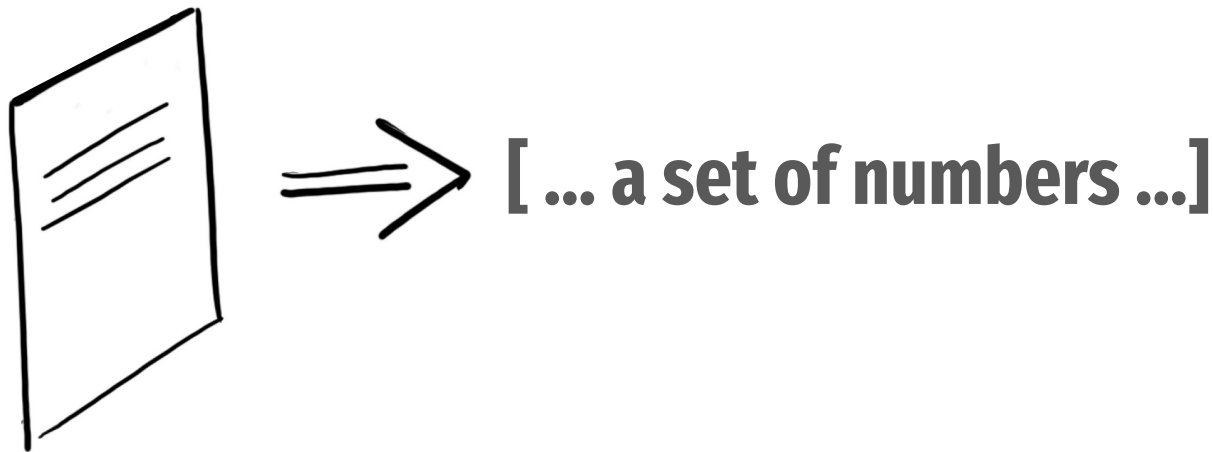
Matching meaning beyond keywords (**semantic search**) <

(also sometimes called RAG or
embedding search)

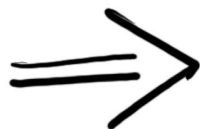
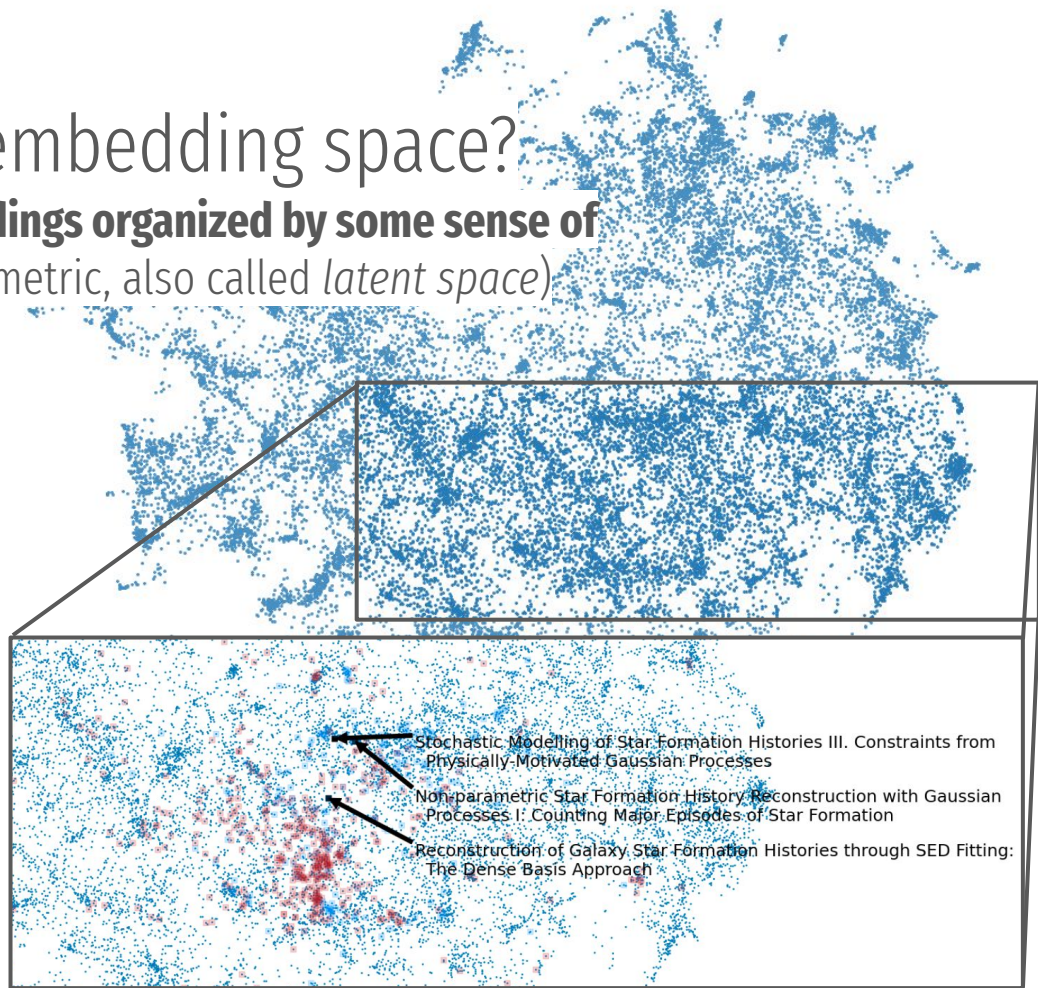


What's an embedding?

**A transformation from a piece of text to a vector
(in some high-dim representation)**



What's an embedding space?
a collection of embeddings organized by some sense of
similarity (having a metric, also called *latent space*)



> Embedding space

Words are translated into numbers (embeddings) using a model. Similar concepts are placed closer together in this mathematical space.

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The defining characteristics: mass, charge, and angular momentum.

1. Dark Matter (DM)	95.3%
2. Ergosphere	90.7%
3. Inflation	89.6%
4. Galaxy Formation	88.9%

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Kepler

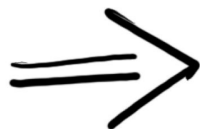
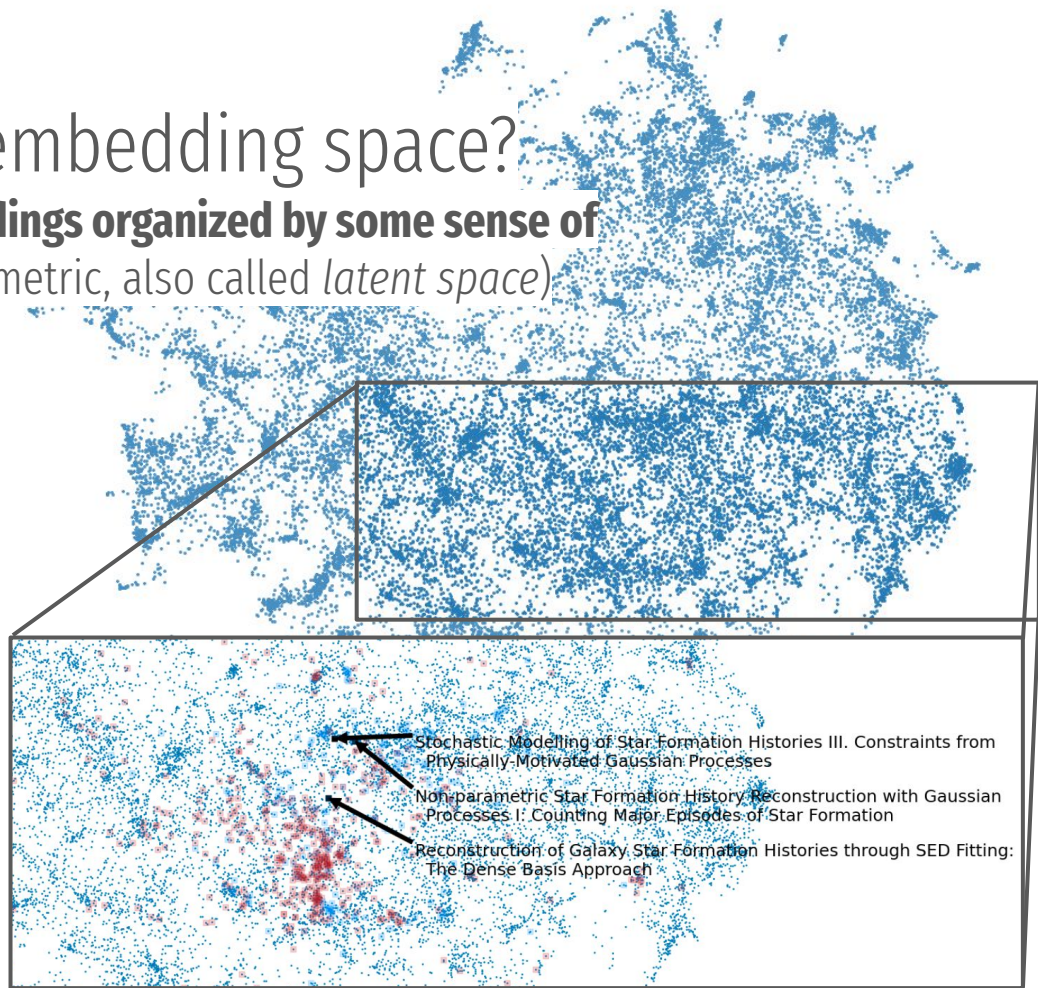
Retired space telescope that discovered thousands of exoplanets in a specific patch of sky.

NEAREST NEIGHBORS (SIMILAR CONCEPTS):

- | | |
|---------------------------|-------|
| 1. TESS | 86.8% |
| 2. Transit Method | 84.5% |
| 3. Very Large Array (VLA) | 81.6% |
| 4. Rubin Observatory | 80.4% |

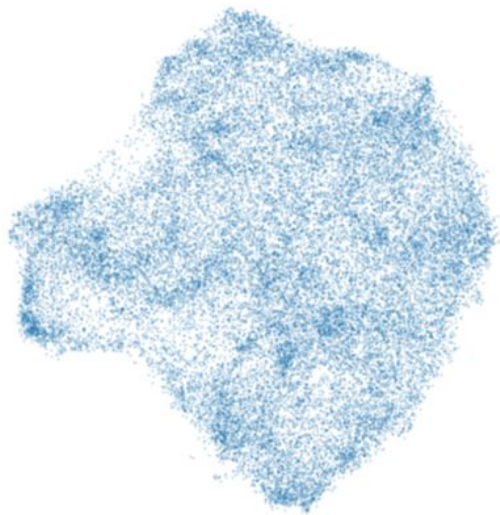
Reset View

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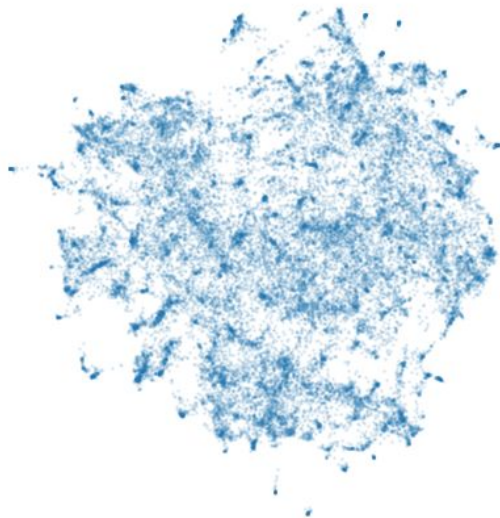


The embedding space **encodes what the model has learned**

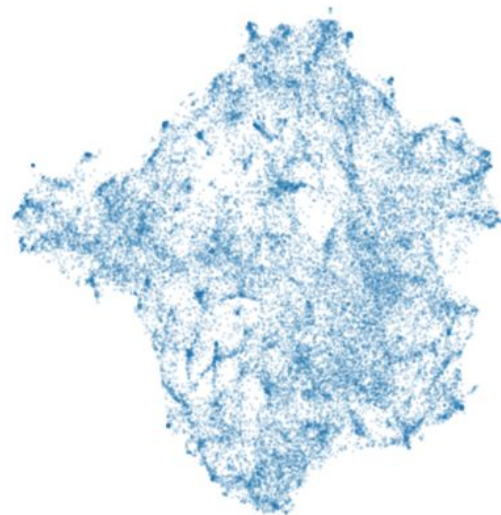
Doc2Vec



General LLM

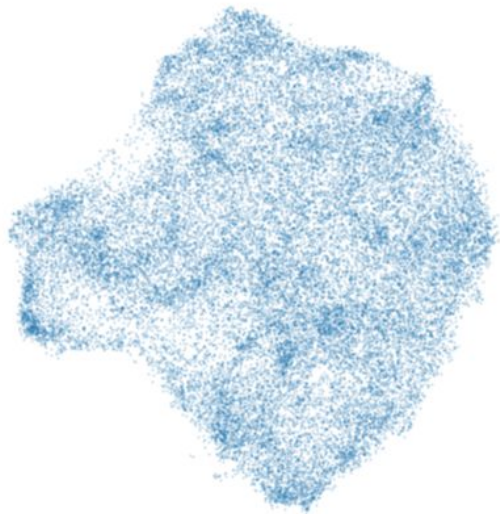


Fine-tuned LLM [AstroLLaMA]

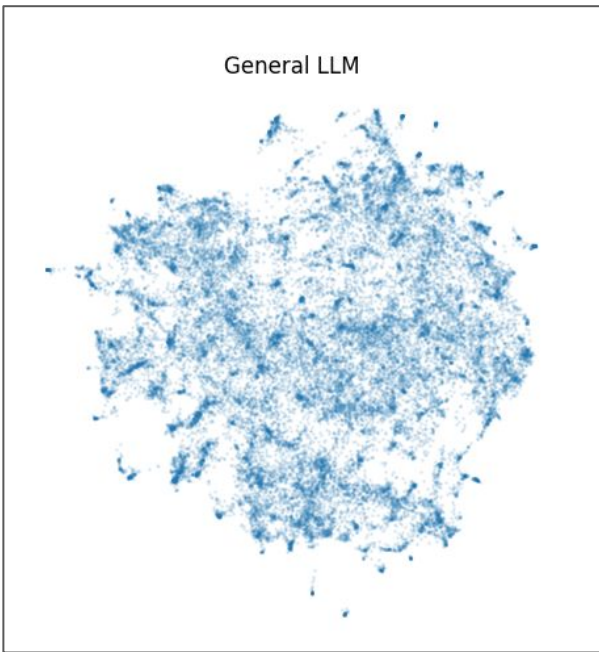


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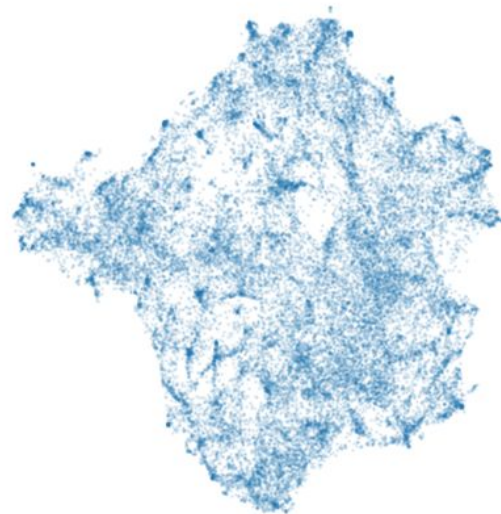
Doc2Vec



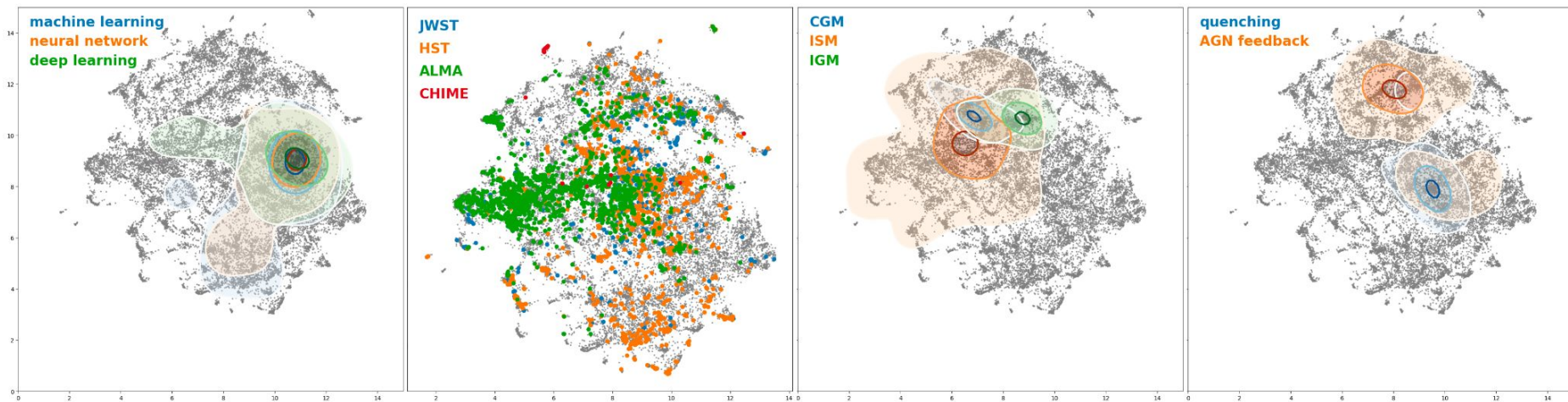
General LLM



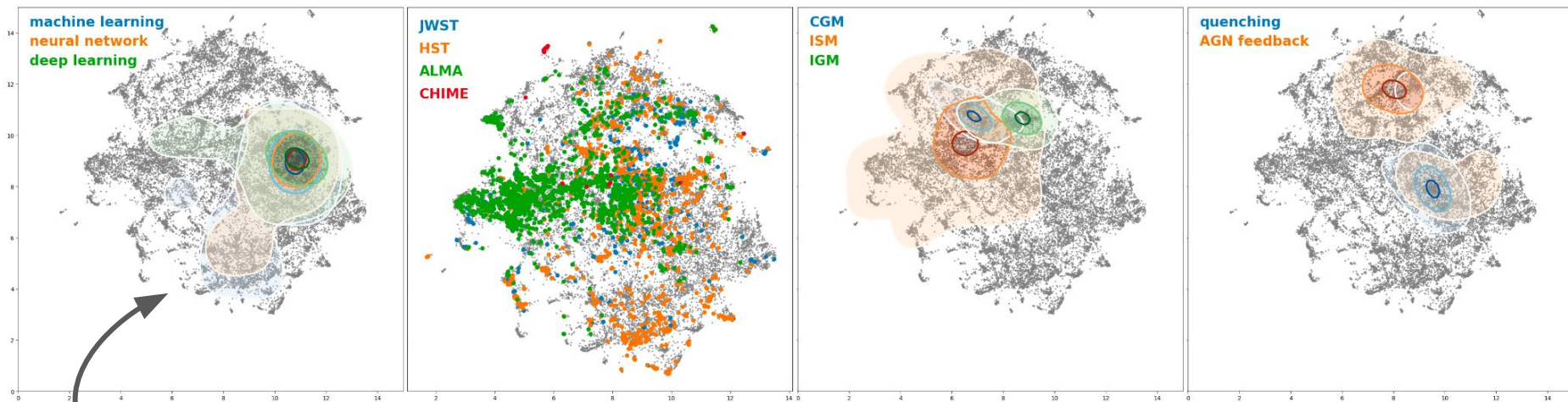
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An **interpretable** latent space

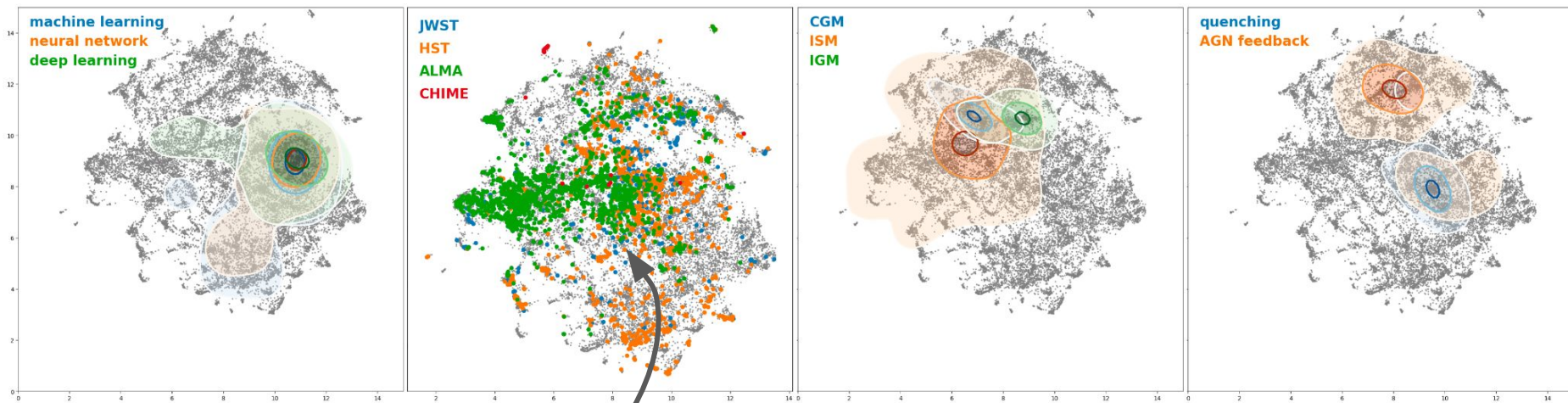


An **interpretable** latent space



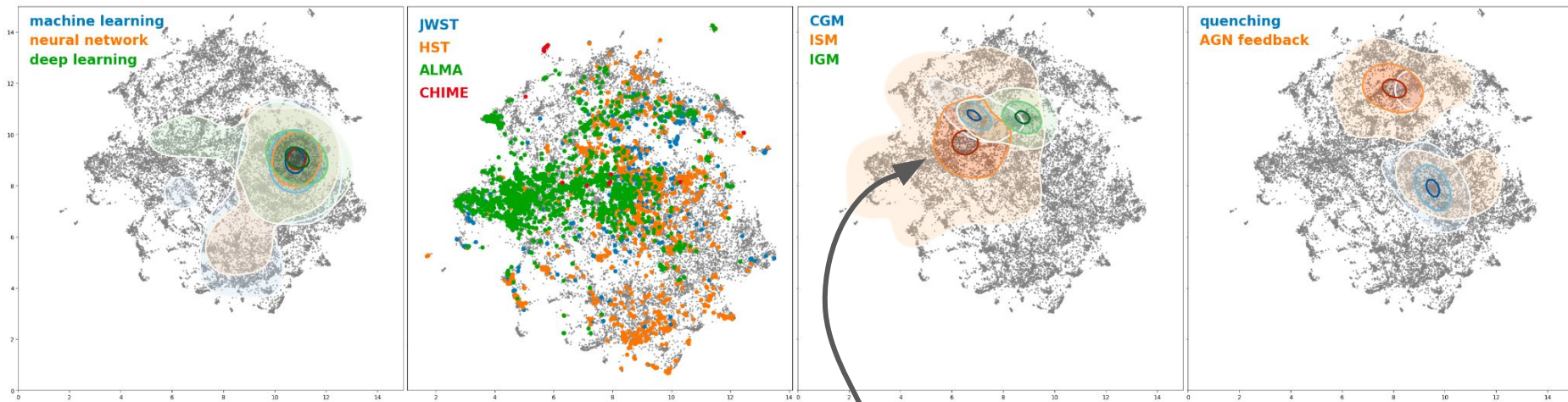
Nested semantic topics

An **interpretable** latent space



Papers focused on certain
telescopes/observatories

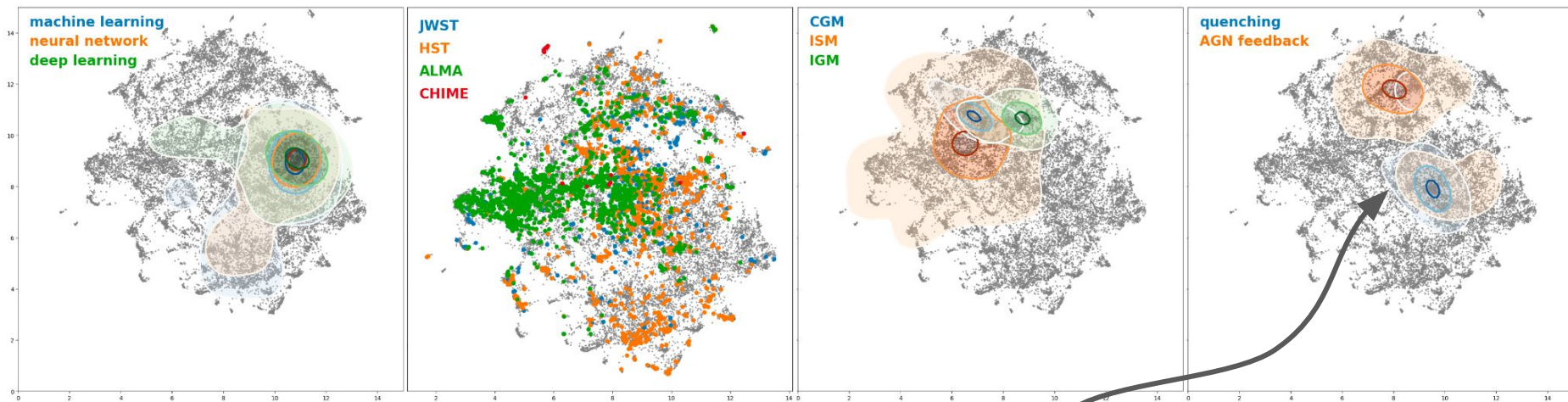
An **interpretable** latent space



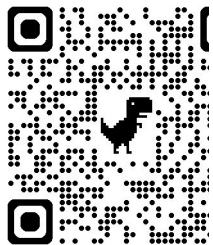
Different galactic neighborhoods

ISM: interstellar medium (within galaxies)
CGM: circumgalactic medium (around galaxies)
IGM: intergalactic medium (between galaxies)

An **interpretable** latent space



**Observable phenomenon
<-> physical mechanism**



Search papers b



Total Papers

166,381

Visible

141,111

Zoom Level

50.7x

Categories

- SUB
- star formation
- galaxies
- dark matter
- magnetic fields
- stars
- galaxy clusters
- X-ray emission
- NGC
- It

Extending the space to all astronomy papers

Key:

Mountains: well studied/established areas

Plains: fields of regular study

Shallow waters: currently active fields

Deep waters: no papers here

A map of the lands of astronomy papers

(astro-ph as on July 2024)
Browse at <https://pfdi.app/>



A map of the lands of **astronomy papers**

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Supernovae

Pulsars

Galaxy clusters

Gravitational
waves

Cosmic rays

Dark Energy

Gamma-ray
bursts

Dark Matter

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Try it out yourself at
<https://pfdr.app>



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Evolution over time

HST - 1990
SDSS - 1998
Chandra - 1999
Spitzer - 2003
Planck - 2009
Gaia - 2013
ALMA - 2013
JWST - 2021
Euclid - 2023

1951

Stellar physics

the
Milky Way
galaxy

Galaxy formation
& evolution

Black holes
& AGN

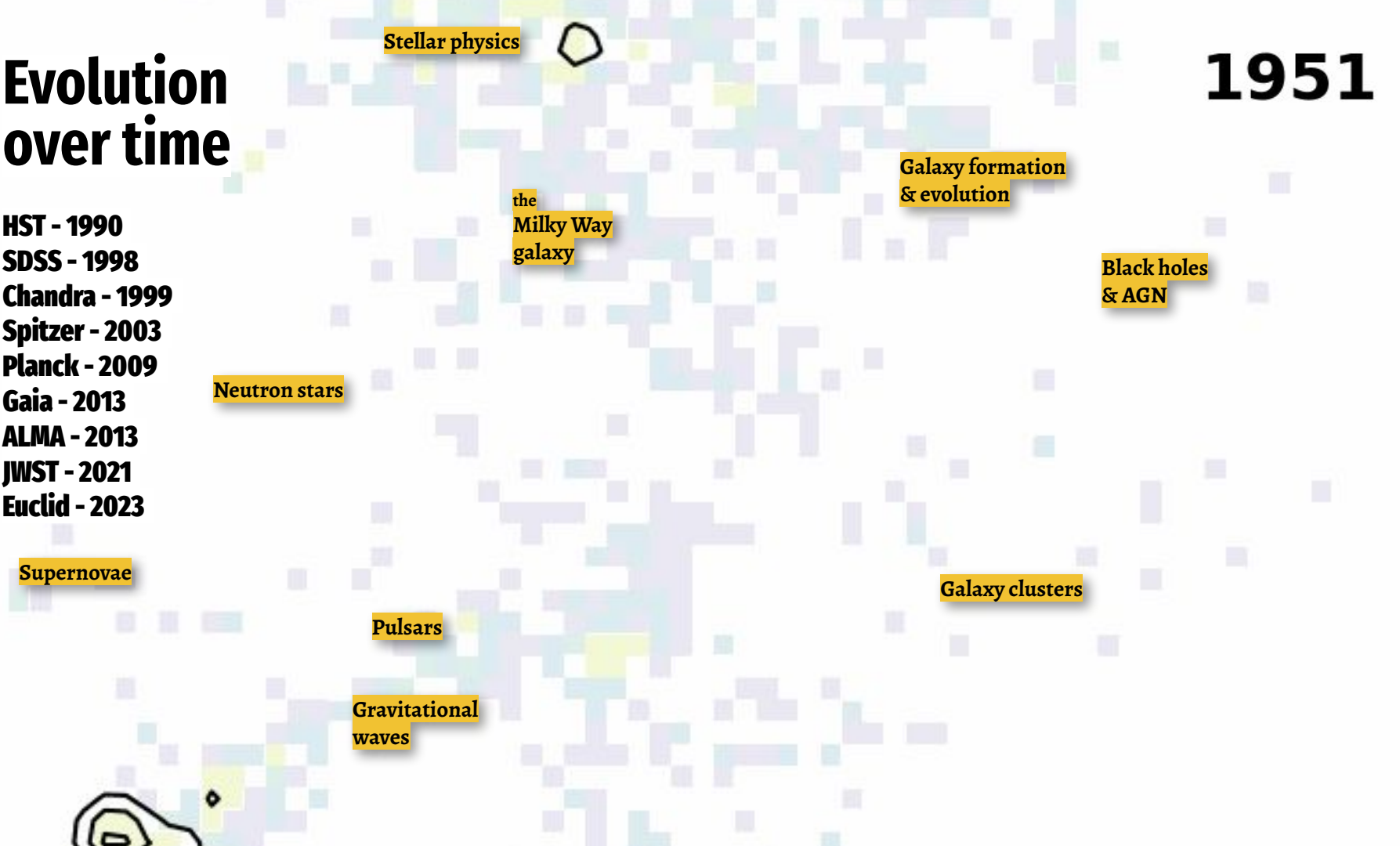
Neutron stars

Supernovae

Galaxy clusters

Pulsars

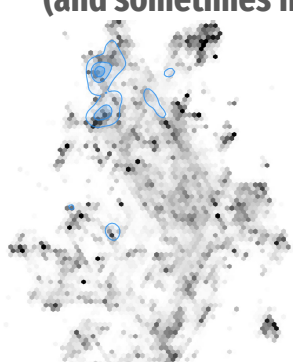
Gravitational
waves



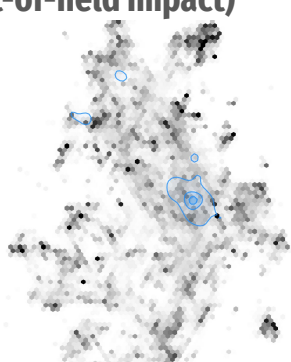
Explore the impact of **observatories/missions**

(and sometimes find out-of-field impact)

Juno(N: 125)
SDO(N: 622)
Parker(N: 458)
Kepler(N: 4420)
Gaia(N: 3309)
Gallex(N: 400)

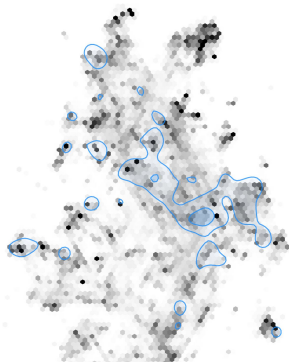


Kepler (planets)



GALEX (UV)

Gallex(N: 400)



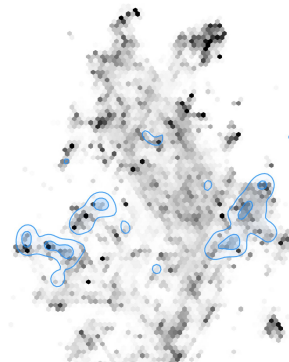
HST(N: 2773)

HST (UV-NIR)



ALMA (sub-mm)

ALMA(N: 287)



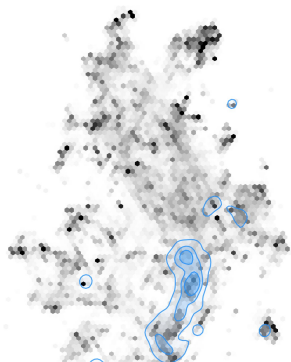
Chandra(N: 5277)

Chandra (X-ray)



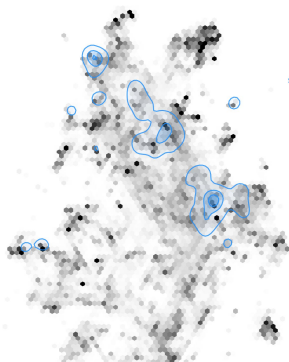
Planck (CMB)

Planck(N: 4033)



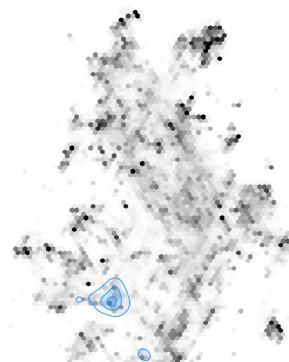
Euclid (Vis-NIR)

Euclid(N: 661)



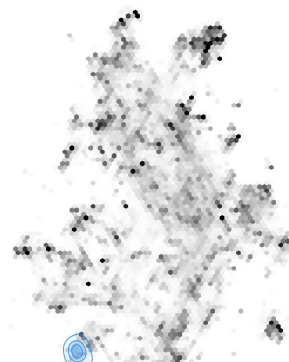
Spitzer(N: 2773)

Spitzer (IR)



LIGO (GWs)

LIGO(N: 182)



IceCube (neutrino)

IceCube(N: 1300)

A map of the lands of
astronomy papers

(astro-ph as on July 2024)
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What can we do with an embedding?
Grounded Q&A

Try it out yourself at
<https://pfdx.app>





OPEN ACCESS

pathfinder: A Semantic Framework for Literature Review and Knowledge Discovery in Astronomy

Kartheik G. Iyer, Mikael Yunus, Charles O'Neill, Christine Ye, Alina Hyk, Kiera McCormick, Ioana Ciucă, John F. Wu, Alberto Accomazzi, Simone Astarita [Show full author list](#)

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Authors Figures Tables References

Article information

Abstract

The exponential growth of astronomical literature poses significant challenges for researchers navigating and synthesizing general insights or even domain-specific knowledge. We present *pathfinder*, a machine learning framework designed to enable literature review and knowledge discovery in astronomy, focusing on semantic searching with natural language instead of syntactic searches with keywords. Utilizing state-of-the-art large language models (LLMs) and a corpus of 385,166 peer-reviewed papers from the Astrophysics Data System, *pathfinder* offers an innovative approach to scientific inquiry and literature exploration. Our framework couples advanced retrieval techniques with LLM-based synthesis to search astronomical literature by semantic context as a complement to currently existing methods that use keywords or citation graphs. It addresses complexities of jargon, named entities, and temporal aspects through time-based and citation-based weighting schemes. We demonstrate the tool's versatility through case studies, showcasing its



Paper:

<https://arxiv.org/abs/2408.01556>

<https://iopscience.iop.org/article/10.3847/1538-4365/ad7c43>

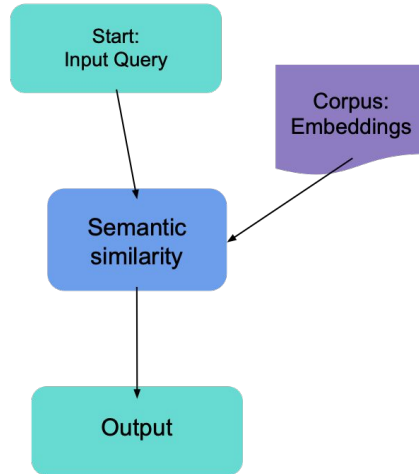
Online app:

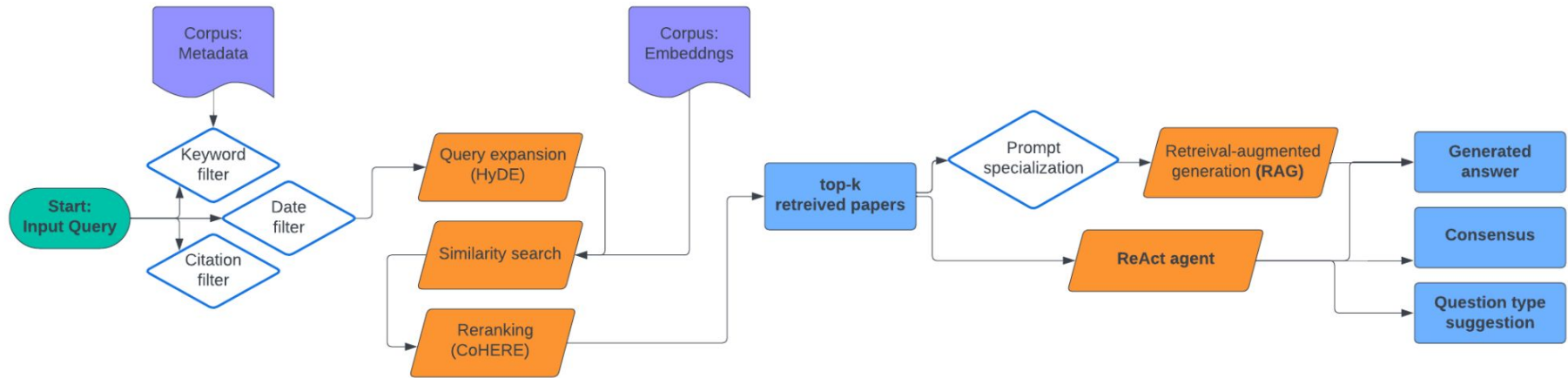
<http://v2.pfdr.app/>

<https://explorepfdr.netlify.app/>

Dataset:

https://huggingface.co/datasets/kiyer/pathfinder_arxiv_data





pathfinder

What is Pathfinder? / How do I use it?

Ask me anything

what is the highest redshift galaxy with a cold disc currently known?

top-k

Number of papers to retrieve

28

Optional Keywords (comma-separated)

Weight by

weighting retrieved papers



Keywords



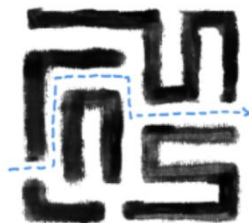
Time



Citations

Prompt Specialization

Image



Pathfinder

LLM enabled literature search

Run pfdr!

wha

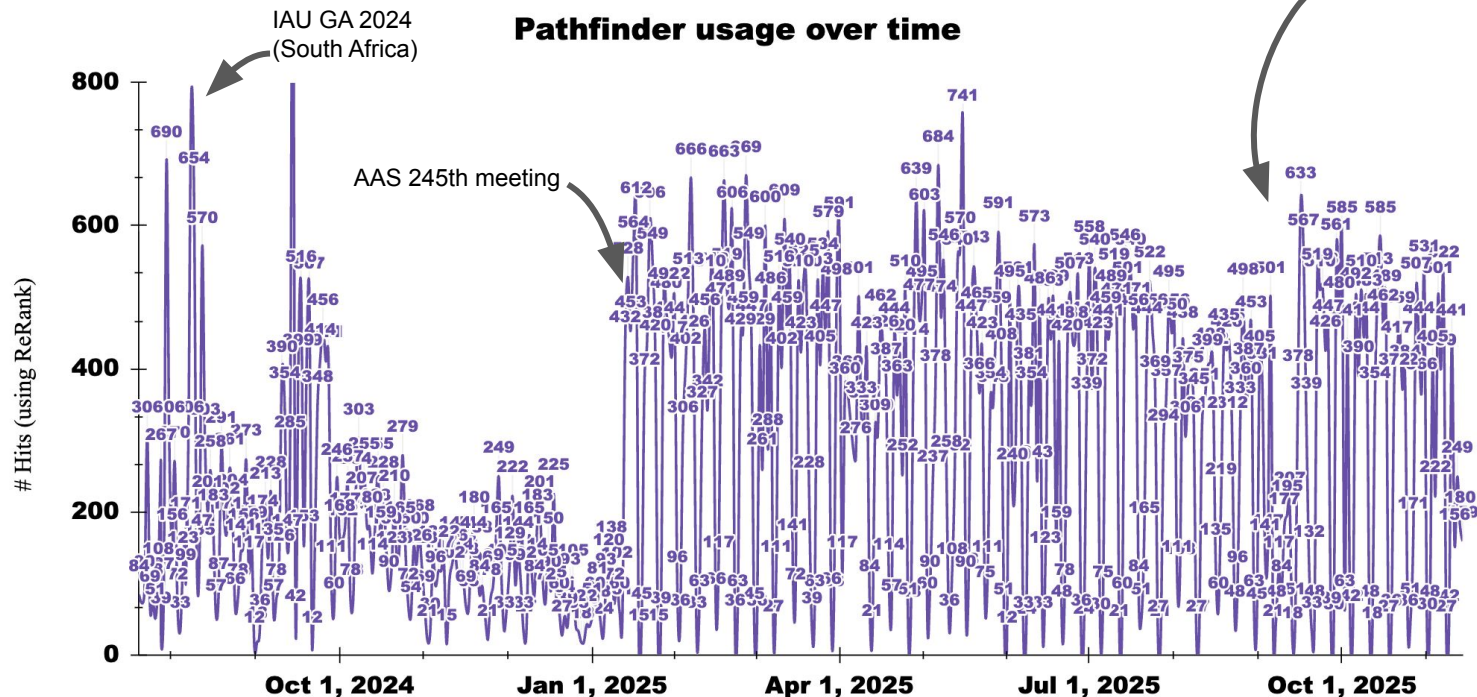
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**Crossed 100k uses
in Aug 2025!**

a dynamical

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pathfinder

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Ask me anything

what is the highest redshift galaxy with a cold disc current

top-k28

Number of papers to retrieve

Optional Keywords (comma-separated)

Weight by

weighting retrieved papers

☒ Keywords

☒ Time

☐ Citations

Prompt

2024arXiv240506025R0

The highest redshift galaxy with a

K what is the highest redshift disk galaxy currently known that has been kinematically confirmed to have a rotating disk?

Investigating highest redshift disk galaxy with rotating disk

🕒 3s ▾

I'll search for the most up-to-date information on this topic.

🌐 highest redshift disk galaxy kinematically confirmed rotating disk

10 results ▾

Based on the search results, the highest redshift disk galaxy that has been kinematically confirmed to have a rotating disk appears to be REBELS-25, which is located at redshift $z = 7.3$.

According to research published in October 2024, REBELS-25 existed when the Universe was only about 700 million years old, making it "the most distant strongly rotating disk galaxy ever discovered." [Astronomers Discover Mos...](#) The galaxy was initially detected using the Atacama Large Millimeter/submillimeter Array (ALMA), with follow-up observations at higher resolution confirming its rotating disk nature.

The researchers noted that REBELS-25 appears surprisingly orderly for a galaxy from such an early cosmic epoch. The high-resolution ALMA observations not only confirmed its rotation but also hinted at more developed features similar to those in the Milky Way, including possibly a central elongated bar and even spiral arms. though more observations would be



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- Extracts data and analyzes all the relevant papers from 200 million papers database
- Comprehensive answers generated by analyzing the 10 most relevant papers with proper citations

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Undermind finds the papers others miss, helping you

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e.g. research topic

Research my topic



Ask me anything

what is the hubble tension? ELI5

The Hubble tension is a disagreement among scientists about how fast the universe is expanding. Imagine blowing up a balloon: the speed at which it expands can be measured in different ways. Some measurements, like those using supernovae (exploding stars), suggest the universe is expanding faster than other measurements that rely on the early universe's conditions, like the cosmic microwave background radiation. This difference in speed estimates is what we call the Hubble tension. It's a big puzzle in cosmology because it suggests there might be something we don't fully understand about the universe.



Paper:

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Online app:

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Dataset:

https://huggingface.co/datasets/kiyer/pathfinder_arxiv_data





Ask me anything

write me a sonnet about the hubble tension

In cosmos vast, where stars and galaxies gleam,
A tension brews, a riddle to unfold,
The Hubble constant, once a simple dream,
Now whispers secrets that the night has told.

From distant realms, the light of ages past,
In cosmic dance, the universe expands,
Yet local measures clash, a shadow cast,
As time and space slip through our eager hands.

With supernovae, we chart the skies so wide,
But early echoes from the cosmic dawn,
Reveal a gap, a chasm deep and wide,
Where theories clash, and certainties are drawn.

Oh, Hubble tension, challenge bold and bright,
In your embrace, we seek the truth of light.



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Ask me anything

tell me about the hubble tension in spanish

La "tensión de Hubble" es un problema significativo en la cosmología moderna que se refiere a la discrepancia aparente en las mediciones de la constante de Hubble (H_0). Esta constante mide la tasa de expansión del universo. Existen dos enfoques principales para determinar H_0 : las mediciones locales, que utilizan supernovas tipo Ia y otras técnicas, y las inferencias basadas en la radiación cósmica de fondo, que se relacionan con el modelo estándar de cosmología (Λ CDM).

Las mediciones locales sugieren un valor de H_0 de aproximadamente 73 km/s/Mpc, mientras que las inferencias del modelo cosmológico dan un valor cercano a 67 km/s/Mpc. Esta discrepancia, conocida como la tensión de Hubble, plantea preguntas sobre nuestra comprensión del universo y su evolución. A pesar de los esfuerzos por resolver esta discrepancia, sigue siendo uno de los desafíos más importantes en la cosmología actual.



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top-k retrieved papers

date	cites	title
2023-07-01	3	Improving constraints on models addressing
2020-11-01	96	Running Hubble tension and a H_0 diagnostic
2022-01-01	12	The Ellipsoidal Universe and the Hubble ten
2025-01-10	0	On the True Significance of the Hubble Tens
2021-05-01	4	Cosmological analysis using Panstarrs data:
2026-01-03	0	A model-independent measurement of the Hubble
2022-07-01	4	Another look on the connections of Hubble t
2023-02-01	13	Questioning the H_0 tension via the look-bac
2025-01-12	3	Revisiting the Hubble tension problem in th
2023-01-11	4	Supernova calibration by gravitational wave

Pathfinder

LLM enabled literature search

Ask me anything

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tell me about the hubble tension in spanish





LLM enabled literature search

Ask me anything

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What can **Pathfinder** currently do?

Access *pathfinder* online at **pfd.r.app**

Pathfinder: *Papers in Astronomy Traced and Harnessed For INtelligent Discovery, Exploration, and Research?*
<https://arxiv.org/abs/2408.01556>

- > **Find similar papers** given a natural language query
- > **Synthesize information / answer questions** from paper abstracts
 - > **Fine tune search** by keywords/recency/citations
 - > **Explore** the landscape of astronomy literature
 - > **Translate, simplify and contextualize** results
- > **Quantify trends** in research, mission impact, and more



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astrophysics
data system

In theory, **factually grounding an LLM** is quite straightforward:

1. Feed the model context
along with your question

**2. Get the model to
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context in its response**

3. Verify that it's actually
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bits of the context.

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2a. If possible, directly determine which parts of context are used.

2b. If not, feed the answer and context into a model/schema and correlate

Case studies: What are the physical mechanisms that quench star formation in galaxies?

Multi-paper synthesis questions

Star formation in galaxies can be quenched by several physical mechanisms, including:

1. Environmental Effects:

- **Ram Pressure Stripping:** This occurs when a galaxy moves through a dense medium, such as a galaxy cluster, causing gas to be stripped away, which can halt star formation.
- **Galaxy Mergers and Interactions:** Mergers can lead to the redistribution of gas and trigger intense star formation initially, but can also result in the depletion of gas and quenching over time.

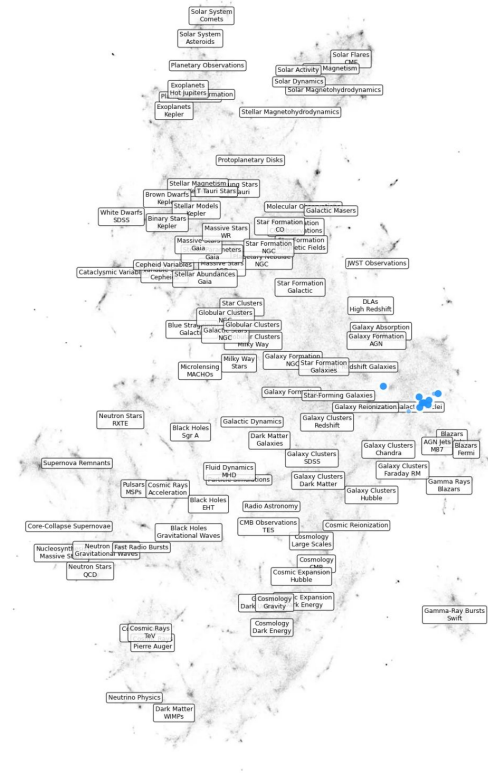
2. Internal Processes:

- **Feedback from Star Formation:** Energy and momentum from supernovae and stellar winds can heat the surrounding gas, preventing it from cooling and collapsing to form new stars.
- **Active Galactic Nuclei (AGN) Feedback:** The energy output from supermassive black holes at the centers of galaxies can expel gas and heat it, suppressing star formation.

3. **Gas Exhaustion:** Over time, a galaxy can exhaust its supply of cold gas needed for star formation, especially in massive galaxies where star formation rates are high.

4. **Stellar Population Effects:** As a galaxy evolves, the stellar population changes, and the presence of older stars can lead to a decline in star formation activity.

These mechanisms can act individually or in combination, and their relative importance can vary depending on the specific conditions of the galaxy and its environment. Understanding these processes is crucial for studying galaxy evolution and the lifecycle of galaxies.



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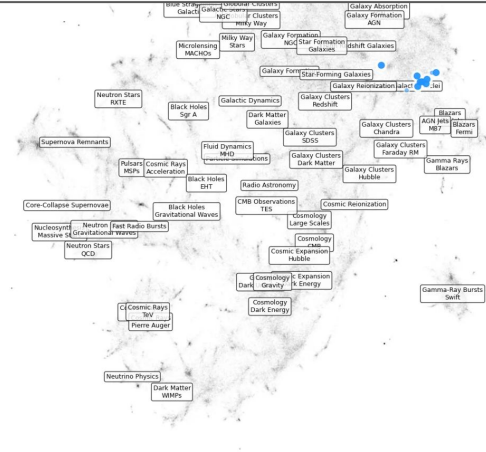
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1	The EDGE-CALIFA survey: exploring the role of ...	[Colombo, D., Sanchez, S. F., Bolatto, A. D., ...]	1.498210	2020-09-01	31
2	How is star formation quenched in massive gala...	[Gabor, J. M., Davé, R., Finlator, K., Oppenhe...	1.398462	2010-01-01	84
3	Towards a physical picture of star formation q...	[Mendel, J. Trevor, Simard, Luc, Ellison, Sara...	1.299720	2012-11-01	63
4	Spatially resolved signature of quenching in s...	[Quai, Salvatore, Pozzetti, Lucia, Moresco, Mi...	1.287702	2019-10-01	9
5	Significance of bar quenching in the global qu...	[George, K., Subramanian, S., Paul, K. T.]	1.246831	2019-07-01	10
6	Star Formation Quenching Timescale of Central ...	[Hahn, ChangHoon, Tinker, Jeremy L., Wetzel, A...	1.238143	2016-09-01	40
7	Star-forming early-type galaxies and quiescent...	[Paspaliaris, E. -D., Xilouris, E. M., Nersesi...	1.216826	2022-09-01	16
8	The role of stochastic and smooth processes in...	[Kipper, Rain, Tamm, Antti, Tempel, Elmo, de P...	1.193953	2021-01-01	10
9	Bar quenching in gas-rich galaxies	[Khoperskov, S., Haywood, M., Di Matteo, P., L...	1.182370	2017-09-01	87
10	When the Milky Way turned off the lights: APOG...	[Haywood, M., Lehnert, M. D., Di Matteo, P., S...	1.170259	2016-01-01	131



Case studies: What are the physical mechanisms that quench star formation in galaxies?

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'Ram Pressure Stripping (environmental effect)',
'Galaxy Mergers and Interactions (environmental effect)',
'Feedback from Star Formation (internal process)',
'Active Galactic Nuclei (AGN) Feedback (internal process)',
'Gas Exhaustion (internal process)',
'Stellar Population Effects (internal process)'

Case studies: What are the physical mechanisms that quench star formation in galaxies?

Highlights Legend: evidence

class: evidence
attributes: {claim_supported: Active Galactic Nuclei (AGN) Feedback (internal process), paper_id: Paper 1}

Paper 1: Colombo et al. (2020), titled: The EDGE-CALIFA survey: exploring the role of molecular gas on galaxy star formation quenching

Abstract: Understanding how galaxies cease to form stars represents an outstanding challenge for galaxy evolution theories. **This process of "star formation quenching" has been related to various causes, including active galactic nuclei activity**, the influence of large-scale dynamics, and the environment in which galaxies live. In this paper, we present the first results

, such

triggering over

r winds

Highlights Legend: evidence

class: evidence
attributes: {claim_supported: Gas Exhaustion (internal process), paper_id: Paper 3}

actively forming stars. Afterwards, the star formation resumed at a much lower level to form the thin disk. These events observed in our Galaxy are very well matched by the latest observation of MW-type progenitors at high redshifts. **In late-type galaxies, the quenching mechanism is believed to be related to a long and secular exhaustion of gas.** Our results show that in the Milky Way, the shut-down occurred on a much shorter timescale, while the chemical continuity between the stellar populations formed before and after the quenching indicates that it is not the exhaustion of the gas that was responsible for the cessation of the star formation. While quenching is generally associated with spheroids in the literature, our results show that it also occurs in galaxies like the Milky Way

► Play ◀◀ Previous ▶▶ Next

Entity 17/18 | Pos [20379-20492]

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Grounding claims with LangExtract

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'Feedback from Star Formation (internal process)',
'Active Galactic Nuclei (AGN) Feedback (internal process)',
'Gas Exhaustion (internal process)',
'Stellar Population Effects (internal process)'

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>  Core Concepts > Metrics > Available Metrics

List of available metrics

 Copy page

Ragas provides a set of evaluation metrics that can be used to measure the performance of your LLM application. These metrics are designed to help you objectively measure the performance of your application. Metrics are available for different applications and tasks, such as RAG and Agentic workflows.

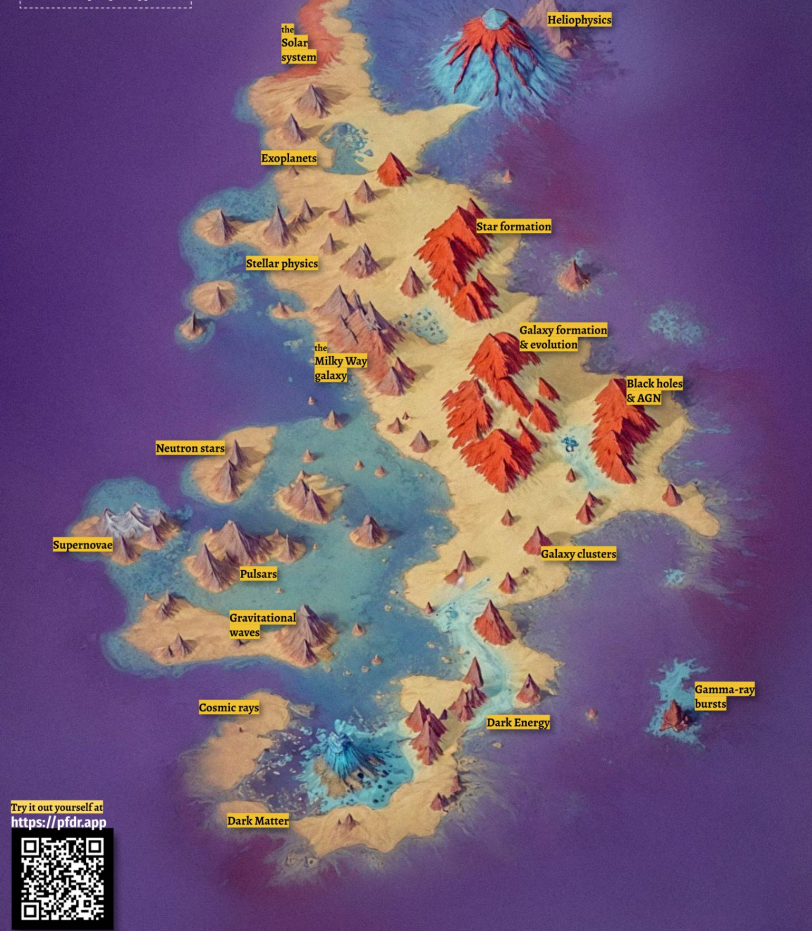
Each metric are essentially paradigms that are designed to evaluate a particular aspect of the application. LLM Based metrics might use one or more LLM calls to arrive at the score or result. One can also modify or write your own metrics using ragas.

Retrieval Augmented Generation

- Context Precision
- Context Recall
- Context Entities Recall
- Noise Sensitivity
- Response Relevancy
- Faithfulness
- Multimodal Faithfulness
- Multimodal Relevance

A map of the lands of astronomy papers

(astro-ph as on July 2024)
Browse at <https://pfdx.app/>



Try it out yourself at
<https://pfdx.app>



State-of-the-art Getting RAG to work **at scale**

Linear vs graph-RAG

Query Expansion

Reranking

Hybrid searches
(e.g. plain RAG vs RAG+BM25)

Agentic RAG setups

Harnesses and tool calls

[Demo on Colab](#)

Citation grounding, RAG and other ways
to make LLMs show their sources

Summary & Conclusions

As the volume of literature grows with increasing data & increases in problem complexity necessitate interdisciplinary collaboration, **academic literature becomes increasingly difficult to stay up-to-date with.**

Large language and vision models can help create efficient recovery and synthesis tools to assist researchers, **grounded by techniques that mitigate risk and help verify the accuracy** of generated responses. Try [v2.pfdr.app](#) and [lodestone.wiki](#)

Astronomy provides a vital testing ground for these techniques, while also aiding in astrophysical research.

Being aware of the strengths and pitfalls of these models and approaches will be vital as they become larger parts of our lives.

Get in touch! kiyer@hawaii.edu, or at universetbd.org





LLM enabled literature search

Research Question

LLM enabled literature search - e.g., 'How is machine learning used in astronomy?'

Search Parameters

Papers to retrieve: 10

Additional Keywords

comma-separated keywords

Analysis Type

- Single Paper Focus
Questions that need ~1 paper to answer
- Multi-Paper Analysis**
Synthesize across multiple papers
- Bibliometric Analysis
Citation and trend analysis, ADS queries
- Broad & Nuanced
Complex, multi-faceted questions
- Deep Research

Search Method

- Semantic Search
Basic semantic similarity
- Semantic + HyDE
With hypothetical document embedding
- Semantic + Rerank
With Cohere reranking
- Full Pipeline**
All enhancement methods

Lodestone vo.6

Search

Explorer

- > AGN
- > Cosmology
- > Data Science
- > Dust
- > Early Universe
- > Feedback
- > Galaxy Demographics
- > Galaxy Evolution
- > Galaxy Properties
- > General
- > Instrumentation
- > ISM & Gas
- > Scaling Relations
- > SED Fitting
- > Simulations
- > Spectral Lines
- > Spectroscopy

Lodestone

Mar 06, 2026, 3 min read

>>> Something missing or wrong? Suggest an edit on [GitHub](#), or provide [feedback](#).



A living encyclopedia of astrophysics and cosmology, built from the research literature.

Lodestone is an automatically generated wiki drawn from thousands of peer-reviewed papers in galaxy evolution, cosmology, and observational astrophysics. Each page synthesizes findings from across the literature into a coherent narrative, tracing how our understanding of a concept has developed over time, where consensus exists, and where open questions remain.