Exploring the Strong Coupling Through Natural Language Processing

Patrick L.S. Connor, **Antonin Sulc**

Hamburg, 21.02.2024

HELMHOLTZ

Strong Coupling

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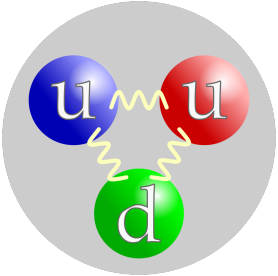

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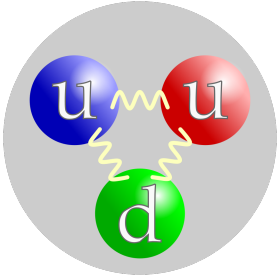

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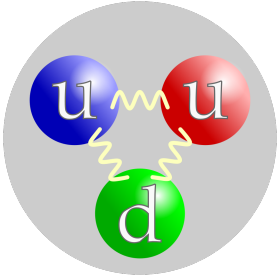

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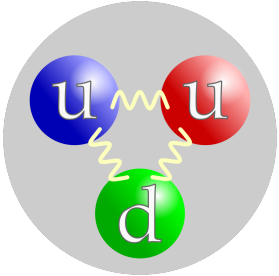
- Yet it is one of the least known parameters (only known at percent-level accuracy).



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Approach

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- Build and analyse the citation graph.

Approaches

Embedding

Analysis of semantic similarity through vector representation of abstracts.

`...Space-Time Geometry Using Young diagrams...` $\rightarrow \mathbf{e} = [0.1, 0.3, -0.2 \ldots]$

`...Status of NNLO 3-jet calculations..` $\rightarrow \mathbf{e} = [0.1, -0.3, 0.2 \ldots]$

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Topic Modeling

”Clustering” of abstracts and extraction of their most characteristic words.

`...Space-Time Geometry Using Young diagrams...` $\rightarrow Topic_1 = \{young, diagram\}$

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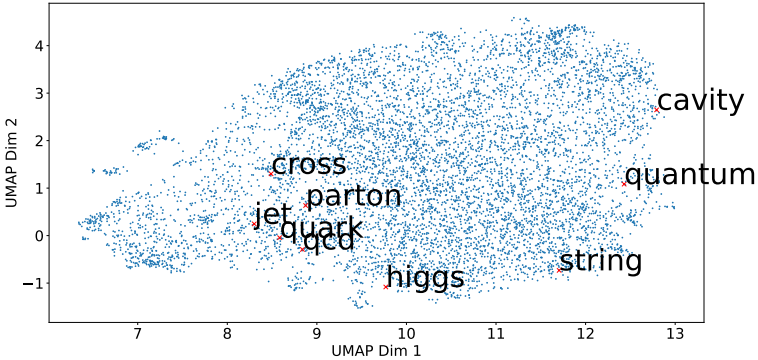
Citation Graph

Building a directed graph on citations and identification of important nodes in this graph.

Word Embedding

Representing individual words as vectors.

$$\texttt{cavity} \rightarrow \mathbf{w} = [0.1, -1, 2, \dots]$$
$$\texttt{qcd} \rightarrow \mathbf{w} = [0.2, 0.8, 1.8, \dots]$$
$$\texttt{photon} \rightarrow \mathbf{w} = [0.18, 1.1, 1.8, \dots]$$

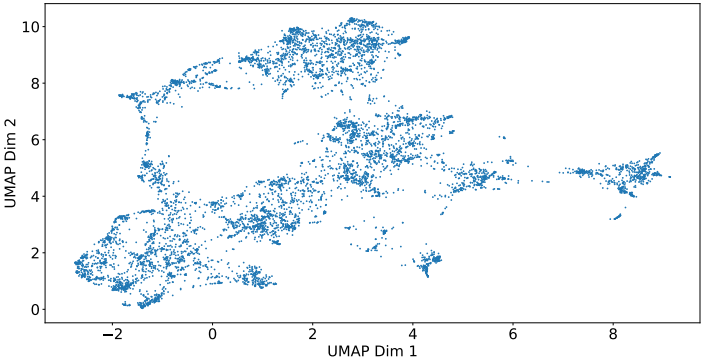


Sentence Embedding

Representing sentences as vectors.

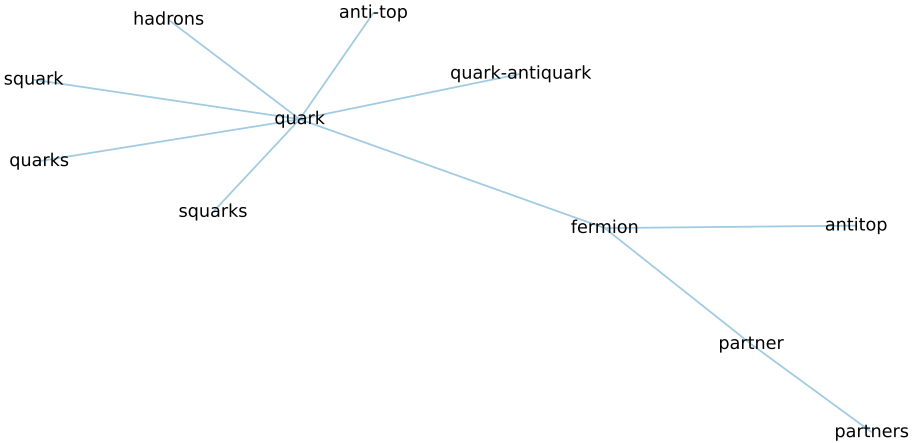
`...using Young ...` $\rightarrow \mathbf{e} = [0.1, \ldots]$

`...NNLO 3-jet ...` $\rightarrow \mathbf{e} = [0.8, \ldots]$



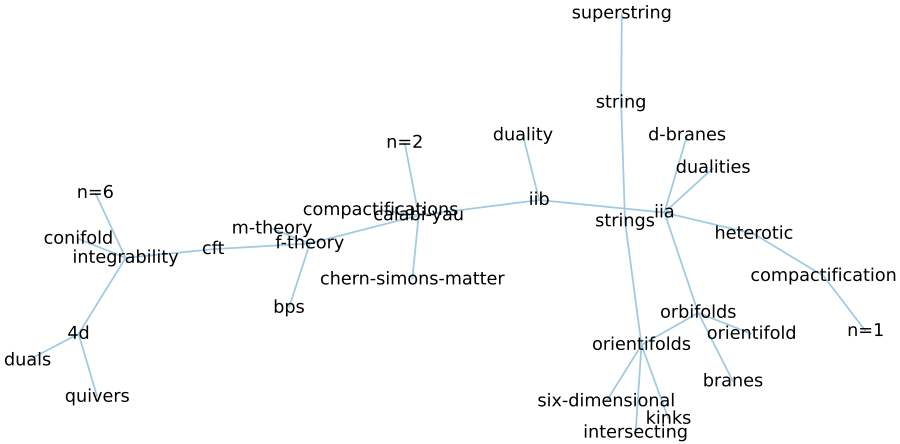
Word Embedding - Quark Similarity Graph

Quark



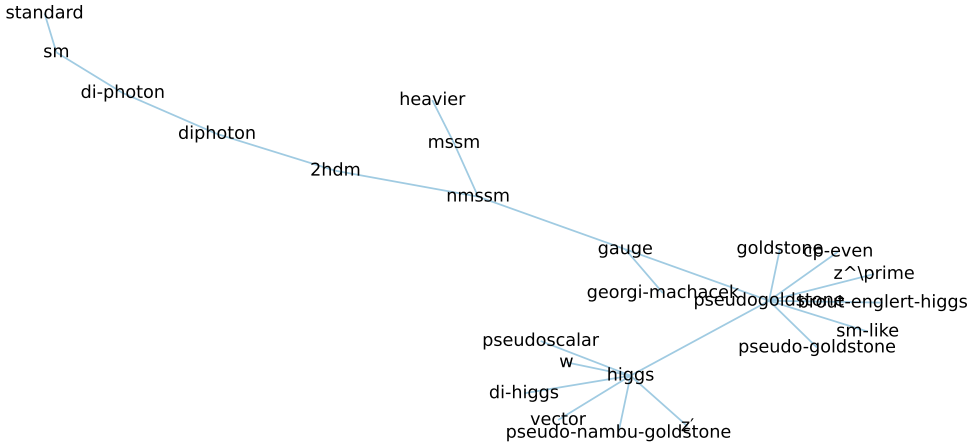
Word Embedding - String Similarity Graph

String

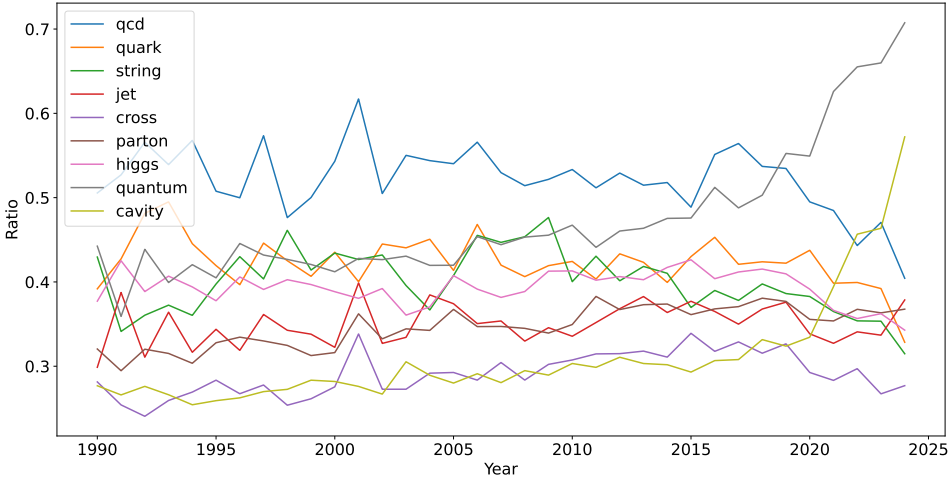


Word Embedding - Higgs Similarity Graph

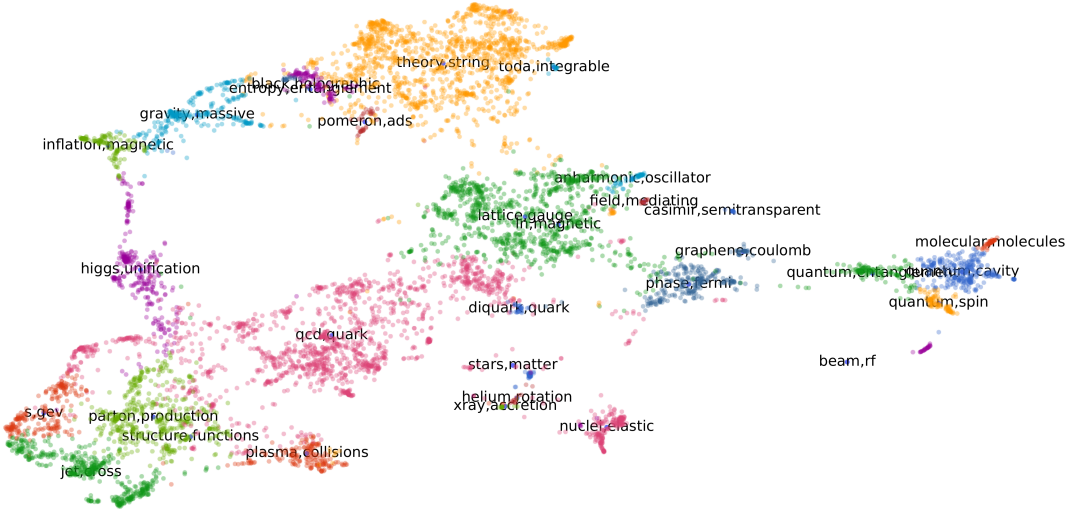
Higgs



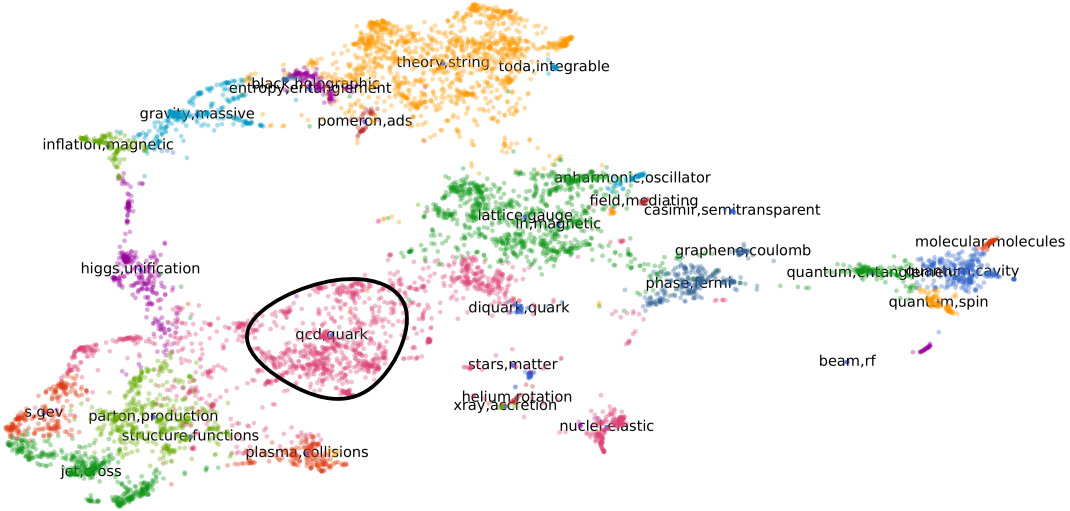
Trends of Selected Words



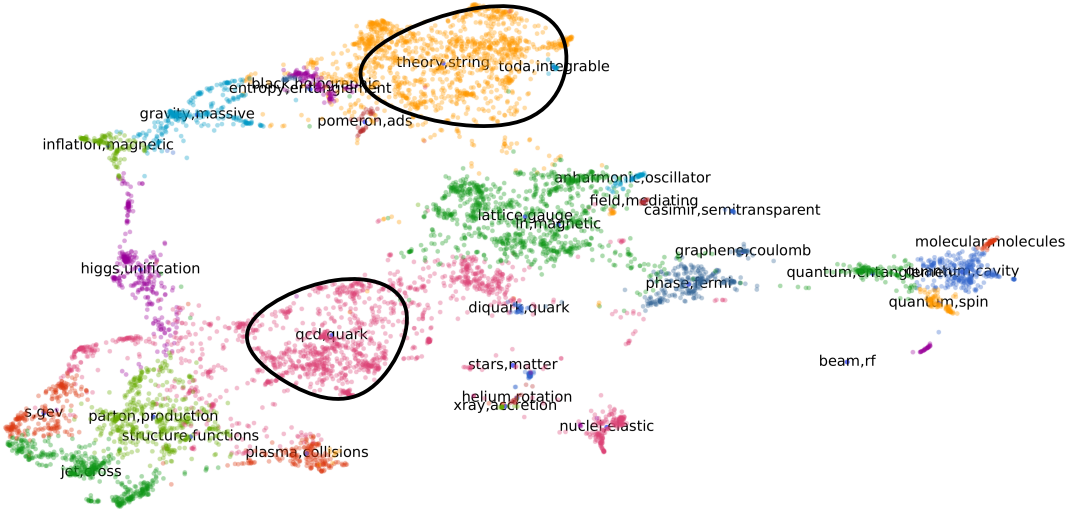
Topic Modelling



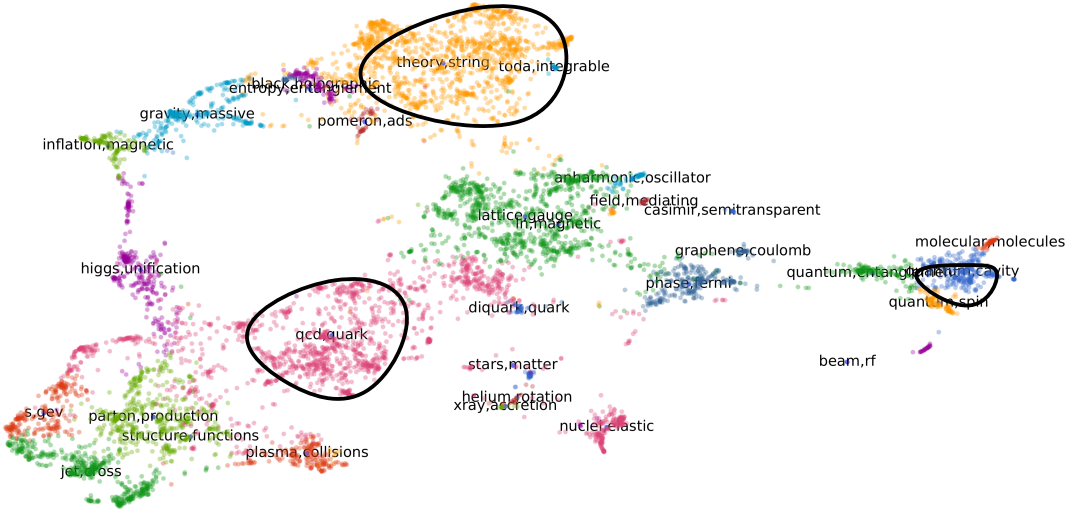
Topic Modelling - QCD, Quark



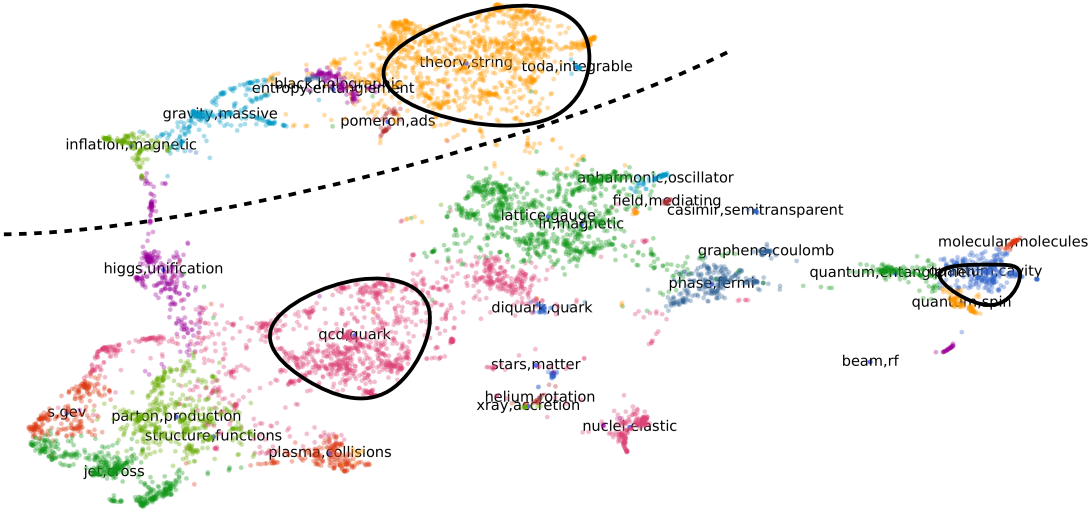
Topic Modelling - String Theory



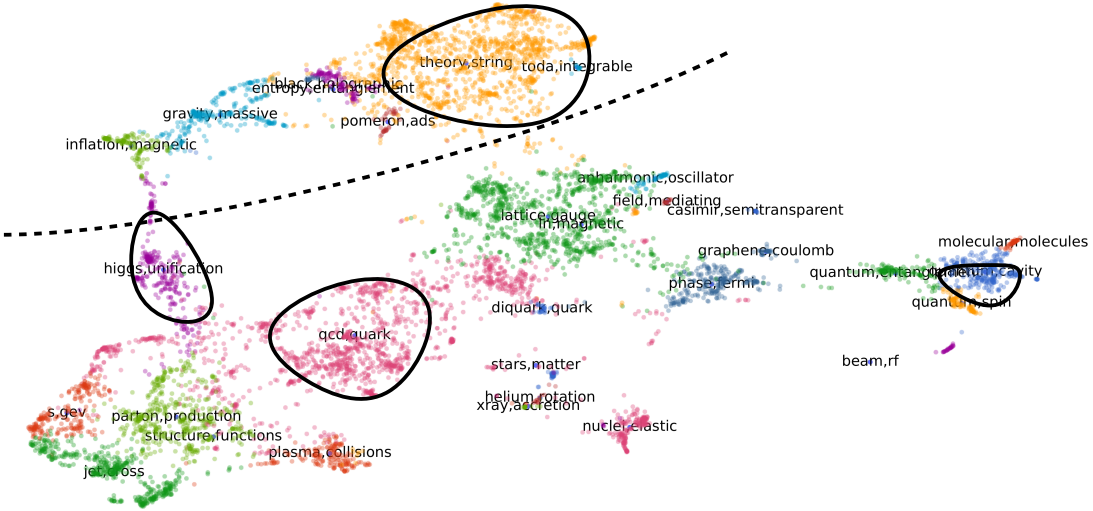
Topic Modelling - Quantum



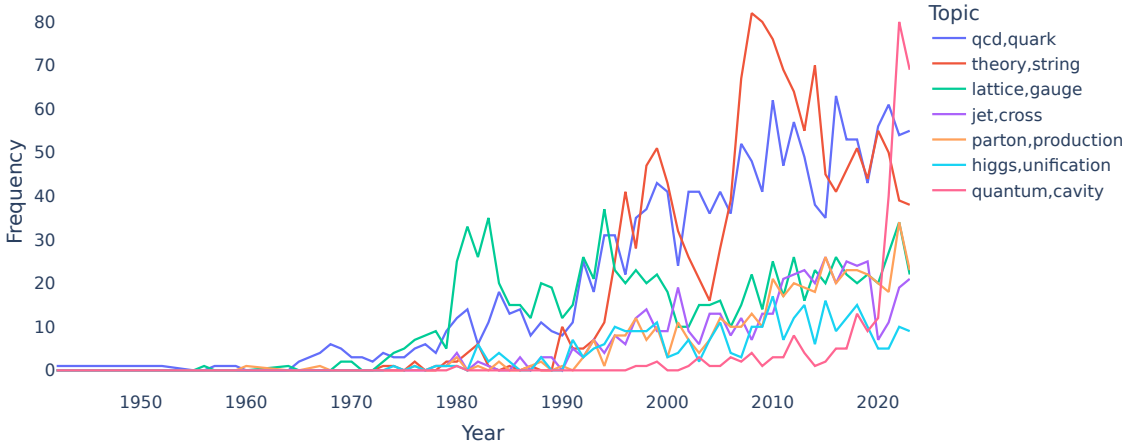
Topic Modelling - Border



Topic Modelling - Higgs, Unification



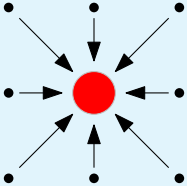
Topics over Time



Analysis of Citation Graph - Degree Centrality

Degree centrality

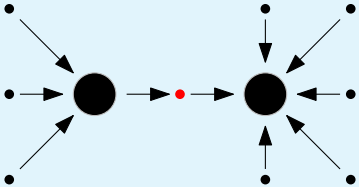
Most cited papers



- **0.043** `Gauge theory correlators from noncritical string theory`
- **0.015** `Confinement of Quarks`
- **0.014** `The Shear viscosity of strongly coupled N=4 supersymmetric Yang-Mills plasma`

Analysis of Citation Graph - Between-ness Centrality

Between-ness centrality

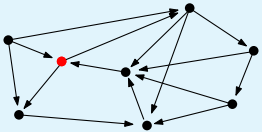


> **0.22** Confinement of Quarks
> **0.21** Gauge theory correlators from noncritical string theory
> **0.08** The QCD Running Coupling

Analysis of Citation Graph - PageRank

PageRank centrality

A node with high PageRank means: routes to other nodes, and has many visits over iterative passes.



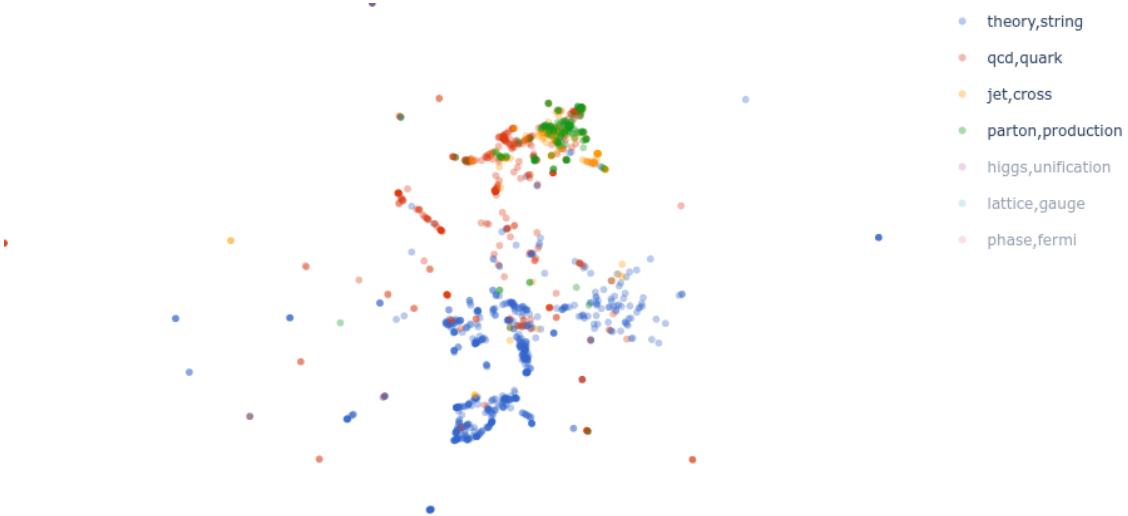
- **0.005** `Gauge theory correlators from noncritical string theory`
- **0.003** `Cavity quantum electrodynamics`
- **0.002** `Confinement of Quarks`

Citation Graph Embedding - {Theory, String,...} Topic

Citation Graph Embedding - {QCD, Quark,...} Topic

Citation Graph Embedding - {Jet, Cross,...} Topic

Citation Graph Embedding - {Parton, Production,...} Topic



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Citation Graph

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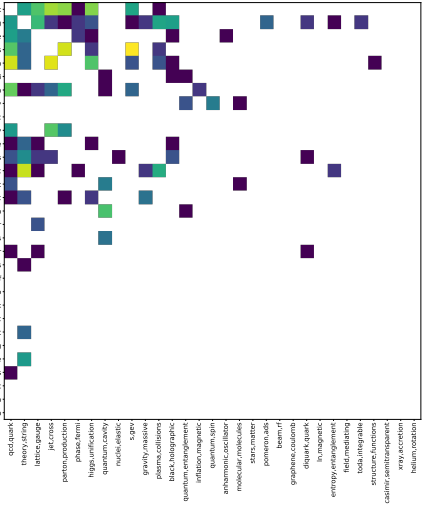

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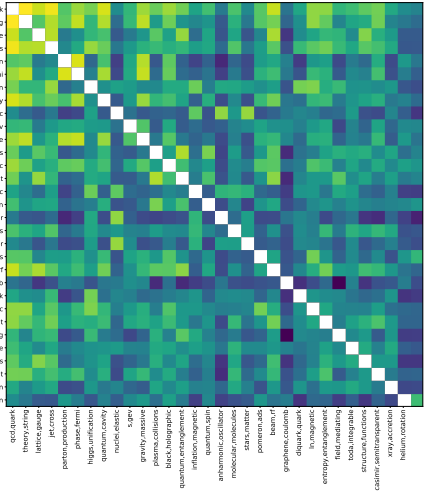

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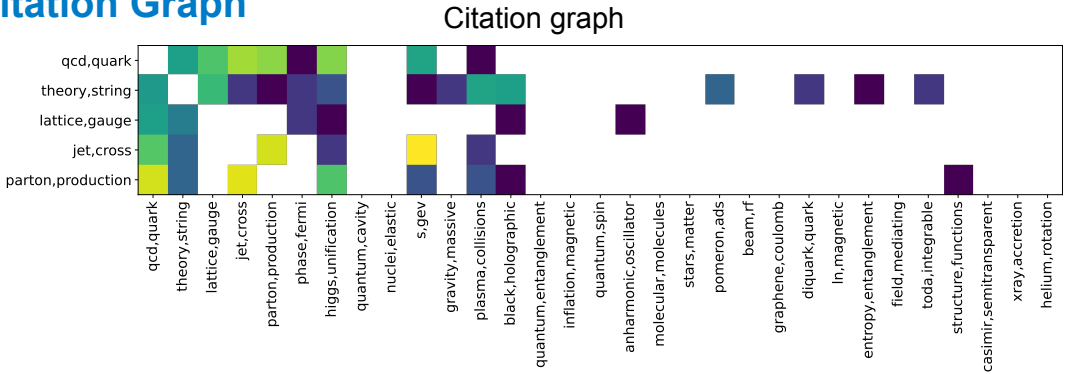

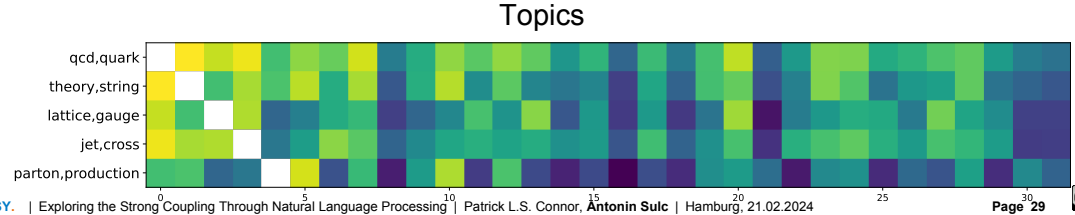

Conclusion & Summar

- You heard about embedding of abstracts into vectors.
- You learned about (unsupervised) topic modelling of the current **string coupling** publication landscape from InspireHEP.
- You saw that you can built knowledge graph just based data from abstracts.
- You learned something about about community and citations.

Future Work

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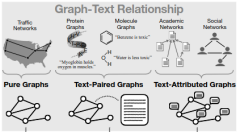
Large Language Models on Graphs: A Comprehensive Survey

Bowen Jin*, Gang Liu*, Chi Han*, Meng Jiang, Heng Ji, Jiawei Han

Abstract—Large language models (LLMs), such as GPT4 and LLaMA, are creating significant advancements in natural language processing, due to their strong text encoding/decoding ability and newly found emergent capability (*e.g.*, reasoning). While LLMs are mainly designed to process pure texts, there are many real-world scenarios where text data is associated with rich structure information in the form of graphs (*e.g.*, academic networks, and e-commerce networks) or scenarios where graph data are paired with rich textual information (*e.g.*, molecules with descriptions). Besides, although LLMs have shown their pure text-based reasoning ability, it is underexplored whether such ability can be generalized to graphs (*i.e.*, graph-based reasoning). In this paper, we provide a systematic review of scenarios and techniques related to large language models on graphs. We first summarize potential scenarios of



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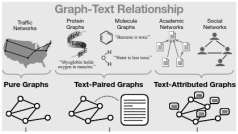

GraphRAG: Unlocking LLM discovery on narrative private data

Published February 13, 2024

By Jonathan Larson, Senior Principal Data Architect; Steven Truitt, Principal Program Manager

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Future Work - Cont'd

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- Link, Predict, Associate?

Article

Mathematical discoveries from program search with large language models

https://doi.org/10.1038/s41586-023-06924-6

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Thank you!

Contact

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