Hauptseminar II

Quantum Information Processing: Principles and physical platforms

WS 2022/23

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Fachbereich Physik

Technische Universität Kaiserslautern

Goals of the seminar:

- Learn how to inform yourself about a specific research subject from original literature
- Learn how to prepare a presentation on the subject
- Practice to give a talk and answer questions in the subsequent discussion

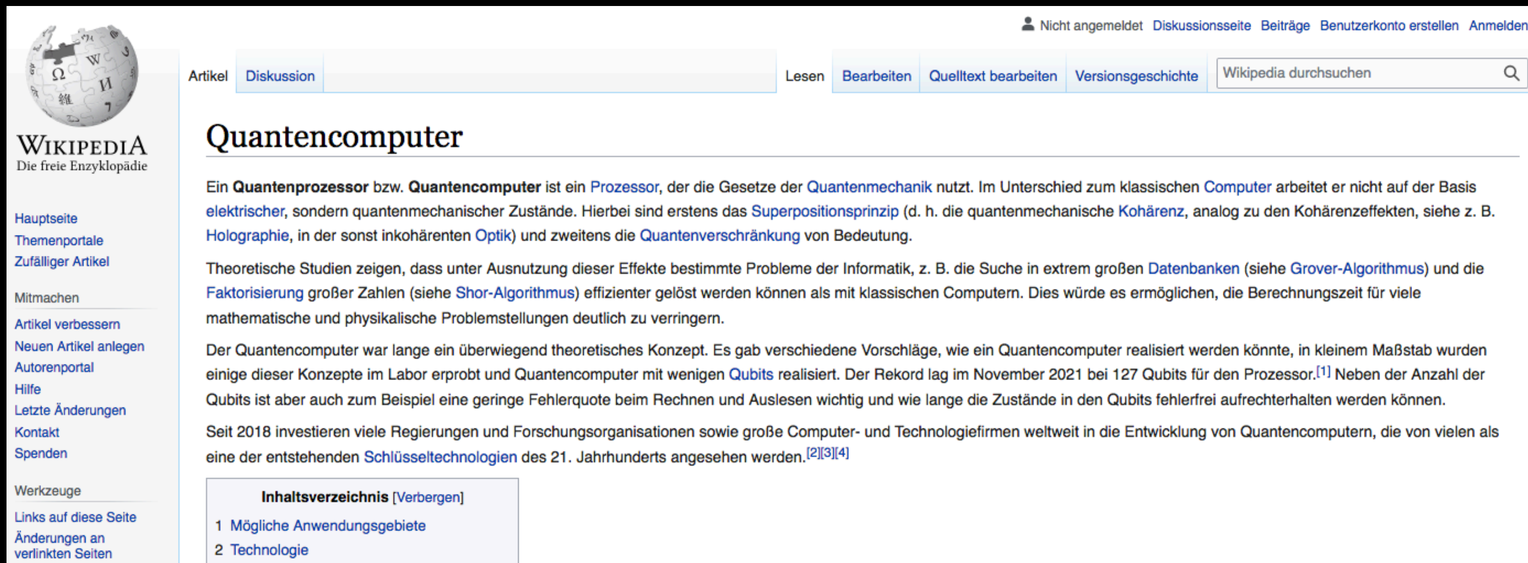
Rules:

- Active participation in all seminar talks; in person (unless in quarantine)
- Preparation of talk from given literature & own literature search
- Presentation of scientific talk (35 – 45 min) (english preferred)
- Subsequent scientific discussion (15 – 30 min)
- Oral & written feedback about presentation (15 min)

1. Inform yourself about the subject

- Start reading given material approx. 4 weeks before presentation !
- Additional sources or if no material given:
  - Review articles / thesis are a good starting point
  - Wikipedia good for more general subjects; beware: can be biased if topic is more specialized
  - Google scholar; web of Science; Scopus
- Discuss / ask supervisor or colleagues

- The more prepared you are the more confident you'll be !
- Always know much more than you actually talk about!



Nicht angemeldet Diskussionsseite Beiträge Benutzerkonto erstellen Anmelden

WIKIPEDIA
Die freie Enzyklopädie

Artikel Diskussion | Lesen Bearbeiten Quelltext bearbeiten Versionsgeschichte | Wikipedia durchsuchen

Hauptseite
Themenportale
Zufälliger Artikel

Mitmachen
Artikel verbessern
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Hilfe
Letzte Änderungen
Kontakt
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Werkzeuge
Links auf diese Seite
Änderungen an verlinkten Seiten

Quantencomputer

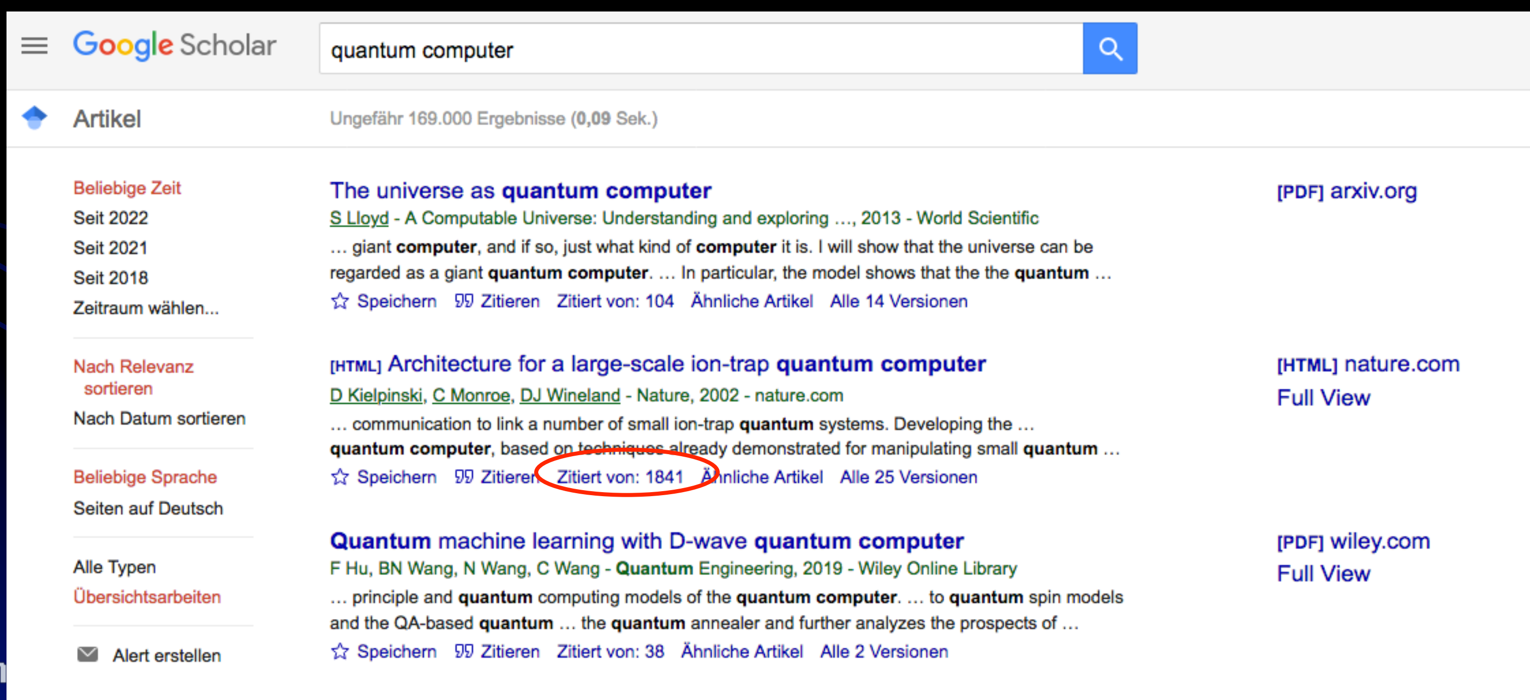
Ein **Quantenprozessor** bzw. **Quantencomputer** ist ein Prozessor, der die Gesetze der Quantenmechanik nutzt. Im Unterschied zum klassischen Computer arbeitet er nicht auf der Basis elektrischer, sondern quantenmechanischer Zustände. Hierbei sind erstens das Superpositionsprinzip (d. h. die quantenmechanische Kohärenz, analog zu den Kohärenzeffekten, siehe z. B. Holographie, in der sonst inkohärenten Optik) und zweitens die Quantenverschränkung von Bedeutung.

Theoretische Studien zeigen, dass unter Ausnutzung dieser Effekte bestimmte Probleme der Informatik, z. B. die Suche in extrem großen Datenbanken (siehe Grover-Algorithmus) und die Faktorisierung großer Zahlen (siehe Shor-Algorithmus) effizienter gelöst werden können als mit klassischen Computern. Dies würde es ermöglichen, die Berechnungszeit für viele mathematische und physikalische Problemstellungen deutlich zu verringern.

Der Quantencomputer war lange ein überwiegend theoretisches Konzept. Es gab verschiedene Vorschläge, wie ein Quantencomputer realisiert werden könnte, in kleinem Maßstab wurden einige dieser Konzepte im Labor erprobt und Quantencomputer mit wenigen Qubits realisiert. Der Rekord lag im November 2021 bei 127 Qubits für den Prozessor.[1] Neben der Anzahl der Qubits ist aber auch zum Beispiel eine geringe Fehlerquote beim Rechnen und Auslesen wichtig und wie lange die Zustände in den Qubits fehlerfrei aufrechterhalten werden können.

Seit 2018 investieren viele Regierungen und Forschungsorganisationen sowie große Computer- und Technologiefirmen weltweit in die Entwicklung von Quantencomputern, die von vielen als eine der entstehenden Schlüsseltechnologien des 21. Jahrhunderts angesehen werden.[2][3][4]

Inhaltsverzeichnis [Verbergen]



Google Scholar | quantum computer

Artikel | Ungefähr 169.000 Ergebnisse (**0,09** Sek.)

Beliebige Zeit
Seit 2022
Seit 2021
Seit 2018
Zeitraum wählen...

Nach Relevanz sortieren
Nach Datum sortieren

Beliebige Sprache
Seiten auf Deutsch

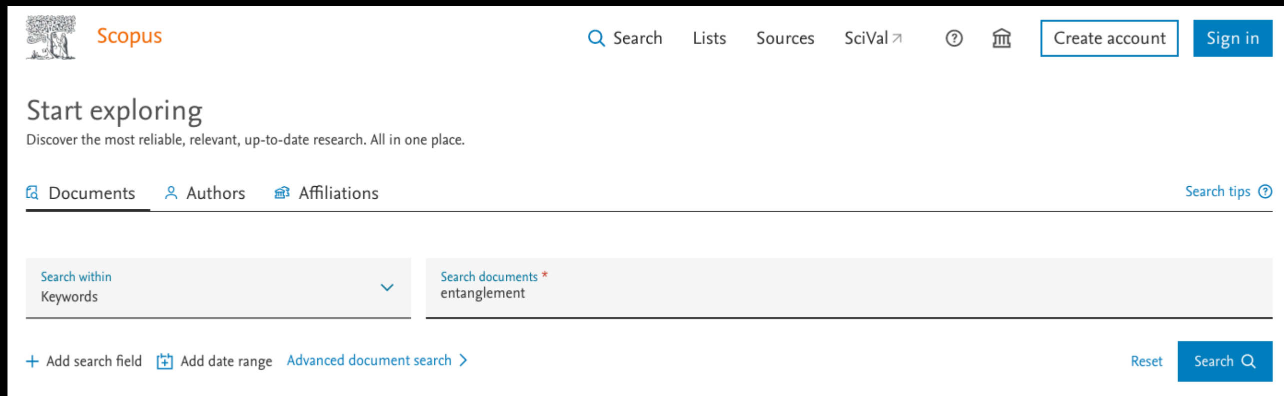
Alle Typen
Übersichtsarbeiten

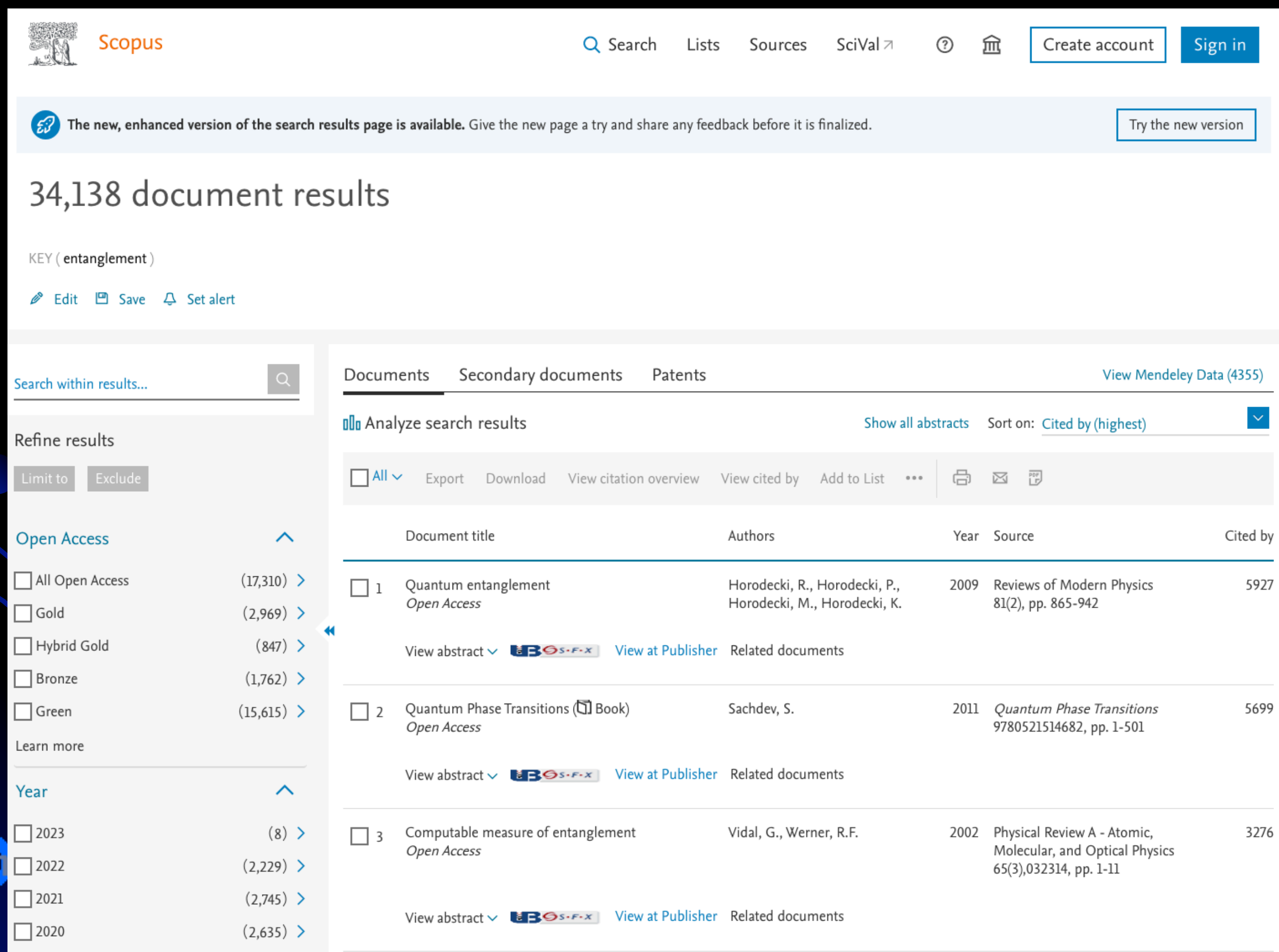
Alert erstellen

The universe as quantum computer — [PDF] arxiv.org
S Lloyd - A Computable Universe: Understanding and exploring …, 2013 - World Scientific
… giant **computer**, and if so, just what kind of **computer** it is. I will show that the universe can be regarded as a giant **quantum computer**. … In particular, the model shows that the the **quantum** …
Speichern Zitieren Zitiert von: 104 Ähnliche Artikel Alle 14 Versionen

[HTML] **Architecture for a large-scale ion-trap quantum computer** — [HTML] nature.com Full View
D Kielpinski, C Monroe, DJ Wineland - Nature, 2002 - nature.com
… communication to link a number of small ion-trap **quantum** systems. Developing the … **quantum computer**, based on techniques already demonstrated for manipulating small **quantum** …
Speichern Zitieren Zitiert von: 1841 Ähnliche Artikel Alle 25 Versionen

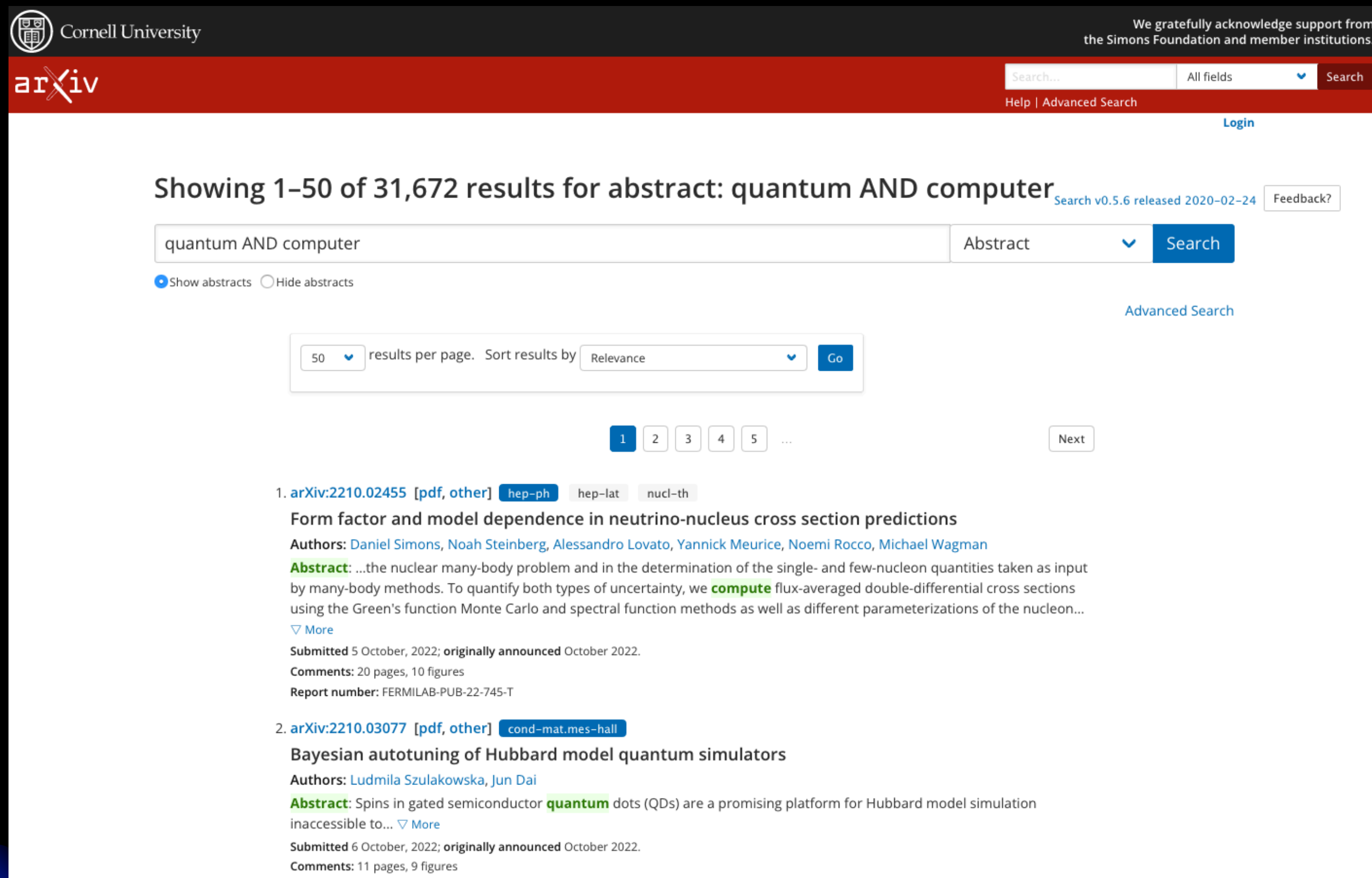
Quantum machine learning with D-wave quantum computer — [PDF] wiley.com Full View
F Hu, BN Wang, N Wang, C Wang - **Quantum** Engineering, 2019 - Wiley Online Library
… principle and **quantum** computing models of the **quantum computer**. … to **quantum** spin models and the QA-based **quantum** … the **quantum** annealer and further analyzes the prospects of …
Speichern Zitieren Zitiert von: 38 Ähnliche Artikel Alle 2 Versionen





Fachbereich

Technische Universität Kaiserslautern



Fachbereich Physik

Technische Universität Kaiserslautern

2. Prepare your presentation

step 1: identify your audience

step 2: determine how much time you have

step 3: identify the main points you want to convey
(2-3 main points in a 20 – 30 min talk)

step 4: create an outline of your talk

step 5: prepare slides (and backup slides)

step 6: practice, practice, practice !!

2. Prepare your presentation

Organizing a 30 min talk ?

no unique recipe (depends on what type: short / long talk; colloquium

I. Background & Introduction

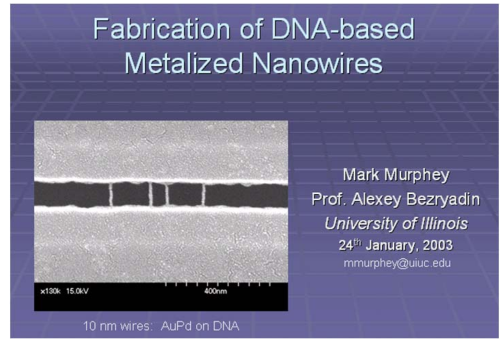
- Title slide
- Outline slide (can be skipped in short talk)
- Overview slide (if appropriate) *why is research important ?*
- 1-2 Background slides (if approporiate) *provides background for non-experts*

II. Main body of talk

III. Summary

- Summary of key points (2-4 for 20 – 30 min talk)
- Acknowledgement *sources; people involved; funding sources*

The title slide and outline prepares the audience to listen and shows organization of talk

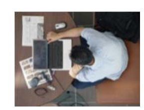


Title slide

- Your names and affiliations
- Paper citation (for JC)
- Venue and date
- Attention-getting graphic

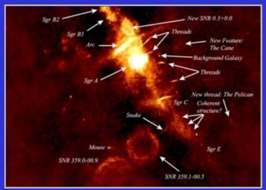
Outline or overview of presentation

- Prepares the audience to listen
- Provides a logical structure for your talk
- Provides motivation and context
- Summarizes key points (limit to two or three for a 20- to 30-minute talk)

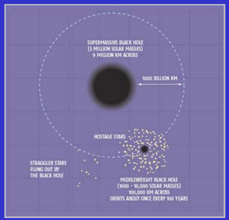


Overview

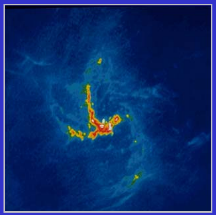
Black holes and star clusters



The galactic center



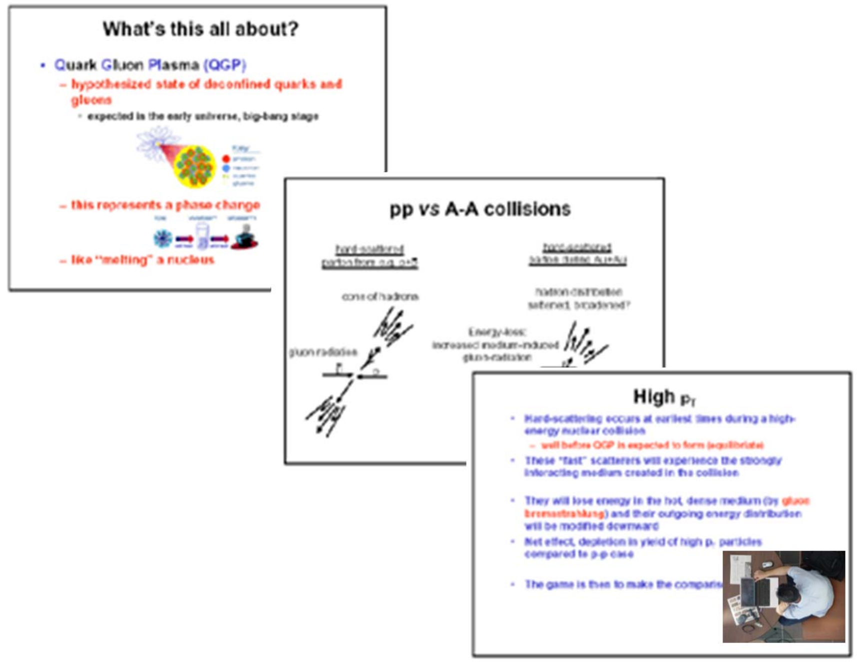
Intermediate-mass black hole kinematics



Here, we have a VISUAL and WRITTEN outline and it's not too long !

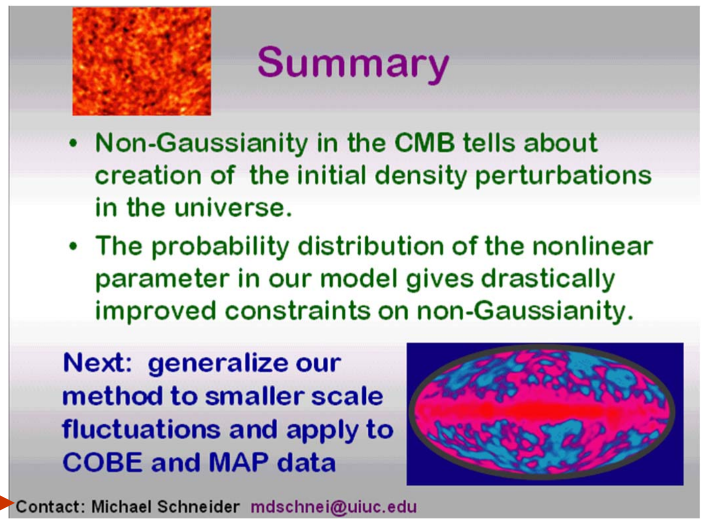
The “body” of your presentation is the intellectual content of your talk

Problem statement, motivation
~1–2 slides
Previous work
~1-2 slides
Methods
~1–3 slides
Key Results
~5–6 slides

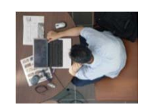


Provide a "summary" slide

Recap key results and conclusions
Reiterate main critiques (for JC)



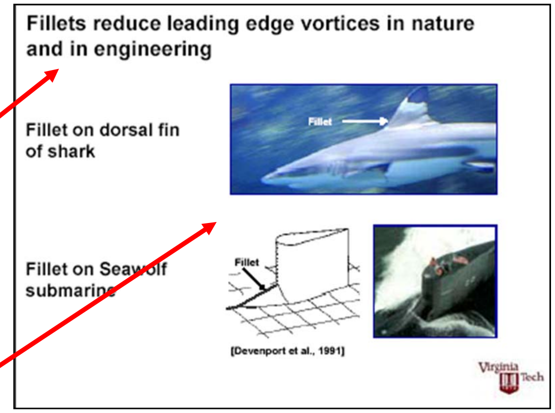
This slide will probably stay on the screen during the question period and will thus get the longest audience exposure—make it count!



Tips for preparing slides

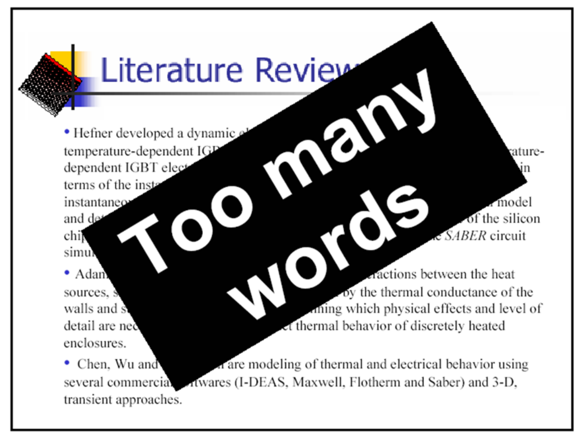
Have only 1 idea per slide

Use the header to state the main idea of the slide, and use the body of the slide to support that idea



Use well-labeled graphs and figures to illustrate your key points   this makes the slide more real and interesting to the audience

Avoid too much text   .



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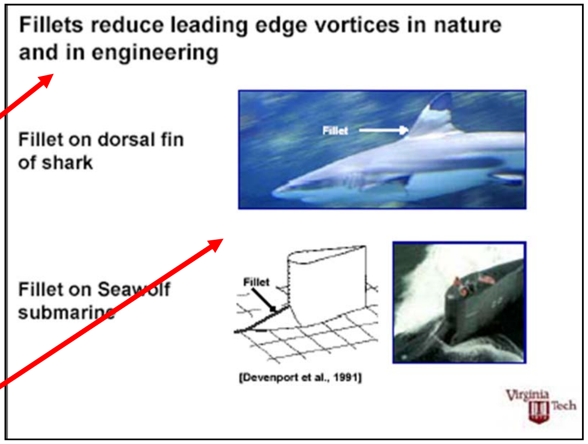
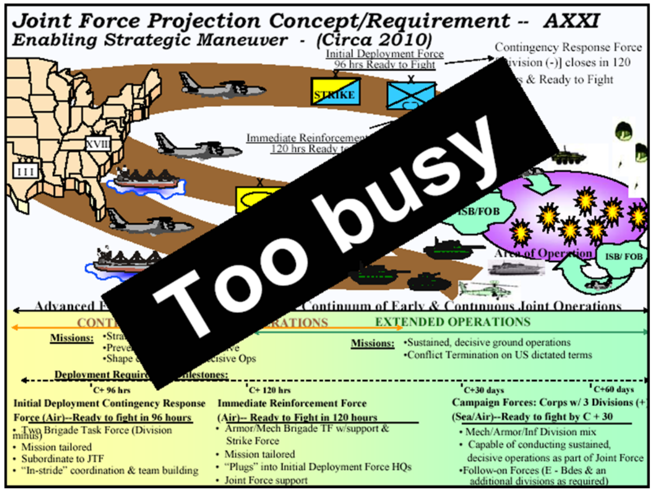
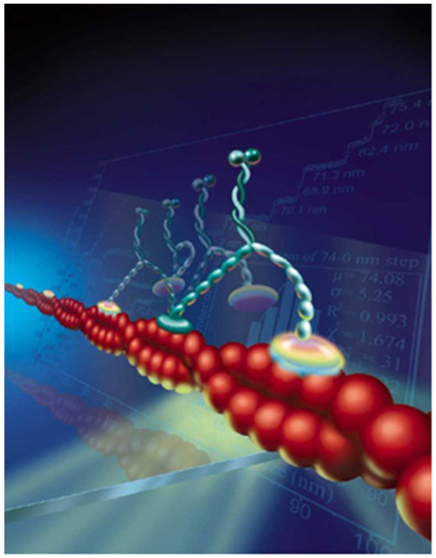


Use well-labeled graphs and figures to illustrate your key points   this makes the slide more real and interesting to the audience

.or too many distracting images



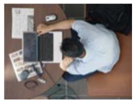
Use figures to illustrate your key points



Myosin "walking" on actin
Courtesy of P. Selvin

Figures:

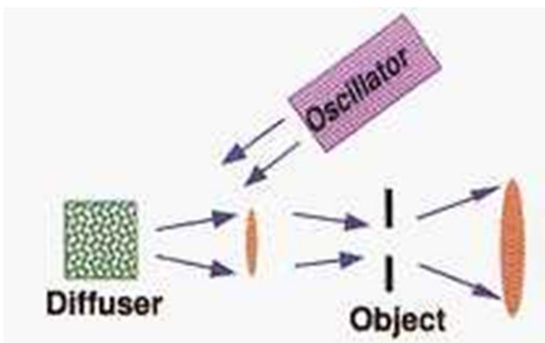
- enliven slides
- promote audience interest
- provide supporting evidence for key points
- help explain complex ideas and relationships quickly
- show how things work, etc.



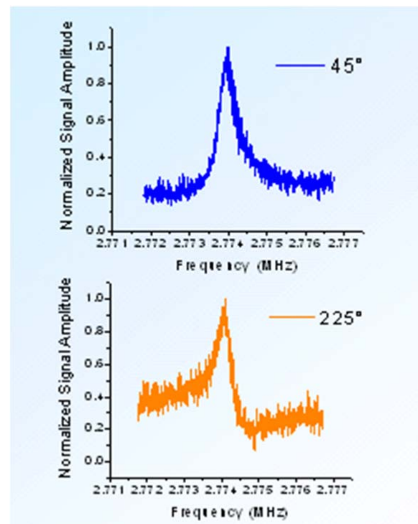
Tips for preparing slides

Label all elements in a figure

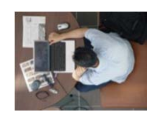
- Point out important features
- Label both axes of graphs and show units
- Provide a brief caption
- Give credit to source



The Nike laser system uses discharge pre-amplifiers.
(*Courtesy US Navy*)



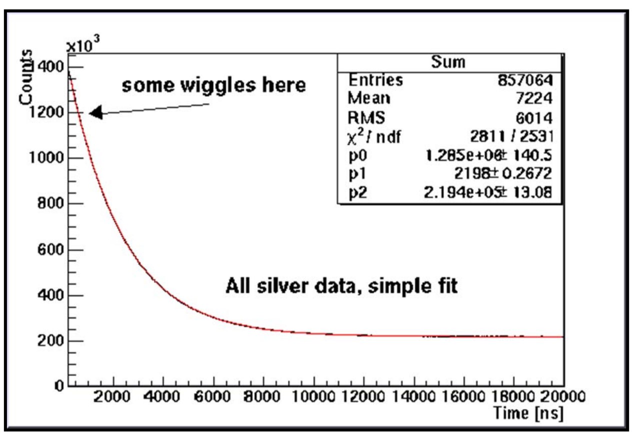
Sample normalized signals from the two-beam optical drive.
(*Courtesy C. Michael*)

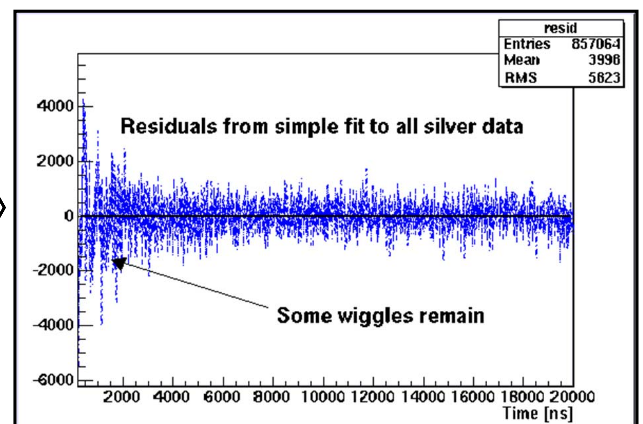


Tips for preparing slides

Presenting data is your most important and challenging task

- **Avoid copying a graph from a formal article – they have a different style, e.g., labels are too small**
- **Use color and make lines thick, labels legible**
- **Label axes and annotate important points with arrows and add words**
- **Use tables sparingly – if used highlight important parts**

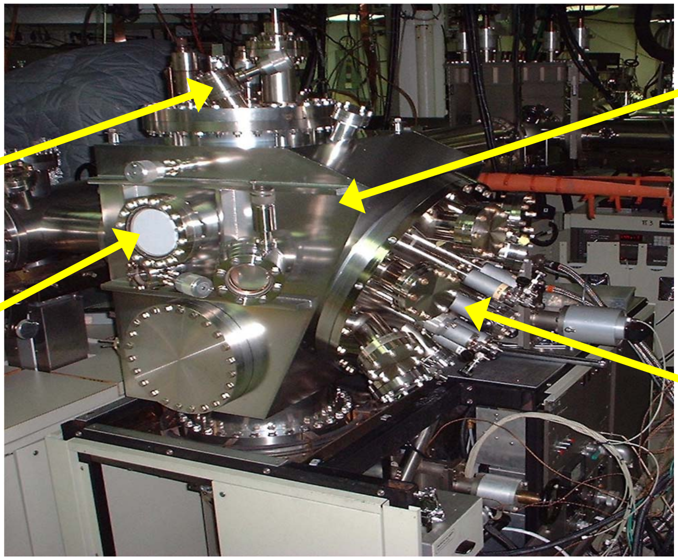




Tips for preparing slides

Show the equipment IF it helps as part of your proof – but sparingly, not just because you love it

- **Photographs** give scale and reality – but add labels
- **Schematics** provide concept
- **Diagrams** strip away unnecessary details
- **ALL OF THESE** can be useful in combination

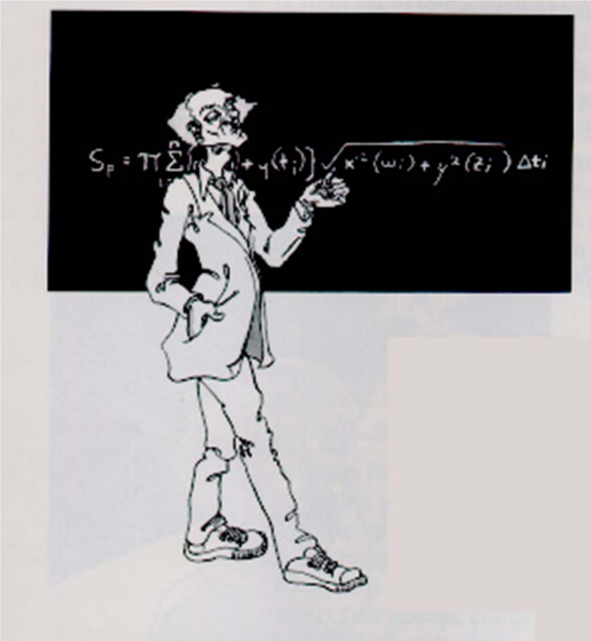


OK, but could be better

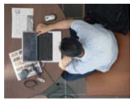
Tips for preparing slides

Use equations sparingly

- Use equations only when necessary
- If you use equations
  - Slow down
  - Talk through step by step
  - Explain relevance
  - Combine with a picture that illustrates the physical principle involved



If you must use mathematics in your presentation, slow down, and talk the audience through each equation...



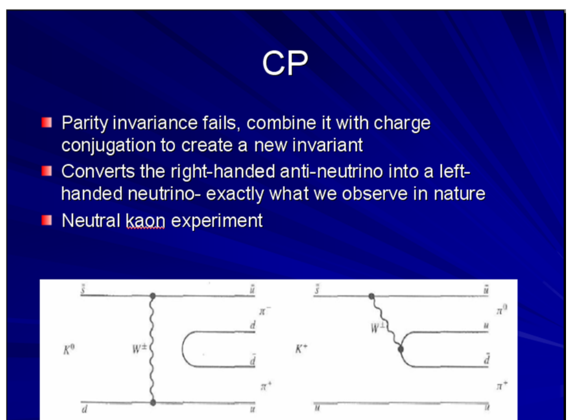
Tips for preparing slides

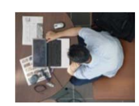
Remember, your goal is to convey your ideas, so avoid distracting text and effects!

Don't overuse PowerPoint animations and sounds!

Make sure there is good contrast between text and background

Use simple (or no) backgrounds on slides





Tips for preparing slides

Eschew weird fonts

Don't use *calligraphy*
or serif fonts

USE THE SAME FONT
THROUGHOUT THE TALK

Make all text at least 20 pt

Use “normal” colors

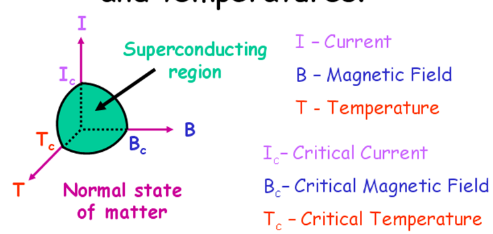
DON’T use red/green or red/blue as contrasting colors

Make sure colors looks the way you expect using an LCD projector!

Avoid neon colors and pastels

Don’t use many random colors; people expect color to *mean* something

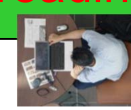
Superconductivity is an electronic state of matter that exists below certain currents, magnetic fields, and temperatures.



Strive for easy reading

Strive for easy reading

Strive for easy reading



... and think of the color blind ...

3. Tips for giving a good talk

Maintain eye contact with audience
Don't stare at screen or monitor

Do not read your talk!

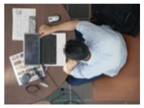
Avoid nervous mannerisms
Pacing, bobbing, waving arms, jingling coins

Use laser pointer or stick directed at screen
Don't point directly at overhead on projector
Don't block the screen

Train yourself to speak slowly and distinctly—practice!

Avoid "fillers": "uh", "like", "um", "okay"

Be enthusiastic!
If you don't act excited by your results,
don't expect the audience to be!



3. Tips for giving a good talk

Don’t show any material on slides (e.g., figures, equations, text, etc.) you can’t explain!!

Rehearse how you’ll end your talk

Don’t end with “Well, I guess that’s it ”

Don’t just stop and let the committee guess that you’re done

Thank the audience!

Focus on communicating not performing

(humor is good but don‘t overdo it)

Keep it simple

Pepare key phrases

(it is o.k. to write out some important statements first)

3. Tips for giving a good talk

Rehearse Your Talk!

A few days before

Practice in front of friends and check timing

Rehearse likely questions

Solicit feedback about logic and clarity

Revise (*shorten*)

The night before

Go over one more time

Put all materials *in order* (number your slides!)

Prof. Per Ahlberg delivering the Presentation Speech for the 2001 Nobel Prize in Chemistry at the Stockholm Concert Hall.

4. Tips for question & answers session

Handling questions is an essential part of giving a talk

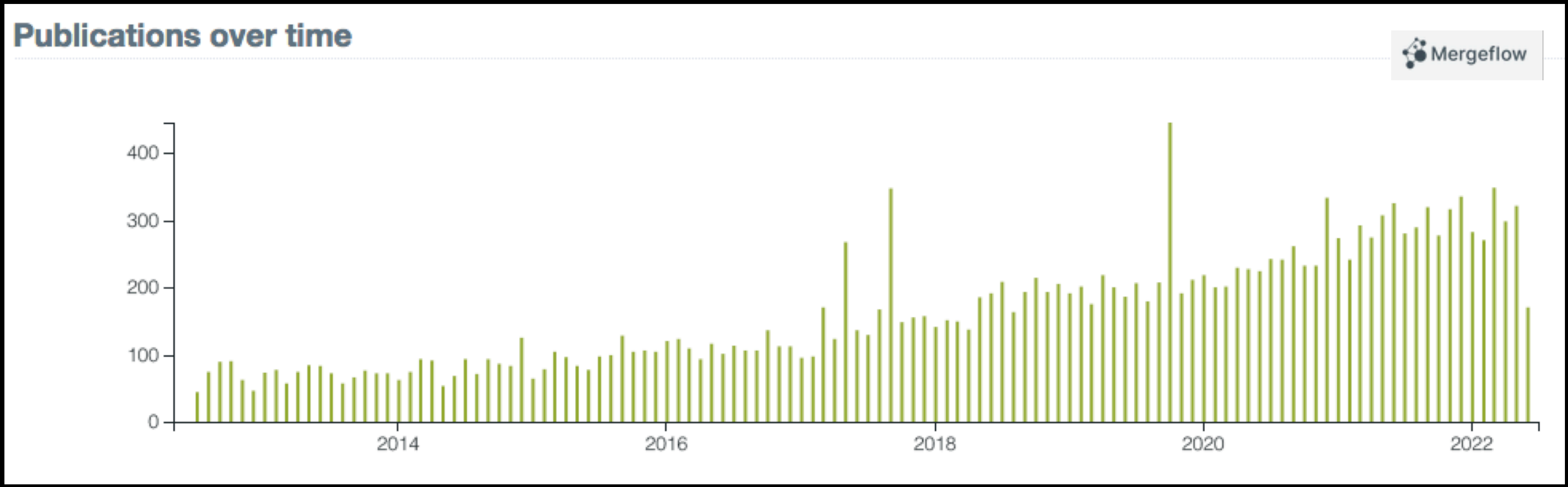
- **As part of preparing your talk, try to anticipate questions you might get**
  - In each slide, try to identify what the weak points are, what questions you might ask, etc.
- **Be prepared to repeat simple derivations of equations or estimates presented on your slides**
- **If you don’t know the answer?**
  - Say “That’s an excellent question. I’m not sure; I’ll have to look into it” or “Let’s talk about it afterward”

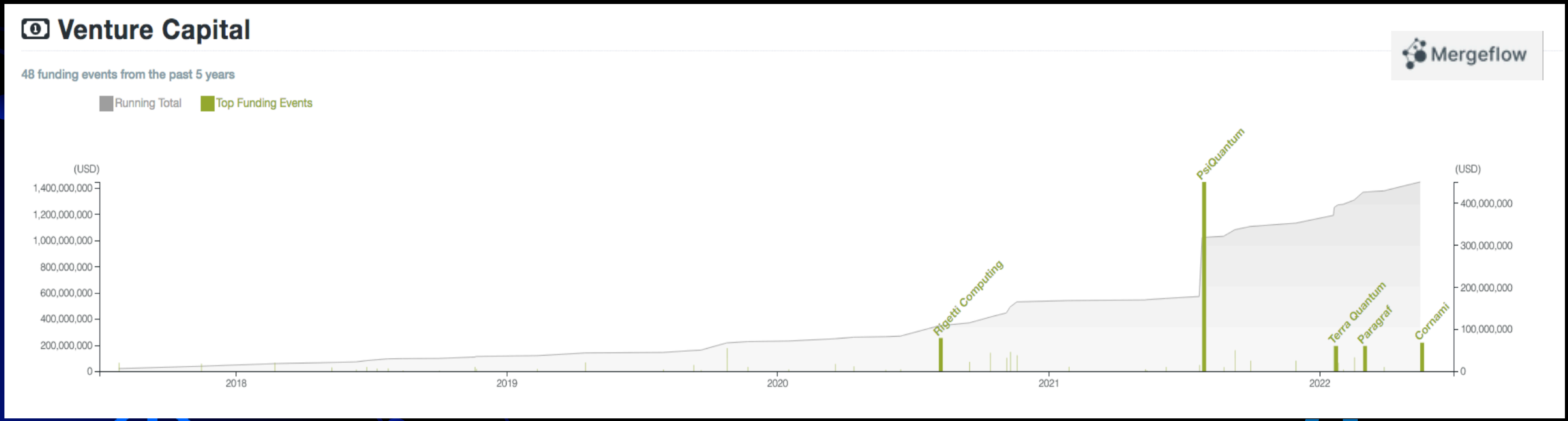
Fachbereich Physik

Technische Universität Kaiserslautern

Why ?
„Quantum Information Processing“

Publications & Venture Capital Investments





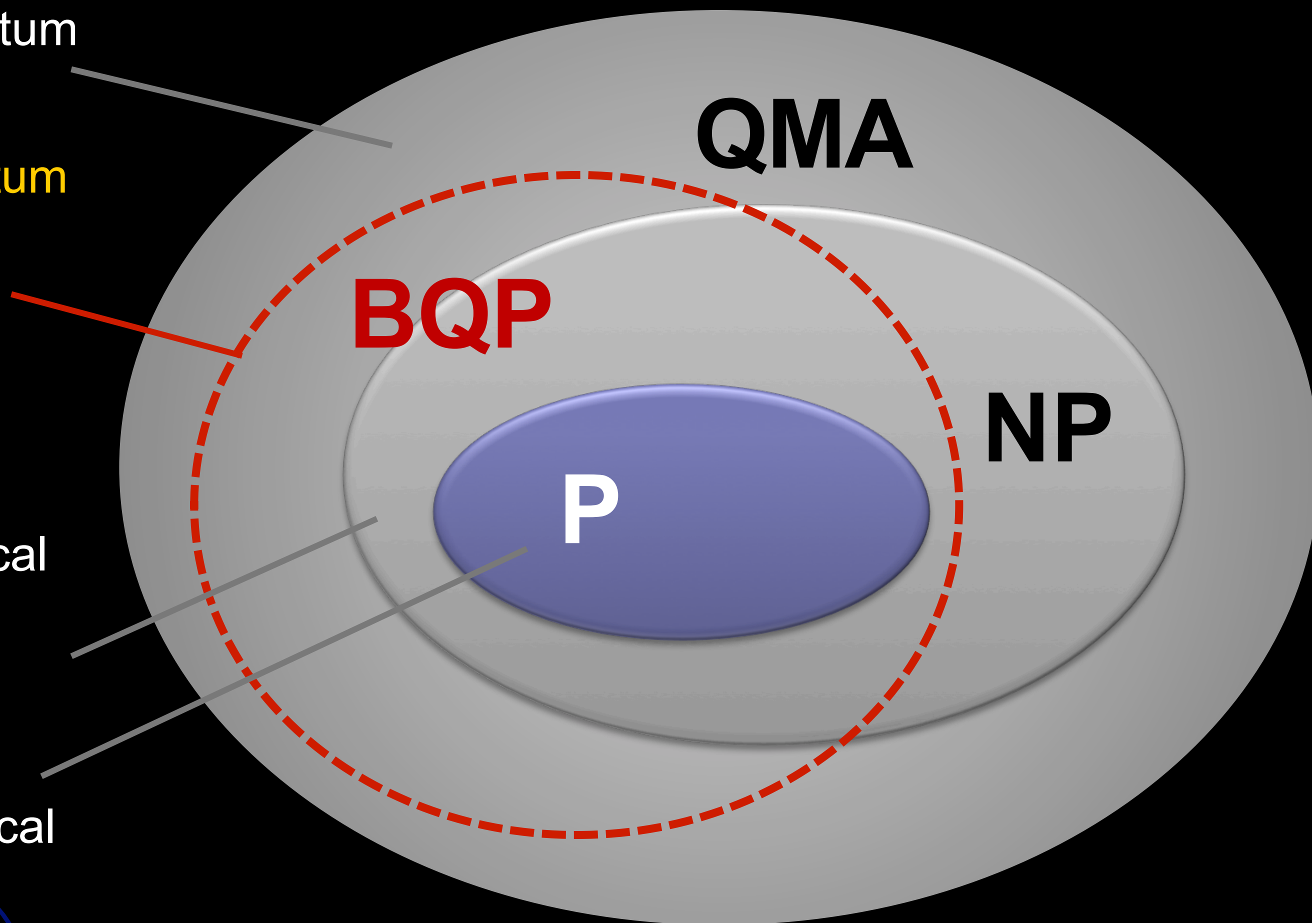
Mathematical problems:

verifiable with Quantum computer

solvable* with Quantum computer:

verifiable with classical computer

solvable* with classcal computer



* with polynomial effort

Deutsch-Josza algorithm

valid

front back

invalid

front back

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Deutsch-Josza algorithm

$$f: \quad \underset{\text{front} \quad \text{back}}{\{0, 1\}} \longrightarrow \underset{\text{head} \quad \text{tail}}{\{0, 1\}}$$

$$f(0) = 0 \qquad f(0) = 1$$
$$f(1) = 0 \qquad f(1) = 1$$

constant (invalid)

$$f(0) = 0 \qquad f(0) = 1$$
$$f(1) = 1 \qquad f(1) = 0$$

balanced (valid)

To find out if f constant or balanced
two inquiries neded!

Deutsch-Josza algorithm

$$|0\rangle|1\rangle \longrightarrow \Big(|0\rangle + |1\rangle\Big)\Big(|0\rangle - |1\rangle\Big)$$

f encoded in unitary transfo

$$U_f : \quad |x\rangle|y\rangle \longrightarrow |x\rangle|y \oplus f(x)\rangle$$

$$U_f|x\rangle\left(|0\rangle + |1\rangle\right) = \begin{cases} |x\rangle\left(|0\rangle + |1\rangle\right) & \text{constant} \\ -|x\rangle\left(|0\rangle - |1\rangle\right) & \text{balanced} \end{cases}$$

A <u>single</u> inquiry sufficient!

Topics for talks

Basics & fundamental experiments

- Bell inequalities: *quantum correlations are stronger than classical one's*
- Quantum teleportation: *how to transport an unknown quantum state from A to B*
- Quantum crypotography: *how to use peculiarities of quantum mechanics to create secure keys?*

Topics for talks

Quantum computing principles

- Network quantum computer: *quantum bits and gates (M. Fleischhauer)*
- Measurement-based quantum computation: *how to replace gate operations by measurements on massively entangled states*

Topics for talks

Physical platforms for quantum computing

- Ion-trap quantum computers
- Neutral atoms in strongly coupling cavities
- Rydberg atoms & Rydberg polaritons
- Superconducting qubits
- Topological qubits (external lecture)

Topics for talks

Physical platforms for quantum networks

- Photon exchange between strongly coupled cavities
- Quantum memories for light based on atomic ensemble
- Duan-Lukin-Cirac-Zoller quantum repeater

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