Efficient cross-platform verification

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based on arXiv:2405.06544

My collaborators

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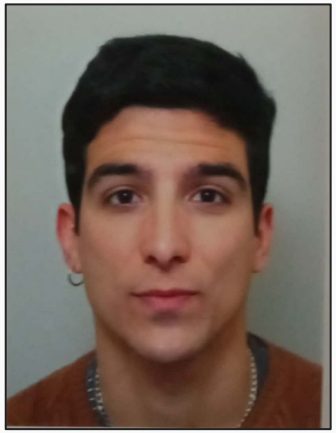
Lorenzo Leone

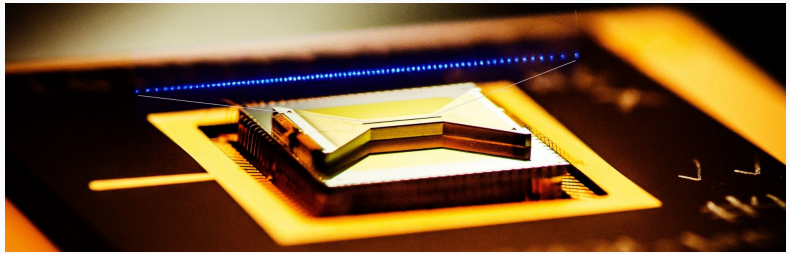
Jens Eisert

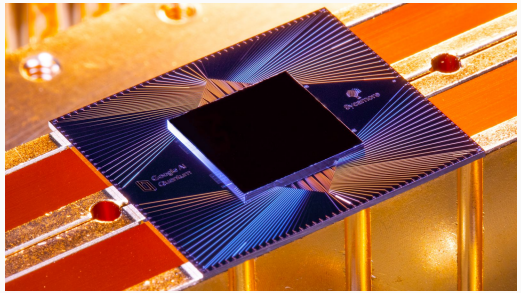


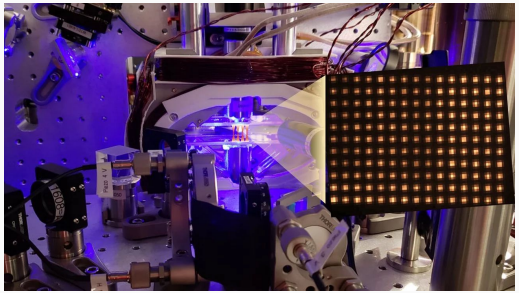
Jose Carrasco

The many platforms of quantum computing

- Trapped ions
- Neutral atoms
- Superconducting qubits
- Photons
- …

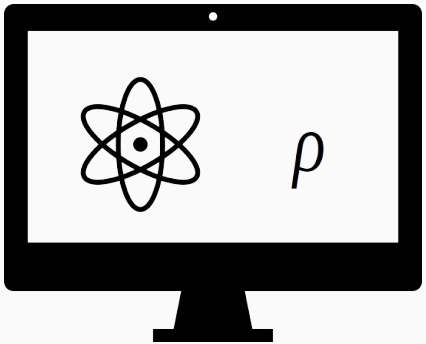




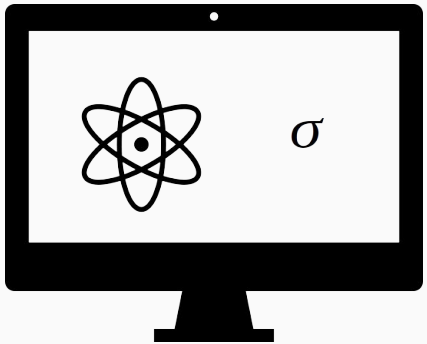


The need for comparing platforms

- Benchmarking performance
- Detecting hardware specific features
- Validation of results

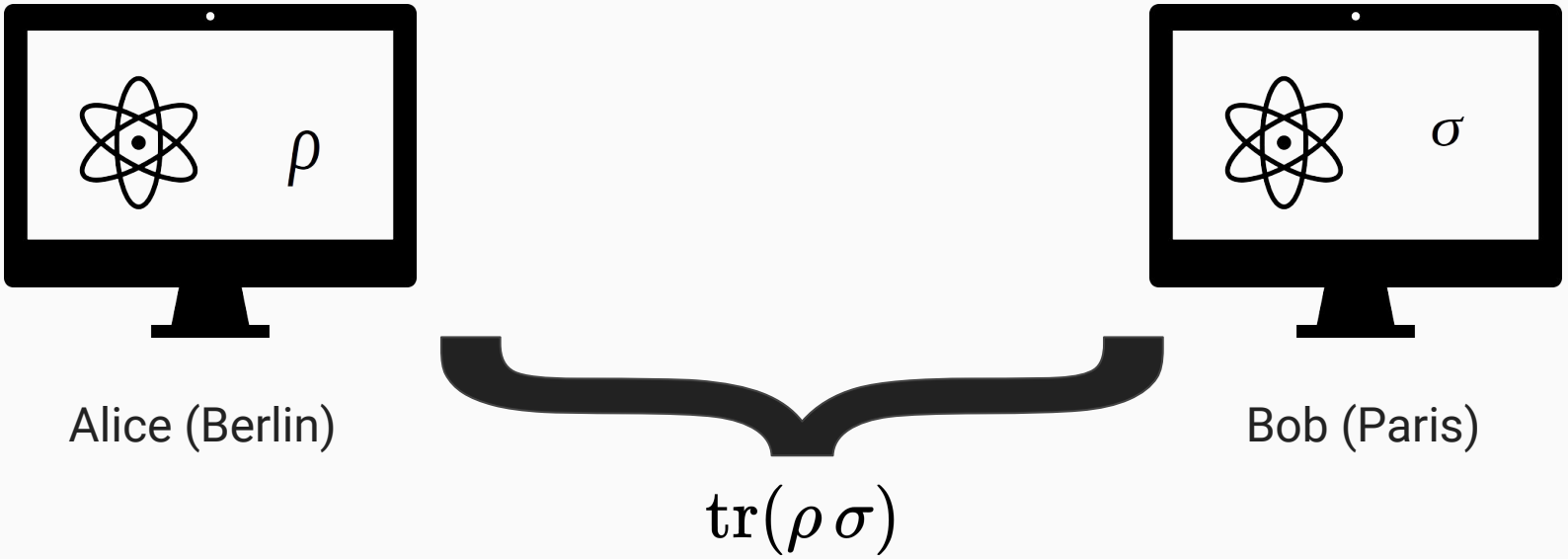


Alice (Berlin)

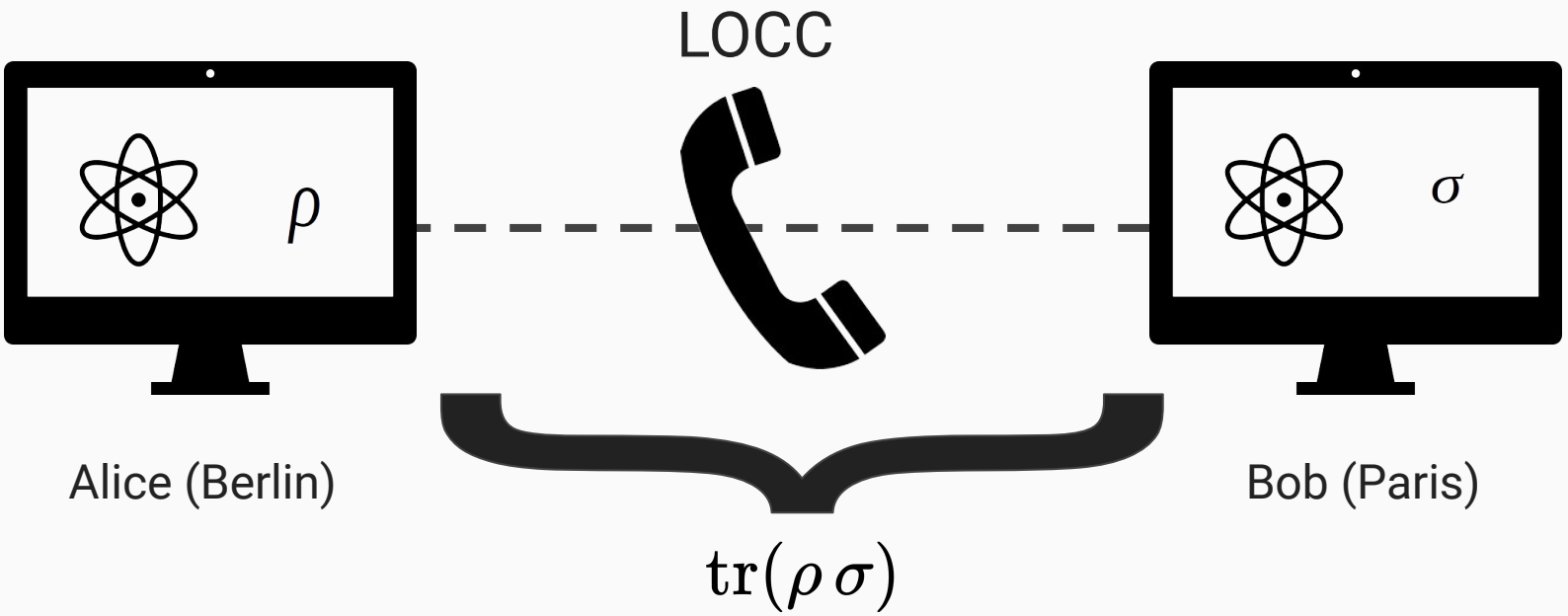


Bob (Paris)

Inner product estimation



Distributed inner product estimation



Previous work

- Elben et al, PRL 2020
  - First protocol for *cross-platform verification*

- Zhu et al, Nat. Com. 2022
  - Small-scale experimental implementation across different platforms (up to n=13)

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  - Small-scale experimental implementation across different platforms (up to n=13)
- Anshu, Landau, and Liu, STOC 2022
  - Rigorous theoretical lower bound $\Omega(2^{n/2})$ on sample complexity (better than tomography, but still exponential)

Cross-platform verification

- is cool, relevant 👍
- but scales **exponentially** 😞

Cross-platform verification

- is cool, relevant 👍
- but scales **exponentially** 😞
  without any assumptions

Our starting point

Question: Which assumptions on ρ, σ allow for an

efficient approach?

Design principles

1. **Coordination**:

   Alice and Bob should *coordinate* which bases they measure in.

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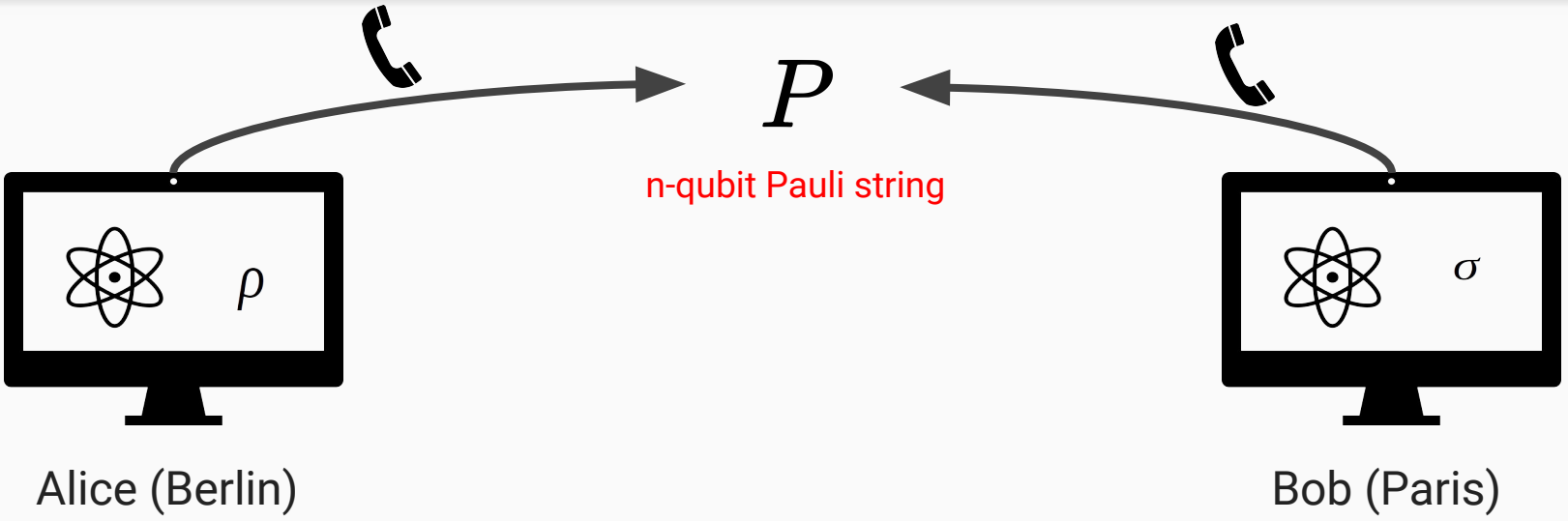
1. **Coordination**:

   Alice and Bob should *coordinate* which bases they measure in.

2. **Tailoring**:

   Alice and Bob should use prior knowledge to *tailor* the choice of measurement basis to their respective state.

Our approach: coordinated Pauli measurements



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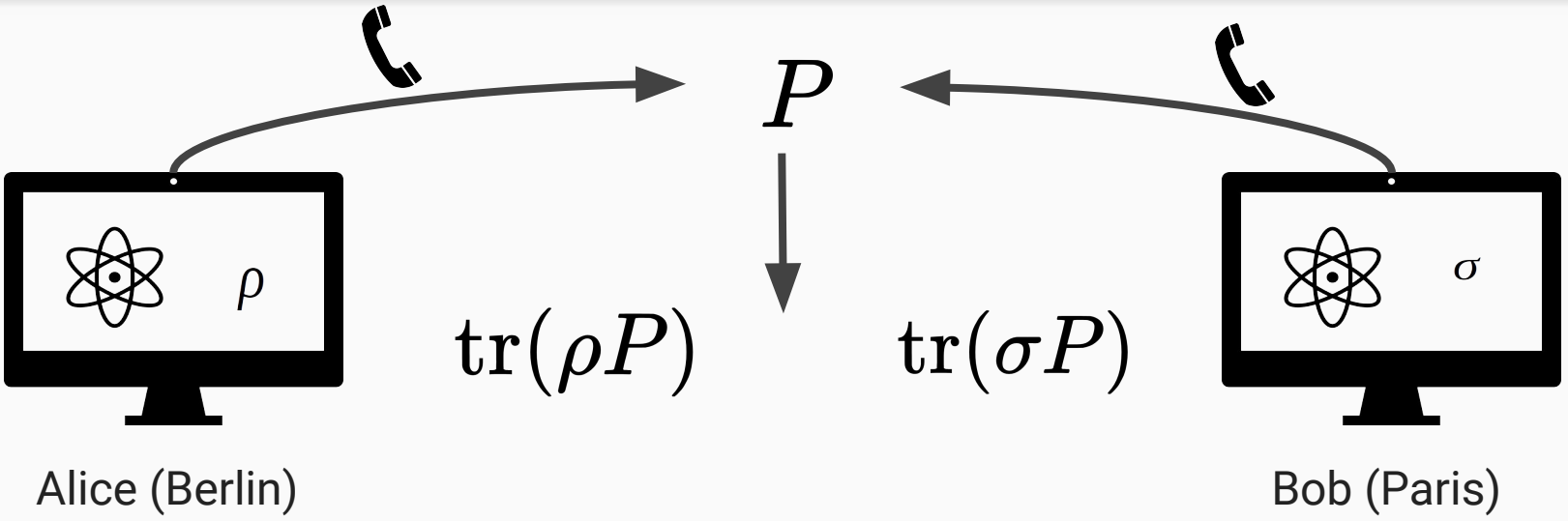

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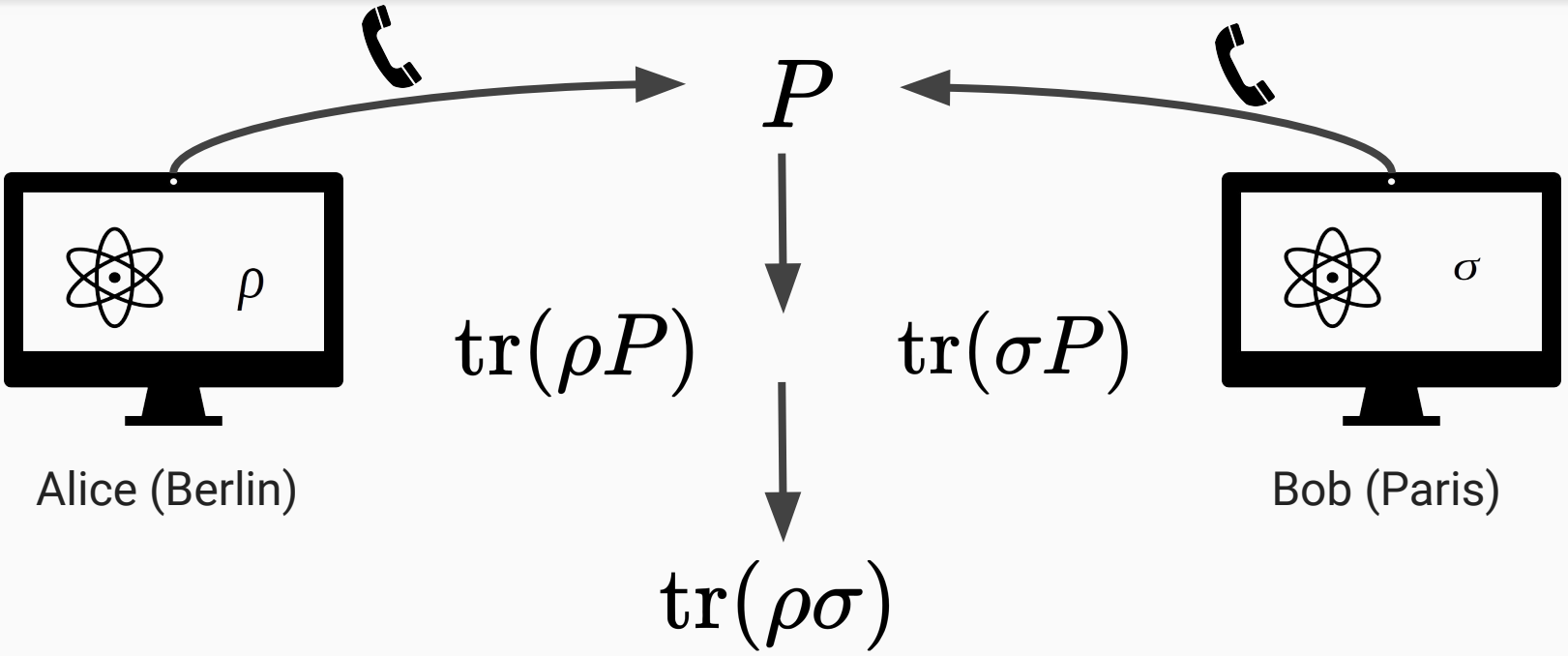

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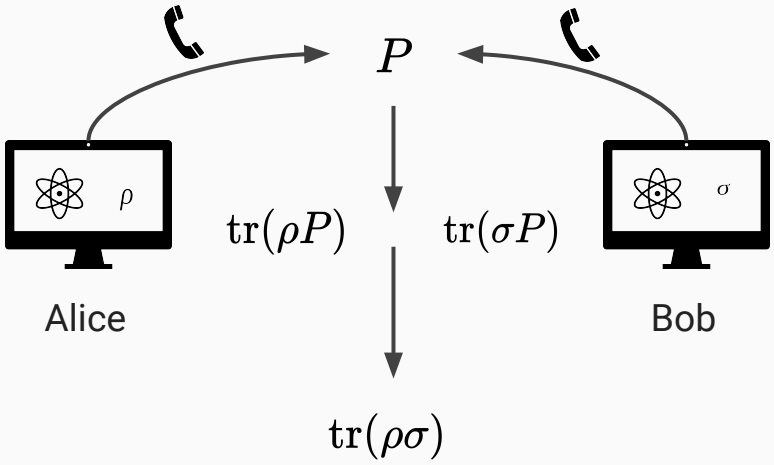

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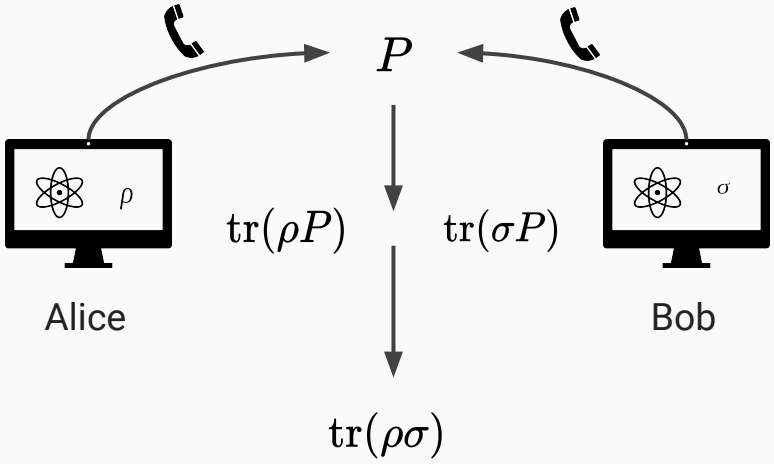
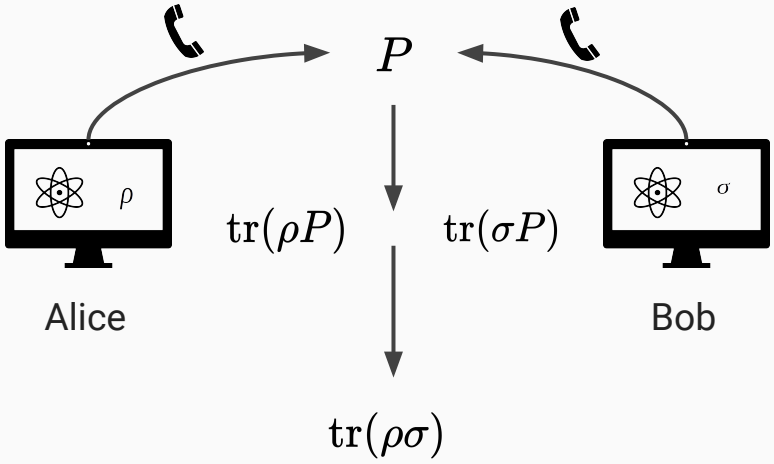


Tailoring:

How to choose the Paulis P? There are exponentially many to choose from…

Our approach: coordinated Pauli measurements

Coordination:



Tailoring:

Importance sampling according to the *Pauli distribution*:

$$p_\rho(P) = \frac{1}{2^n}\frac{\mathrm{tr}(\rho P)^2}{\mathrm{tr}(\rho^2)}$$

We call this *Pauli sampling*.

Connection to magic and entanglement

Pauli distribution: $$p_\rho(P) = \frac{1}{2^n}\frac{\mathrm{tr}(\rho P)^2}{\mathrm{tr}(\rho^2)}$$

- Magic ≅ entropy of p_ρ
  - *Stabilizer entropies* (Leone, Oliviero, Hamma ‘21)

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- Magic ≅ entropy of p_ρ
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- Entanglement ≅ marginals of p_ρ

Complexity

Q: Which assumptions on ρ, σ allow for an efficient approach?

A: Low magic and entanglement.

Summary

1. Cross-platform verification is a **distributed** benchmarking task.

2. We proposed and analyzed a novel protocol for this task based on coordinated Pauli measurements.
    a. it is efficient under certain additional assumptions

Thanks!

Pauli sampling

Goal: Sample from the *Pauli distribution*

$$p_\rho(P) = \frac{1}{2^n} \frac{\mathrm{tr}(\rho P)^2}{\mathrm{tr}(\rho^2)}$$

Our approach: the qubit-by-qubit algorithm

$$P_1 \to P_2 \to \cdots \to P_n$$

$$p_\rho(P) = p_\rho(P_1) p_\rho(P_2|P_1) \cdots p_\rho(P_n|P_1, \ldots, P_{n-1})$$