

Quantum Machine Learning for Sustainability



Presented by:

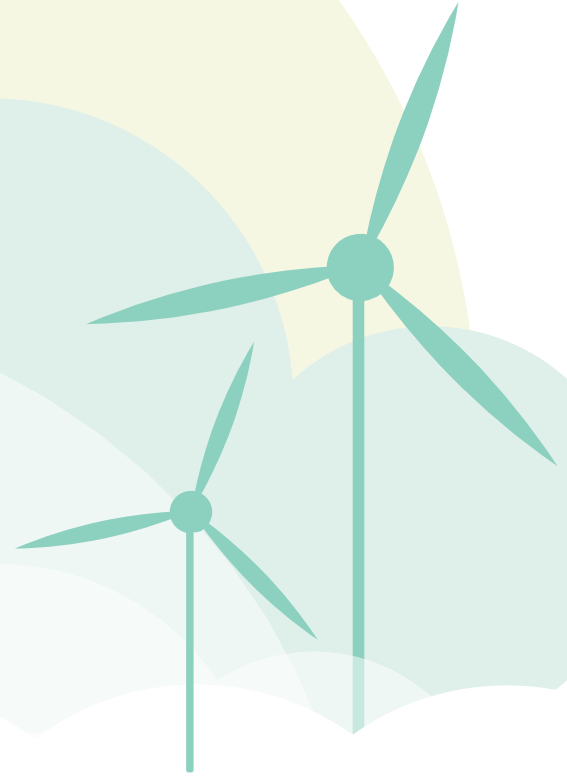


**QUANTUM SOCIETY
AUSTRIA**

**37.12
Milliarden
Tonnen
CO₂**

In 2021

60% mehr als in 1990



DECARBONIZATION



ENERGY SYSTEMS



TRANSPORTATION



AGRICULTURE





Growing **Complexity** &

Need for **Real-Time Decision** making



**Classical Models
are
limited !**





01.

Availability of high-quality training data

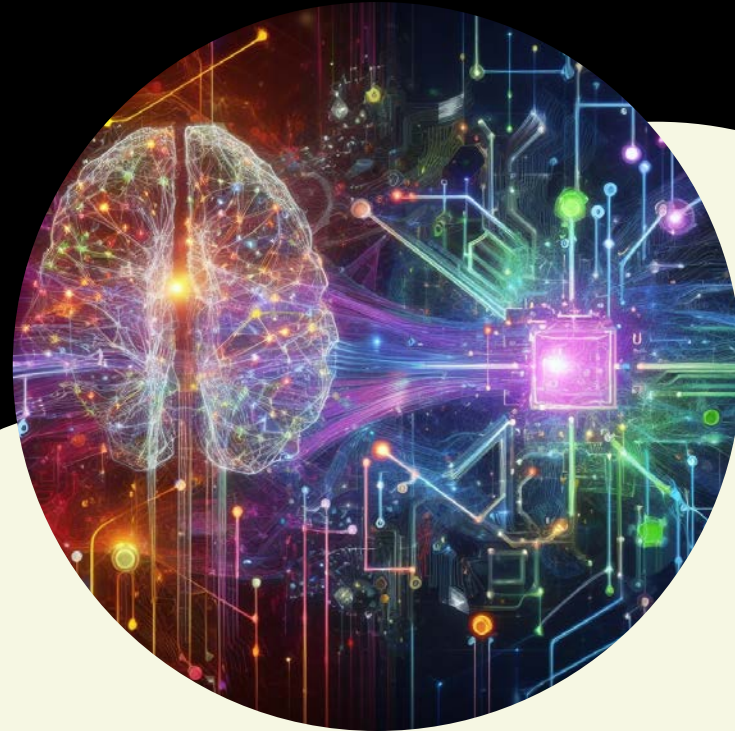


02.

**Computational Resources
for
immense data volume**

THE SOLUTION:

Hybrid Quantum-Classical Neural Networks

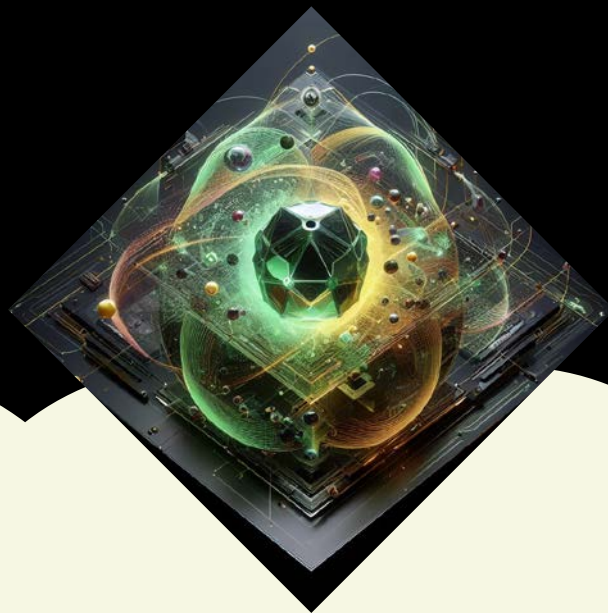


Quantum Machine Learning

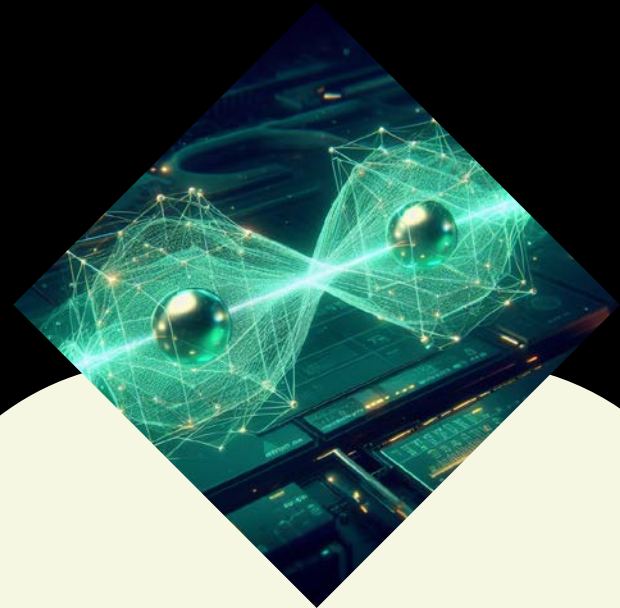
QUBITS



SUPERPOSITION

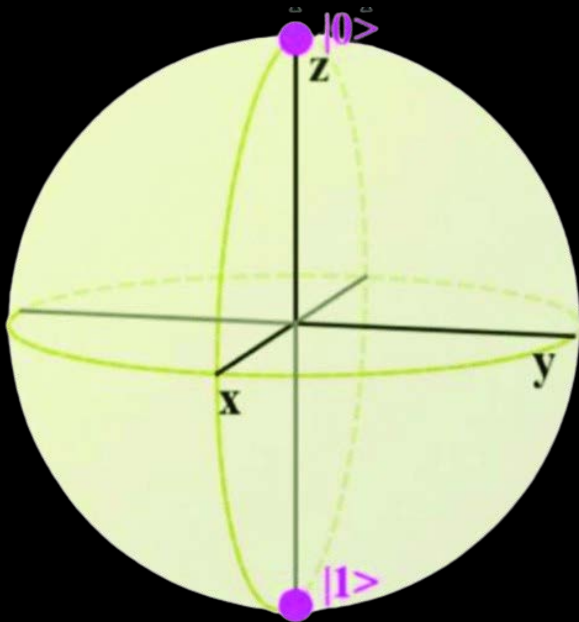


ENTANGLEMENT





What are qubits?

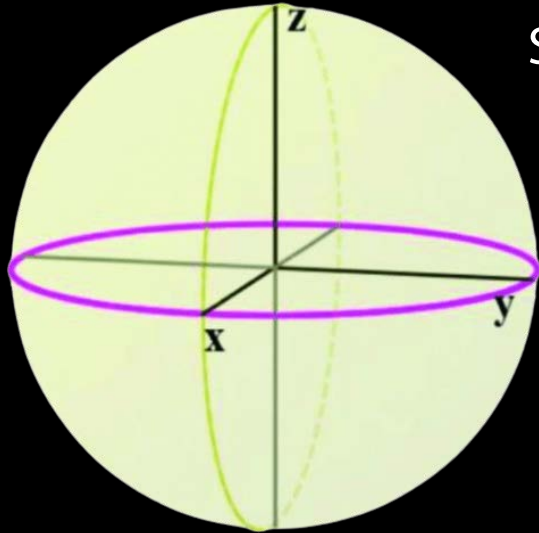


→ Fundamental unit of quantum information

→ Represented on a Bloch sphere

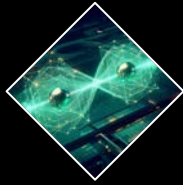


What is superposition?

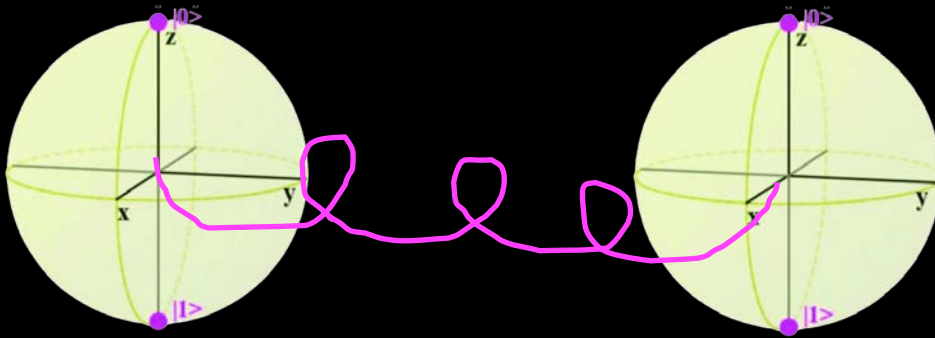


Superposition:

- Representing both 0 and 1 simultaneously
- Parallel processing

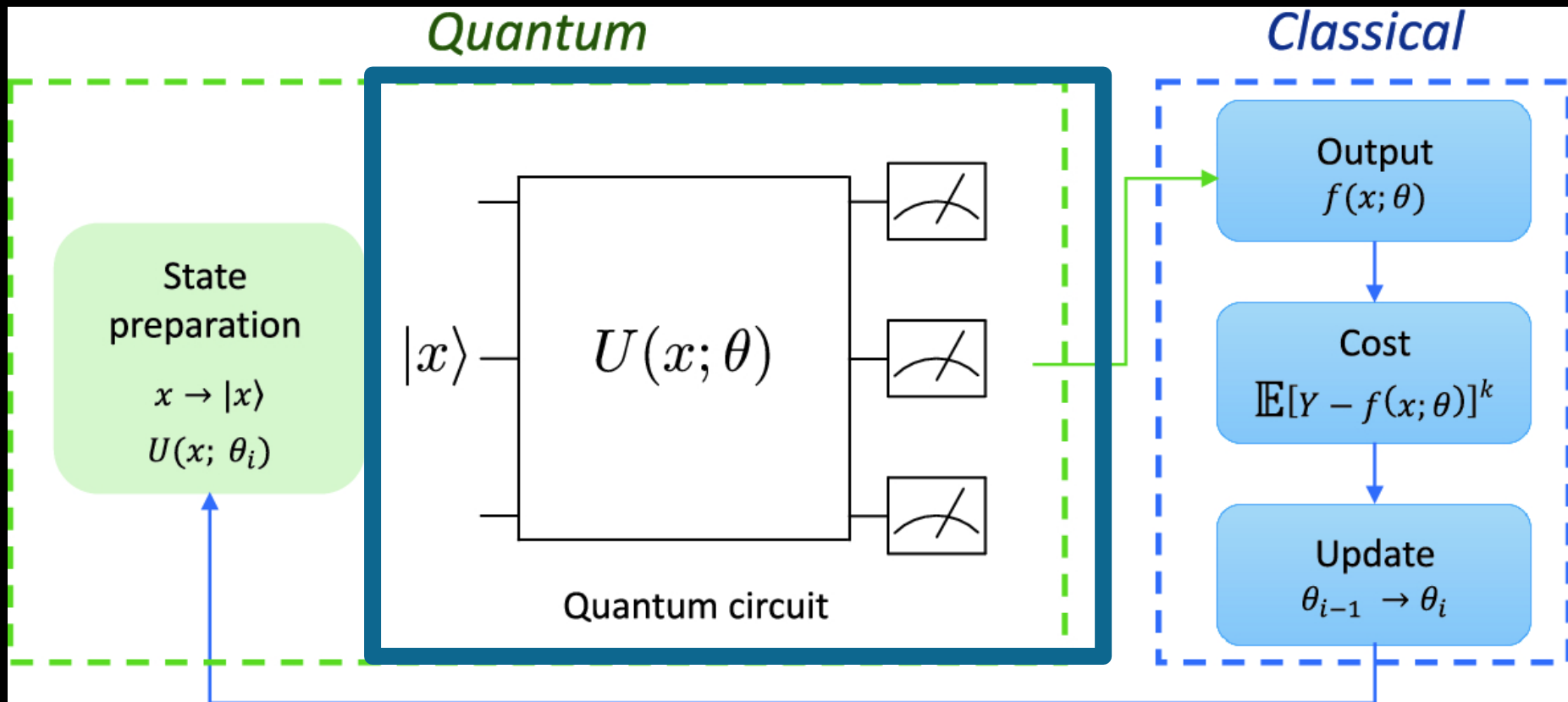


What is entanglement?



→ Related states between qubits

Hybrid Quantum-Classical QNN





Applications in Energy Systems



01. Controller in photovoltaic system



1. Energy Systems: Controller in photovoltaic system

Research Paper:



*Quantum Neural Network
Feed-forward network*

*Ensure **Maximum Power Point Tracking***

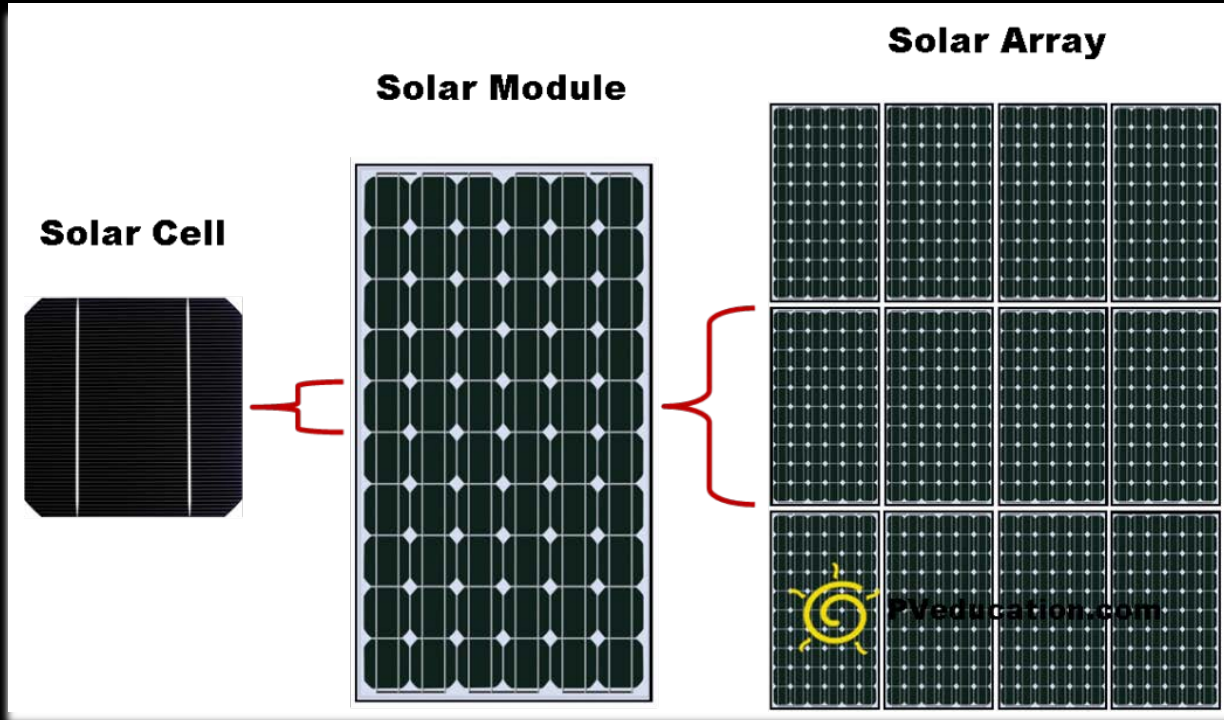
faster adaptability to environment

better optimization



Energy Systems: Controller in photovoltaic system

Research Paper:



Energy Systems: Controller in photovoltaic system

Maximum Power Point Tracking

Research Paper:



maximum power:
transfer from PV panel
to the load



for certain
irradiation and
temperature



controller complies quickly
and adapts to the new
environmental conditions

Energy Systems: Controller in photovoltaic system

Research Paper:



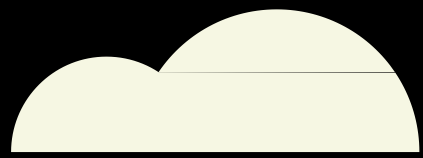
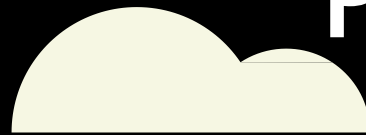
QUANTUM IS THE FASTEST!

| Method | Theoretical MPP (W) | Tracked MPP (W) | Tracking Time (s) | Efficiency (%) |
|---------------------|---------------------|-----------------|-------------------|----------------|
| QNN | 162.5 | 161 | 0.037 | 99 |
| P&O | 160 | 159 | 0.05 | 99.4 |
| Fuzzy Logic | 84 | 79.7 | 0.03 | 94.8 |
| ANN | 240 | 230 | 0.03 | 95.8 |
| PSO | 854 | 852 | 0.186 | 99.7 |
| Mayfly optimization | 505 | 500.4 | 0.05 | 99.1 |

MPPT Techniques



02. Solar Irradiance Prediction



2. Energy Systems: Solar Irradiance Prediction

Research Paper:



Quantum LSTM

Ensure **Scheduling** of Electric Power for Secure Grid
Operation

higher accuracy

combination LSTM + VCQ



2. Energy Systems: Solar Irradiance Prediction

Research Paper:



QLSTM IS THE FASTEST!

| City | Model | Spring | | | Summer | | | Autumn | | | Winter | | |
|--------|--------|---------------|---------------|--------------|---------------|---------------|--------------|---------------|---------------|--------------|---------------|---------------|--------------|
| | | RMSE | MAE | R^2 | RMSE | MAE | R^2 | RMSE | MAE | R^2 | RMSE | MAE | R^2 |
| Urumqi | SARIMA | 65.227 | 34.229 | 0.950 | 74.246 | 36.968 | 0.949 | 39.581 | 19.282 | 0.969 | 35.461 | 15.725 | 0.958 |
| | CNN | 83.327 | 50.106 | 0.918 | 93.286 | 58.958 | 0.920 | 46.588 | 23.699 | 0.957 | 39.302 | 17.967 | 0.949 |
| | RNN | 66.582 | 37.764 | 0.948 | 76.897 | 46.692 | 0.945 | 43.472 | 23.436 | 0.962 | 36.556 | 17.122 | 0.956 |
| | GRU | 62.648 | 33.158 | 0.954 | 72.043 | 40.474 | 0.952 | 36.560 | 16.977 | 0.973 | 33.841 | 13.589 | 0.962 |
| | LSTM | 60.221 | 27.068 | 0.957 | 71.276 | 30.952 | 0.953 | 34.411 | 13.946 | 0.976 | 32.604 | 11.514 | 0.965 |
| | QLSTM | 57.065 | 24.224 | 0.962 | 66.021 | 27.442 | 0.960 | 32.784 | 11.535 | 0.979 | 31.786 | 9.790 | 0.967 |
| Hohhot | SARIMA | 69.559 | 34.335 | 0.953 | 87.990 | 46.390 | 0.924 | 46.946 | 23.431 | 0.961 | 34.104 | 15.659 | 0.967 |
| | CNN | 74.220 | 34.542 | 0.947 | 96.697 | 50.484 | 0.908 | 45.604 | 20.524 | 0.964 | 34.114 | 14.999 | 0.967 |
| | RNN | 65.287 | 29.551 | 0.959 | 80.858 | 38.632 | 0.936 | 40.253 | 17.128 | 0.972 | 32.952 | 14.163 | 0.970 |
| | GRU | 64.509 | 25.641 | 0.960 | 81.362 | 37.215 | 0.935 | 37.834 | 14.606 | 0.975 | 31.962 | 12.670 | 0.971 |
| | LSTM | 66.369 | 29.071 | 0.958 | 83.814 | 40.475 | 0.931 | 40.650 | 17.623 | 0.971 | 31.319 | 13.102 | 0.972 |
| | QLSTM | 63.299 | 23.225 | 0.961 | 79.627 | 35.010 | 0.938 | 36.103 | 12.557 | 0.977 | 29.966 | 10.315 | 0.975 |
| Harbin | SARIMA | 79.958 | 39.311 | 0.922 | 98.143 | 54.161 | 0.874 | 42.393 | 20.875 | 0.962 | 20.145 | 10.169 | 0.984 |
| | CNN | 81.444 | 39.967 | 0.919 | 97.281 | 52.995 | 0.876 | 41.092 | 20.081 | 0.964 | 23.723 | 11.633 | 0.977 |
| | RNN | 79.719 | 40.512 | 0.923 | 106.036 | 60.601 | 0.853 | 51.357 | 25.943 | 0.944 | 24.099 | 11.270 | 0.977 |
| | GRU | 73.150 | 30.886 | 0.935 | 91.638 | 44.160 | 0.890 | 35.982 | 14.624 | 0.972 | 20.447 | 9.518 | 0.983 |
| | LSTM | 73.919 | 32.706 | 0.933 | 91.773 | 47.406 | 0.890 | 36.416 | 15.494 | 0.972 | 18.496 | 7.552 | 0.986 |
| | QLSTM | 71.901 | 28.636 | 0.937 | 91.005 | 43.159 | 0.891 | 34.611 | 13.413 | 0.975 | 17.326 | 6.908 | 0.988 |

Hybrid Models are the Key!

PERFORMANCE

C

60%

Q

40%



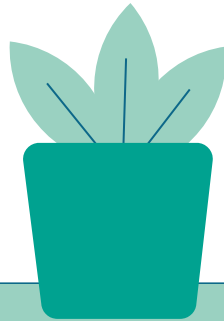
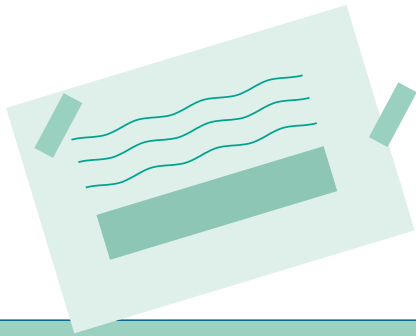
C + Q

PERFORMANCE

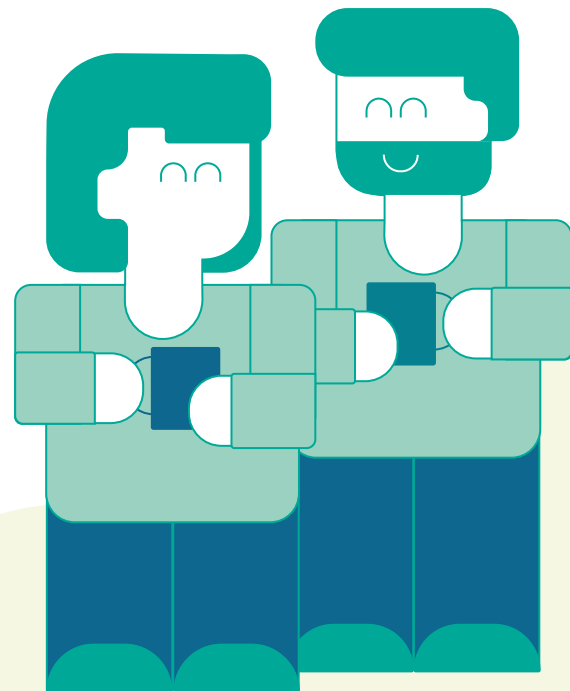
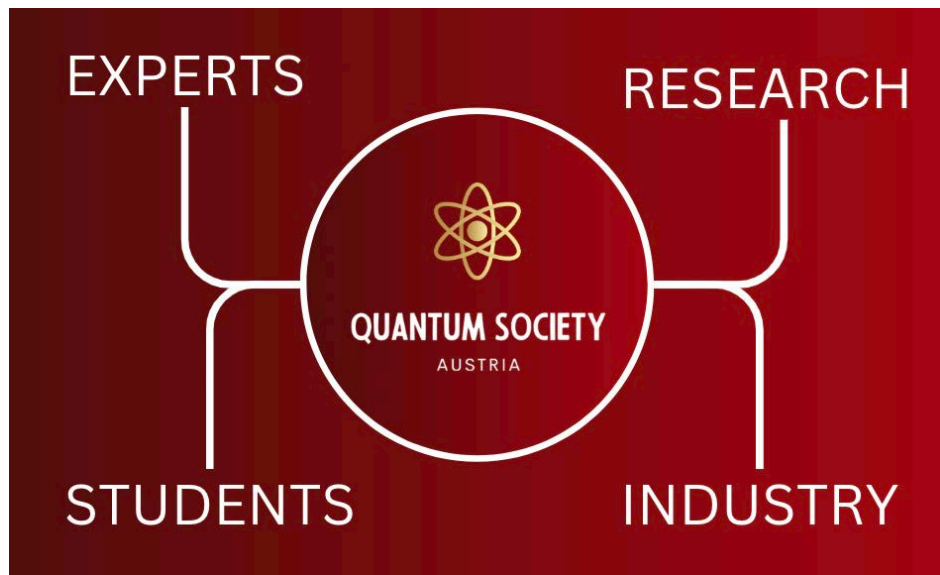
95%

Quantum Society Austria

[quantumsocietyaustria.com](https://www.quantumsocietyaustria.com)



About Quantum Society Austria



Quantum Events

24th November 2022



11th November 2023



Discord Server & LinkedIn





THANKS!

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