Quantum Computing within HEP

Christian Bauer
LBNL

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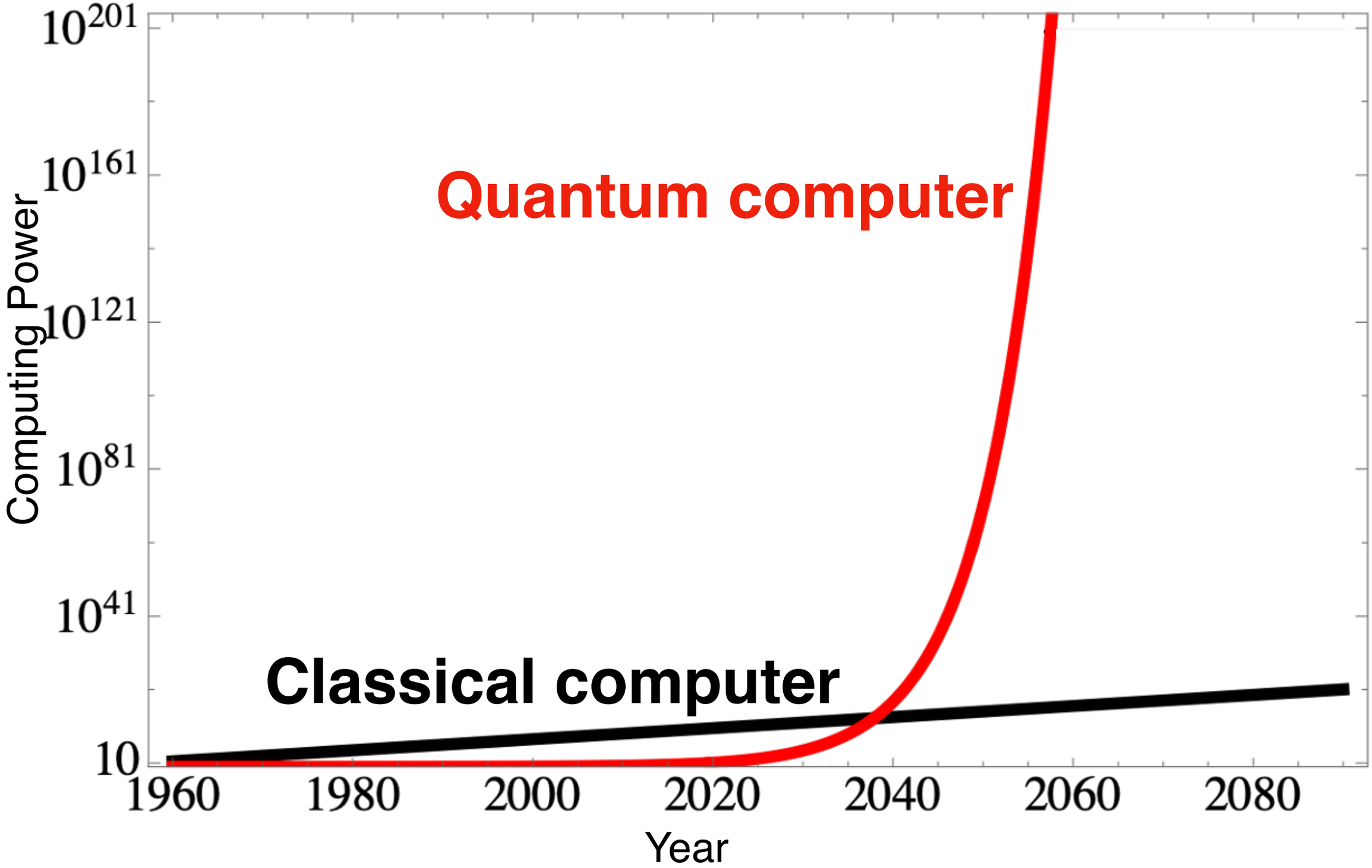
The standard argument for quantum computing is that it outperforms a classical computer exponentially



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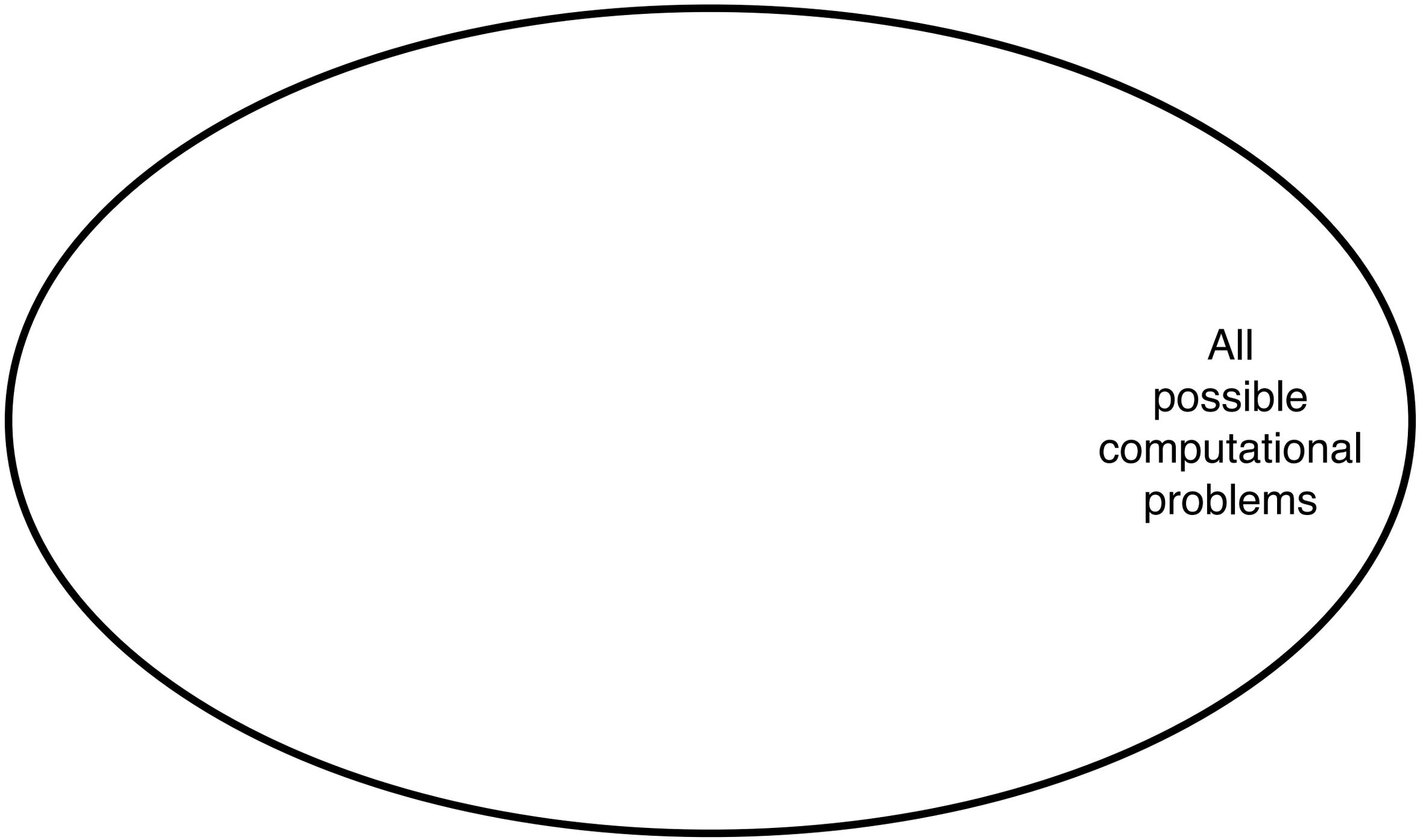

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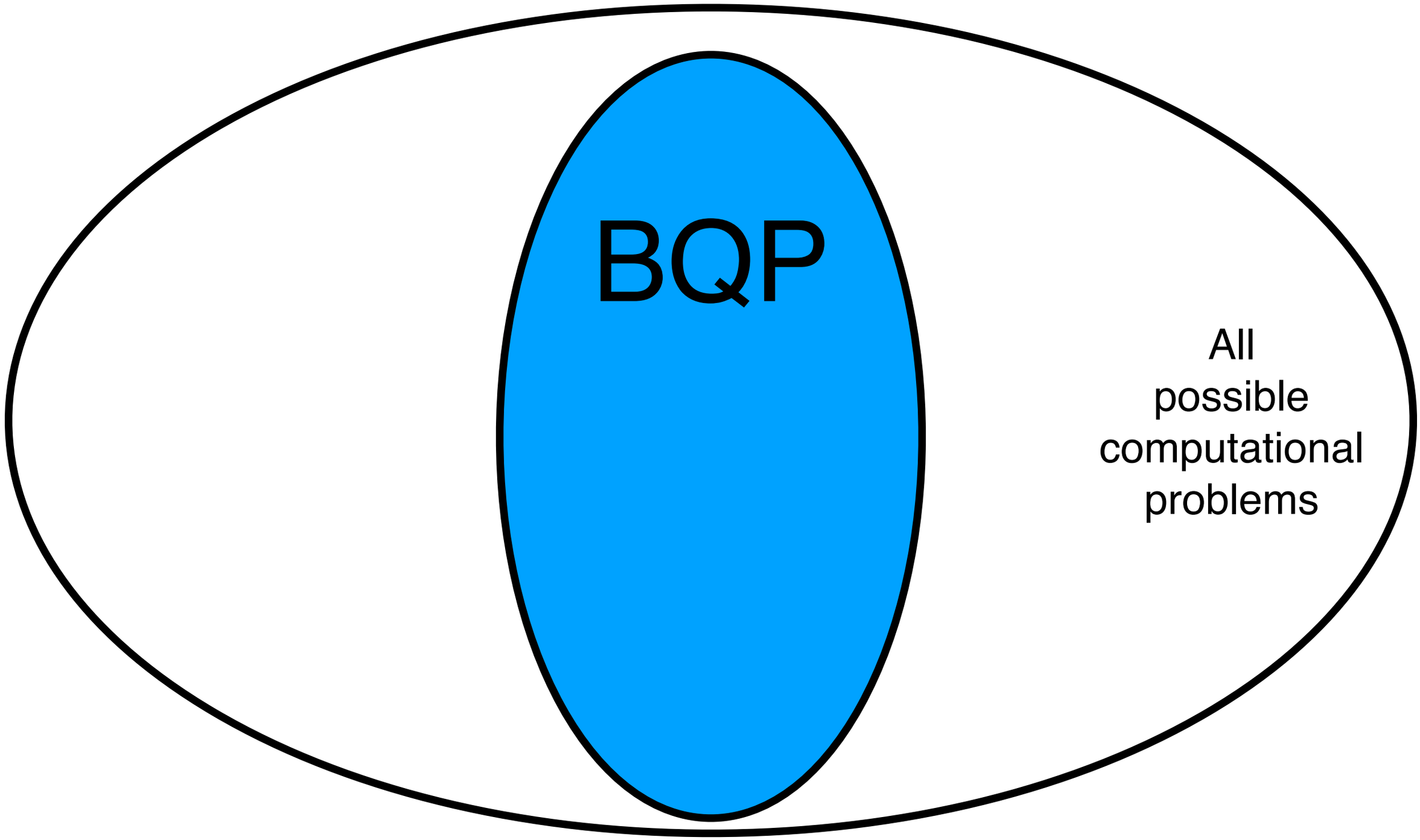

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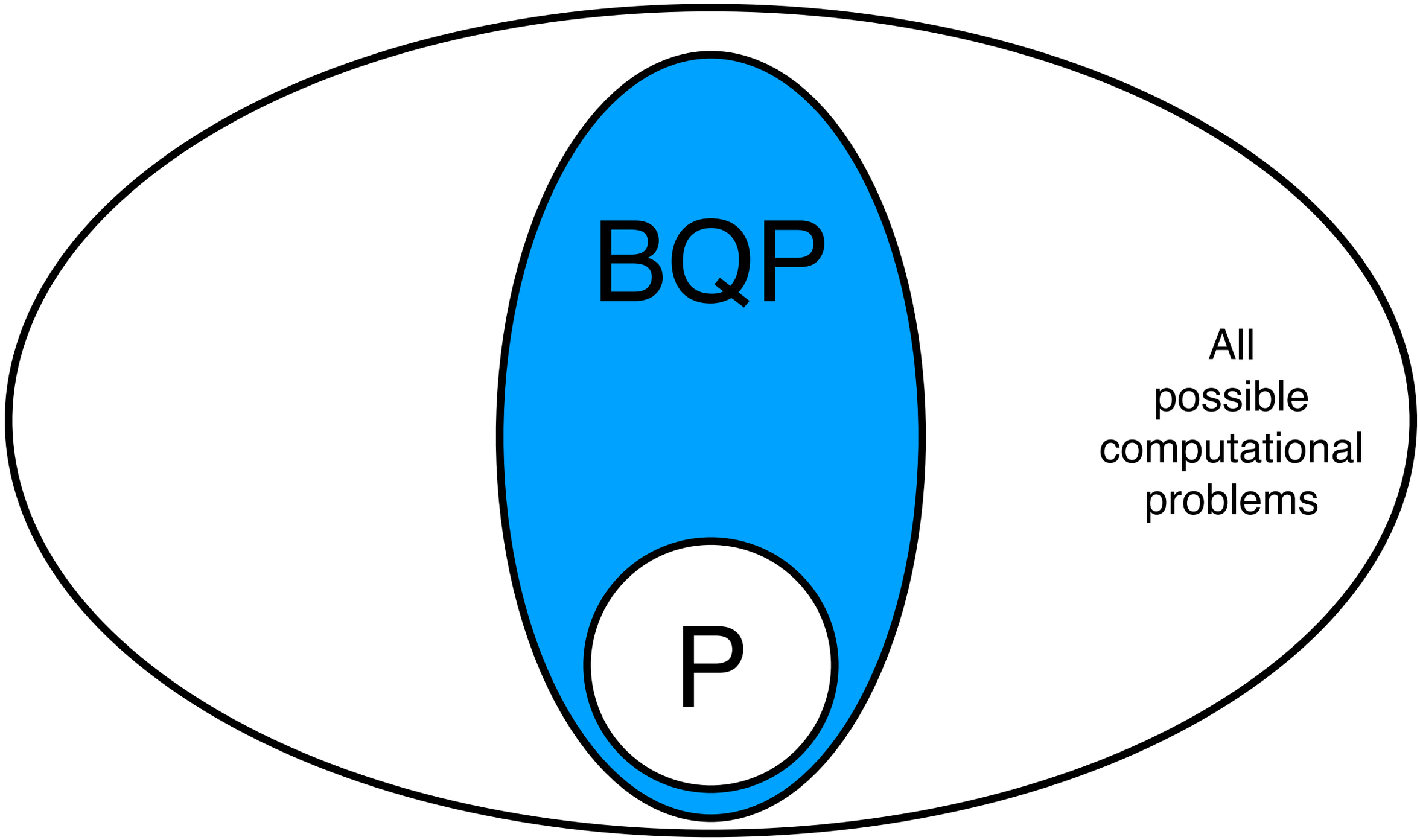
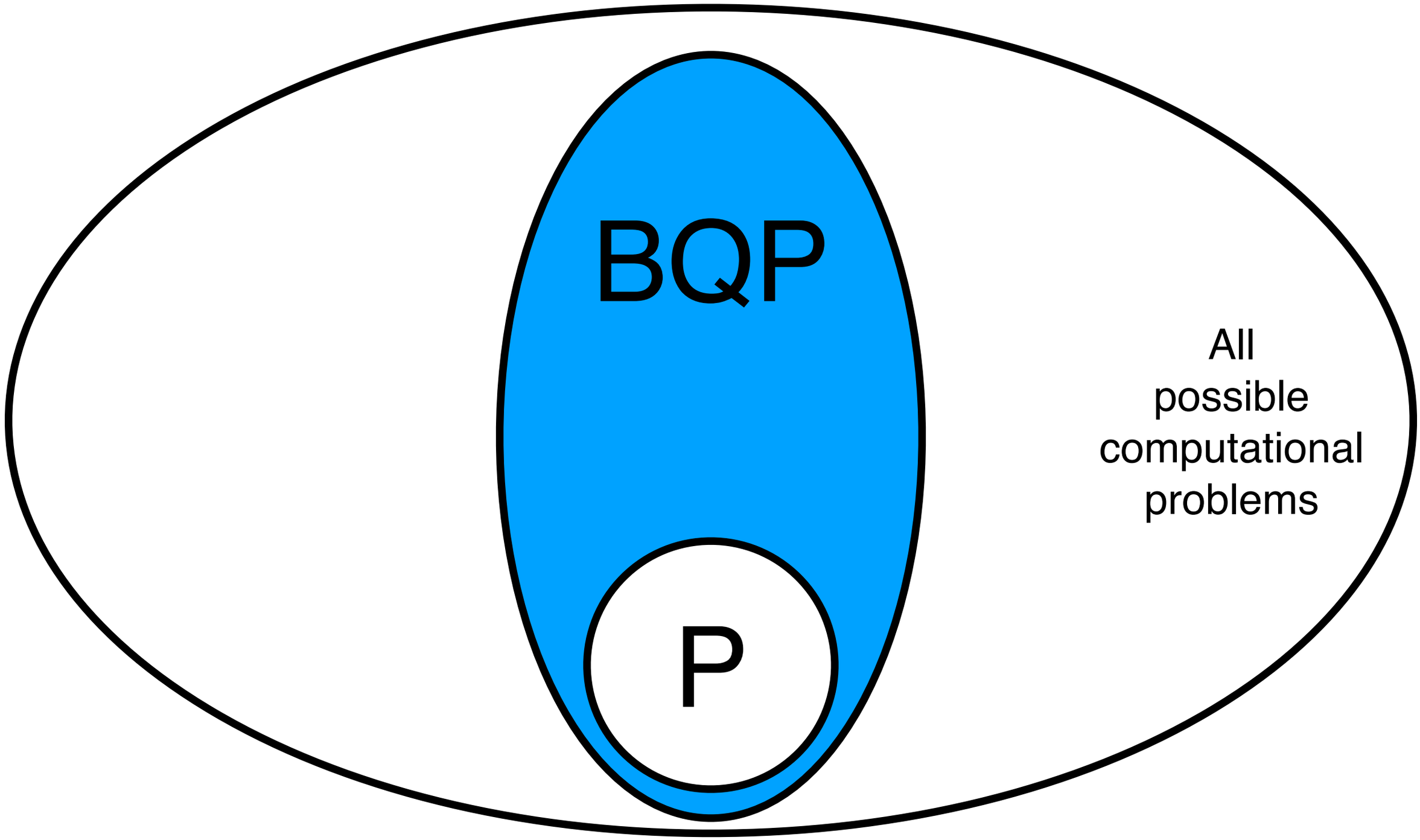


Need HEP problems for which a quantum computer outperforms a classical computer



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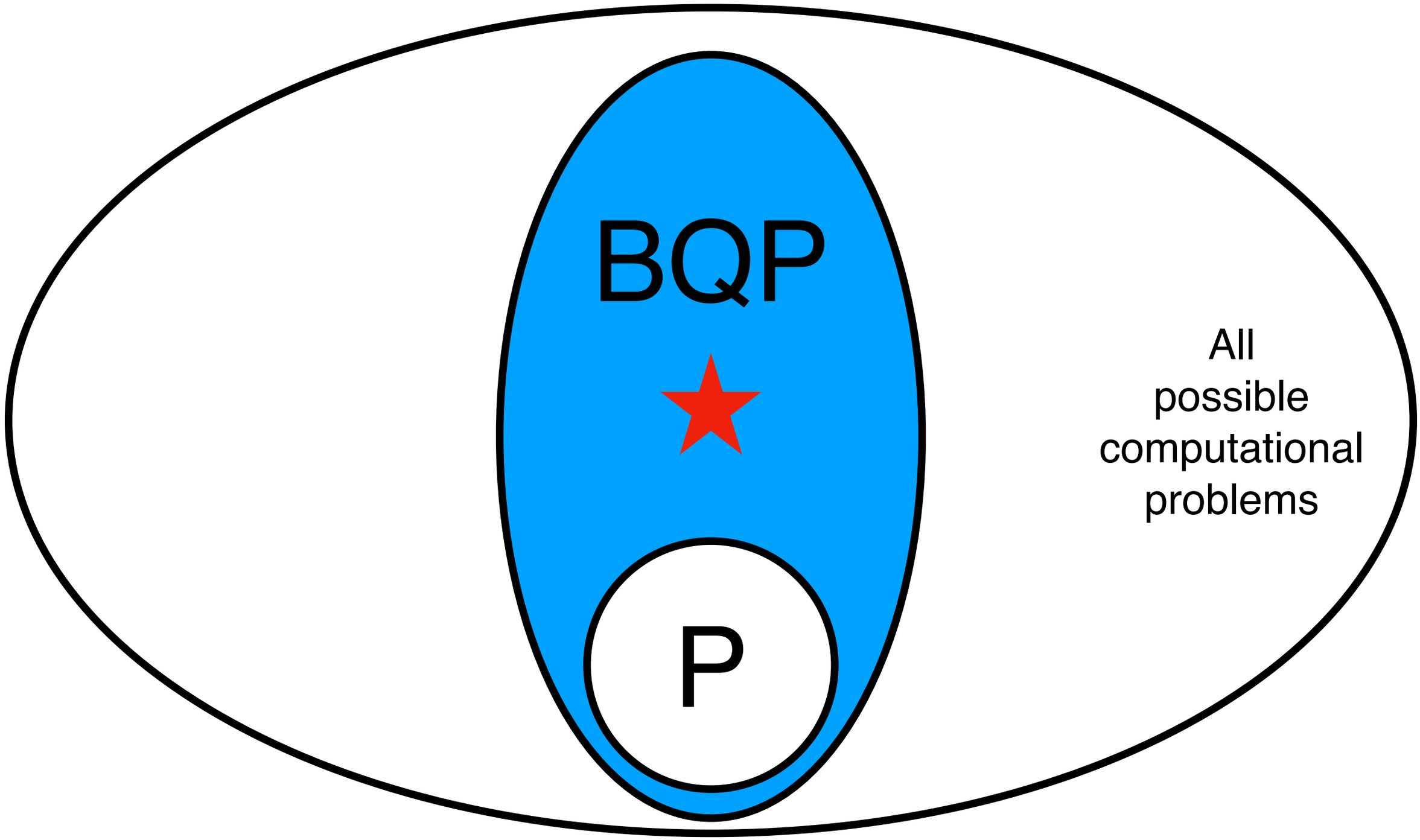
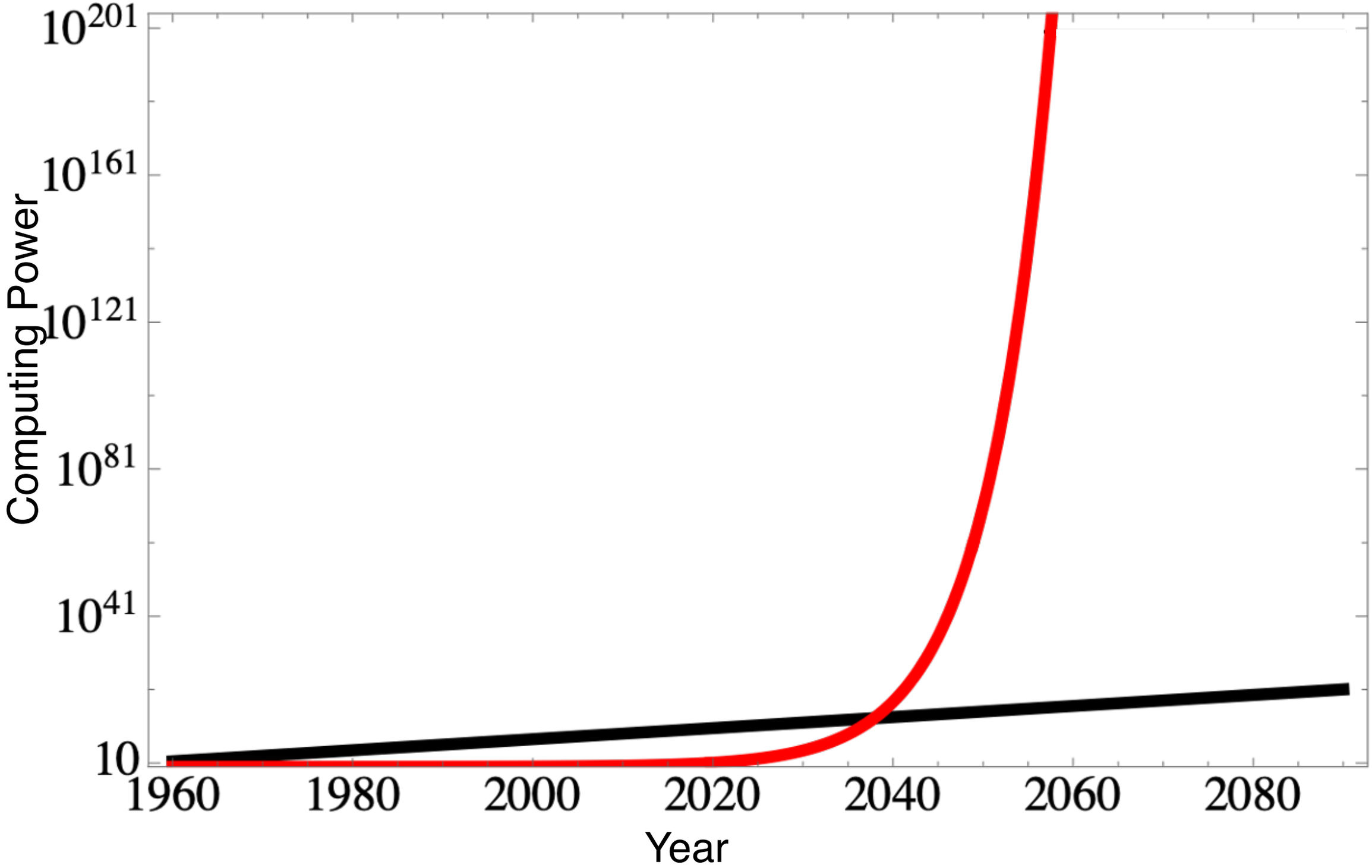


The important message is that there are transformational problems in HEP for which QC outperforms CC



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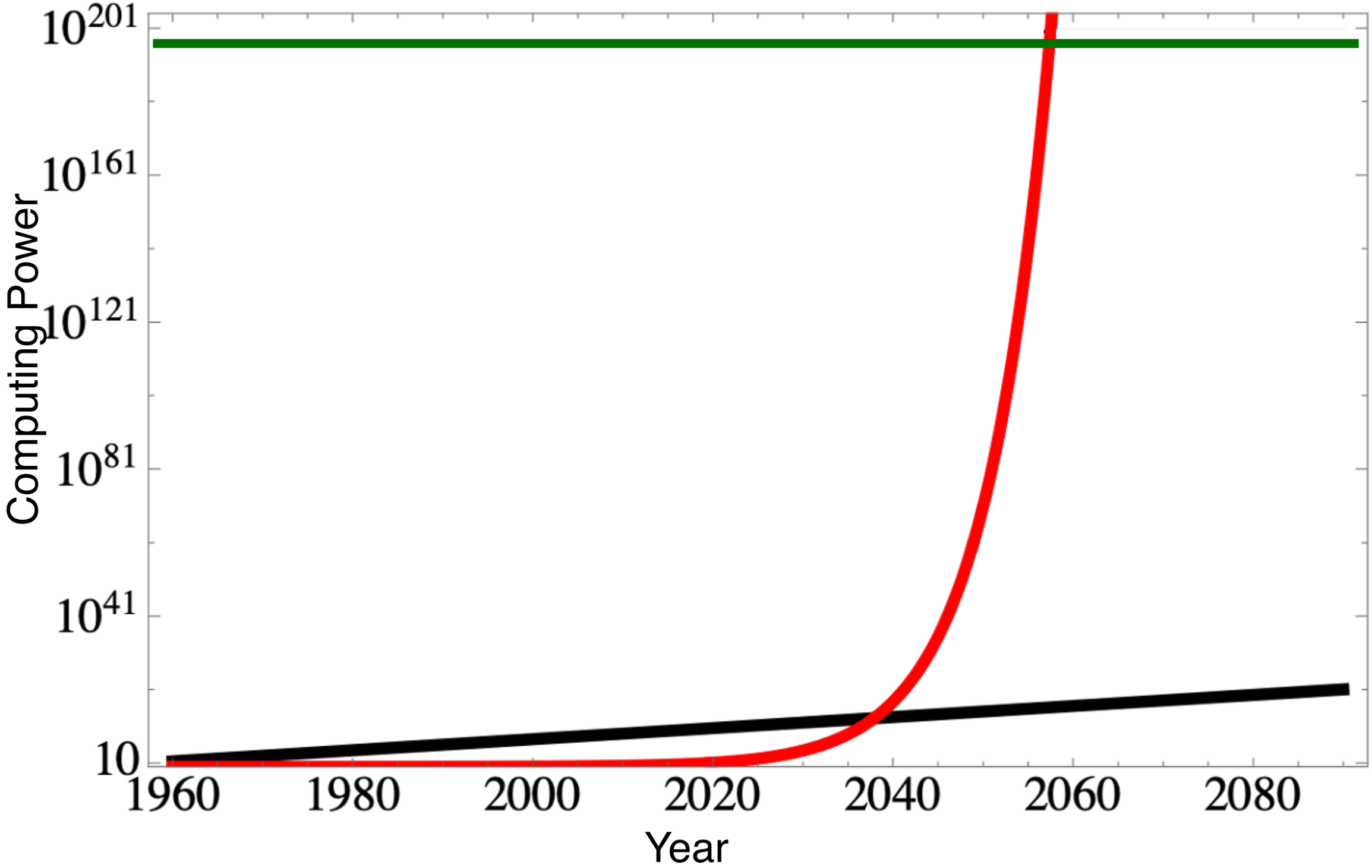

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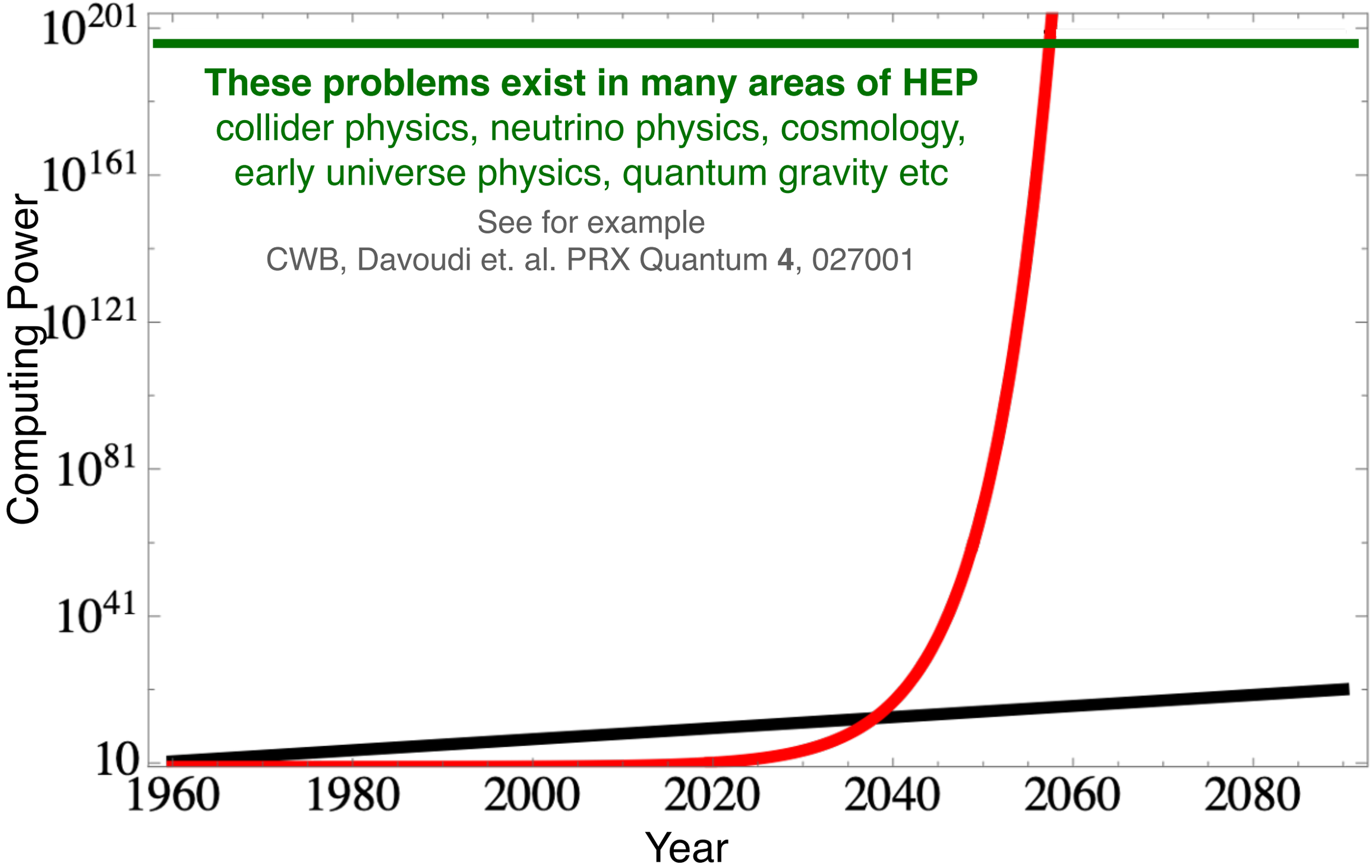


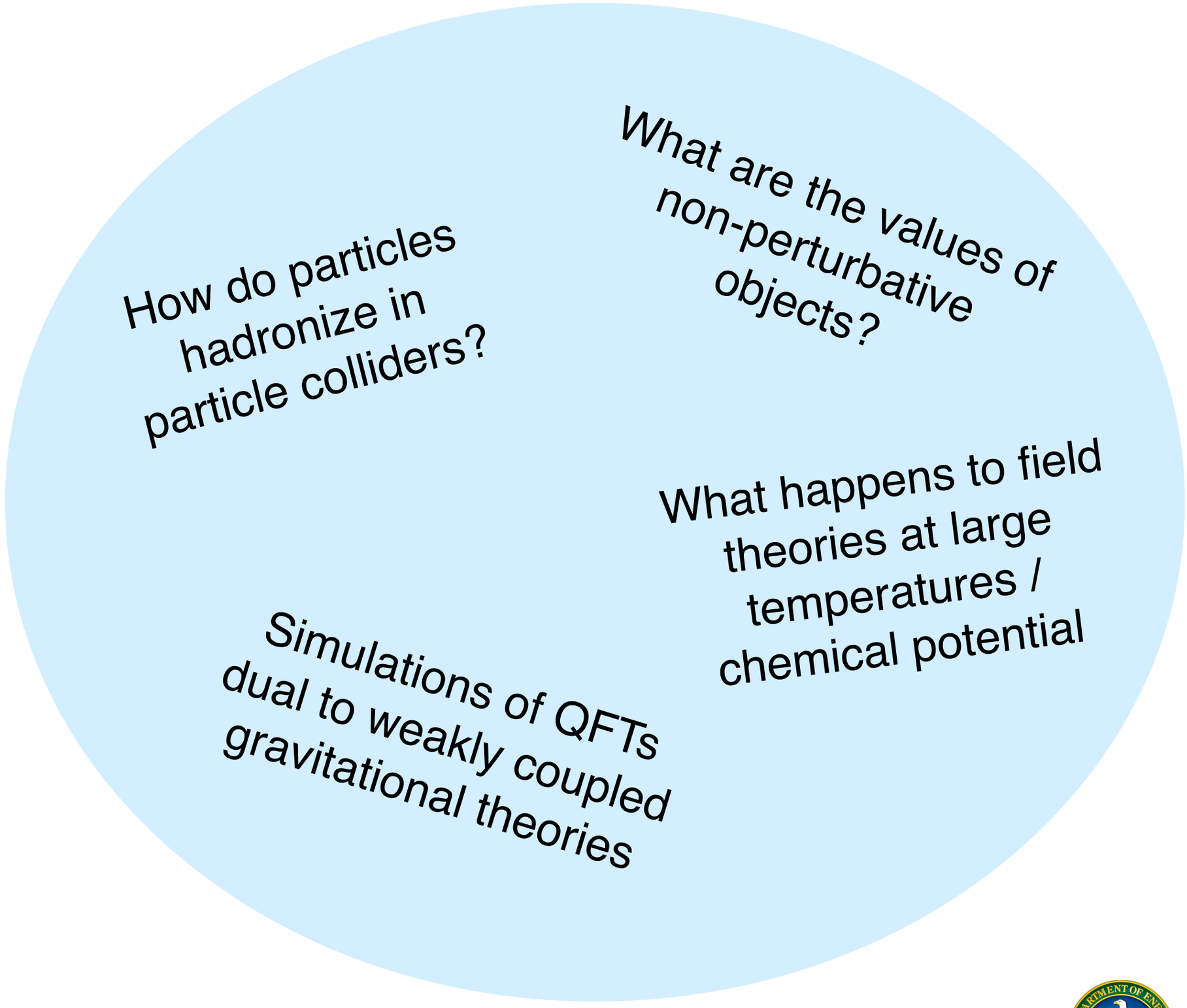
Quantum Algorithms for Quantum Field Theories

Stephen P. Jordan,[1]* Keith S. M. Lee,[2] John Preskill[3]

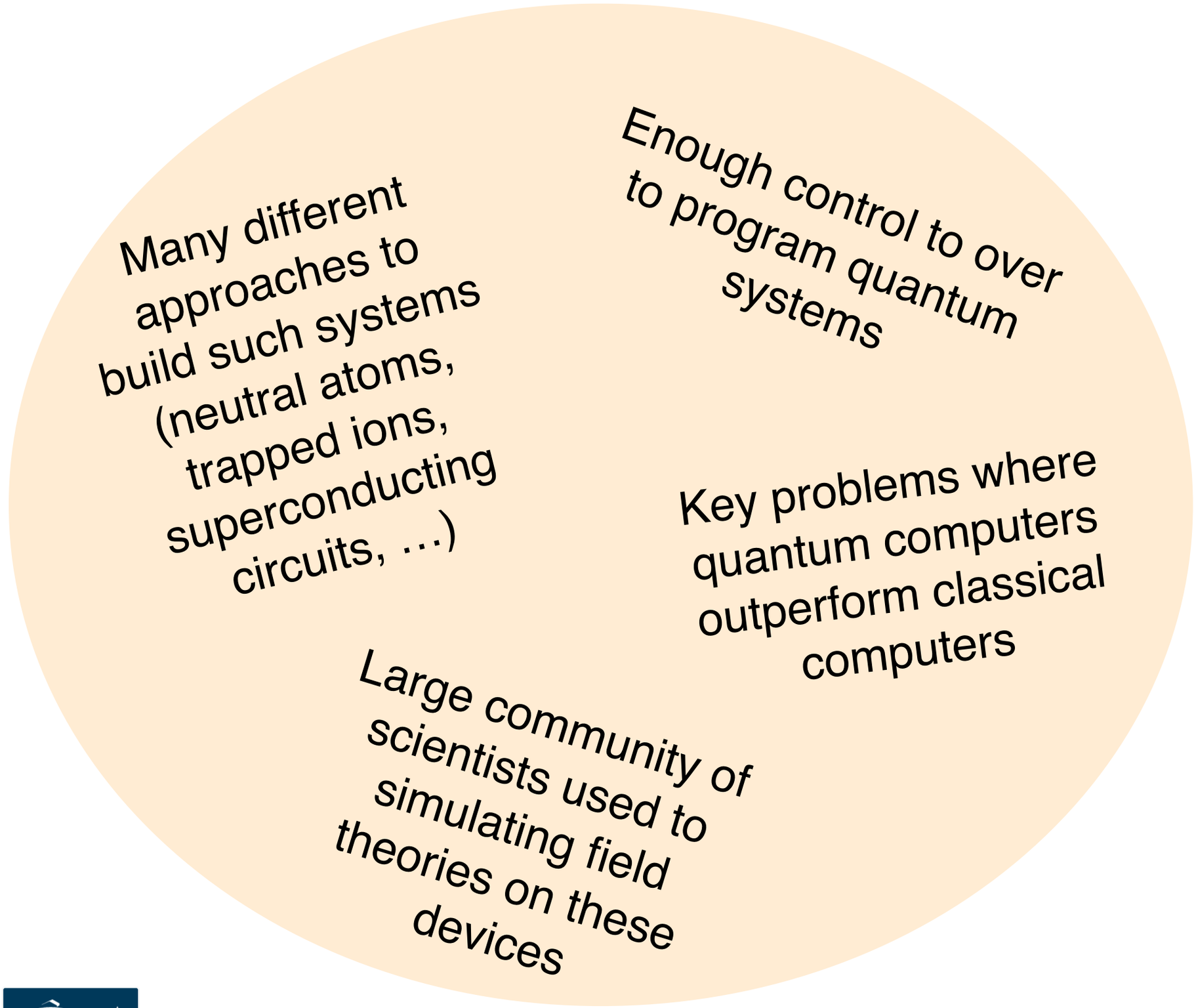
Quantum field theory reconciles quantum mechanics and special relativity, and plays a central role in many areas of physics. We developed a quantum algorithm to compute relativistic scattering probabilities in a massive quantum field theory with quartic self-interactions (ϕ^4 theory) in spacetime of four and fewer dimensions. Its run time is polynomial in the number of particles, their energy, and the desired precision, and applies at both weak and strong coupling. In the strong-coupling and high-precision regimes, our quantum algorithm achieves exponential speedup over the fastest known classical algorithm.

Jordan, Lee, Preskill, Science **336**, 1130, 2012

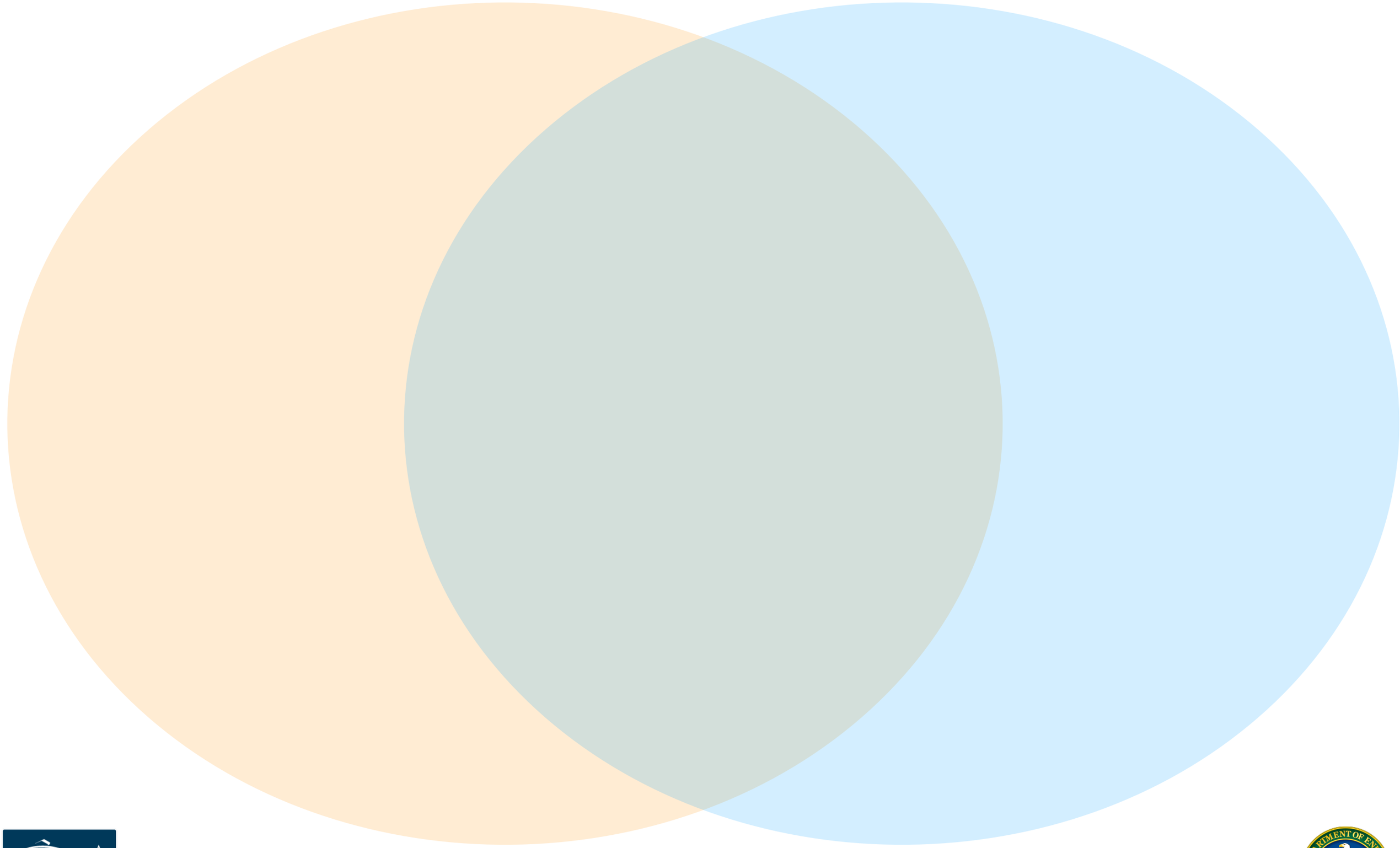
There are many questions in particle physics that we would love to have numerical answers to



The QIS community is rapidly advancing to build large quantum systems in laboratory setting



Embracing the QIS within HEP has huge advantages for both fields



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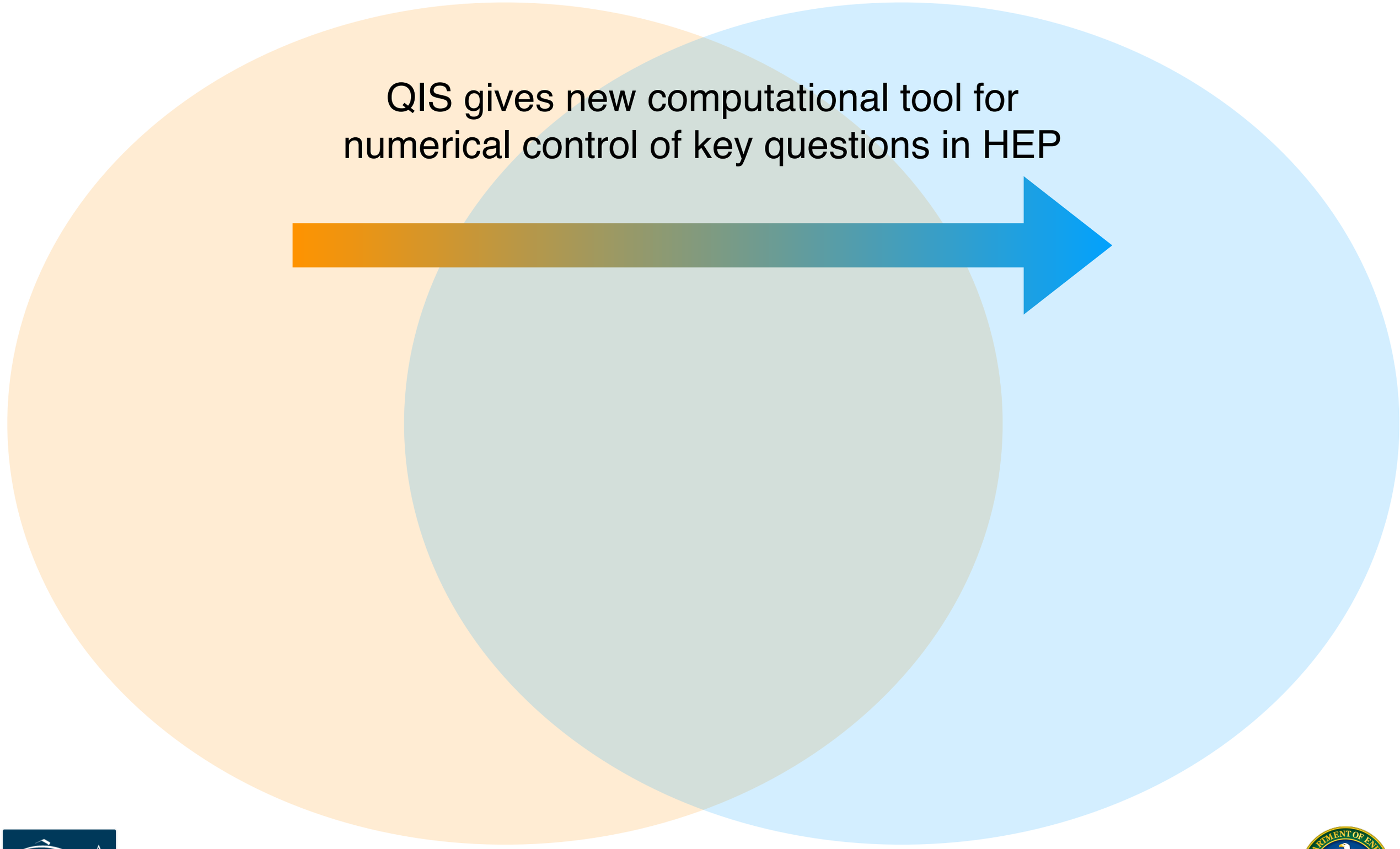

Embracing the QIS within HEP has huge advantages for both fields

QIS gives new computational tool for numerical control of key questions in HEP

Provides important benchmark applications and high profile scientific targets to QIS

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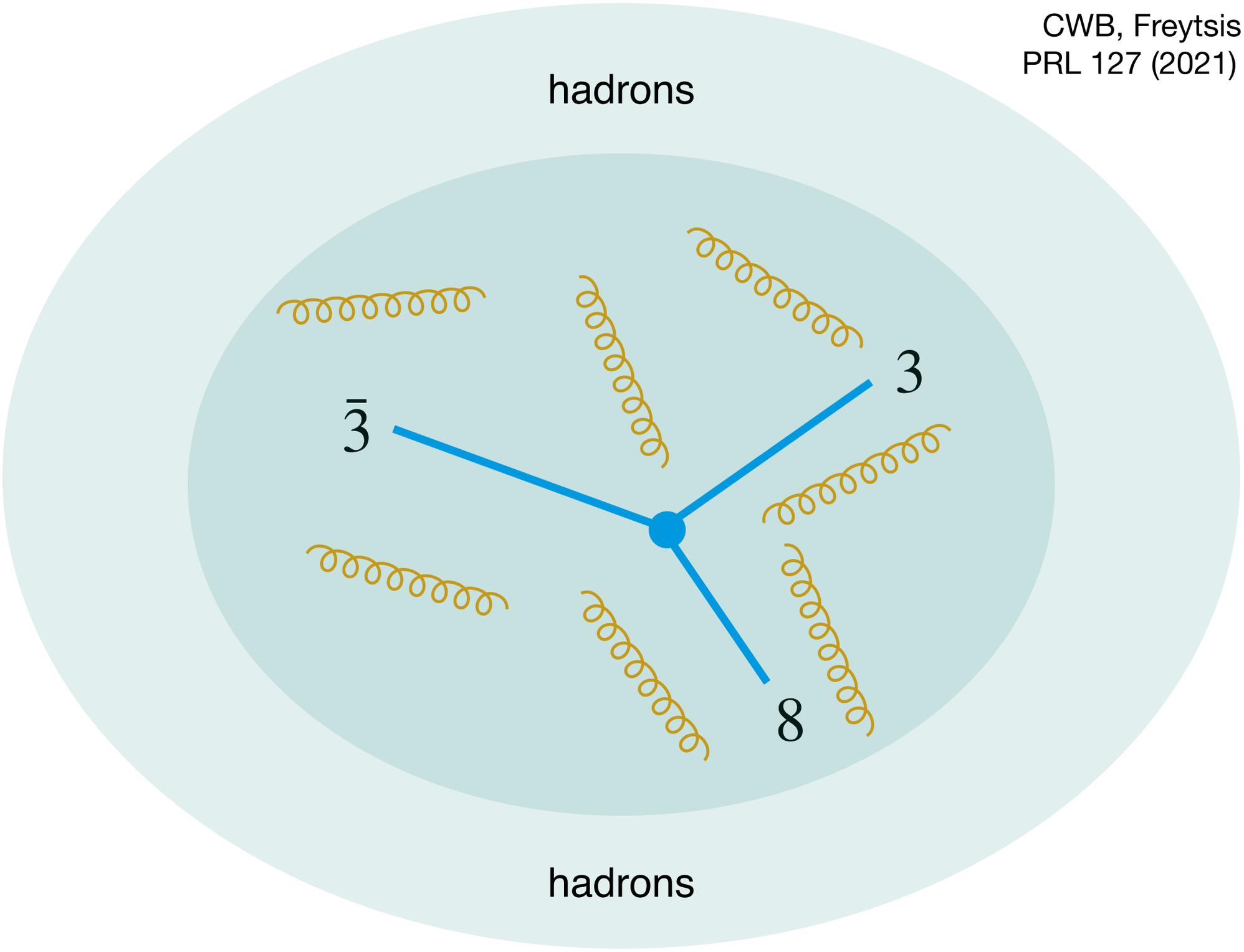
QIS gives new computational tool for numerical control of key questions in HEP

Allows scientists from both fields to learn about QFTs in regimes that have not previously been tackled

Provides important benchmark applications and high profile scientific targets to QIS

One of things one can compute on quantum computers is soft function describing color reconnection at colliders

CWB, Freytsis, Nachman,
PRL 127 (2021) 21, 212001



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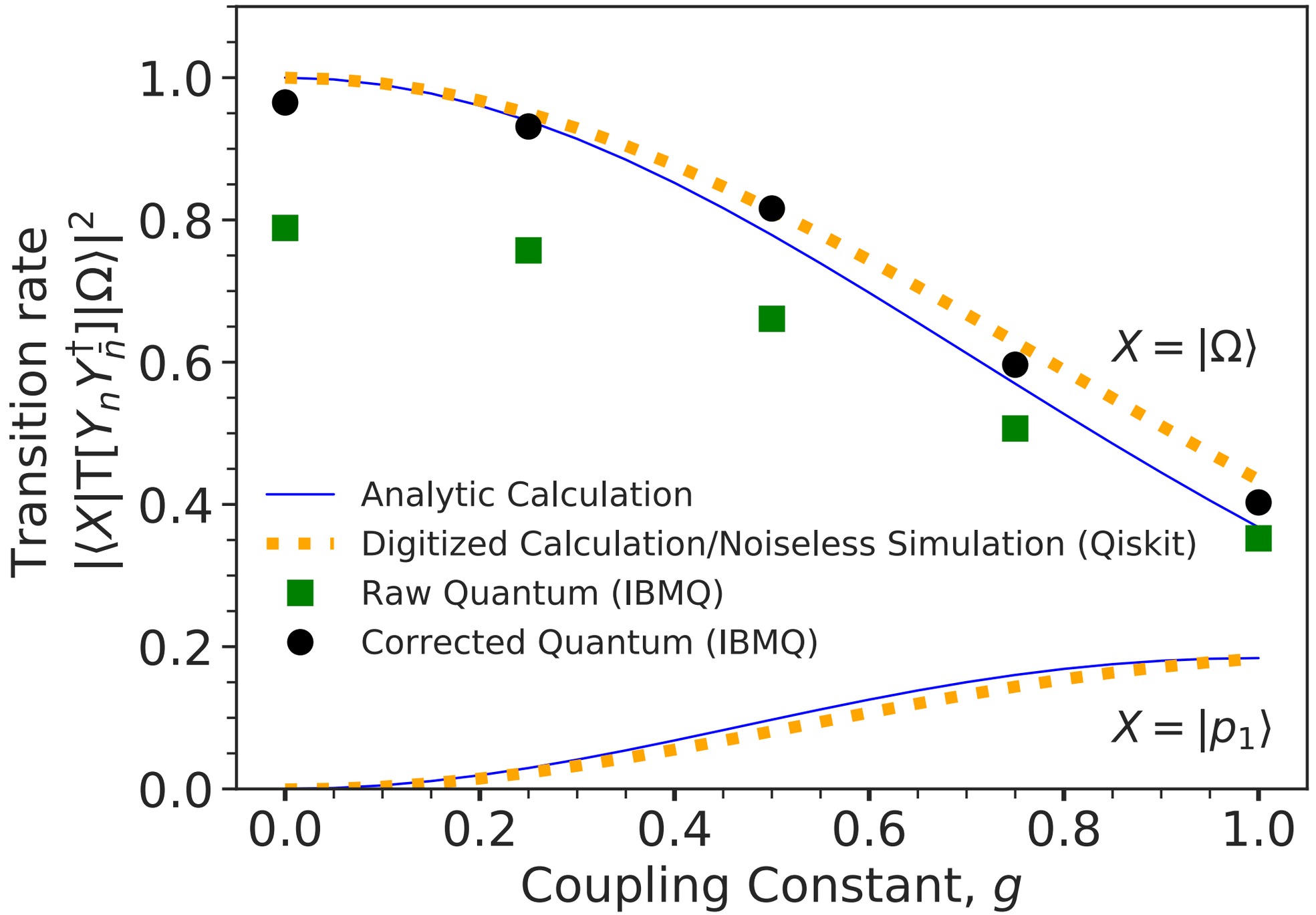

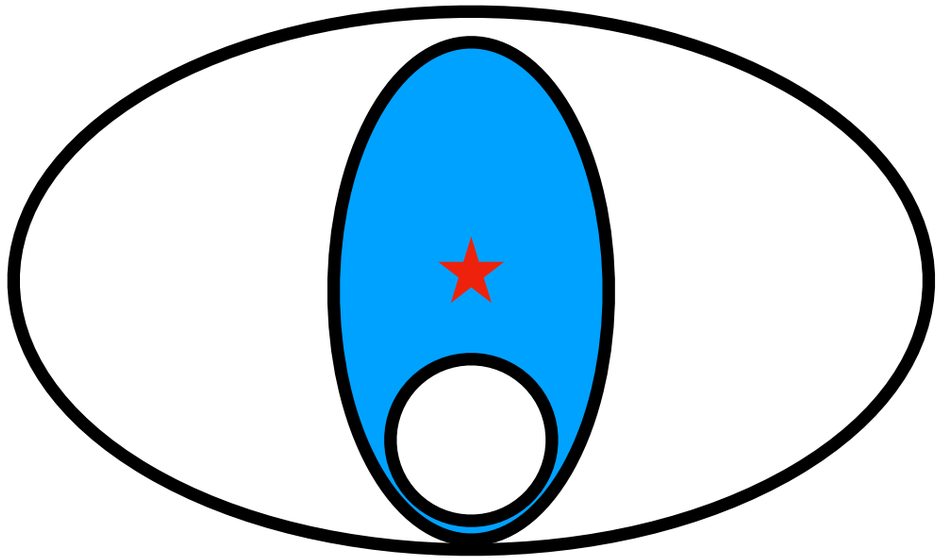

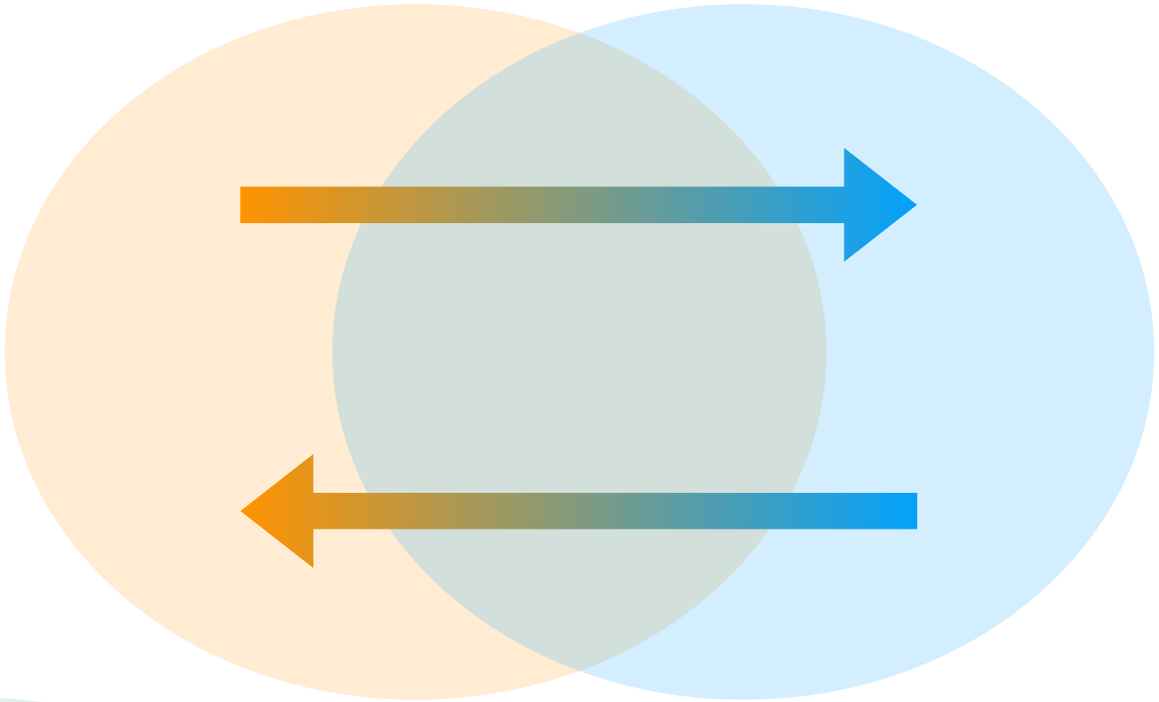

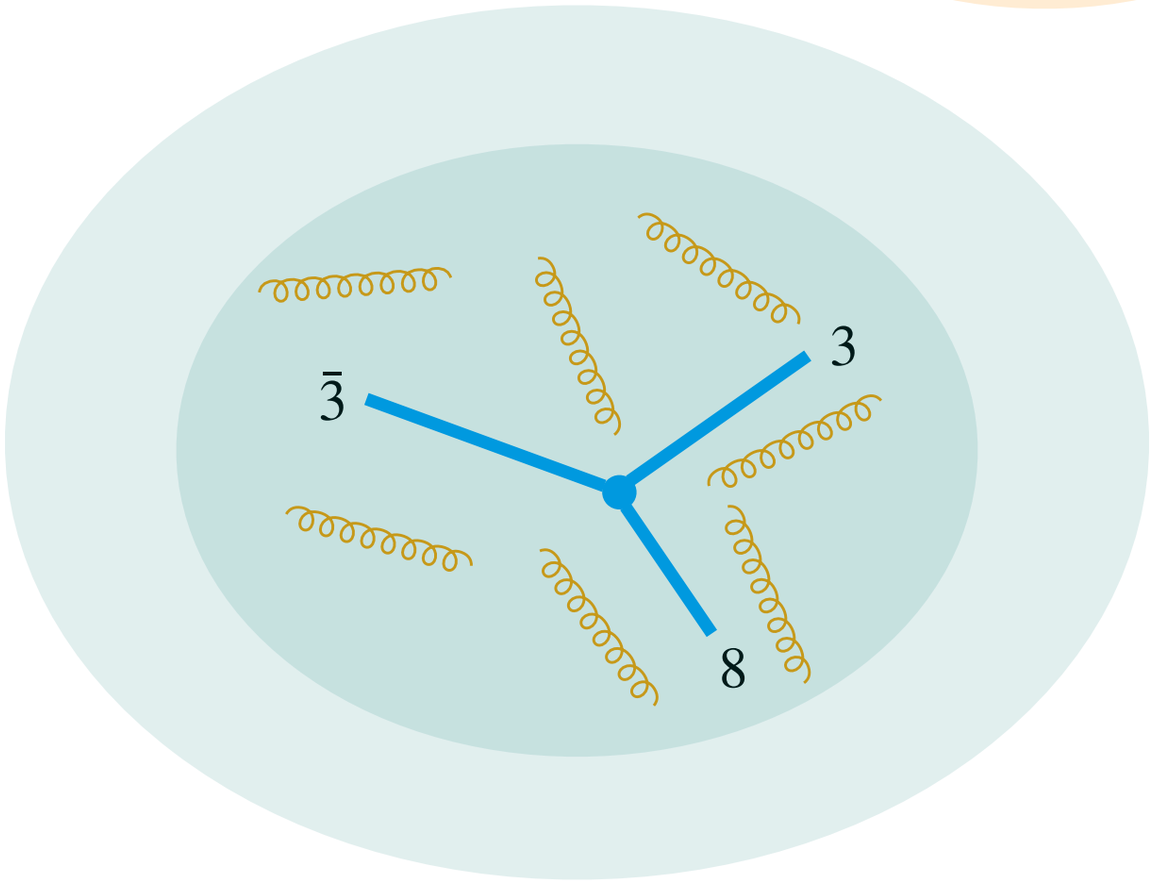

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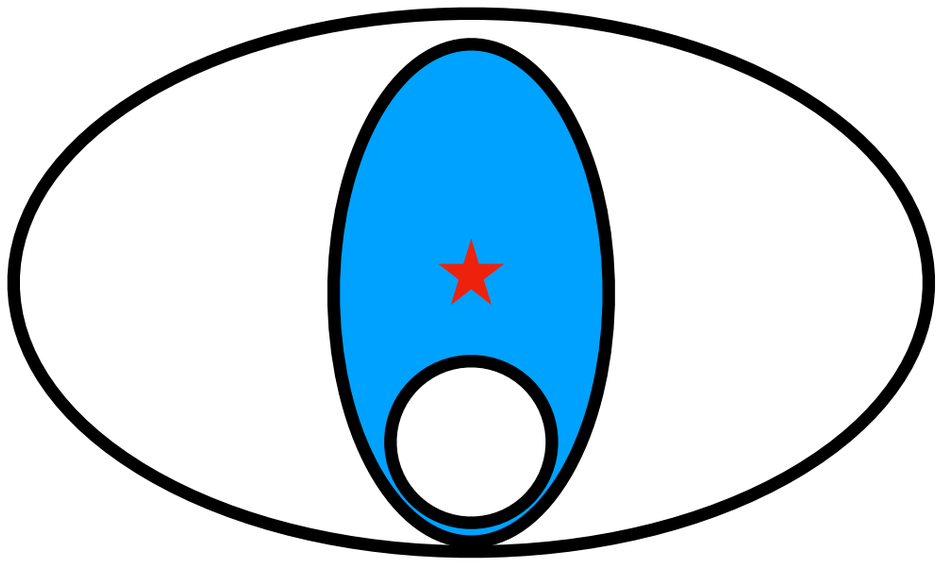

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