Quantum MCMC Speedup Analysis: Comprehensive Results (a) Quantum Speedup vs Classical Gap (b) Mixing Time Comparison **−−** Theory:  $\propto 1/\sqrt{\text{(gap)}}$ -- No speedup  $3 \times 10^{1}$  $6 \times 10^{0}$ Ouantum Mixing Time  $5 \times 10^{1}$   $10^{1}$  $2 \times 10^{0}$  $6 \times 10^{0}$  $10^{-1}$ 10<sup>2</sup>  $10^{1}$ Classical Spectral Gap Classical Mixing Time (c) Circuit Complexity vs Speedup (d) Error Bound vs Speedup  $9.825 \times 10^{-2}$  $3 \times 10^{1}$ 0.9  $9.8 \times 10^{-2}$  $9.775 \times 10^{-2}$ o 2 Success Probability Circuit Depth  $^{2}$  Circuit  $^{2}$  Circuit Depth  $^{2}$  Circuit Depth **Error Bound**  $9.75 \times 10^{-2}$  $9.725 \times 10^{-2}$  $9.7\times10^{-2}$ 0.6  $9.675 \times 10^{-2}$  $9.65 \times 10^{-2}$ 0.5  $2 \times 10^{0}$  $3 \times 10^{0}$   $4 \times 10^{0}$  $2 \times 10^{0}$  $3 \times 10^{0}$  $4 \times 10^{0}$  $6 \times 10^{0}$  $6 \times 10^{0}$ 

Quantum Speedup Factor

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