Contribution ID: **417** Type: **Oral presentation**

Real-time Quantum Calculations of Phase Shifts On NISQ Hardware Platforms Using Wavepacket Time Delay

Monday, July 26, 2021 10:00 PM (15 minutes)

We introduce a new method to calculate phase shifts on noisy intermediate scale quantum (NISQ) hardware platforms using a wave packet edge time delay. The method uses the early and intermediate stages of the collision because the standard method based on the asymptotic out-state behavior is unreachable using today's NISQ platforms. The calculation was implemented on a 4-site transverse Ising model in one spatial dimension with and without a potential interaction. A time evolution operator describing the progression of the system was constructed and transmission and reflection coefficients were calculated based on the identified quantum Fourier transformed momentum states. The detailed analysis of the phase shift calculations on both IBM superconducting transmon and University of Maryland ion trap quantum computers shows the platform independence of the methodology. This successful implementation of this wave packet preparation and projection on momentum eigenstates can now be performed with actual quantum computing hardware platforms. This method provides a procedure for calculating phase shifts and opens the possibility of using noisy intermediate scale quantum devices to perform real-time quantum mechanics and quantum field theory scattering calculations.

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Session Classification: Algorithms (including Machine Learning, Quantum Computing, Tensor Networks)

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