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Beyond Semiclassical Physics: Consistent Hybrid Quantum-Classical Dynamics?

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Combining quantum and classical degrees of freedom provides a useful approximation in many practical applications. Examples include the study of quantum particles in a classical external potential (textbook quantum mechanics), or quantum field theory on a classical curved background. In these examples, only the classical affects the quantum, but not the other way around. If these approximations can provide valuable insight, then what can we learn from a fully consistent framework capable of describing mutual interaction between quantum and classical systems?

Quantum and classical mechanics share a formal canonical structure. We investigate the possibility of leveraging this common structure to construct a consistent framework for "quantum-classical" dynamics. Previous attempts have been proposed and criticized in multiple no-go theorems. We generalize the procedure for constructing canonical hybrid dynamics and find a precise mathematical condition for the desired consistency. We show that the consistency requirement places constraints on the allowed interactions between quantum and classical systems.

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