Equivalence of Hamiltonians in Atom Optics

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The linearity of quantum mechanics and the resulting Hilbert structure of quantum space allows an amazing freedom in choosing an appropriate representation to describe a given quantum phenomena. Position, momentum or energy Eigenstates conserve and equivalent spaces to obtain a prediction for an observable. Although, the details of this analysis may be different in the individual representations, the final expressions for the probability for a measurement outcome are, of course, identical.

In the present talk, we [1] show that this freedom is not restricted to the choice of representations but also extends to the very heart of quantum dynamics, that is to setting up the appropriate Hamiltonian. In particular, we demonstrate this frame dependence of quantum phenomena using the example of the phrase difference between two atom waves in the Kasevich-Chu interferometer. We show that this quantity arises from different terms in the Hamiltonian. A crucial role in this analysis is played by the canonical momentum whereas in classical physics it cannot be observed, all of quantum mechanics rest on it. In this talk we emphasise this crucial difference.

[1] M. Zimmerman, M. A. Efremov, F. A. Narducci and W. P. Schleich, *Equivalence of Hamiltonians in Atom Optics*, Memorial Issue for Jonathan Patrick Dowling AVS Quantum, to be published.