The development of quantum limited acceleration and rotation devices is a key research direction. In the context of ultra-cold atoms, whether thermal clouds or Bose-Einstein condensates, this is usually realized by atomic matter-wave interferometers [1].

The numerical solution of associated three-dimensional equations of motion -- e.g. Schrödinger or Gross-Pitaevskii -- is cumbersome if not vitually impossible.
However, designing and simulating matter-wave interferometers is, in many ways, analog to the design of high precision optical devices.
In case of the latter, one does not rely on Maxwell's equations but rather on efficient semi-classical ray tracing methods. In the same spirit, we approximate the dynamics of thermal clouds or Bose-Einstein condensates with a ray tracing formalism.
To this end, we employ the effective single-particle Wigner function as a phase space representation of the atom cloud [2], which is well suited for describing partially coherent matter-waves used for interferometry. When classical transport theory is valid, the Wigner function flows along the classical phase space trajectories. On the other hand, when the ensemble interacts with a coherence creating device, like a beam splitter or double slit, one has to use an appropriate map.

We discuss advantages and shortcomings of this approach. Moreover, we show results of simulations relating to realistic experimental setups.

References:
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