In the last years different atom interferometers have been suggested [1] and realized [2], which probe a linear potential and have a contribution to the phase shift that scales as $T^3$, in contrast to conventional atom interferometers with a phase scaling as $T^2$. Here $T$ denotes the total interferometer time. Moreover, recently a Stern-Gerlach interferometer [3-5] has been constructed which reveals a pure cubic phase scaling.

We review and compare these interferometers by applying a representation-free formalism [6]. In particular, we show that the cubic phase is a result of a branch-dependent linear potential, which is piecewise constant in time. Furthermore, a $T^3$-interferometer should be closed in order to obtain a high contrast, that is the differences in momentum $\delta p(t)$ and position $\delta z(t)$ between its two branches, depicted exemplarily in Fig. 1, have to vanish for $t = T$. Finally, we relate the resulting cubic phase shift to the area in space-time enclosed by the two interferometer branches.

![Diagram](image)

Fig. 1: Displacements in momentum $\delta p(t)$ and position $\delta z(t)$ between the two branches of a $T^3$-interferometer.

[6] M. Zimmermann et al., to be submitted