Dynamics of Point Vortices with Massive Cores in a Boson Bynary Mixture

A Richaud[1], V Penna[2], and A L Fetter[3]

[1]*Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy*
[2]*Applied Science and Technology, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129, Turin, Italy.*
Contact Phone: +0039-110907303
[3]*Stanford University, Stanford CA, USA*
Contact Email: vittorio.penna@polito.it

We investigate topological composite states occurring in the immiscible regime of a bosonic binary mixture loaded in a boxlike circular trap. Such states are characterized by one component exhibiting point vortices while the second component features soliton-like peaks confined in the vortex cores. In [1], the dynamics of this system has been conjectured to be represented by poinlike massive cores with topological charge obeying effective Lorentz equations. Here, we explicitly derive these equations by applying the time-dependent variational method to the Gross-Pitaevskii (GP) field Lagrangian describing the binary mixture. After showing how the resulting effective Lagrangian indeed resembles that of charged particles in a static electromagnetic field, we study the simplest example of a single vortex with a rigid circular boundary. Unlike a massless vortex, which can only precess uniformly, we show that a vortex core equipped with a sufficiently large mass can trigger an unstable precession, while a small core mass can determine small radial oscillations witnessing, in turn, the associated inertial effect. The numerical solution of coupled two-component GP equations with a single vortex combined with a small second-component core confirms such radial oscillations, implying that this more realistic GP vortex also acts as if it has a small massive core.

References

[1] A Richaud, V Penna, R Mayol and M Guilleumas, Phys. Rev. A **101**, 013630 (2020)

[2] A Richaud, V Penna and A . Fetter, Phys. Rev. A **103**, 023311 (2021)