The Gross-Pitaevskii equation: Dynamics of solitons and vortices

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The Gross-Pitaevskii equation is a mean field equation that has been incredibly successful in describing the dynamics of Bose-Einstein condensates. The equation features a non-linear term and thus allows for stable soliton solutions in 1D and additional topological defects such as vortices in 2D. The goal of this project is to study these phenomena using the split-step Fourier method.

This report summarizes the results of the final project we conducted as part of the lecture course on Computational Quantum Dynamics, held by Dr. Martin Gärttner. All numerical work was done using the Python programming language.

1 Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.
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And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.
After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of

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1.1 The Split-Step Fourier method

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2 Evolution of dark solitons in a homogeneous 1D Bose gas

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3 Dynamics of solitons in a homogeneous 2D Bose gas

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4 Visualizing the dynamics of vortices in a 2D Bose gas

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5 Conclusion

References

[1] Sebastian Erne. “Characterization of solitonic states in a trapped ultracold Bose Gas”. Diploma thesis. Heidelberg University, 2012.

[2] Thomas Gasenzer & Markus Karl. “Strongly anomalous non-thermal fixed point in a quenched two-dimensional Bose gas”. In: *New J. Phys.* 19 093014 (2017).

[3] Carlo F. Barenghi & Nick G. Parker. *Primer on Quantum Fluids*. arXiv:1605.09580. Cham: Springer, 2016.