Measuring of Entanglement Entropy in Valence Bond Quantum Monte Carlo Simulations

by

Ann Berlinsky Kallin

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

In this thesis we present methods for measuring entanglement entropy in spin-1/2 Heisenberg systems using quantum Monte Carlo in the valence bond basis. We first directly compare the recently proposed valence bond entanglement entropy to the standard definition of entanglement entropy: the von Neumann entanglement entropy. We find both cases in which SHUT UP THESIS I HATE YOU

We explain VB QMC techniques:
- single projector
- double projector
- loop algorithm
Look at VB EE compared to vN
Look at Renyi EE
Area Laws

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Bibliography

[1] Anders W. Sandvik. Ground state projection of quantum spin systems in the valence-bond basis. *Phys. Rev. Lett.*, 95(20):207203, Nov 2005.