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Exploiting hidden low-rank structures in physics

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Tensor networks are a powerful tool for compressing wave functions and density matrices of quantum systems in physics. Recent developments have shown that tensor network techniques can efficiently compress many functions beyond these traditional objects. Notable examples include the solutions to turbulence in Navier–Stokes equations [1] and the computation of Feynman diagrams [2,3]. These advancements have heralded a new era in the use of tensor networks for expediting the resolution of various complex equations in physics.

In this presentation, we will overview our recent research in this domain. Initially, we will discuss the compression of the space-time dependence of the correlation function in quantum systems [3] through the use of the "Quantics Tensor Train."[4,5] This method leverages the inherent length-scale separation in the system to represent the function efficiently. Our approach demonstrates solving diagrammatic equations in a compressed format.

Subsequently, we will introduce a novel and robust tool named "Quantics Tensor Cross Interpolation."[6] This method is designed to learn a quantics low-rank representation of a given function, showcasing the versatility and potential of tensor network techniques in handling complex functions in physics.

If time is allowed, we will briefly review our open-source libraries implementing these technologies.

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[4] I. V. Oseledets, Dokl. Math. 80, 653 (2009).
[5] B. N. Khoromskij, Constr. Approx. 34, 257 (2011).
[6] M. K. Ritter, ⋯, H. Shinaoka and X. Waintal, PRL 132, 056501 (2024).

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