# Topic 3: Tensor Renormalization Group Algorithm

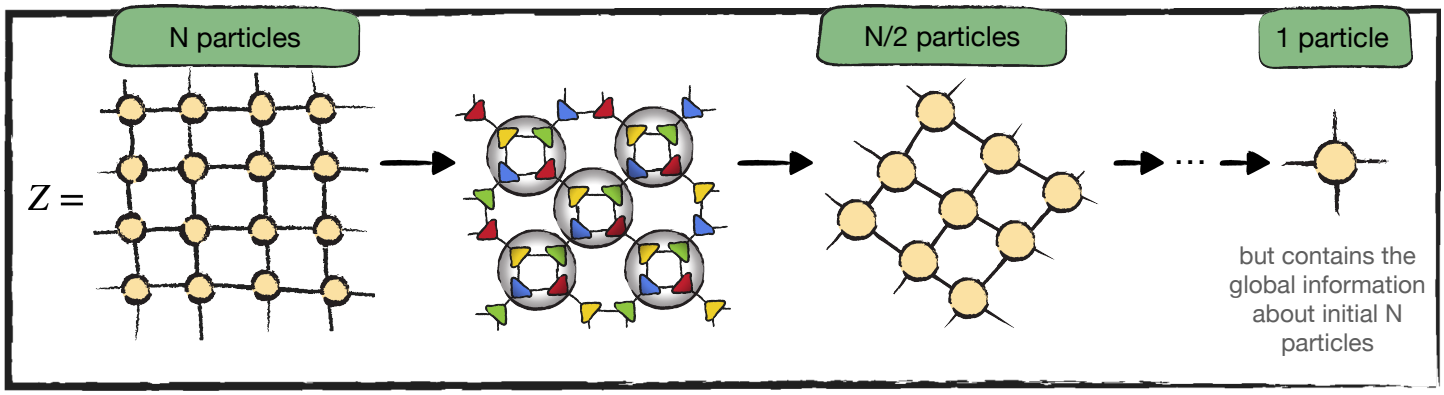
## What to expect

In this project, you will explore a renormalization technique for analysing many-body systems in physics. For this topic you don't need a strong previous knowledge of tensor networks and it can be a nice opportunity to familiarize yourself with the notation and compression techniques. Previous knowledge of basic concepts from classical statistical physics is needed.

## Overview

The renormalization group is a theoretical framework developed to understand the properties of many-body systems in thermodynamic limit. The main idea relies on the assumption that many-body systems at large scales show universal behaviour driven by the collective phenomena, rather than the individual interactions between the constituents. Thus, the aim is to identify and analyise these universal properties which remain unchanged regardless of the scale of the observation.

The mechanism on which the renormalization group analysis is based is coarse-graining the lattice: we gradually map a system of large number of particles into the one of a smaller number of particles, while retaining the a part of information about the bigger system. In this challenge, we focus on is a family of implementations of the renormalization group idea based on the tensor network techniques, and in particular, implementing the Tensor Renormalization Group (TRG) algorithm[5] for the 2D classical Ising model.




## Tasks

- Understand how to write the partition function of a many-body Ising spin model in 2D as a tensor network
- Implement the TRG algorithm to compute the system's Helmholtz free energy per site
- Determine the critical temperature of the system
- Compare the results with the exact solution and analyse the algorithm's performance in the different Hamiltonian parameter and convergence parameter regimes
- **Optional**: investigate how to compute the system's magnetization
- **Optional**: explore the possible improvements of the TRG algorithm

[5] M. Levin and C. P. Nave, Phys. Rev. Lett. **99**, 10.1103/PhysRevLett.99.120601 (2007).