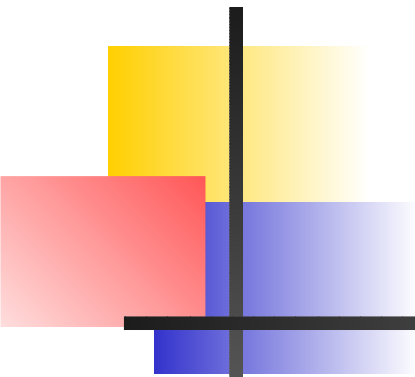# **Tutorial I**

- I Exercise (analytical)

- II Practice (numerical): the XY and quantum Heisenberg chains

Exercise (analytic)

- Question: prove recursively the orthogonality of the $n + 1^{\mathrm{th}}$ Lanczos vector $\left| \Phi_{n+1} \right\rangle$ w.r.t **all** previous ones.

Numerics on (quantum) XY and Heisenberg chain

- **Power method**: Calculate the GS energy per site $e_0(L)$ for rings of size $L = 6$, 8, 10, 12 etc...

- Check the finite size scaling of $e_0(L)$?

- **Lanczos method**: check the convergence of the lowest 10 eigenenergies of a small Heisenberg ring with the number of iterations (for fixed Sz and k).

- Compute the dispersion of the lowest triplet excitations and compare with Des Cloizeaux-Pearson (1962) exact expression.