

Two key questions of quantum model order reduction (QMOR) :

- (1) When is a physical system NOT running a quantum computation?
- (2) Can all such systems be simulated with polynomial resources?

A1: Symmetric systems

- Group theory

A2: Low-energy systems

Kähler-manifold QMOR in a nutshell:

$$|\Psi\rangle = \begin{matrix} \begin{bmatrix} {}^1c_{+j}^1 \\ \vdots \\ {}^1c_{-j}^1 \end{bmatrix} & \otimes & \begin{bmatrix} {}^1c_{+j}^2 \\ \vdots \\ {}^1c_{-j}^2 \end{bmatrix} & \otimes & \begin{bmatrix} {}^1c_{+j}^3 \\ \vdots \\ {}^1c_{-j}^3 \end{bmatrix} & \otimes \dots \otimes & \begin{bmatrix} {}^1c_{+j}^n \\ \vdots \\ {}^1c_{-j}^n \end{bmatrix} \\ & & \begin{bmatrix} {}^2c_{+j}^1 \\ \vdots \\ {}^2c_{-j}^1 \end{bmatrix} & & \begin{bmatrix} {}^2c_{+j}^2 \\ \vdots \\ {}^2c_{-j}^2 \end{bmatrix} & & \begin{bmatrix} {}^2c_{+j}^3 \\ \vdots \\ {}^2c_{-j}^3 \end{bmatrix} & & \begin{bmatrix} {}^2c_{+j}^n \\ \vdots \\ {}^2c_{-j}^n \end{bmatrix} \end{matrix}$$

New insights from quantum computing have inspired new methods for achieving quantum model order reduction (QMOR)

A4: Noisy systems

- Model order reduction by Dirac-Frenkel projection onto Kähler manifolds
- System noise modeled as covert measurement.

$\langle \delta\Psi | H - i\partial_t | \Psi \rangle = 0$ (Dirac-Frenkel projection)
... model noise as a covert measurement process.

The best-suited (yet least-studied) method for emulating large asymmetric high-temperature quantum systems.

What these systems have in common:

- They reduce the system complexity class from EXP to P.
- They are linked to beautiful physics, deep mathematics and virtualization.