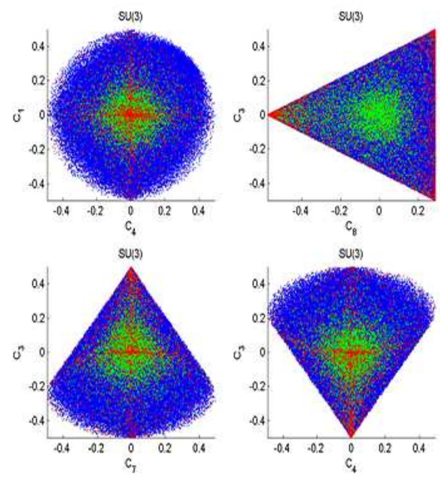
The short version / Intro text

What is QLib?

QLib is an open-source Matlab package intended to provide everybody within the Quantum Information community with a comprehensive toolset, and to allow us to

- Quickly and efficiently frame and explore ideas
- Form intuition through the use of visualizations
- Rule-out or validate hypothesis through the use of optimization



QLib currently covers most, if not all, of the "textbook" primitives and provides us with a rich toolset with which to advance knowledge in out field and engage in "experimental theory".

On the QLib site you will find everything you need: the software itself, a “getting started” guide, examples, forums to ask questions, report bugs and request features – everything necessary to get you up and running as quickly as possible.

QLib is free to use and modify, and is licensed under the GPL. Our goal is to have QLib continually developed by the community and for the community, to the benefit of us all.

The longer version

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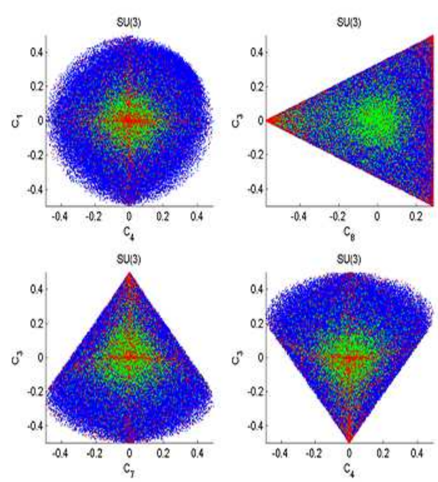
Some simple examples

Example 1: Bloch “Hyper-Sphere”

Have you ever wondered why the Bloch sphere cannot be extended to higher dimensions?

$$\rho_2 = \tfrac{1}{2}\left(\mathbf{1}+\vec{n}\cdot\vec{\sigma}\right) \qquad \rho_d = \tfrac{1}{d}\left(\mathbf{1}+\sum_{i=1}^{d^2-1} c_i \mathbf{g}_i\right)$$



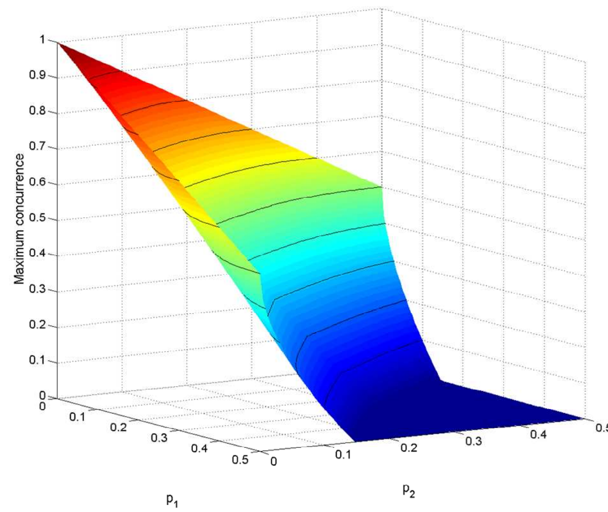
With QLib, you can simply generate a few million random density matrices and check. In the graph to the right you see 2d projections of the “hypersphere”.

With a few extra lines of code, you can also easily verify, for example, that all pure states are on the surface, but that not all the surface is pure.

Example 2: Maximally entangled mixed state

Starting with a separable state

$$\begin{pmatrix} p & 0 \\ 0 & 1-p \end{pmatrix} \otimes \begin{pmatrix} q & 0 \\ 0 & 1-q \end{pmatrix}$$



How entangled can you get with a global SU(4)?

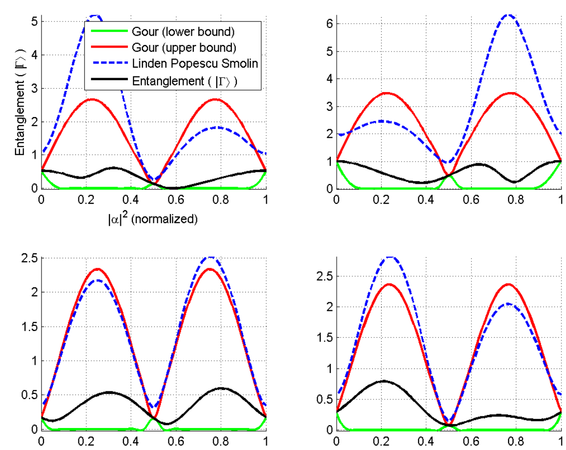
Apparently, very entangled. Even if one of the qubits is initially fully mixed.

Again, this requires very little coding, as QLib can optimize the goal function over any SU(n).

Example 3: Entanglement of superposition

If we look at the superposition of two entangled states

$$|\Gamma\rangle = \alpha|\Psi\rangle + \beta|\Phi\rangle$$



How entangled can be get? Can we easily bound the entanglement of superposition?

QLib allows you to easily visualize the problem, gaining intuition and testing possible limits.

Apparently, depending on α, the entanglement can have two maxima and two minima. Also, plotting the existing limits (green, red & blue) left a lot to be desired.

What is QLib capable of?

Current capabilities include:

- **Objects manipulated:**
  - Classical probability distributions
  - Pure states
  - Density matrices (including special handling of the separable subspace)
  - Unitary (U(n) and SU(n) & Hermitian matrices

  All of these objects are supported for any number of particles of any dimension

- **Entanglement:** Peres-Horodecki test, entanglement, concurrence, negativity, tangle, logarithmic negativity, ent. of formation, relative entanglement, robustness, singlet fraction

- **Entropy:** Shannon, Von Neumann, linear entropy, relative entropy, participation ratio, purity

- **Measurement:** Orthogonal (collapse or mixture), POVM, weak

- **Basic object handling**
  - Reorder particles, partial trace, partial transpose
  - See objects in the regular representation or as tensor with index per particle
  - Convert to/from computational base to SU(n)
  - Miscellaneous: Schmidt decomposition, famous states, famous gates

- **Distance measures:** Hilbert-Schmidt, trace distance, fidelity, Kullback-Leibler, Bures, Bures Angle, Fubini-Study

- **Miscellaneous:** Majorization, mutual information, spins in 3D

- **Strong optimization infrastructure**
  All of the objects above are points in the appropriate parameter space, enabling search, generation of random elements, etc.

- **General purpose utilities:**
  - Linear algebra (e.g. Gram Schmidt, spanning using base matrices)
  - Numerics: approximately compare, epsilon tensor, etc, etc
  - Graphics: quickly plot out functions

- **Demos:** Covering many of QLib's capabilities

- **Help:** Just type "help qlib" for an overview or get help on every individual function

For a full list of features and capabilities, see the QLib site.