

# Training and Development

## **PLUS+ TRAINING AND DEVELOPMENT PROGRAM: Four Assorted Quantum Pieces**

DR. KAROL ŻYCZKOWSKI

May 04, 2021

10:00 to 12:00

Online (Zoom)

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### **Talk 3. Iso-entangled Mutually Unbiased Bases and Mixed-state $t$ -designs**

A Euclidean design is a finite set of points in  $\mathbb{R}^n$  with certain approximation properties. This concept can be generalized to give the notion of pure-state designs: vectors selected in such a way that the average values of the first  $t$  moments averaged over the design coincide with the moment obtained by integrating over the set of all states. We introduce a related notion of a mixed-state  $t$ -design, which consist of a finite number of density matrices of order  $N$  with analogous properties. Mixed-state designs can be obtained by partial trace of pure states of size  $N^2$  forming a pure state design. We construct a set of five iso-entangled Mutually Unbiased Bases (MUBs) in  $H_4$ , consisting of 20 pure states with the same degree of entanglement. Performing a partial trace on any of both subsystems leads to 20 single-qubi

mixed states which form a regular dodecahedron inside the Bloch ball and a mixed 3-design [3]

[3] S. Denisov, T. Lapyeva, W. Tarnowski, D. Chruściński and K. Życzkowski, Universal spectra of random Lindblad operators, Phys. Rev. Lett. 123, 140403 (2019).

**Due to recommendations in place to contribute containing the spreading of COVID-19, the Theory Lectures will be carried out remotely via Zoom. In case you want to receive an invitation to attend the online session, you can send an email to [Alba.Berenguer@icfo.eu](mailto:Alba.Berenguer@icfo.eu)**

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