Massive Generation of Contextual Quantum Sets

Mladen Pavičić[1,2]

[1]*Center of Excellence for Advanced Materials and Sensing Devices (CEMS), Photonics and Quantum Optics Unit, Ruđer Bošković Institute, Zagreb, Croatia*
Email: mpavicic@irb.hr, web site: http://www.irb.hr/users/mpavicic

[2]*Department of Physics—Nanooptics, Faculty of Mathematics and Natural Sciences, Humboldt University of Berlin, Germany*

"What gives quantum computers that extra oomph over their classical digital counterparts? An intrinsic, measurable aspect of quantum mechanics called contextuality, it now emerges." [1] This also gives an additional impetus to a massive generation of Kochen-Specker (KS) contextual sets we started in [2-5].

In this talk we shall present new classes of such sets in 4-, 6-, and 8-dimensional Hilbert spaces with billions of KS sets each as well as methods we make use of to generate them. The main breakthrough in massive generation of KS sets has been achieved by representing them by means of the so-called MMP diagrams which are kinds of hypergraphs in which vertices represent vectors and edges orthogonalities between them. By employing the hypergraphs we reduce the exponential complexity of solving nonlinear equations describing the orthogonalities of vectors to nearly polynomial one of handling the hypergraphs. Figure 1 shows some examples of hypergraph representation of critical KS sets we recently generated.
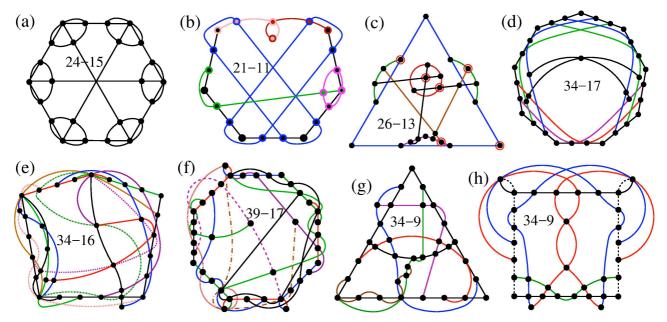

Fig1. MMP diagrams of critical KS sets (ones that would stop being KS sets, if we removed a single vertex from them) from (a) 24-24 4-dim class; (b,c) 60-105 4-dim; (d) 60-74 4-dim; (e,f) 256-1216 6-dim; (g,h) 120-2024 8-dim

As for 3-dim KS sets, we shall present a bottom-up generation of their MMP diagrams. In addition, we consider properties of 3-dim KS sets and show why recently presented 13 vector set [6] and its experimental implementation [7] do not prove the Kochen-Specker theorem.

1. S.D. Bartlett, *Nature*, **510,** 345 (19 June, 2014).
2. M. Pavičić, J.-P. Merlet, B.D. McKay, and N.D. Megill**,** *J. Phys. A*, **38**, 1577 (2005).
3. M. Pavičić, N. Megill, P. K. Aravind, and M. Waegell, *J. Math. Phys.*, **52**, 022104 (2011).
4. Megill, N., K. Fresl, M. Waegell, P. K. Aravind, and M. Pavičić, *Phys. Lett. A*, **375**, 3419 (2011).
5. M. Pavičić, *Companion to Quantum Computation and Communication* (Wiley) (2013).
6. S. Yu and C.H. Oh, *Phys. Rev. Let.* **108**, 030402 (2012).
7. C. Zu, Y.-X. Wang, D.-L. Deng, X.-Y. Chang, K. Liu, P.-Y. Hou, H.-X. Yang, and L.-M. Duan, *Phys. Rev. Let.* **109**, 150401 (2012).

Presentation Method: Invited Oral 30 minutes