Quantum magnetism on the Cairo pentagonal lattice

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In this talk I will present our recent analytical and numerical study [1] of the antiferromagnetic Heisenberg model on the Cairo pentagonal lattice, the dual of the Shastry-Sutherland lattice with a close realization in the $S = 5/2$ compound Bi$_2$Fe$_4$O$_9$ [2], and more recently in Bi$_4$Fe$_5$OF$_{13}$ [3].

We consider a model with two symmetry-inequivalent exchange couplings, and investigate the nature of the ground state as a function of their ratio $x$ and the spin $S$. After establishing the classical phase diagram, we switch on quantum mechanics in a gradual way that highlights the different role of quantum fluctuations on the two inequivalent sites of the lattice. The most important findings for $S = 1/2$ include: (i) a surprising interplay between a collinear and a four-sublattice orthogonal phase due to an underlying order-by-disorder mechanism at small $x$ (related to an emergent $J_1$-$J_2$ effective model with $J_2 \gg J_1$), and (ii) a non-magnetic and possibly spin-nematic phase with $d$-wave symmetry at intermediate $x$.

References: