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On Combinatorial Hopf Algebras

We introduce a combinatorial structure which generalizes graphs, multigraphs, hypergraphs, simplicial and delta complexes, colored graphs and more, which we call multi-complexes. It has a Hopf algebra structure similar to that of the Hopg algebra of graphs, where the isomorphism types of multi-complexes provide a basis and multiplication and comultiplication record assembly and disassembly combinatorial information. We find a basis of in the space of primitives of this Hopf algebra, which has combinatorial relevance in as the formulas giving the original basis in terms of primitives have non-negative integer coefficients. We give cancellation and grouping free formulas for the primitives, and also obtain the cancellation and grouping free formula for the antipode. This recovers such formulas in various other particular cases. Time permitting, we explain how some conjectures in combinatorics (specifically, graph theory) can be approached via this setup. This work is joint with Jaiung Jun.