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Commutativity in double interchange semigroups

We extend the work of Kock and Bremner & Madariaga on commutativity in double interchange semigroups (DIS) to 10 arguments, motivated by potential applications to double categories. Our methods involve algebraic operads: the free symmetric operad generated by two binary operations with no symmetry, its quotient by the two associative laws, its quotient by the interchange law, and its quotient by all three. We also consider a geometric realization of free double interchange magmas by rectangular partitions of the unit square I^2. We define morphisms between these structures which allow us to represent elements of free DIS both algebraically as tree monomials and geometrically as rectangular partitions. With these morphisms we reason diagrammatically about free DIS and prove our new commutativity relations.

References:

[1] J. Kock, Note on commutativity in double semigroups and two-fold monoidal categories, *Journal of Homotopy and Related Structures* 2 (2007) no. 2, 217–228.

[2] M. Bremner and S. Madariaga, Permutation of elements in double semigroups, *Semigroup Forum* 92 (2016) 335–360.

*Joint work with Fatemeh Bagherzadeh. Research supported by a Discovery Grant from NSERC.