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The ternary commutator obstruction for internal crossed modules

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In finitely cocomplete homological categories, co-smash products give rise to (possibly higher-order) commutators of subobjects. We use binary and ternary co-smash products and the associated commutators to give characterisations of internal crossed modules and internal categories, respectively. The ternary terms are redundant if the category has the Smith is Huq property, which means that two equivalence relations on a given object commute precisely when their normalisations do. In fact, we show that the difference between the Smith commutator of such relations and the Huq commutator of their normalisations is measured by a ternary commutator, so that the Smith is Huq property itself can be characterised by the relation between the latter two commutators. This allows to show that the category of loops does not have the Smith is Huq property, which also implies that ternary commutators are generally not decomposable into nested binary ones. Thus, in contexts where Smith is Huq need not hold, we obtain a new description of internal categories, Beck modules and double central extensions, as well as a decomposition formula for the Smith commutator. The ternary commutator now also appears in the Hopf formula for the third homology with coefficients in the abelianisation functor.

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