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Skew monoidales, skew warpings and quantum categories

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Kornel Szlach\'anyi recently used the term skew-monoidal category for a particular laxified version of monoidal category. He showed that bialgebroids H with base ring R could be characterized in terms of skew-monoidal structures on the category of one-sided R-modules for which the lax unit was R itself. We define skew monoidales (or skew pseudo-monoids) in any monoidal bicategory $\mathscr M$. These are skew-monoidal categories when $\mathscr M$ is Cat. Our main results are presented at the level of monoidal bicategories. However, a consequence is that quantum categories in the sense of Day-Street with base comonoid C in a suitably complete braided monoidal category $\mathscr V$ are precisely skew monoidales in $\mathrm{Comod} (\mathscr V)$ with unit coming from the counit of C. Quantum groupoids are those skew monoidales with invertible associativity constraint. In fact, we provide some very general results connecting opmonoidal monads and skew monoidales. We use a lax version of the concept of warping defined recently by Booker-Street to modify monoidal structures.

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