Quantum Physics

Unsharp Values, Domains and Topoi

Andreas Doering, Rui Soares Barbosa

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The so-called topos approach provides a radical reformulation of quantum theory. Structurally, quantum theory in the topos formulation is very similar to classical physics. There is a state object, analogous to the state space of a classical system, and a quantity-value object, generalising the real numbers. Physical quantities are maps from the state object to the quantity-value object -- hence the `values' of physical quantities are not just real numbers in this formalism. Rather, they are families of real intervals, interpreted as `unsharp values'. We will motivate and explain these aspects of the topos approach and show that the structure of the quantity-value object can be analysed using tools from domain theory, a branch of order theory that originated in theoretical computer science. Moreover, the base category of the topos associated with a quantum system turns out to be a domain if the underlying von Neumann algebra is a matrix algebra. For general algebras, the base category still is a highly structured poset. This gives a connection between the topos approach, noncommutative operator algebras and domain theory. In an outlook, we present some early ideas on how domains may become useful in the search for new models of (quantum) space and space-time.

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