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The exogenous quantum propositional logic (EQPL) was proposed in [13, 14, 15] for modeling and reasoning about quantum systems, embodying all that is stated in the relevant postulates of quantum physics (as presented, for instance, in [9, 16]). The logic was designed from the semantics upwards, starting with the key idea of adopting superpositions of classical models as the models of the proposed quantum logic.

The EQPL approach to quantum reasoning is quite different from the mainstream approach [8, 10]. The latter, as initially proposed by Birkhoff and von Neumann [6], focuses on the lattice of closed subspaces of a Hilbert space and replaces the classical connectives by new connectives representing the lattice-theoretic operations, while the semantics of the former uses superpositions of classical models, leading to a natural extension of the classical language containing the classical connectives (just as modal languages are extensions of the classical language). Furthermore, EQPL allows quantitative reasoning about amplitudes and probabilities, being in this respect much closer to the possible-worlds logic for probability reasoning than to the mainstream quantum logics. Finally, EQPL is designed to reason about finite collections of qubits and, therefore, it is suitable for applications in quantum computation and information. In fact, each EQPL model is a superposition of classical valuations that corresponds to a unit vector expressed in the computational basis of the Hilbert space resulting from the tensor product of the independent qubit systems.

It is possible to express in EQPL a wide range of properties of states of such a finite collection of qubits. For example, one can impose that some qubits are independent of (that is, not entangled with) other qubits; one can prescribe the amplitudes of a specific quantum state; one can assert the probability of a classical outcome after a projective measurement over the computational basis; and, one can also impose classical constraints on the admissible quantum states.

The talk is focused on a decidable fragment of EQPL obtained by relaxing the semantic structures of EQPL [7]: inner product spaces over an arbitrary real closed field and its algebraic closure are used instead of Hilbert spaces. The decidability results from the fact that the first order theory of such fields is decidable [5, 17], using a technique inspired by related work on probabilistic logic [1].

More recent developments are mentioned at the end of the talk, namely the exogenous quantum temporal propositional logic [12] and applications to the verification of quantum protocols [2, 3, 4, 11].


