A FIRST-ORDER EPISTEMIC QUANTUM
COMPUTATIONAL SEMANTICS

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Quantum computational logics have been semantically characterized at a
sentential level. In this framework, sentences are supposed to denote pieces
of quantum information (density operators of convenient Hilbert spaces),
while logical connectives correspond to quantum logical gates (unitary quan-
tum operations that transform quantum information in a reversible way).
The sentential quantum computational semantics can be extended to an
epistemic semantics for a language expressing sentences like “Alice knows
that Bob does not know that the spin-value in the $x$-direction is up”. We
investigate the possibility of generalizing this semantics to the case of a
first-order language, where sentences like “All know that somebody does not
know that the spin-value in the $x$-direction is up” can be formalized. Both
knowledge operators and logical quantifiers can be represented as Hilbert-
space operations that are generally irreversible. One is dealing with a kind
of theoretic “jumps” that seem to be similar to quantum measurements.
Unlike most first-order semantic approaches, the quantum computational
semantics does not refer to any domain of individuals dealt with as a closed
set (in a classical sense). The interpretation of a universal sentence (say,
“All photons have null mass”) does not require “ideal tests” that should be
performed on all elements of a hypothetical domain. This way of thinking
seems to be in agreement with a number of concrete semantic phenom-
ena (even far from quantum physics), where the individual-domain appears
highly indeterminate. Such situations, however, do not generally prevent a
correct use of the logical quantifiers.

REFERENCES

Quantum Computational Structures in a Hilbert-Space Environment”, Fundamenta