Quantum Collect-Calling

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We show that it is possible to use a massless field in the vacuum to communicate in such a way that the signal travels slower than the speed of light and such that no energy is transmitted from the sender to the receiver. Instead, the receiver has to supply a signal-dependent amount of work to switch his detector on and off. This type of signalling is related to Casimir-like interactions and it is made possible by dimension ---and curvature--- dependent subtleties of Huygens' principle [1].

To model the receiver and sender we use Unruh-DeWitt particle detectors (UDW). Since its introduction, the UDW detector has proven to be an important tool for investigating QFT on curved spacetimes. More recently, in the field of Relativistic Quantum Information, the behaviour of UDW detectors has been studied from a Quantum Information theoretical perspective [2].

The results presented in this talk are part of a research program studying communication between UDW detectors [3-5]: Understanding the effect of curvature and relativistic motion on our capability to communicate via quantum fields, measured in terms of the channel capacity, could provide us with a framework to quantify the causal structure of spacetime.

The effects we discuss in this talk originate from the behaviour of the field commutator. On spacetimes that do not obey the strong Huygens' principle, the commutator is non-vanishing in the future lightcone. This is, in general, the case in curved spacetimes but in particular it is true in two- and three-dimensional Minkowski space.

It is interesting to see that the signals we are describing appear in leading order of perturbation theory already [5]. This implies that they cannot be understood as the exchange of energy carrying quanta, because such terms only appear in subleading order of perturbation theory.

In fact, we show that no transmission of energy from the sender to the receiver is necessary at all. An analysis of the energy cost of coupling a detector to the field shows that instead the energy the receiver requires to switch his detector depends on the sender's signal.

Our results do not only challenge our intuitive understanding of signalling in massless fields. Being leading order effects the described phenomena might soon be demonstrable in experiment, e.g., in cavity QED. The prospects of this we are currently investigating.

This is joint work with E. Martín-Martínez, and A. Kempf.

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