Relativity and vacuum fluctuations in quantum measurement

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Vacuum fluctuations can obscure the detection signal of the measurement of elementary quantum objects like single particles seemingly implying a fundamental limit to measurement accuracy. However, as we show relativistic invariance implies the disappearance of fluctuations for the space-like frequency-wavevector spectrum of an observable at zero temperature. This complete absence of noise can be harnessed to perform noiseless measurement of single particles, as we illustrate for electrons or photons. We outline a general scheme to illustrate the noiseless measurement involving the space-like spectrum of observables based on the self-interference of counter-propagating paths of a single particle in a triangular Sagnac interferometer.

[1] Adam Bednorz and Wolfgang Belzig, Effect of relativity and vacuum fluctuations on quantum measurement, Phys. Rev. D 105, 105027 (2022) [arXiv:2203.13187]