Low-frequency qubit noise: beyond the power spectrum

Mark Dykman[1], Filip Wudarski[2], Yaxing Zhang[3], Alexander Korotkov[3], and A. G. Petukhov[3]

[1] *Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA*
[2] *USRA Research Institute for Advanced Computer Science (RIACS), Mountain View, CA 94043, USA*
[3] *Google Research, Mountain View, CA 94043, USA*

Due to the probabilistic nature of quantum measurements, many currently implemented quantum algorithms rely on repeatedly running a quantum computer. Qubit parameters should remain essentially the same between the runs. This makes it important to understand the nature of slow fluctuations of qubit parameters, and in particular slow qubit frequency fluctuations. Such understanding requires measuring both the spectrum and the statistics of the fluctuations, but also looking into other ways of characterizing them. This talk will describe an approach based on measuring the correlators of the outcomes of periodically repeated Ramsey measurements. The analysis makes it possible, in particular, to evaluate the two-time correlator of the outcomes for the noise from two-level systems and obtain two- and three-time correlators for Gaussian noise. The explicit expressions for the correlators are compared with extensive simulations. A significant difference of the higher-order correlators of the noise from two-level systems and from Gaussian low-frequency noise is demonstrated.

One of the important general problem faced in studying qubit fluctuations is whether the data are ergodic. Ergodicity implies that the noise source has explored all its states while measurements were performed, so that the time averaging of the results is equivalent to the ensemble averaging. As we show, profoundly nonergodic measurements provide an important tool for characterizing the noise source. Our results also show that the transition to ergodicity is delicate: quantum measurements become (quasi)ergodic depending on the parameters of the instrument, not just the properties of the noise