Spectroscopy methods with quantum sensors

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We consider the problem of quantum spectroscopy, namely reconstruction of the frequency components of a time dependent Hamiltonian. This task is of great interest to chemical analysis, nano-scale NMR and frequency standards. We examine theoretically and experimentally the following questions: Given an oscillating Hamiltonian, what is the best achievable precision in detecting the frequency and how well can we resolve between two close frequencies. It turns out that some misconceptions have led to suboptimal techniques and a considerable improvement can be introduced. This observation is demonstrated experimentally with a new technique [1]. We find, quite surprisingly, that the precision of the frequency tracking scales as $\frac{1}{T^{1.5}}$, while for long enough probe coherence time a scaling of $\frac{1}{T^2}$ is achievable (with a suitable control). We show that these control methods basically give rise to an accelerated phase accumulation which results in an enhanced sensitivity [2]. Relevance to nano-scale NMR and future challenges are also discussed.

References

[1] Simon Schmitt et al. *Sub-millihertz magnetic spectroscopy performed with a nanoscale quantum sensor*, accepted to Science (2017)
[2] Tuvia Gefen, Fedor Jelezko, and Alex Retzker, arXiv preprint arXiv:1702.07408 (2017).

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