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Quantum metrology using a strongly interacting spin ensemble

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One of the most promising routes towards high-sensitivity quantum metrology is to utilize high density spin ensembles. However, as the density of a spin ensemble is increased, strong spin-spin interactions can impose a limit to the coherence time and thus the maximum achievable sensitivity. In this talk, we will discuss two promising methods to overcome this limitation. In the first approach, a spin ensemble is periodically manipulated in order to effectively decouple spin-spin interactions while keeping its sensitivity to an external probe signal. We present a novel framework to design such a control sequence that is fault-tolerant against both disorder in the system and imperfections in the control parameters. We demonstrate this method using an ensemble of dipolar interacting nitrogen-vacancy color centers and improve the sensitivity beyond that of conventional protocols such as the XY-9 sequence. Our second approach actively utilizes interactions and is based on stable non-equilibrium states of quantum matter such as discrete time crystals. We present explicit protocols to perform Floquet enhanced measurements of an oscillating magnetic field, in which quantum correlations stabilized by strong interactions and periodic driving allow to enhance the sensitivity and/or bandwidth of the protocol beyond the standard quantum limit.

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