Ultimate precision limit of multi-parameter quantum magnetometry

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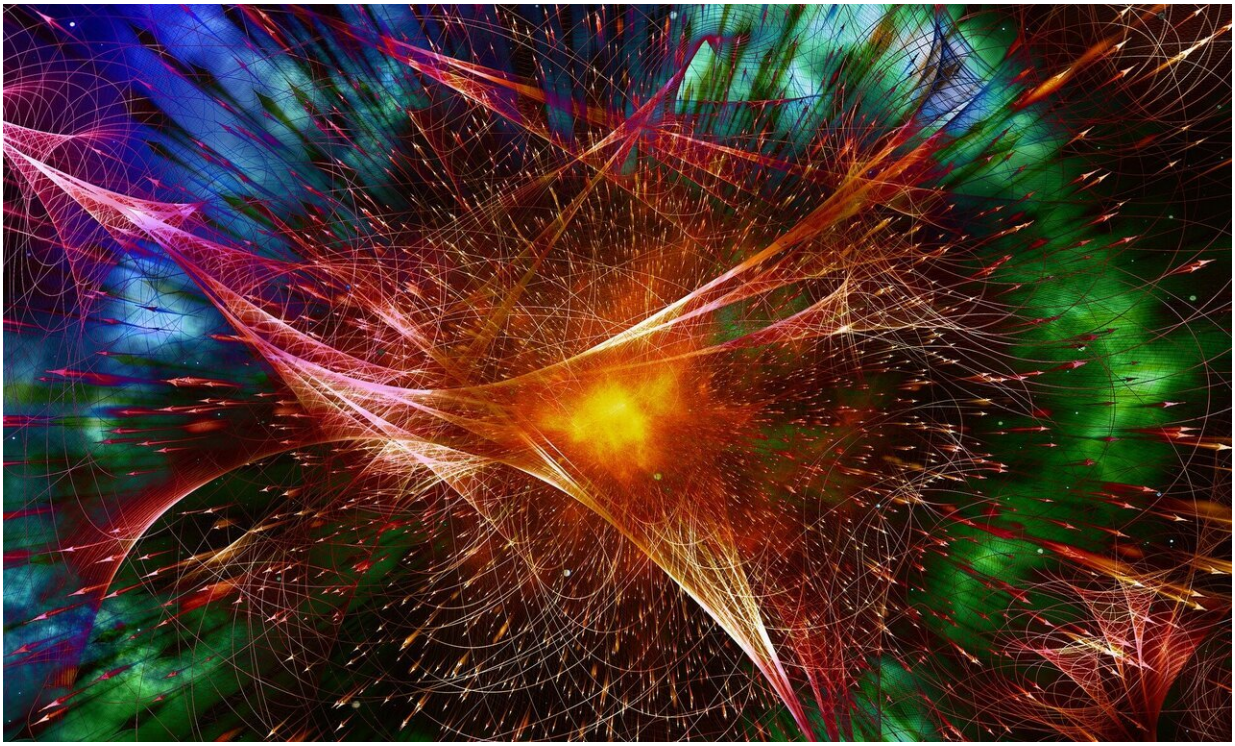

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Quantum magnetometry, one of the most important applications in quantum metrology, aims to measure the magnetic field with the highest precision. Although estimation of one component of a magnetic field has been well studied over many decades, the highest precision that can be achieved with entangled probe states for the estimation of all three

components of a magnetic field remains uncertain.

In particular, the specific questions include how to balance the precision tradeoff among different parameters, what is the ultimate precision, can this precision limit be achieved, and how to achieve it.

Under the lead of Prof. Guo Guangcan, Prof. Li Chuanfeng and Prof. Xiang Guoyong from University of Science and Technology of China (USTC) of the Chinese Academy of Sciences, together with Prof. Yuan Haidong from the Chinese University of Hong Kong, obtained the ultimate precision for the estimation of all three components of a magnetic field with entangled probe states under the parallel scheme. The study was published online in *Physical Review Letters*.

The researchers found that the tradeoff comes from the incompatibility of the optimal probe states, and presented an approach to quantify the tradeoff induced by the incompatibility of the optimal probe states. Using this approach, they obtained the minimal tradeoff and the ultimate precision for the multi-parameter quantum magmetometry under the parallel scheme.

Furthermore, they demonstrated that this ultimate precision limit can be achieved and they constructed the optimal probe states and measurements to achieve it.

The ultimate precision of quantum magnetometry under the parallel scheme is of fundamental interest and importance in quantum metrology. It can also be directly used as the benchmark for the performance of quantum gyroscope and quantum reference frame alignment.

This approach connects the tradeoff directly to the constraints on the probe states and the generators, which can lead to many useful bounds in

various scenarios of multi-parameter quantum estimation.

More information: Zhibo Hou et al, Minimal Tradeoff and Ultimate Precision Limit of Multiparameter Quantum Magnetometry under the Parallel Scheme, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.125.020501

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