Towards Quantum Biomolecular Sensing: from Fundamentals to Applications

Changhyoup Lee

Institute of Theoretical Solid State Physics
Karlsruhe Institute of Technology, Karlsruhe, Germany

Quantum sensing techniques have been developed and investigated over the last few decades in various sensing scenarios such as magnetic field sensing or force sensing. Many quantum sensing schemes have been suggested, but they all suffer from realistic issues to achieve the quantum advantage over the optimized classical counterpart. In this regard, I have addressed several aspects in a range from fundamentals to applications, which I will overview in this talk.

I will begin with the most important issue in quantum metrology to achieve the quantum advantage. It is to find out an optimal state and an optimal measurement setting for given sensing scenarios, with which quantum enhancement is maximized. For significant experimental relevance, I have focused on Gaussian metrology that employs Gaussian states as a probe state, which are experimentally feasible with current technology. I have identified feasible optimal measurement settings for various sensing scenarios, from single-parameter to multi-parameter estimation. These findings will be useful when developing applied quantum sensors in the future. One promising applied photonic sensor is plasmonic sensors due to their ability to confine light below the diffraction limit, greatly enhancing sensitivity. I will introduce a new scheme called quantum plasmonic sensing, which I have proposed with an aim to beat the shot-noise limit and the diffraction limit, simultaneously. It has led to several theoretical and experimental studies, which have shown to be useful for measuring the refractive index of blood protein, e.g., Bovine serum albumin.

Finally, I will lay out future research plan, constructed with an ultimate aim to develop *applied quantum biomolecular sensors* for the next few years. It is composed of three objectives: (i) quantum scattering theory, (ii) quantum state engineering and measurement technique, and (iii) quantum biomolecular sensors. The necessity and great importance of the individual objectives are explained in detail, upon with a strong interconnection over the objectives.