Book of Abstracts

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Poster # 1

The two-Lorentzian noise spectra in shallow NV centers

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Shallow NV centers act as nanoscale quantum sensors at room temperature. However, the physical origin of decoherence in shallow NV centers is not currently well understood. The noise power spectral density (PSD) can be described by two-Lorentzian spectra. In this work, we investigate the origins of the two noise components, including electric fields, magnetic fields, and strain fluctuation.

Poster # 2

Homogeneous Bias Field Design for Single-Sided Quantum Magnetometers

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In highly sensitive quantum magnetometer using nitrogen-vacancy (NV) center ensembles in diamond, applying a sufficiently homogeneous bias magnetic field across the ensemble is a key factor for achieving high sensitivity. Conventionally, a "double-sided" configuration has been used to apply a homogeneous bias magnetic field, where coils or magnets are placed on both sides to sandwich the diamond. However, the double-sided configuration restricts bringing the NV centers close to the target object, posing a challenge in versatility of diamond-based quantum magnetometer probes.

Therefore, in this study, we designed a "single-sided" configuration, where magnets are placed on only one side of the NV center ensemble, capable of applying a highly homogeneous bias magnetic field. This design utilizes a combination of a ring magnet and an array of cylindrical magnets tilted toward the center axis of the array. Numerical simulation showed that the homogeneity of the applied field by this magnet system is expected to be about 200 ppm within 1 mm^3 volume. Achieving a homogeneous bias magnetic field with a single-sided configuration will lead to the realization of versatile quantum magnetometer probes with high sensitivity. We will discuss the magnet system design, the homogeneity, and its application in this workshop.

Poster # 3

Evaluation of the Temperature Dependence of Group IV-V Center Creation in Atmospheric Pressure Thermal Treatment

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Group IV-V centers in diamond are expected to exhibit long spin relaxation times on the order of milliseconds at extremely low temperatures, and, given their strong luminescence from the zero-phonon line (ZPL), they are expected to find applications as single-photon sources.

To efficiently form Group IV-V centers, we have been optimizing thermal treatment under atmospheric pressure using a standard lamp furnace, rather than the high-temperature, high-pressure annealing typically employed. Our previous research revealed that, under atmospheric pressure at 1800°C, the formation efficiency improves as the heat treatment time increases; however, for SiV, it decreases after reaching a peak. For SiV, it is possible that 1800°C is too high a temperature. In this study, we investigated the formation efficiency of Group IV V centers in the temperature range of 1000–1800°C.

Poster # 4

Quantifying microwave-drive-induced thermal coherent errors in on-chip boron-doped diamond circuits for NV spin control

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Microwave self-heating in integrated spin-control circuits can dynamically shift the resonance frequency of nitrogen-vacancy (NV) centers and introduce coherent control errors that cannot be removed by a single static calibration. We present a reference-calibrated framework for evaluating such thermal effects using an on-chip boron-doped diamond (BDD) microwave circuit. Frequency-detuned microwave pulses were applied to generate controlled thermal loading, while Ramsey measurements were used to characterize the residual resonance shift after microwave excitation. Rabi measurements provided a complementary diagnosis of heat-related changes in the driven-spin response. The experimentally calibrated response was incorporated into a reduced-order thermal model to estimate detuning-induced phase and rotation errors under different pulse and timing conditions. The analysis indicates that the post-heating waiting time is a more influential control parameter than the heating-pulse duration within the investigated regime. The resulting thermal-error map is intended as a comparative timing-design tool rather than as a certified operating boundary. This approach provides a practical and transferable procedure for connecting microwave-induced thermal responses to fidelity-relevant error budgets in integrated NV-spin control devices.

Poster # 5

Nanoscale diffusion sensing using phase-encoded statistical spin polarization

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When a spin ensemble contains only a small number of spins within a nanoscale volume, statistical polarization arising from spin fluctuations can dominate over thermal polarization [1,2]. Whether such statistical polarization can serve as an information carrier for molecular transport dynamics, however, remains an open question. Encoding transport information into statistical spin polarization could provide a route toward imaging nanoscale transport phenomena that are inaccessible to conventional measurement techniques.

Nitrogen-vacancy (NV) centers in diamond are well suited to investigate this possibility because nanoscale nuclear magnetic resonance of spins near the diamond surface has already been demonstrated [3]. Here, we propose a sensing framework in which pulsed magnetic-field gradients encode transport-induced phase information into statistically polarized spins. This information is subsequently transferred to and detected through the quantum state of an NV center. We discuss the physical feasibility of this concept, its fundamental limitations, and possible routes toward experimental implementation.

Acknowledgements: This work was supported by JST FOREST Program (Grant Number JPMJFR2547, Japan). E. K. acknowledge the support from JSP SPRING (Grant Number JPMJSP2180, Japan).

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Poster # 6

Charge State Conversion of NV Centers in Diamond by Local Anodic Oxidation Using Atomic Force Microscopy

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Nitrogen-vacancy (NV) centers in diamond have attracted considerable attention as quantum sensors operable at room temperature and are expected to enable magnetic field sensing and imaging with nanoscale spatial resolution. To achieve high spatial resolution, shallow NV centers located near the diamond surface are essential. In quantum sensing applications, the charge state of NV centers (NV^- and NV^0) play a crucial role. It is well known that the charge state strongly depends on the surface termination of diamond. Oxygen termination stabilizes the NV^- state, whereas NV^0 or NV^+ becomes dominant under hydrogen termination. In general, diamond surface termination is controlled over the entire substrate by acid treatment or plasma processing; however, local surface oxidation can also be achieved using atomic force microscopy (AFM). In this study, we report the localized formation of NV^- centers on hydrogen-terminated diamond using this local oxidation technique.

Poster # 7

NV Center Formation in Diamond by High-Energy Convergent Electron-Beam Irradiation under In Situ Heating

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Nitrogen-vacancy (NV) centers in diamond are useful for quantum sensing at room temperature. The highest reported NV density is 45 ppm, obtained by 2 MeV electron irradiation for 285 h. Recently, transmission electron microscopes (TEMs) have been used to form NV centers locally and to reduce the irradiation time.

In this study, we investigated NV center formation using a convergent MeV electron beam. A high-pressure and high-temperature (HPHT) Type Ib diamond was irradiated with a 1.25 MeV electron beam at 800 °C in an ultra-high-voltage electron microscope (HVEM). After irradiation, the sample was evaluated by confocal fluorescence microscopy (CFM).

Strong NV fluorescence was observed in the irradiated region. The estimated NV density approximately 40 ppm for a 10 μm beam diameter, a 30 s irradiation time, and an electron fluence of 7.2×10^{19} electrons/cm^2. However, the fluorescence intensity decreased as the irradiation time increased. This result suggests that excessive electron irradiation reduced crystal quality and caused local graphitization. Further work is needed to optimize the irradiation conditions and suppress crystal damage.

Poster # 8

Magnetic resonance imaging of dark electron spins with scanning diamond NV probe microscopy

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Magnetic resonance imaging has played a significant role in advancing the understanding of the internal structure of materials, despite limited spatial resolution at the micrometer scale. Recent advances in scanning probe microscopy with nitrogen-vacancy (NV) quantum sensors (SNVM) have enabled nanoscale imaging of magnetic structures in magnetic materials [1] and have been used to image an individual, optically addressable electron spin [2]. In this work, we present a preliminary result of magnetic resonance imaging of optically dark electron spins on the surface of a paramagnetic spins-formed material using the double electron-electron spin resonance (DEER) protocol. The surface dark electron spins are confirmed by an electron paramagnetic resonance spectrum with a Landé g-factor of about 2.

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Poster # 9

Towards quantum entanglement for enhancing magnetic sensitivity in diamond NV centres.

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In recent years, diamond nitrogen-vacancy (NV) centres have attracted significant attention as a highly promising platform for quantum sensing, owing to their operability and long coherence times under ambient conditions, as well as their high spatial resolution at the nanometer scale. NV centres respond sensitively to the environmental changes such as external magnetic fields and temperature. Increasing the number of NV centres improves sensitivity, while using the same number of entangled NV centres achieves much higher sensitivity than the same number of independent NV centres. Therefore, we focus on the entanglement between NV centres.

To entangle NV centres, closely spaced NV pairs must be prepared, since NV-NV entanglement relies on the dipole-dipole interaction between them. Thus we employed a method of molecular ion implantation into phosphorous-doped CVD diamond, which enables the formation of closely spaced NV centres, while phosphorus doping provides the long coherence time required to achieve high sensitivity. As a result, oscillation potentially indicating the dipole-dipole interaction between NV centres were observed in Hahn-echo measurement. Moreover, the obtained T2 was longer than that reported in previous research. This demonstrates there is a possibility to generate NV-NV entanglement with a long T2, in other words, high sensitivity.

Going forward, we will pursue theoretical advancements in entanglement generation and Bell state preparation, as well as the development of highly sensitive magnetic sensing.

Poster # 10

Lead-Vacancy Centers in Diamond for Quantum Networks: Material and Process Development

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Quantum networks require optically addressable spin qubits that emit indistinguishable photons and have coherence time long enough for entanglement distribution. The group-IV colour centers in diamond meet the optical requirement through their inversion-symmetric split-vacancy configuration, which gives first-order insensitivity to electric field fluctuations and correspondingly narrow, spectrally stable emission.

Among the group-IV colour centers, a lead-vacancy (PbV) center is distinguished by a ground state splitting of approximately 3870 GHz, the largest reported in the series. This large splitting suppresses phonon-mediated orbital relaxation, and millisecond-scale spin coherence is expected to be achieve at an elevated temperature as high as 9 K. This removes the need for dilution refrigerators and easing a key constraint on scalable quantum network hardware.

Realising superior properties strongly depends on the incorporation method of Pb atoms into the diamond lattice. Here, we report recent progress in the material and process engineering developed, together with optical characterisation of the resulting centers.

Poster # 11

Quantification and characterization of Nitrogen Vacancy Defects in a Chemical Vapor Deposition – Grown diamond

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Closely placed nitrogen vacancy (NV) centers with nanometer-scale separation inherently interact strongly with each other, making them better candidates for entanglement generation, which is expected for NV-based quantum qubits and sensors [1,2]. Because the strength of dipolar coherent interaction is a function of the distance of separation between (NV) centers in a diamond, investigating NVs' distance is a crucial factor deciding the efficiency of entanglement. In this study, a CVD-grown diamond sample with a certain amount of nitrogen impurity, which forms single NVs in the diamond sample, was used. We examined single NVs' density and NVs' distances by measuring optically detected magnetic resonance (ODMR), and the spin coherence time (T2) of the NVs was evaluated.

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Poster # 12

pH sensing with Nitrogen-Vacancy centers in detonation nanodiamonds

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Nanodimaonds (NDs) containing nitrogen-vacancy (NV) centers are promising biocompatible quantum sensors for measuring physical and chemical parameters, including magnetic fields, temperature, and pH. However, conventional NDs are typically around 100 nm in size, much larger than many biological targets. Here, we investigated pH sensing using nitrogen-enriched detonation nanodiamonds (DNDs) with an average particle size of 6.6 nm, in which intentional nitrogen doping increased the NV- center concentration. The DNDs were treated with boiling acid for two days to remove residual metals and sp2 carbon and introduce surface carboxyl groups. The treated DNDs exhibited millisecond scale NV spin-relaxation times that varied with pH, demonstrating their potential for nanoscale pH sensing.

Poster # 13

Crystallographic Symmetry Generates Phononic Holonomic Gates with Biased-Erasure Channels

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Fault-tolerant solid-state quantum processors need control mechanisms whose errors are both small and interpretable by quantum error-correction decoders. This work shows that crystallographic symmetry can provide such a control layer in strain-coupled solid-state Λ systems. By exploiting a shared two-dimensional irreducible representation, the authors use two phase-locked mechanical modes to generate a rotating strain field that enables complex phononic control without local microwave fields. They construct a superadiabatic holonomic gate and simulate it for a nitrogen-vacancy center, obtaining 99.88% conditional average fidelity in 1.833 μs. The resulting noise channel exhibits a 0.47% erasure probability and 0.168% residual Z error. Simulations with the XZZX code indicate a nominal 64% reduction in required data qubits compared with an unstructured Rabi baseline. The results suggest crystallographic symmetry as a hardware-level principle for jointly designing phononic control, leakage behavior, noise bias, and quantum-error-correction decoding.

Poster # 14

Probing of Diamond Surface Conditions under Different Vacuums via Shallow NV Centers

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Nitrogen-vacancy (NV) centers in diamond have attracted considerable attention as highly sensitive quantum sensors. Shallow NV centers formed near the diamond surface can provide high-sensitivity and high-spatial-resolution sensing; however, their spin properties can be degraded by surface defects and contamination caused by adsorbed molecules. Therefore, reducing these surface effects is important for improving their sensing performance. In this study, shallow NV centers formed by low-energy N^+ ion implantation at 3 keV into ^{12}C isotopically purified diamond substrate were used as quantum sensors to investigate how the variations of diamond surface condition under different vacuums affect the spin properties of shallow NV centers beneath the surface. Fluorescence imaging optically detected magnetic resonance (ODMR), Rabi oscillation measurements, and T_1 and T_2 spin relaxation measurements were performed under ambient, low-vacuum, and high-vacuum conditions. Based on these measurements, we discuss changes in the diamond surface with vacuum conditions and the effect of adsorbed molecules such as water.

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Poster # 15

Temperature sensing with a single nitrogen-vacancy center in phosphorus-doped diamond

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The electron-spin coherence time is a key factor determining the sensitivity of temperature sensing with nitrogen-vacancy (NV) centers in diamond. Previously, we reported the longest coherence times at room temperature for a single NV center in phosphorus-doped chemical-vapor-deposition (CVD) diamond. We also achieved comparably long coherence times using tert-butylphosphine (TBP), a less toxic phosphorus precursor, despite difficulties in controlling phosphorus incorporation. Building on these results, we perform D-Ramsey thermometry using a single NV center in TBP-grown phosphorus-doped diamond and estimate a temperature sensitivity of 4 $\mathrm{mK}/\sqrt{\mathrm{Hz}}$, surpassing previously reported values.

Poster # 16

Formation of high-density nitrogen delta-doped diamond via point-arc microwave plasma chemical vapor deposition method

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Nitrogen-vacancy (NV) centers in diamond have unique properties that make them attractive as room-temperature quantum sensors. High-sensitivity sensing requires a large number of NV centers to ensure sufficient fluorescence intensity. However, sensitivity decreases as the NV layer becomes thinner, whereas spatial resolution decreases as it becomes thicker, resulting in a trade-off between the two in magnetic sensing. Therefore, achieving both high sensitivity and high spatial resolution requires the formation of an ultra-thin, high-density NV layer (a nitrogen delta-doping layer) within a few nanometers of the surface. To this end, we employed a point-arc microwave chemical vapor deposition system in which the plasma and substrate are spatially separated. Using this system, we established synthesis conditions that simultaneously achieve low growth rate and heavy nitrogen doping and successfully formed a nitrogen delta-doped layer. This approach thus enables the fabrication of shallow, high-density nitrogen delta-doped layers with confirmed NV formation and room-temperature spin control, representing a promising route toward high-performance diamond quantum sensors.

Poster # 17

Charge-State-Based pH Sensing with a Shallow NV Layer in Bulk Diamond

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Monitoring solution pH with reusable probes is attractive for electrochemical sensing. Here, we investigate whether the charge-state population of near-surface nitrogen-vacancy (NV) centers in diamond can encode changes associated with solution pH. Using bulk diamond containing a shallow, thin NV layer, we quantified the NV-/NV0 population ratio while sweeping pH over a broad range. The ratio exhibited a clear pH dependence, with the measurable dynamic range concentrated primarily in acidic conditions. These results demonstrate charge-state-based optical pH readout in bulk diamond and support the development of reusable diamond-based electrochemical sensors.

Poster # 18

Study on NV Conversion Efficiency in Diamond CVD Growth for High-Sensitivity NV Quantum Sensors

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Nitrogen-vacancy (NV) centers in diamond have attracted considerable attention as solid-state quantum sensors for highly sensitive magnetic-field detection. Enhancing the sensitivity of NV-based quantum sensors requires a high NV conversion efficiency, defined as the ratio of the concentration of negatively charged NV centers (NV-) to the total nitrogen concentration in the diamond crystal. However, for as-grown diamond layers synthesized on (100) substrates by plasma-enhanced chemical vapor deposition (PECVD), the highest previously reported NV conversion efficiency was only 0.7%. In this study, diamond samples were synthesized using different nitrogen concentrations in the feed gas, and their NV conversion efficiencies were evaluated. The results showed that lowering the nitrogen concentration in the feed gas increased the NV conversion efficiency.

Poster # 19

Development of Diamond-Based Detection Systems for ALP and WIMP Dark Matter Search,

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Diamond possesses a variety of unique physical properties that are highly attractive for detector applications in astroparticle physics, including nitrogen-vacancy (NV) centers for quantum sensing, the highest Debye temperature among crystals, and a wide variety of optical color centers.

In this study, we are developing diamond-based measurement systems to search for dark matter, which remains one of the long-standing mysteries in astroparticle physics. We present two complementary approaches targeting leading dark matter candidates, axions and WIMPs: quantum sensing using NV centers for axion searches and a diamond scintillating bolometer for WIMP searches.

Poster # 20

Bright Emission and Two-Photon Interference of Lead-Vacancy Centers in Diamond Solid Immersion Lenses

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Negatively charged lead-vacancy (PbV) centers in diamond are emerging as a promising quantum emitter for the implementation of large-scale quantum networks. PbV centers exhibit high robustness against the phonon interaction among group-IV vacancy centers due to its large ground state splitting, and thus to show qubit operation without a dilution refrigerator [1]. Although fluorescence enhancement using photonic structures plays a key role, it remains underexplored for the PbV center due to the rough diamond surface after high-pressure and high-temperature (HPHT) anneal. In this study, we demonstrate the fabrication of the diamond solid immersion lenses (SILs) incorporating PbV centers on rough HPHT-treated diamond substrates and enhancement from emission of the single-like PbV centers. Furthermore, transform-limited linewidths were observed under resonant excitation for multiple enhanced emitters. Finally, we achieve two-photon interference using one single PbV center in a SIL.

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Poster # 21

Fabrication of Ferromagnetic Thin Films for Individual Spin Manipulation of NV Centers with Same Orientation in Diamond

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Nitrogen-vacancy (NV) centers in diamond formed in close proximity and coupled by dipole-dipole interactions have attracted attention for applications in quantum computing and magnetic-field sensing using quantum entangled states. We have established a technique to form multiple NV centers with a spacing of ~10 nm by implantation of organic compound ions. Individual manipulation of such multi-qubit NV centers is essential for their application as quantum devices. For NV centers with the same orientation, it is necessary to separate their individual resonance frequencies by applying a gradient magnetic field. Individual manipulation of dipole-dipole-coupled NV centers requires a strong magnetic field gradient on the nanometer scale. We investigated a technique for generating a gradient magnetic field using ferromagnetic nano-tips. In this research, we report a method for fabricating ferromagnetic thin films on the diamond surface and their magnetic-field properties.

Poster # 22

Magnetic Levitation of Millimeter-Scale Diamond in paramagnetic fluids

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Magnetic levitation of diamond provides a contact-free platform for particle manipulation and offers opportunities for precision sensing and levitated mechanics. Owing to the weak diamagnetic susceptibility of diamond, however, levitating macroscopic diamond requires sufficiently strong magnetic-field gradients. Here, we demonstrate magnetic levitation of millimeter-scale diamond in a paramagnetic liquid using a compact trap based on NdFeB permanent magnets.

The trap employs a linear arrangement of four permanent magnets designed to generate a strong magnetic-field gradient within a localized levitation region. Numerical simulations of the magnetic-field distribution predict values of the magnetic force parameter $(\mathrm{B}\cdot\nabla)\mathrm{B}$ exceeding $2000\,\mathrm{T}^2/\mathrm{m}$. Immersing the diamond in a paramagnetic liquid increases the magnetic-susceptibility contrast between the particle and the surrounding medium, enhancing the effective magnetic force on the diamagnetic particle and enabling gravitational compensation with a compact permanent-magnet configuration.

Experimentally, we observe levitation of millimeter-scale diamond, as well as trapping of smaller diamond particles and silica. The approach combines passive permanent-magnet confinement with susceptibility engineering of the surrounding medium, providing a simple and scalable method for manipulating macroscopic diamond without mechanical contact. This platform opens a route toward systematic studies of equilibrium, dynamics, and controlled motion of levitated diamond particles and provide a testbed for future sensing and levitated-mechanics experiments.

Poster # 23

Energy Optimization of L-Arginine Molecular Ion Implantation for NV$-^{13}$C Hybrid Qubits in Diamond

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The nitrogen-vacancy (NV) centers in diamond, also known as quantum bit operating at room temperature, have been recognized as a leading platform for quantum information and sensing. The electron spin of the NV center, along with the nuclear spins of the incorporated nitrogen atom and the neighboring isotope of carbon-13, act as a hybrid quantum register. By utilizing such quantum resister, quantum error correction [1], magnetic sensing [2] and quantum teleportation [3] have been demonstrated.

Previously, we have developed ion beams of 65 keV adenine (C_5N_4Hn) containing four nitrogen atoms [4], 284 keV phthalocyanine ($C_{32}N_8H_{18}$) containing eight nitrogen atoms [5], and 90 or 100 keV L-arginine (13C6H1415N4O2) with isotopically enriched ^{13}C and ^{15}N [6, 7]. The implanted molecular ions are designed to dissociate into individual atoms at the surface, then progress through the diamond forming vacancies, halting with a spatial spread (~9±4 nm) for all molecular ions. The implanted nitrogen atoms combined with the vacancies via thermal treatment, forming the NV centers.

In this study, we optimized the implantation energy of L-arginine ions to make a strong hyperfine coupling where the distance between NV and 13C is closer. A comparative analysis of the molecular ion energy for creating ^{15}N-13C has been conducted where the resulting hybrid multi-qubits are characterized by pulsed optically detected magnetic resonance (ODMR), Ramsey spectroscopy, XY8 spectroscopy, etc. In the presentation we will explain the NV created by L-arginine implantation. This research was supported by JST ASPIRE JPMJAP24C1.

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Poster # 24

Magnetically levitated resonators with low mechanical loss for quantum sensing

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Levitated mechanical resonators have the potential to achieve low mechanical loss and high quality factor (Q factor), which is critical for many applications, e.g., high-precision sensors, and exploring fundamental quantum physics. Diamagnetic levitation is a promising technique, which requires no energy input and can trap massive objects. However, conductive pyrolytic graphite, one of the strongest room-temperature diamagnetic materials, suffers severe eddy damping, leading to a very low Q factor.

We explored different methods to increase the Q factor to satisfy a variety of applications. Firstly, we cut slots into the graphite plate to interrupt the eddy currents and the Q is increased by a factor of ~ 40 while keeping the integrity of the plate itself. In the second method, we make insulating composites by blending the insulating-coated graphite powders with vacuum-compatible wax. The cm-sized composite resonators achieve motional Q factor at the scale of 10^5. We also cool the center-of-mass motion of the composite resonator by 3 orders of magnitude, using the feedback method. These low-mechanical loss resonators provide ideal platforms to build ultra-precise sensors, e.g. gravimeters, and study macroscopic quantum states for exploring quantum gravity.

To generate macroscopic superpositions, we propose two magneto-mechanical schemes, where the spatial separation between the individual cats: Δx, are much larger than their zero point motion xzpm. We use the magnetic force from superconducting flux qubit to drive a levitated micron-sized magnet or a levitated flux qubit itself to motional superposition states. We examine that these massive systems can reach ultra-large superpositions with $\chi \equiv \Delta x / x_{zpm} \sim 10^4 - 10^6$ at reasonable conditions.

Poster # 25

Potential engineering by coupling spin to mechanical motion with diamond NV centers

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In many levitated systems the shape of the trapping potential is static, being determined by the specific geometry of the lasers, electrodes or magnets. While it is possible to tailor these potentials (e.g. using AODs in optical traps [1]) at high frequencies it cannot be done dynamically in response to the particles position due to detection latency. Dynamic shaping of the potential opens a path towards the implementation of analogue computing protocols [2] and leveraging nonlinearities for measurements [3]. We seek to achieve this through taking advantage of the enormous lifting force available to diamagnetic levitation. These lifting capabilities allow us to levitate materials and objects traditionally locked out of this field using graphite plates as 'lifting pads' enabling the construction of novel levitated systems. Here, we suspend diamond samples containing nitrogen-vacancy (NV) centers to utilize the force exerted on their associated spin in a magnetic field gradient. This force is proportional to the population of initialized NV centers, which is controlled by the intensity of incident laser light. When combined with the low latency of our detection system and low oscillation frequency we can apply feedback forces in real time. Not only does this enable feedback cooling but also the shifting of the secular frequencies, generation of double wells and even modifications of the trap's nonlinearity. All of which can be done dynamically. Moreover, it offers control over the phase space of the oscillator paving the way towards the generation of phase space crystals [4].

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Poster # 26

Coupling NV centres in nanodiamonds to hollow microbubble resonators

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Nitrogen-vacancy centres are solid-state quantum systems that are promising for information processing, communication, and sensing. However, efficient coupling of NV-centre emission to optical resonators while preserving optical resonances with ultrahigh quality factors remains a significant experimental challenge. In this work, we investigate the coupling of ensembles of NV centres contained in nanodiamonds to hollow whispering-gallery resonators. By comparing the spectral measurements obtained under several experimental configurations, we analyze the coupling efficiency of the NV centres as a function of the nanodiamond positions and the geometrical parameters of the microbubble resonators.

Our system offers enhanced light-matter interactions in cavity quantum electrodynamics and for development of compact quantum devices.

Poster # 27

13C hyperpolarization of the diamond near LAC through optical excitation of the NV centers

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Hyperpolarization of 13C nuclear spins in diamond can enhance nuclear magnetic resonance signals and provide long-lived spin resources for quantum sensing and information storage. Here, we theoretically investigate nuclear polarization in an optically pumped NV–P1–13C system near level anticrossings (LACs) in the high-field regime. We map the LAC structure as a function of the angle between the NV quantization axis and the applied magnetic field. Using a Lindblad master equation, we then simulate the system's non-unitary dynamics, accounting for orientation-dependent NV optical pumping and four representative NV–13C hyperfine couplings. Our simulations show that interaction-induced state mixing near the LACs enables polarization transfer to 13C, producing polarization more than 1,000 times the thermal value. We also resolve fine structure near electron–electron anticrossings arising from the interplay between NV–P1 and electron–nuclear interactions. These results provide a theoretical account of optically driven 13C polarization near level anticrossings in diamond.

Poster # 28

Formation of ensemble NV-centers by electron irradiation for quantum sensing applications

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A negatively charged nitrogen-vacancy (NV^-) center in diamond is a type of quantum defect that functions as a highly sensitive sensor for magnetic fields and temperature. Sensitivity enhancement in NV-based quantum sensing is typically achieved by extending spin relaxation times or increasing NV^- center density. Electron irradiation of type-Ib diamonds followed by thermal annealing produces high-density NV^- centers efficiently, resulting in enhanced fluorescence intensity, improved signal-to-noise ratios, and shorter measurement times. These advantages are particularly beneficial for continuous-wave optically detected magnetic resonance (CW-ODMR) magnetometry, which enables compact and simple sensor designs. In this study, we discuss the formation efficiency of NV^- centers in type-Ib HPHT diamonds through electron irradiation and annealing, and introduce the NV center fabrication process employed at our institute.

Poster # 29

Nanophotonic Single-Photon Detection and Biological Electron-Transfer Sensing toward Quantum-Enabled In Vitro Diagnostics

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Recent advances in nanophotonics and quantum sensing provide new opportunities for probing biological processes at the single-molecule and single-particle levels, potentially enabling highly sensitive in vitro diagnostics. Here, we present our recent progress in nanophotonic platforms that bridge single-photon fluorescence detection, molecular electron-transfer sensing, and single extracellular-vesicle analysis, and discuss their future integration with diamond-based quantum sensors.

First, we developed a dual-wavelength dielectric metalens capable of simultaneously focusing excitation light and collecting fluorescence emission in an epi-fluorescence configuration. The high numerical aperture and dual-wavelength operation enable fluorescence correlation spectroscopy of individual fluorescent molecules and real-time detection of single nanoparticles, demonstrating an ultracompact optical platform for single-photon-level biosensing.

Beyond fluorescence detection, we developed metasurface-driven plasmonic resonance energy transfer (PRET) hyperspectral imaging for probing molecular absorption fingerprints and electronic-state changes. Spectrally engineered metapixels enable multiplexed detection of biomolecules including chlorophylls and cytochrome c. In particular, PRET provides an optical means of monitoring redox-dependent spectral changes of cytochrome c, establishing a label-free approach for interrogating biological electron-transfer processes.

We further extended time-resolved single-photon detection to the analysis of individual extracellular vesicles (EVs). Two-color fluorescence cross-correlation spectroscopy combined with coincident photon-burst analysis enables simultaneous identification of EV membranes and specific protein cargo at the single-vesicle level. The approach quantifies EV size, cargo loading, and changes in actin-containing EV populations associated with cellular differentiation and amyloid-Î²-induced pathological conditions, highlighting its potential for molecular diagnostics of neurodegenerative disease.

These nanophotonic approaches provide complementary routes for interrogating biological systems through individual photons, molecular electronic states, and nanoscale vesicular biomarkers. As a future direction, we envision integrating these optical platforms with nitrogen-vacancy centers in nanodiamonds, whose spin-dependent photophysics, photostability, and nanoscale sensing capabilities could provide additional quantum-sensitive observables of local biological environments. Such integration may ultimately establish a multimodal diagnostic framework combining single-photon fluorescence, electron-transfer spectroscopy, and nanodiamond quantum sensing for highly sensitive in vitro diagnostics.