HL 31: Materials and Devices for Quantum Technology I

Time: Wednesday 15:00–16:15 Location: POT/0251

HL 31.1 Wed 15:00 POT/0251

Escaping AB caging via Floquet engineering: photo-induced long-range interference in an all-band-flat model — Aamna Ahmed, •Mónica Benito, and Beatriz Perez-Gonzalez — Institute of Physics, University of Augsburg, 86159 Augsburg, Germany

Flat-band lattices hosting compact localized states are highly sensitive to external modulation, and the tailored design of a perturbation to imprint specific features becomes relevant. Here we show that periodic driving in the high-frequency regime transforms the all-flat-band diamond chain into one featuring two tunable quasi-flat bands and a residual flat band pinned at zero quasienergy. The interplay between lattice geometry and the symmetries of the driven system gives rise to drive-induced tunneling processes that redefine the interference conditions and open a controllable route to escaping Aharonov-Bohm (AB) caging. Under driving, the diamond chain effectively acquires the geometry of a dimerized lattice, exhibiting charge oscillations between opposite boundaries. This feature can be exploited to generate two-particle entanglement that is directly accessible experimentally. The resulting drive-engineered quasi-flat bands thus provide a versatile platform for manipulating quantum correlations, revealing a direct link between spectral fine structure and dynamical entanglement.

HL 31.2 Wed 15:15 POT/0251

Floquet theory for the quantum-to-classical crossover of light-matter models — •Beatriz Perez Gonzalez[1], Sigmund Kohler[2], and Mónica Benito[1] — [1]Institute of Physics (University of Augsburg), Augsburg, Germany — [2]Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC), Madrid, Spain

Rabi-type Hamiltonians, comprising either a time-periodic driving or a quantized electromagnetic field, have become ubiquitous across physics. Despite the well-established physics of both the semi-classical and quantum descriptions, when and how classical Floquet physics emerges from a fully quantum treatment remains the subject of active debate [1] and study [2].

We present a unified framework for the quantum-to-classical mapping, emphasizing the gauge-invariant formulation of the quantum Rabi Hamiltonian. This allows a systematic comparison of quasienergies, spectra, entanglement, and dynamics across high- and low-frequency regimes, and clarifies how Floquet frames correspond to gauge choices once photonic Fock states are interpreted as Fourier harmonics. We further assess the suitability of quantum high-frequency expansions and benchmark them against alternative methods for deriving effective Hamiltonians, including Schrieffer-Wolff transformations and projector-based approaches.

[1] Phys. Rev. Lett. 129, 183603 (2022); Phys. Rev. Research 2, 033033 (2020); [2] B. Perez-Gonzalez et al., Quantum 9, 1633 (2025); Comm. Phys. 7, 419 (2024)

HL 31.3 Wed 15:30 POT/0251

Understanding optically detected magnetic resonance (ODMR) of InSi-Sii-defects — •Kevin Lauer[1,2], Bernd Hähnlein[1], Mario Bähr[1], Kai Kühnlenz[1], Philipp Kellner[1], Dirk Schulze[2], Stefan Krischok[2], Alexander Rolapp[3], Christian Möller[1], and Thomas Ortlepp[1] — [1]CiS Forschungsinstitut für Mikrosensorik GmbH, Konrad-Zuse-Str. 14, 99099 Erfurt, Germany — [2]Technische Universität Ilmenau, Institut für Physik, Weimarer Str. 32, 98693 Ilmenau, Germany — [3]IMMS Institut für Mikroelektronik- und Mechatronik-Systeme gGmbH, Konrad-Zuse-Str. 14, 99099 Erfurt, Germany

Defects from the acceptor-interstitial silicon (ASi-Sii)-defect category were found to be promising candidates for qubits in silicon-based quantum technology [1]. To further explore their qubit properties optically detected magnetic resonance (ODMR) measurements are carried out on quenched indium-doped silicon samples featuring InSi-Sii-defects. Depending on the antenna design (omega or rod) four different ODMR signals are found in the spectra. An approach to understand these spectra in frame of a triplet system formed by two holes at the InSi-Sii-defect will be discussed. On that basis possible electronic level schemes are proposed.

[1] K. Lauer et al., 'Examining the properties of the ASi-Sii-defects for their potential as qubits', presented at the GADEST but unpublished, Bad Schandau: ResearchGate, May 2024. doi: 10.13140/RG.2.2.18793.51048.

HL 31.4 Wed 15:45 POT/0251

Time-bin encoded quantum key distribution over 120 km with a telecom quantum dot source — •Jingzhong Yang[1], Jipeng Wang[1], Joscha Hanel[1], Zenghui Jiang[1], Raphael Joos[2], Michael Jetter[2], Eddy. Patrick Rugeramigabo[1], Simone. Luca Portalupi[2], Peter Michler[2], Xiao-Yu Cao[3], Hua-Lei Yin[3,4], Shan Lei[5], Jingzhong Yang[1], Michael Zopf[1], and Fei Ding[1] — [1]Leibniz University of Hannover, Hannover, Germany — [2]University of Stuttgart, Stuttgart, Germany — [3]Nanjing University, Nanjing, China — [4]Renmin University of China, Beijing, China — [5]Anhui University, Hefei, China

Quantum key distribution (QKD) with deterministic single photon sources has been demonstrated over intercity fiber and free-space channels, but mainly on polarization encoding schemes. In contrast, time-bin encoding offers inherent robustness and has been widely adopted in mature QKD systems using weak coherent laser pulses.

In this work, we presents the first demonstration of the time-bin encoded quantum key distribution (QKD) using the telecom single photons from a quantum dot. A maximum tolerable transmission distance of 127 km is identified as the system error ratio approaches the security threshold. The result demonstrates the feasibility of realizing robust and scalable quantum communication network based on solid-state single-photon technology.

HL 31.5 Wed 16:00 POT/0251

high-efficiency photonic interfaces for VV centres in silicon carbide — •Nien-Hsuan Lee[1,2], Jonas Schmid[1,2], Berke Demiralp[3], Felix David[1], Kevin Menguelti[3], Stephan Kucera[1], Eva Weig[3,4,5], and Florian Kaiser[1,2] — [1]Luxembourg Institute of Science and Technology, Belval, Luxembourg — [2]University of Luxembourg, Belval, Luxembourg — [3]Technical University of Munich, Garching, Germany — [4]Munich Center for Quantum Science and Technology, Munich, Germany — [5]TUM Center for Quantum Engineering, Garching, Germany

In this work, we present a systematic investigation of etching processes aimed at optimising photonic structures for VV centres in bulk SiC. A wide range of fabrication parameters is explored, including metallic and non-metallic etch masks, plasma chemistries, and etching strategies to reduce surface and sidewall roughness while improving reproducibility. Structural and optical characterisation of the resulting waveguides enables identification of key loss mechanisms and the critical parameters governing high-efficiency photon transmission. Building on these process developments, we demonstrate a new generation of free-standing SiC waveguides with high wafer-scale uniformity and excellent reproducibility, enabling very high coupling efficiencies. Furthermore, we introduce a nanocone photonic structure in SiC, which simulations indicate can achieve more than a ten-fold enhancement in photon collection efficiency compared with unstructured bulk SiC. These results provide a scalable and reproducible photonic platform for wafer-scale integration of SiC colour centres for quantum communication.