Highly Anisotropic Charge Dynamics in the Trilayer Nickelate La4Ni3O10

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We study the ab-plane and c-axis charge dynamics of La4Ni3O10 using optical spectroscopy. While a pronounced Drude profile, i.e. metallic response, is observed in the ab-plane optical conductivity σ1ab(ω), the c-axis optical spectra σ1c(ω) exhibit semiconducting-like behavior. The zero-frequency extrapolation of the optical conductivity σ1(ω → 0)≡1/ρdc gives a resistivity anisotropy of ρc/ρab at 300 K for La4Ni3O10, which is much larger than the values in iron-based superconductors but comparable to that in high-Tc cuprates. The interband response is also highly anisotropic, showing salient orbital selectivity for light polarized in the ab plane and along the c axis. The interband transition peaks in both σ1ab(ω) and σ1c(ω) are located at lower energies compared to theoretical predictions, signifying considerable electronic correlations. By investigating the spectral weight transfer, we find that in the pristine phase, Coulomb correlations dominate the charge dynamics, whereas in the density-wave state, a gap opens and the Ni-dz^{2} orbital is involved.

Evidence plasmonic polaron in ZeSexTe2－x

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Polarons — quasiparticles formed by the dressing of charge carriers through interactions with col- lective excitations — are central to many emergent phenomena in condensed matter systems, rang- ing from superconductivity and charge-density-wave order to metal－insulator transitions. While conventional polarons are typically mediated by phonons, the collective oscillations of conduc- tion electrons, can also give rise to plasmonic polarons with distinct energy scales and strong carrier-density dependence. However, direct experimental evidence of such quasiparticles and their tunability remain elusive, particularly in layered materials. Here, we report the observation and control of plasmonic polarons in the layered transition-metal dichalcogenide (TMD) system ZrSexTe1-x using synchrotron-based angle-resolved photoemission spectroscopy (ARPES). Non-dispersive polaronic satellite bands emerge below the conduction-band minimum at M point, with energy separations that significantly exceed the longitudinal optical phonon energy — a hallmark of non-phononic coupling. The polaronic binding energy more than doubles upon Te substitution (x = 1.33), and systematic in situ alkali-metal doping reveals a pronounced carrier-density dependence of both effective mass and polaronic energy. These observations provide compelling evidence for a plasmon－polaron coupling mechanism and establish ZrSexTe1-x as a model platform for engineering and probing collective electronic quasiparticles. Our findings not only expand the landscape of polaron physics beyond conventional phonon-mediated paradigms but also open new avenues for exploring many-body interactions and quasiparticle engineering in layered quantum materials.

Molecular beam epitaxial growth of La3Ni2O7 films and research of their electronic structure

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This work presents initial progress on the molecular beam epitaxial (MBE) growth of $La_3Ni_2O_7$ thin films on $SrLaAlO_4$ (001) substrates. We report on the development of a growth process, where adjusting the La/Ni flux ratio, temperature, and O_2 pressure has yielded films with promising structural quality, as indicated by the XRD. Preliminary structural characterization by HAADF-STEM shows regions consistent with the target $La_3Ni_2O_7$ phase, though observations also indicate the common occurrence of stacking faults and local intergrowths of phases such as La_2NiO_4. Initial angle-resolved photoemission spectroscopy (ARPES) measurements on a $La_{2.75}Sm_{0.25}Ni_2O_7$ film suggest the presence of electronic features, including what appear to be the α and β bands dominated by Ni 3d orbitals at a photon energy of 75 eV. However, our early data does not show evidence of the predicted γ band near the Γ' point. These initial findings represent a first step towards the synthesis and deeper electronic structure investigation of this complex nickelate system.

Expanding the trilayer Ruddlesden-Popper nickelate family: Synthesis and characterization of Sm4Ni3O10-δ single crystals

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The discovery of high-temperature superconductivity in Ruddlesden-Popper (RP) nickelates has attracted significant attention. Bulk superconductivity emerges under pressure in trilayer nickelates La4Ni3O10-δ (Tc ≈ 30 K) and Pr4Ni3O10-δ (Tc ≈ 40.5 K), where the reduced ionic radius of Pr3+ may generate internal chemical pressure and enhance Tc. However, synthesizing trilayer RP phases with smaller rare-earth elements (Ln) is extremely challenging. So far, only the La, Pr, and Nd analogues have been synthesized with stable phases in the single rare-earth form. Here we report the first successful high-pressure and high-temperature (HPHT) synthesis of samarium-based compound Sm4Ni3O10-δ. Magnetization and transport measurements consistently confirm a density wave (DW) transition at ~ 180 K at ambient pressure. Through a careful fitting to the structural data of Sm4Ni3O10-δ, it is found that the bond angle of (Ni-O-Ni) associating with the interlayer apical oxygen is much smaller than 180°, which was assumed to be the key factor for the occurrence of superconductivity. By applying pressures up to 80 GPa, despite partial suppression of insulating behavior and the DW order, but superconductivity is not observed in our present study. Density functional theory calculations suggest that the 3dz2 and 3dx2-y2 are separated from other t2g orbitals and make a primary contribution to the Fermi surface. The newly synthesized trilayer nickelate Sm4Ni3O10-δ offers a unique platform for probing the fundamental physics of RP nickelates.

Superconducting gap structure and bosonic mode in La2PrNi2O7 thin films at ambient pressure

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Abstract: The recent discovery of high temperature superconductivity in nickelate systems has generated tremendous interests in the community. The core issue to understand the pairing mechanism is about the superconducting gap and its symmetry. We have successfully synthesized the superconducting thin films of La2PrNi2O7 with Tconset = 41.5 K, and measured the superconducting tunneling spectra after we expose the superconducting layer by using the tip-excavation technique. The spectrum shows a two-gap structure with $\Delta 1 \approx 19$ meV, $\Delta 2 \approx 6$-8 meV, and fittings based on the Dynes model indicate that the dominant gap should have an s-wave structure with low anisotropy, this allows us to put the priority in selecting the s$\pm$ pairing symmetry. Furthermore, a clear bosonic mode with energy $\Omega \approx 30 \pm 2$ meV is observed, which further supports a sign reversal gap. Our results shed new light in understanding the mystery of superconductivity in bilayer nickelate superconductors.

Low charge noise quantum dots in Ge/SiGe heterostructures

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Hole spin in germanium provide an interesting and competitive platform with excellent properties such as strong spin-orbital coupling (SOC) for fast qubit manipulation, operation at sweet spots and the potential for long-range qubit coupling via spin shuttling and hopping. However, charge noise remains a critical challenge throughout the computational process, limiting the performance of quantum information processing. Here, we employ three distinct methods to quantify 1/f noise in multiple quantum dot devices fabricated on Ge/SiGe heterostructures. We report a notably low level of average charge noise of $\sqrt{S}=0.5$ μeV/$\sqrt{\text{Hz}}$ at 1 Hz and $\sqrt{S}=21.99$ μeV/$\sqrt{\text{Hz}}$ at 1 mHz.

From Fracton Self-Statistics to Quasi-Fractonic Mobility in Quantum Codes

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This talk bridges the fundamental physics of fracton order with the design of novel Quantum Low-Density Parity-Check (QLDPC) codes. We first establish self-exchange statistics for immobile fractons as a key tool for characterizing these exotic phases. In parallel, our topological analysis of a prominent QLDPC code family reveals surprising, related phenomena, most notably quasi-fractonic mobility—an echo of the restricted mobility in fracton systems. This work demonstrates that concepts from exotic matter provide powerful, universal tools for advancing fault-tolerant quantum computation.

References:

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Crystal Structure, Magnetic Properties, and Platinum Incorporation in a 2H-Perovskite Ruthenate

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2H-perovskites have emerged as a fertile platform for studying quasi-one-dimensional (quasi-1D) magnetism, where alternating octahedra and trigonal prisms stack along the c-axis to form magnetic chains. The canonical member, Sr4Pt06, is diamagnetic due to Pt4+ (5d6, low spin), but its flexible crystallographic sites enable diverse elemental substitutions and magnetic behaviors. Ruthenates, containing Ru, are particularly intriguing for their unconventional superconductivity, Mott insulating states, and strong spin－orbit coupling.

Here, we report the growth of a novel 2H-perovskite, Sr4Ru0.3Pt0.706, via a high-temperature flux method in a Pt crucible.1 Single-crystal X-ray diffraction and energy-dispersive spectroscopy confirm that Ru^{4+} selectively substitutes for Pt4+ in the (Pt/Ru)06 octahedra, maintaining the R-3c quasi-1D framework of Sr4Pt06. By partially replacing non-magnetic Pt4+ with magnetic Ru4+ (4d4, S = 1), we transform a non-magnetic parent into a paramagnetic system. Magnetic susceptibility and specific-heat data reveal dominant antiferromagnetic interactions, and no long-range order above 1.8 K. This study establishes a chemical-doping route to induce low-dimensional magnetism in 2H-perovskites while preserving structural integrity. Sr4Ru0.3Pt0.706 offers a promising platform to explore Haldane physics and other quantum phenomena and reveals an unexpected Pt-crucible doping effect during crystal growth.