Session 22AP

Lattice dynamics and heat capacity of 2D helium and rare gases solids on graphite and metallic substrates **22AP1**

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An analytical approach is developed to describe the lattice dynamics of two-dimensional closely packed atomic monolayers adsorbed on substrates of different kinds. Phonon spectra of a perfect triangular lattice and a triangular lattice with a uniform distortion along one of the closely packed directions in the monolyer are found in explicit form without using the long-wave approximation. Heat capacity temperature dependences are calculated for both commensurate and incommensurate structures. The obtained theoretical results are used to interpret and discuss in detail available experimental data on the 2D lattice excitation spectra and the specific heat of rare gas monolayers with emphasis on ^{3}He and ^{4}He monolayers on graphite and metal substrates.

NMR of Hydrogen Adsorbed on Carbon Nanotubes **22AP2**

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Hydrogen gas is introduced to multi-wall carbon nanotubes and the hydrogen adsorption is studied by using ^{1}H nuclear magnetic resonance(NMR). The resonance spectrum, peak position shift, signal intensity, and the spin-spin and spin-lattice relaxation times are measured as the functions of hydrogen gas pressure and temperature. The peak position shift is inversely proportional to temperature and resulted from the super-paramagnetic Fe catalysts remained in the nanotubes. Due to the distribution of Fe impurities the relaxation behavior becomes non-single exponential type. The spin-lattice relaxation time increases and the spin-spin relaxation time decreases as temperature is decreased. The observed spectrum and time-dependent signal intensity indicate that the hydrogen adsorbed on carbon nanotubes is H_2, $i.e.$ the molecular hydrogen. We will discuss about dynamic properties of the adsorbed molecules.

22AP3 Theoretical NMR line shapes for orientational ordering study

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A peculiar NMR lineshape was reported for orientational ordering study of submonolayer films of H_2 molecules adsorbed on hexagonal boron nitride. This low-temperature (below 200 mK) NMR line shape was seen for relatively high ortho concentration [x[H_2]$\leq$0.74] and was interpreted a signature of the hindered rotor state. Recent computer simulations of the NMR line shapes for hydrogen, however, indicate that the peculiar NMR lineshape could be formed due to the combination of three different NMR line structures, and suggest that there might existed well-defined clusters in two dimensions with three different order parameters which dominated the orientational ordering. In addition to the hindered rotor lineshape, the order-parameter-dependent quadrupolar glass NMR lineshape will be discussed.

22AP4 Diffusive Motions in HD Films Physisorbed on Graphite

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High-resolution quasielastic neutron scattering was used to study diffusive motions in two-dimensional (2D) liquid and solid phases of deuterium hydride (HD) submonolayers adsorbed on graphite. Several interesting phenomena were observed: In the commensurate $(\sqrt{3} \times \sqrt{3})R30^o$ (C) phase and in the incommensurate (IC) solid phase molecular mobility already starts to wake up about 8 K below the melting temperature and can be described by a 2D hexagonal jump model. For the first time it could be unambiguously clarified that the novel reentrant fluid (RF) phase at the C-IC transition has the character of a viscous fluid and that particle motion in this phase is a complex process (kink diffusion of domain-walls).

22AP5 Quartz Microbalance Study of Superfluid Helium Thin Films Absorbed on a Hydrogen Pre-plated Golde surface

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We have developed highly sensitive torsional oscillator technique for probing the effect of the substrate character on the Kosterlitz-Thouless transition in thin helium films. We have measured the vortex diffusivity in thin superfluid helium films adsorbed on a hydrogen pre-plated gold substrate at temperatures from 1.4 K to 2.0K. We study the finite amplitude and frequency effects for substrate velocity up to 9 cm/sec and in frequency range from 3.3MHz to 36MHz of single quartz crystal microbalance.

Amplitude and Frequency Effects on the Kosterlitz-Thouless Transition in Thin Helium Films **22AP6**

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We have developed a technique for probing the Kosterlitz-Thouless transition in thin helium films in which a single quartz crystal microbalance is excited at six different harmonic frequencies. We operate a single quartz crystal microbalance at two different harmonic frequencies simultaneously in frequency range from 3.3 MHz to 36 MHz. We observe previously unreported non-linear behavior in superfluid dissipation associated with finite amplitudes, at the various frequencies. In addition we measure the shifts and broadenings of the transition associated with the predicted finite frequency effects.

Thermodynamic properties of ^{3}He in thin ^{3}He–^{4}He films **22AP8**

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We examine the thermodynamic properties of the quasi two-dimensional system, ^{3}He adsorbed in thin ^{4}He superfluid films. In this note, we ignore the effects ^{3}He–^{3}He interactions and consider the system as a gas of independent quasi-particles. The ^{3}He atoms are characterized by their hydrodynamic effective mass and a discrete single-particle spectrum that models the effects of the substrate. We calculate the magnetization steps, certain fixed points in the phase diagram, the equation of state and the specific heat. We show how the magnetization steps at finite-temperature evolve from the zero-temperature limit. We show that there exist points in the phase diagram through which all isotherms pass. We point out that the pressure has a negative temperature derivative at coverages near the endpoints of the magnetization steps. We show that the specific heat has a broad Schottky-like maximum at low coverages.

Study of dynamical properties of superfluid ^{3}He film flow by interdigited capacitors **22AP9**

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We have developed a new technique to study film flow of adsorbed superfluid ^{3}He film. By this technique utilizing interdigitated capacitors, flow and thickness of the film can be controlled. We measured superfluid critical temperatures of film T_c^f for various thicknesses(0.2-7.5μm). The result agrees with the theoretical criterion that $2d_c \approx \pi\xi(T_c^f)$, where d_c is the film thickness and $\xi(T)$ is the temperature-dependent coherence length of superfluid ^{3}He.

22AP10 Torsion pendulum studies of thin ^{3}He slabs

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A high precision torsional oscillator has been developed for the detection of two dimensional superfluidity in ^{3}He films of thickness comparable to the superfluid coherence length, 70 nm at $T = 0$. The mass loading from such a film can be detected with a 0.1% resolution. The oscillator is fabricated from coin-silver alloy, and the working surfaces are two highly polished coin silver discs, that are diffusion welded together using a copper gasket. Measurements on normal films show an unexpected de-coupling from the surface with decreasing temperature, below 60mK. The frequency shift and dissipation data can be interpreted using a phenomenological interfacial friction model. Progress on studies of the superfluid transition and superfluid density of such ^{3}He slabs will be discussed.

22AP11 Specific Heat Measurements of Two-dimensional ^{3}He on ^{4}He Films

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We report heat capacity measurements of two-dimensional liquid ^{3}He on superfluid ^{4}He films. Our group previously measured the coverage dependence (0.02-1.65 bulk-density ^{3}He layers) of the heat capacity of ^{3}He on 4.33 bulk-density layers of ^{4}He over the temperature range $90 < T < 160$ mK.[1,2] We have improved the refrigerator and installed melting curve thermometry for measurements at lower temperatures. We will report new results as they are available for lower temperatures and different ^{4}He coverages. Analysis yields a determination of the hydrodynamic mass and the Landau parameter F_1^S, and, by comparision with NMR measurements[3], F_0^A is also determined. [1] P.C. Ho and R.B. Hallock, Phys. Rev. Lett. **87**, 135301 (2001). [2] H. Akimoto, P.C. Ho and R.B. Hallock, Bull. Am. Phys. Soc. **47**, 1016 (2002). [3] R.H. Higley, D.T. Sprague, and R.B. Hallock, Phy. Rev. Lett. **63**, 2570 (1989).

22AP12 Exact Diagonalization for the Vibronic Levels of Dynamic Yahn-Teller Systems –E_g Orbitals with e_g modes in Trigonal Fields–

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We calculate electronic states of degenerate E_g orbitals of d-leves coupled with vibrational modes of e_g. This is the typical Longuet-Higgins system of dynamic Jahn-Teller effects(DYTE). Further, the effect of the trigonal fields on some low-lying levels has also discussed. Here, we perform the exact diagonalization without approximations used in previous work, to discuss clearly DYTE.

Simulated Avalanches in the Draining of Superfluid Helium From Nuclepore 22AP12

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One observes avalanches in the pore draining of superfluid ^{4}He from Nuclepore within a narrow range of chemical potential. The avalanches involve pores distributed across the entire sample and they are enabled by the superfluid film. The statistics of the avalanches depend on whether the superfluid film has limited or unimpeded access to flow pathways from the substrate during draining. We have simulated the avalanches in Nuclepore and when third sound perturbations are a factor during the draining of the pores, we find simulated avalanche statistics similar to the experimentally observed statistics we see when flow from the substrate is limited. When third sound is not included in our simulated draining, we see statistics similar to those we observe when flow from the substrate is unimpeded.

The possible origin of the unusual peak observed in the spin-diffusion coefficient of ^{3}He films 22AP13

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We show a theoretical result that yields the existence of a peak in the spin diffusion coefficient as a function of density ($D_s(n)$) in a dilute two dimensional Fermi liquid. We argue that may be an explanation for the unusually peaked $D_s(n)$ observed in ^{3}He films by Sheldon and Hallock [PRL **85**, 1468 (2000)]. We are able to fit the up and downturns in the experimental data using a hard disk radius consistent with older measuraments of the spin susceptibility. It is found that if no other scatterinc process besides diffusional scattering is theoretically included, the peak in $D_s(n)$ becomes a divergence for a given value of n. Further implications of these results are discussed together with possible mechaninsms that may be responsible for the observed saturation of $D_s(n)$ for intermediate densities.

Helium Molecules Within Carbon Nanotubes 22AP14

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The ground state properties of ^3He and ^4He dimers and trimers in infinite carbon nanotubes are studied. The ground state eigen-functions of one helium atom in tubes of different radii are obtained numerically and then fitted by analytic expressions. Total wave function is assumed to be a product of Jastrow-Feenberg pair correlation and one particle functions. After extensive Monte Carlo calculation in two successive stages, VMC (simple variational Monte Carlo) and DMC (diffusion Monte Carlo) it is found that binding depends on the radius and has maximum for a certain tube width. We expect to show that the physical difference between fermions and bosons will disappear inside narrow enough tubes.

22AP15 The Adsorption of ^{4}He on Single Wall, Closed-end Carbon Nanotube Bundles

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Volumetric adsorption isotherm measurements of ^{4}He deposited on single wall, closed-end carbon nanotube bundles performed over an extended range of temperatures above 2.5K will be reported. We have probed the very high binding energy sites in the initial stages of adsorption, the graphite-like adsorption at completion of a monolayer, and the multilayer regime up to four layers. We wil compare these results to those obtained previousy on H_2 and D_2 adsorbed on the same nanotubes by isotherms and elastic neutron scattering, and will present preliminary heat capacity measurements of ^{4}He above 1.5K at a few selected coverages.

22AP16 Competitive Adsorption of ^{4}He and H_2 on Single-wall Carbon Nanotubes

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We have used a temperature-programmed desorption (TPD) technique to observe that H_2 binds preferentially vs. ^{4}He on single-wall carbon nanotube bundles. Pure ^{4}He TPD work has previously indicated the existence of strong binding sites associated with the nanotube bundles. There are two different strong binding locations on the close-ended tube bundles: outer-groove sites and interstitial channels. Whether H_2 preferential binding occurs in the interstitial channels or on the outer grooves has not yet been unambiguously determined. Complementary measurements are underway, and the results of these will be described.

22AP17 Specific Heat of ^{4}He Film Adsorbed on Three-Dimensional Pores

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We have measured specific heats of ^{4}He and ^{3}He films adsorbed on a new mesoporous material with the pore diameter 27 Å called HMM-2 which has an ordered 3D network. The substrate is organic-inorganic hybrid material made of C_2H_4 and Si_2O_3, and has cages connected in hcp structure ($a = 55.4$ Å, $c = 88.6$ Å). When adsorptions are above one layer, specific heats below about 0.3 K are qualitatively different between ^{3}He and ^{4}He. It indicates that the Bose fluid of the ^{4}He films appears at the second layer. We found that the temperature dependence of the ^{4}He specific heat has a peak at the density where Bose fluid appears. Above 0.1 K, the peak temperature linearly increases as the density of the ^{4}He films increases.

Superfluidity of ^{4}He Film Adsorbed on 47 Å Pores **22AP18**

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The superfluid of ^{4}He films adsorbed on uniform straight pores 47 Å in diameter has been studied using a torsional oscillator in order to investigate the nature of the superfluid transition of the film formed in several nanometer pores. The results show that the film in the pore is certainly superfluid above 1.5 layers. The temperature dependence of the superfluid density below the superfluid transition temperature is not so sharp compared with that expected by the Kosterlitz-Thouless transition. This behavior is similar to the results with porous glass with 50 Å diameter pores and qualitatively explained by the strong confinement of the vortex pairs.

Few Helium Atoms in Quasi Two-Dimensional Space **22AP19**

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Two, three and four ^3He and ^4He atoms in quasi two-dimensional space above graphite and cesium surfaces and in "harmonic" potential perpendicular to the surface have been studied. Using some previously examined variational wave functions and Diffusion Monte Carlo procedure it has been shown that all molecules: dimers, trimers and tetramers, are bound stronger than in pure two- and thee-dimensional space. The enhancement of binding with respect to unrestricted space is more pronounced on cesium than on graphite. Furthermore, for ^3He on all studied surfaces there is indication that the configuration of a dimer and a "free" particle is more stable than the trimer.

Superfluid transition of ^{4}He films adsorbed in one-dimensional MCM-41 ceramic **22AP20**

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An initial study of the superfluid transition of a ^{4}He film adsorbed in 40 Å diameter cylindrical pores of MCM-41 ceramic has been carried out using a torsion oscillator technique. A very broad transition is observed, as expected from the theory of Machta and Guyer for the Kosterlitz-Thouless transition in cylindrical pores when the vortex core size is a substantial fraction of the pore diameter.

22AP21 Striped - Honeycomb Transition of Domain Wall Structure of ^{3}He Submonolayer Solid Film on Graphite

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The adsorption energy of ^{3}He submonolayer solid on a graphite substrate are calculated by the path integral Monte Carlo simulation for some adsorption structures. The results show that structural transition between the striped domain wall and the honeycomb one occurs around 6.8 nm^{-2}. This structural phase transition can explain qualitatively the observed sudden jump of the exchange frequency at this density.

22AP22 Nuclear Spin-Spin Relaxation in ^{3}He-Ne Films

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NMR measurements of the nuclear spin-spin relaxation times are reported for commensurate monolayers of ^{3}He and ^{3}He-Ne films on BN for temperatures $0.1 <$T< 3.5 K. The results are analyzed in terms of particle-particle exchange motions of the adsorbed ^{3}He atoms. The effective exchange rates were observed to change significantly on replacing a fraction of the helium atoms with relatively immobile neon atoms. This is understood if there is a significant 3-particle term in the exchange Hamiltonian that is of opposite sign to that of the 2-spin exchange term. Values of the vacancy formation energy for the monolayer coverage and the atom-vacancy exchange rate are also obtained from the experimental observations.

22AP23 The Magnetic Groundstate Phase Diagram of a Multiple-spin Exchange Model on the Triangular Lattice

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We investigated the groundstate of a multiple-spin exchange model, which is considered to describe the magnetism of the solid ^{3}He adsorbed on the graphite, under the external magnetic field. The model contains the conventional Heisenberg exchange terms as well as four-spin exchange terms. We found numerous groundstate phases with very large spatial structures with up to 144 sublattices by using the mean field approximation. We found novel groundstate phases with 6- and 12-sublattice non-coplanar spin structures when the Heisenberg term is antiferromagnetic. The 6-sublattice phase replaces the 120° phase with decrease of the Heisenberg exchange coupling through a second order transition.

NMR Measurements of Monolayer ^{3}He Absorbed on ZYX Graphite **22AP24**

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So far, theoretically predicted 2D superfluidity in monolayer ^{3}He has not been observed experimentally. This is because the temperature range in previous searches was limited above 1 mK due to localized ^{3}He atoms trapped in heterogeneities of Grafoil substrate or because the single crystalline size ($\approx$10 nm) of Grafoil is shorter than the expected superfluid coherence length ($\geq$ 100 nm). To overcome these problems, we have constructed a high performance nuclear demagnetization refrigerator which can cool the monolayer samples below 200 mK and characterized the ZYX grade exfoliated graphite which has at least ten times longer crystalline size than Grafoil. NMR measurements are now under going to search for the possible 2D and quasi 2D superfluidity in ^{3}He films.

Heat Capacities of Two-Dimensional Solid ^{3}He in Magnetic Fields **22AP25**

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The "quantum spin liquid (QSL)" state is suggested as the ground state of the low density second-layer solid ^{3}He adsorbed on a graphite surface from a previous heat capacity measurement in zero magnetic field which shows a double peak structure. It is theoretically suggested that, with increasing magnetic field, the QSL phase changes into a long-range ordered phase called the "uuud phase" above a certain threshold field, which is a measure of the spin gap of the QSL phase, accompanied by a finite temperature phase transition. We report latest results of ongoing heat capacity measurements of 2D ^{3}He at temperatures below 200 μK in magnetic fields below 1 T.

Heat capacity investigation of two dimensional isotopic fluid helium mixtures **22AP27**

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The properties of a helium fluid mixture, adsorbed as the second atomic layer on the surface of graphite plated by a monolayer of ^{4}He, have been investigated in the temperature range 2 - 80 mK. By using a small tracer of ^{3}He (0.1 nm^{-2}) and progressively increasing the ^{4}He coverage, we find strong support for the theoretically predicted sequence of phases for the second layer ^{4}He film; a self bound liquid and a significant coverage range over which a fluid uniformly covers the surface. We then added ^{3}He, up to a coverage 1 nm^{-2}, to this uniform fluid. We initially observe an anomalous temperature dependence of the heat capacity, which we attribute to virtually complete isotopic phase separation within the layer, giving rise to the formation of two dimensional ^{3}He fluid nanoclusters. Above 0.5 nm^{-2}, the ^{3}He appears to go into a surface state, forming a uniform 2D Fermi fluid floating on the ^{4}He film.

22AP28 Thermodynamic evidence for two dimensional ^{3}He tunnelling excitations

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The heat capacity of the second layer solid of ^{4}He adsorbed on graphite has been measured after doping with ^{3}He atoms, in the temperature range 2-80 mK. Heat capacity isotherms show a distinct maximum over the range of coverages for which the second layer commensurate solid is expected to be stable. In this region the heat capacity exhibits a broad maximum near 50 mK, at a value close to k_B per ^{3}He atom. At higher temperatures the heat capacity decreases slowly, while at lower temperatures it tends to zero faster than linearly. Our interpretation is that the excitations are tunnelling ^{3}He quasiparticles in the host 2D crystalline ^{4}He matrix, with bandwidth and effective mass determined by the sum of all possible cyclic permutations causing a ^{3}He atom to hop. The low temperature behaviour indicates a breakdown of the Fermi liquid arising either from interactions between the excitations or localisation.

22AP29 Very low frequency SQUID NMR measurements of two dimensional solid ^{3}He films

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Pulsed NMR measurements at low kHz frequencies have been performed on ^{3} He films adsorbed on an exfoliated graphite sample of area 2m^2. The spectrometer is constructed using a DC SQUID amplifier, with additional positive feedback, and bandwidth 3.4 MHz. The input circuit is a superconducting flux transformer, and so is intrinsically broadband. NMR measurements of the magnetization of the ^{3}He have been made as a function of magnetic field down to 0.1mT, and to temperatures below 1mK. In addition the thermalization of the graphite substrate can be confirmed by observing the ^{13}C signal. ^{3}He films provide model systems for frustrated two dimensional magnetism, and we report on the use of low frequency SQUID NMR to investigate the magnetic ground state.

22AP30 Droplets of mixtures of ^{3}He-^{4}He at finite vorticity

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We study the properties of ^{3}He-^{4}He mixture droplets using a phenomenological density functional. The structure of liquid drop with and without vortices is investigated using Monte Carlo simulations.

Path Integral Calculation of Superfluid ^{4}He Vortex Core Structure **22AP31**

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A structure of a superfluid ^{4}He vortex core is studied with a path integral Monte Carlo method. The distribution of superfluid and normal fluid densities around the vortex core is obtained. The total particle density decreases in the vortex core region. The radius of the core is nearly equal to particle diameter. The vortex core is filled with normal fluid in the temperature region $T \simeq T_\lambda$. In low temperature region, the normal fluid component of a vortex core decreases remarkably. Consequently the number of particle density of a vortex core region becomes extremely small.

Self-Organization of Thermal Turbulence in Cryogenic Helium Gas **22AP32**

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The use of cryogenic helium gas has made possible the study of fully developed turbulence in the laboratory. Here, an experimental study of highly nonlinear thermal convection, using helium gas near 5K, is reported. Small scale fluctuations within the turbulent flow organize themselves into a self-sustaining large-scale motion and its features,including the irregular reversal of its direction, are discussed. By analyzing various probability density functions, a rough correspondence can be made to self-organized criticality. The existence of this coherent, fluctuating large-scale circulation has many implications for turbulence models and for the interpretation of experimental measurements. These will be discussed in light of recent controversies concerning the asymptotic "ultimate" regime of turbulent convection.

Experimental Study of the Decay of Quantized Vorticity at mK Temperatures in He II **22AP33**

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Recent studies of turbulence in He II have shown unexpected analogies to classical fluids. However, unlike classical fluids, superfluid ^{4}He is well described by a two fluid model; a viscous normal component mutually coexisting with an inviscid superfluid component (with quantised circulation). For temperatures T¡¡1K, the density of the normal fluid component is negligible: so how does the turbulence decay when there are no viscous effects? To answer this question, the free decay of quantised vorticity is being studied in a cell containing high pressure, isotopically pure ^{4}He, at mK temperatures. Preliminary results showed that we can create and detect the decay of vorticity, and suggested a temperature independent decay mechanism below 70mK. The results of recent, more detailed, experiments will be reported and discussed.

22AP34 Stochastic Motion of Vortex Filament. Inverse Kolmogorov Cascade.

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Using the renorm-group methods we study stochastic dynamics of a vortex filament undergoing random agitation with the power-like spectrum. In particular we calculate an effective viscosity, which describes exchange with the energy between smooth (large-scale) distortions of the vortex filaments and the small-scale ones. The effective viscosity is shown to be negative, that implies that energy transfers from small scales (appeared e.g. due to reconnection) to the large ones. The latter means that the inverse Kolmogorov cascade is realized in the system. On that ground we conclude that the real stationary entanglement occurs due to reconnections of the lines and interaction with boundaries but not due to nonlinear Kelvin waves dynamics

22AP35 Quantised vortex line visualisation in superfluid helium using low temperature optics

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The possibilty of visualising quantised vortex lines in liquid helium by light diffraction from the regular array of surface depressions above each line has been considered by Hall. Berry and Hajnal in contrast examine the caustics from an individual vortex in a classical fluid. We combine both analyses to investigate the situation where parallel light normally incident on the surface of rotating superfluid helium penetrates the liquid and is then reflected back from a silvered lower boundary. A cooled CCD camera with suitable low temperature optics above the surface is designed to capture the pattern caused by the array of surface depressions. We show that an array of caustics will be created that can be viewed either directly, or by focussing onto the CCD a virtual image caused by the refraction of the caustic rays.

22AP36 Periodic convection patterns in liquid ^{4}He close to onset.

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High resolution images of convective flow patterns in a vertical axis cylindrical layer of normal liquid helium of diameter 18.25 mm and height 0.56 mm have been obtained near the Prandtl number minimum of 0.5 at 2.6 K. The primary stationary pattern close to the convection threshold is a robust state of straight parallel rolls signalling that the boundary conditions are close to ideal. A periodic response exists at slightly higher Rayleigh numbers in which dislocations climb periodically along the roll axes through the skew-varicose mechanism. Correlated with this regime are periodic oscillations of amplitude 100 μK and period of the same order as the horizontal thermal diffusion time. The dynamics of the periodically varying pattern and of more chaotic patterns at higher Rayleigh numbers are revealed using time-lapse movie sequences of the images.

Diffusion of an Inhomogeneous Vortex Tangle **22AP37**

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The diffusion of an inhomogeneous vortex tangle is studied numerically by the vortex filament model. The initial inhomogeneous tangle is prepared under an applied flow, and switching it off allows the tangle diffuse freely. Comparison with the solution of the inhomogeneous Vinen's equation taking account of the diffusion term shows the extremely small diffusion constant of the tangle. The results are discussed in relation to the recent experiments on grid turbulence in superfluid helium.

Competition between Rotation and Turbulence in Superfluid **22AP38**

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Two types of vortex states have been much studied in superfluid ^{4}He. The first is the vortex array in a rotating container. The second is the vortex tangle in turbulent flow. An experiment attempt to combine these two states by rotating a counterflow was attempted years ago. The data suggest the existence of different flow regimes separated by instabilities, but a theoretical interpretation is still missing. We present work in which we use the vortex filament model to numerically investigate rotating counterflow. We show evidence of a new state of polarized turbulence.

Quantum Turbulence in He II Induced by Second Sound Shock Pulses **22AP39**

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Direct measurements are presented of quantum turbulence in He II induced by second sound shock (SSS) pulses in a wide channel. Through the use of a leaky capacitor model (LCM), a growth and decay characterization of the quantum turbulence is extracted from the measurements. Also taken is an explicit energy account of the quantum turbulence as well as of the SSS pulses that induced the turbulence. A critical energy flux density is proposed for the onset of Gorter-Mellink thermal diffusion with respect to a quantum turbulence background. Tentative decay exponent results indicate that the induced quantum turbulence decays in a comparable way to that induced by a towed grid in a channel.

22AP40 Mapping the Development of Quantum Turbulence in Superfluid ^{3}He-B

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We have investigated the evolution of a localized region of quantum turbulence in the B phase of superfluid ^{3}He at temperatures down to $\sim 0.1 T_c$. We detect the turbulence from the reflection by the associated flow field of incoming quasiparticles by Andreev processes. The turbulence is generated by a vibrating wire resonator which produces vorticity together with a directed quasiparticle beam whenever the wire velocity exceeds the critical velocity for pair breaking. By using an array of detector wires we are able to monitor the development of the turbulence both in space and time. The turbulence propagates preferentially along the the quasiparticle beam direction and falls off exponentially with distance with a characteristic length of $\approx 2\,\mathrm{mm}$. We also observe that the initial turbulent 'front' generated by the source wire propagates at a speed of a few $\mathrm{mm\,s^{-1}}$.

22AP41 Nonlinear vortex-line formation in rotating superfluid ^{3}He-B

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Vortex formation in rotating ^{3}He-B occurs in discrete events with well-defined critical counterflow velocity. Usually, a small number of initial loops is produced per event. They evolve to form a stable cluster of rectilinear vortices in the center of the sample. Below 0.6 T_c the behaviour is observed to change. Here some events can produce a very large number of vortices, such that the final state may approach the equilibrium configuration independently of the initial process by which the first vortex loops were formed. Below 0.5 T_c all instability events behave in this way. We present measurements on the number of vortex lines created per instability event and their flight time to reach stationary confiquration as rectilinear vortex lines in the vortex cluster. The results are compared to a dynamic model of vortex loop expansion.

22AP42 Penetration of Quantized Vortices in Rotating ^{3}He-B Through an Orifice

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We present NMR measurements on the flow of vortices across an orifice separating the sample into a volume with vortex-free counterflow and one with the equilibrium number of vortex lines created under rotation. Vortices are observed to leak through the orifice in isolated bursts which occur repeatedly as a function of the rotation velocity Ω. Above $0.6\,T_c$ the first event occurs at a well-defined critical velocity Ω_c which is independent of rotation direction and rotational acceleration. This process can be understood as Feynman depinning of vortices from the rim of the orifice. Below $0.6\,T_c$ a second mechanism sets in abruptly. It is of stochastic nature, depends on the noise in the rotation drive, displays a much reduced Ω_c, and results in a greatly increased final number of vortex lines from one event of leakage.

SQUID NMR Studies of Dipole Field in Ferromagnetic ^{3}He films **22AP43**

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We use SQUID NMR to observe the magnetization of ^{3}He films with densities between 20 to 24 atoms/nm^2 in the zero field limit. Ferromagnetism in these nearly 2D Heisenberg exchange systems is stabilized by weak anisotropies. In the ferromagnetic phase, the NMR line becomes very broad and shifts to lower frequencies, consistent with a large dipolar field opposing a perpendicular applied field. Grafoil can be modeled by a Gaussian distribution of platelet angles centered on the normal to the grafoil plus a randomly distributed set of platelets. Using the spin dynamics of a 2D polarized sheet with reasonable assumptions for the distributions of platelet angles, we show that the magnetization, frequency shift and lineshape form a consistent picture of a highly polarized sheet.
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QCM Studies of ^{4}He Films Adsorbed on Grafoil **22AP44**

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We applied the quartz-crystal microbalance (QCM) technique to study the slippage of superfluid and nonsuperfluid ^{4}He films adsorbed on graphite at MHz-frequency range. The grafoil substrate was prepared by pasting a piece of grafoil uniformly on Ag electrodes, so that the effective surface area of the substrate was much larger than that of Ag electrodes. We found that the observed slippage of superfluid and nonsuperfluid ^{4}He films shows a rather different behavior compared with that of the torsional oscillator technique.

Thermal gravity-driven convection of the near-critical low temperature fluids in enclosures **22AP45**

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Near-critical fluids possess abnormal physical properties that leads to specific heat transfer and interesting hydrodynamic effects. Classical problems concerning heat transfer and convection in square cavity with side and bottom heating are solved. Numerical simulation is performed using the novel 2D code on the basis of the full Navier-Stokes equations and Van-der-Waals form of the thermodynamic state equation. We have found the calibration forms relating criteria of similarity of near-critical fluid and perfect gas and compared these two media. The results of the simulation of the Rayleigh-Bénard convection (with bottom heating) are compared with experimental data on heat transport in helium above its critical temperature. The requirements for the choice of the heat sources in ground-based experiments are discussed.

22AP46 **^{4}He Confined to 1μm boxes, 0D Crossover, Surface and Edge Effects.**

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We report measurements of the specific heat of ^{4}He confined to 1μm^3 cylindrical boxes patterned in SiO_2. This system crosses from a 3D behavior to a 0D behavior near the critical temperature. This has a marked effect on the specific heat as seen by a pronounced rounding of the maximum and a shift to a temperature much lower than the transition of the bulk system. We plot the data according to correlation-length scaling theory and compare this to a planar system with the same smallest spatial length. Compared to our previous studies of planar systems, the 0D cell has 3$\times$ the surface to volume ratio as well as $\sim$750$\times$ as much edge length. We examine the regions where surface and edge effect contributions can be separated. We find that the data do not reach the expected value for the surface region. There is also evidence for a region where the term associated with edge contributions dominates.