Session 26AP

Explosive growth and collapse of helium 4 crystals **26AP2**

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We have shown that high intensity ultrasound waves can be used to study the nucleation of solid He4 far above its melting pressure $\mathrm{P_m}$. In such conditions, micro-crystals grow and melt at velocities close to the sound velocity. We have found evidence for the generation of shock waves by the crystal collapse, and studied their frequency as a function of crystal size. We also observed that the life time of these crystals is rather short and we consider the various physical mechanisms which may control their dynamics.

Thermodynamics of metastable superfluid helium **26AP3**

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Using Landau's approach of elementary excitations, we calculate thermodynamical properties of superfluid helium 4 at negative pressure. The dispersion curve for the excitations is obtained from the density functional theory by Dalfovo *et al.* [Phys. Rev. B, **52**, 1193 (1995)]. Interactions between excitations are accounted for in the frame of the roton liquid theory. We also consider the liquid above its solidification pressure, and discuss the hypothesis of a softening of the roton mode, which would give raise to spontaneous appearance of spatial order in the liquid.

26AP4 Visualization of ^{3}He Nucleate Boiling

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Boiling behavior of liquid ^{3}He was visualized as shadowgraph image between 0.5K and 2K. A light source and video camera were arranged at room temperature. The light was guided to the ^{3}He cell by an optical fiber, and the shadowgraph image was transferred to the camera by an image fiber. The ^{3}He bubble shape on the heated copper surface was hemispherical reflecting the excellent wetting property. The size at departure from the surface and the bubble growh rate were measured as functions of heat flux and temperature.

26AP5 Homogeneous Nucleation in Phase Separation of Solid ^{3}He-^{4}He Mixtures

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NMR and pressure have been measured during phase-separation in solid ^{3}He-^{4}He mixtures. Spin-echoes were used to observe bounded diffusion and to estimate the diffusion coefficient, size and nuclei concentration in the ^{3}He-enriched phase. The characteristic phase separation time constant of the mixture was found from pressure measurements. The results argue convincingly for homogeneous nucleation. The surface tension of the nuclei is found independently from NMR and from pressure measurements; the two determinations agree well and yield a surface tension coefficient of 4.9×10^{-6}J m^{-2}.

26AP6 Observation of Heterogeneous-Homogeneous Nucleation Transition with Increasing Supercooling Degree of Phase-separated ^{3}He - ^{4}He Mixtures

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The phase-separated solid ^{3}He - ^{4}He mixtures are studied at temperatures 100-200 mK under pressure of 33-34 bar. The measurements display a drastic change in the decay rate within a narrow supercooling degree range. The comparison of the experimental data with a theory taking the finiteness of cooling rate into account makes it possible to estimate the principal parameter of the homogeneous nucleation theory, namely, the surface tension at the boundary of a new phase nucleus as $(5.5 \pm 1) \cdot 10^{-3}$ erg/cm^2.

Scattering of atoms from liquid helium films and slabs **26AP8**

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We have studied the scattering of ^{4}He and impurity atoms from liquid ^{4}He films and slabs. The density profile of the host liquid is computed using the optimized hypernetted–chain theory for inhomogeneous quantum liquids. Inelastic scattering is described by a complex self energy within the correlated–basis–function theory.
We have computed the probabilities of elastic and inelastic reflection, sticking and, in the case of slabs, transmission. In thicker slabs the excitation spectrum of the host liquid is approaching that of bulk liquid ^{4}He, and a detailed analysis of the decay channels gives the production rates of R^- and R^+ rotons. Finally, the atom current in each excitation gives a pictorial view of quantum evaporation. The calculations are relevant for the experiments of the Exeter group.

Transmission of helium atoms through a freely suspended slab of helium-II **26AP9**

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We describe an experiment motivated by a recent theoretical calculation of the transmission probability of ^{4}He atoms through a freely suspended slab of superfluid ^{4}He at low temperatures[1]. In our experiments the slab is realised by using an array of parallel cylindrical holes of diameter 0.05 mm in a glass disc of thickness 0.2 mm. By controlling the chemical potential, the holes can be made to fill or empty with liquid, and the surface curvature varied. We have made preliminary measurements of the transmission of atom beams, generated by a thin-film heater and detected with a sensitive bolometer, through this structure.

[1] C.E. Campbell, E. Krotscheck and M. Saarela, *J. Low Temp. Physics* (1998) **113**, 519.

Topological defects and hcp nucleation in bcc Helium **26AP10**

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We propose a new model for the nature of the nucleation of hcp from bcc Helium. The dynamic release of shear at the surface of the bcc-hcp phase boundary, sustains the simultaneous nucleation and growth of topological defects in the bcc phase. The topological defects are lines of dynamic shear in the bcc phase. The shear energy gain of this process balances the surface tension, as the growing hcp surface is quickly covered by many defect-loops. We show that this scenario gives better agreement with experiments, which differ with the classical theory of homogeneous nucleation by 6-10 orders of magnitude.

26AP11 Reflection of Second Sound Thermal Pulse Obliquely Incident on He II Free Surface

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Reflection of a thermal pulse obliquely incident on a He II surface was investigated by measuring the temperature and also with the aid of an optical visualization. Evaporation from the free surface is induced by the impingement of a thermal pulse with a pulse duration of several hundred micro seconds. However, for large incidence angles a total reflection of a thermal pulse occurs at the pulse front portion, and the situation then transfers to regular oblique evaporation within a pulse. The reflection coefficients are measured both at the moment of the total reflection and during the regular evaporation. The transient gas dynamic state in the evaporated vapor is also investigated.

26AP12 Superfluid ^{3}He A-B Surface Tension

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We have measured the surface energy associated with the interface between the A and B phases of superfluid ^{3}He. The measurements have been made below 300 μK at zero pressure and in magnetic fields up to 400 mT. Using a shaped magnetic field we control the passage of the phase boundary through a small aperture. The interface is held at the aperture by surface tension, and we obtain the inter-phase surface energy from the level of over- or under-magnetisation require to"pop" the interface through the hole. This is the first measurement of inter-phase surface energy in high magnetic fields at ultra-low temperature.

26AP13 Quantum Nucleation On a Wall

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Quantum nucleation of solid ^{4}He on a wall was discussed on a phenomenological model which describes incomplete wetting. While this model behaves as well-known thin wall nucleation model near the equilibrium point, it describes the nucleation as softening of ripplon on the adsorbed film near the critical point. As the corresponding experimental researches were done near the critical point, the nucleation rate W of the model was estimated in the the manner, which was developed by Lifshitz and Kagan, near the critical point. The result indicates the pressure dependence $\ln W \propto (P_{\rm c} - P)^{5/8}$, where $P_{\rm c}$ is a critical pressure. The assumption that the origin of metastability is the structural mismatch between the adsorbed film and the bulk leads to the value of $P_{\rm c}$ and the contact angle dependency of W.

Faceting of ^{3}He crystals **26AP14**

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We report on our optical observations on bcc ^{3}He crystals in the temperature range of 8 ... 55 mK. In a course of growing the crystals show different facets on the surface. With our interferometric technique we were able to identify at least three different types of facets, (110), (100), and (211) at temperatures up to 55 mK. Previously, only the (110) facet was observed at such high temperatures with it's roughening transition at 100 mK. Thus, our observations suggest second and third roughening transitions in ^{3}He crystals to be in the range 55 ... 100 mK, which is in contradiction with existent theoretical predictions.

Melting Rate of U2D2 Solid ^{3}He **26AP17**

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We measured the melting rate of nuclear-ordered solid ^{3}He in a low magnetic field of 0.33 T and in a temperature range of from 0.5 to 0.9 mK. The melting rate strongly depended on temperature and increased as T^{-n} when temperatures decreased, where n is approximately 5.
We evaluated the melting rate for rough surface by two models. We derived the intrinsic melting rate limited by energy dissipation due to surface scattering of magnons. The other model was the extrinsic one in which the thermal impedance of liquid and Kapitza resistance between solid and liquid boundary limited the melting rate. We concluded that the heat transport model agreed with our result of the melting rate.

The effect of substrate roughness on the T_3–dewetting of molecular hydrogen **26AP18**

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Triple-point dewetting is a well-known behaviour of molecular hydrogen and other van der Waals systems like noble gases on a solid substrate. Recent theoretical and experimental investigations (PRL **88**, 55702 (2002)) suggest that it is caused primarily by the roughness of the substrate. Strain induced due to the mismatch of the lattice constant of the substrate and the growing layers of the adsorbed materials is increased by the micro-roughness of the substrate which eventually leads to the growth of only a thin solid film of the adsorbate. The dominating role of the substrate roughness is demonstrated, e.g., by ellipsometric measurements on smooth Si surfaces (rms roughness 0.15 nm), where a much thicker solid hydrogen film than the 3 monolayers on "usual" substrates is observed. We present different ways to modify and improve the surface quality of substrates for such wetting studies of solid van der Waals films.

26AP19 Absence of critical point wetting near the ^{3}He-^{4}He tri-critical point

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We have measured the contact angle of the ^{3}He-^{4}He interface on a sapphire window near the tri-critical temperature $\mathrm{T_t}$. For this we have used an interferometric method in an optical cryostat. We have found that the contact angle does not go to zero when the temperature approaches $\mathrm{T_t}$. This surprising behavior is different from what has been generally found in the case of ordinary critical points where J. Cahn predicted the occurence of a critical point wetting transition. Our results confirm ealier MRI measurements by Ueno et al. We propose tentative interpretations for this surprising behavior.

26AP20 Nonlinear Transport of the Wigner Crystal on ^{3}He-^{4}He Liquid Mixtures

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The Wigner crystal formed on a free surface of liquid He shows a strongly nonlinear electron transport. The nonlinearity is observed both on liquid ^{4}He and ^{3}He, but the characteristics are quite different for these isotopes. For example, the threshold driving voltage at which an abrupt jump of conductivity σ_{xx} occurs on liquid ^{3}He, is more than an order of magnitude small compared to that on ^{4}He. Moreover, in the absence of magnetic field, the conductivity becomes proportional to the driving voltage only on ^{3}He.
In order to elucidate the role of underlying liquid on the Wigner crystal conductivity, we perform a series of transport measurements employing ^{3}He-^{4}He liquid mixtures. By controlling the ^{3}He concentration, one can reveal the effect of ^{3}He surface bound states and of ^{3}He quasiparticles in the bulk part of phase separated liquid. Results for various ^{3}He concentrations will be discussed.

26AP22 Nonlinear transport of ions trapped below the free surface of superfluid ^{3}He - *B*

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We have studied the driving-field dependent transport of ions trapped below the free surface of superfluid ^{3}He-*B*. For small driving-fields the velocity of ions is a linear function of the field. At high electric fields the velocity is observed to be a nonlinear function of the field. The onset velocity of the nonlinearity is consistent in magnitude with the Landau critical velocity. This implies that the nonlinear behavior is caused by the pair-breaking effect of the moving ions.

Ion mobility near a free surface of superfluid BW state **26AP23**

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Recently, mobility of ions located near the free surface of superfluid ^{3}He was measured by RIKEN group. (T. Shiino et al., J. Low Temp. Phys. 126, 493 (2002)) In anisotropic superfluids, the profile of the order parameter changes near the surface and the surface bound states exist below the gap energy $\Delta_{\rm bulk}$. We discuss such surface effects on the ion mobility near the surface.

First Observation and Mobility Measurements of Negative Ions in Superfluid ^{4}He **26AP24**

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We present the results of mobility measurements in superfluid He studied for negative ions of different elements for the first time. Different negative ions like F^-, Cl^- and I^- were produced by laser ablation from targets consisting of NaCl, NaF, NaI, LiF, NaF and KCl immersed in a He bath. In addition to halegonide ions ablated from salts we have studied the mobility of the negative metallic ions Ba- and Ga- implanted into superfluid He.
Besides single drift time measurements at a fixed temperature the temperature dependence of the ions mobility has been investigated in a temperature range where the interaction with rotons is dominant.

Electrons in liquid channels. Comparison with two-dimensional electron system **26AP25**

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A system of channels filled with superfluid helium was used for realization of the quasi-one-dimensional electron system. Studies on properties of the present system were carried out in the wide temperature T =0.5-2K and magnetic field B =0-2.5T regions. The measured dependence of magnetoresistance on the magnetic field showed a significant declination from the earlier both experimental and theoretical results obtained for the two-dimensional system of the surface electrons. Studies on electron behaviour at the zero magnetic field revealed a significant mobility dependence on the carrier density. Experiments carried out with several concentrations showed the mobility decrease with the rise of the carrier density.

26AP26 Quasi-one-dimensional surface electron transport over liquid helium film

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The mobility of quasi-one-dimensional surface electrons on a suspended liquid helium film is studied. The conducting channel has been created by geometrical or electrostatic means. The electron mobility along the channel is calculated considering the processes of scattering by helium atoms, ripplons, and surface defects of the film substrate both in the one-electron approximation and in complete-control regime which takes into account the effect of interelectron collisions on the distribution function. We show that the electron mobility in the low-temperature regime is dominated by the defect scattering and is essentially different from the temperature dependence in the case of the ripplon scattering.

26AP27 Edgemagnetoplasmons in a partially screened electron gas

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We present measurements on the resonant frequencies ω and linewidths of edgemagnetoplasmons in an electron gas supported by a helium surface as a function of magnetic field to test theoretical predictions. Our data are taken in small and intermediate fields. The frequencies are in agreement with Fetter's theory when a sufficient number of terms are used in an expansion and in agreement with the theory of Volkov and Mikhailov in their limits $\omega/\omega_c \ll 1$ and $\omega/\omega_c \gg 1$. The magnetic field and temperature dependence of the linewidths are in qualitative agreement with theory, but disagree in magnitude. The temperature dependence differs from measurements taken by other workers in the high field and over damped limits.

26AP28 A Realistic Model of Spin-Transport in dilute ^{3}He in ^{4}He in a Finite Geometry

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We have investigated the spin-motion of spin-polarised solutions of Fermi-liquid ^{3}He in ^{4}He below 100mK. The linearised version of the equation of motion is solved for a finite cylindrical geometry with fully spin-reflecting boundary conditions, and is used to model an actual NMR spin-echo experiment. We include non-linear gradients as well as the applied, linear gradient and we have also incorporated the effect of finite-amplitude NMR excitation pulses. We find that the boundaries cause marked deviation from the analytical expressions previously used for data analysis. The non-linear gradient causes spin-echoes to be delayed and it is noted that the finite amplitude pulses also have a significant effect on the appearance and timing of spin-echoes. Previous values for the 'anisotropy temperature' in the spin-polarised Fermi-liquid, derived experimentally from spin-echoes, are shown to be overestimates.

Thermal conductivity measurements of polarized liquid He-3 **26AP29**

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We present preliminary measurements of the thermal conductivity of spin-polarized normal liquid He-3 Our experimental apparatus allows good thermal homogeneity of the He-3 as well as high sensitivity to the He-3 conductivity. Initial measurements show the conductivity at 60 mK and 27 bar changes by $<$10% for polarizations up to 70%.

Spin Diffusion in ^{3}He-^{4}He Mixtures with $x_3 \approx 3.8\%$ **26AP30**

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We report measurements of the transverse and longitudinal spin diffusion coefficients $D_\perp, D_\parallel$ for ^{3}He-^{4}He mixtures with ^{3}He concentration $x_3 \approx 3.8\%$ in a magnetic field $B = 14.8$ T. At this special value of x_3 the spin-wave dispersion coefficient $\mu M/D_\perp$ vanishes, permitting a direct measurement of $D_\perp$ without large corrections due to the Leggett-Rice effect. We find $D_\perp \propto 1/(T^2 + T_a^2)$, with an anisotropy temperature $T_a = 4.0 \pm 0.5$ mK. This value for T_a is smaller than expected from extrapolations of earlier experimental results at lower B/T or $x_3 \neq 3.8\%$, but it agrees with the dilute-solution result for this magnetic field. Conversely, $D_\parallel \propto 1/T^2$ down to lower temperatures than $D_\perp$. We observe deviation of $D_\parallel$ from this law at the lowest temperatures, which we attribute to "spin heating" due to irreversible spin diffusion.

Anomalous spin echoes in highly polarised liquid helium mixtures **26AP31**

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NMR experiments are performed on laser polarised liquid helium mixtures in low field (2mT) above 1K. Concentrations range from 0.5% to 10% and nuclear polarisations up to 0.1. For large magnetisations, following a 90°-τ-180° RF pulse pair the spin echo signal detected at time 2τ is significantly smaller than expected from attenuation due to diffusion in the applied static field gradient. Unexpected echoes are also observed at times 3τ, 4τ, 5τ... The first feature may be related to other effects of large dipolar fields in bulk samples (dynamic instabilities, altered transverse decay[1]). Numerical simulations on lattices have been performed in an attempt to quantitatively interpret all spin echo results.

[1] P.-J. Nacher et al, J. Low Temp. Phys. 126 (2002) 145.

26AP32 Spin Polarization of Xenon Films at Low Temperature Induced by ^{3}He

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We report NMR measurements on thin xenon films plated onto a silica-gel substrate and immersed in liquid ^{3}He under high field, low-temperature conditions. The motivation for these experiments is to explore the possibility of preparing hyperpolarized xenon via a brute-force polarization technique. We have observed the ^{129}Xe NMR resonance and measured the spin-lattice relaxation time T_1 for various conditions of cell filling (vacuum, pure ^{3}He, and ^{3}He-^{4}He mixtures). With the cell filled with pure ^{3}He, we find $T_1 \approx 2000$ s at $T = 50$ mK in an 8 T magnetic field. This value agrees well with an estimate of T_1 due to quantum tunneling in the ^{3}He layers in contact with the xenon film.

26AP33 Anomalous Magnetic-Field Dependence of Positive Ion Mobility in Superfluid ^{3}He

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Magnetic field dependence of positive ion mobility in liquid ^{3}He has been studied for the superfluid A_1 and A_2 phases. It exhibits an anomalous behavior, which is sensitive to the liquid pressure especially above 20 bar. The behavior is similar to that observed recently in the normal phase at 3.2 mK. This fact indicates that there exists a similar magnetic scattering mechanism between the positive ion and the ^{3}He quasiparticles in the superfluid phase.

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26AP34 Pressure and Temperature Dependence of Positive Ion Mobility in Superfluid ^{3}He-A_1 and A_2

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The positive ion mobility (μ) in superfluid ^{3}He has been measured as a function of temperature under high magnetic fields up to 15 T at several pressures. It exhbits a steep increase at both transition temperatures T_{A_1} and T_{A_2}. The inversed mobility normalized at T_{A_1} (=$\mu(T_{A_1})/\mu$(T)) is found to follow a field independent universal curve as a function of T/T_{A_1} in the A_1 phase and as a function of T/T_c in the A_2 phase. Here T_c is a zero field transition temperature. The observed behavior and the effect of the pressure is discussed in a so called "two-fluid model".

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Influence of Spin State in Positive Ion Motion in Fermi-Liquid **26AP35**

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Experimental study of ion motion in a degenerate Fermi liquid has shown that the mobility of positive ions has a weak temperature dependence $\mu = A - B * log(T)$, whereas the mobility of negative ions is temperature independent. The mobility of positive ions impure by ^{4}He lays in a middle - the μ(T) is more weak than in pure ^{3}He. The mobility of negative ions is field independent, whereas the μ(T) of positive ions rises at low magnetic fields and reduces as large applied fields are applied. All these effects indicate the important role of spin interactions on ion motion in a Fermi liquid. In this work we discuss the change in polarization of Fermi liquid and solid ion cover.

Vortex Nucleation by Negative Ion in Superfluid He^4 **26AP36**

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In superfluid He^4, moving ions nucleate vortex loops by quantum tunneling through the barrier for $T < 0.3$ K, while thermal phonons activate the system over the barrier at higher temperature[1]. The energy barrier height and the nucleation rate are calculated numerically. These are well fitted with the experimental data for low pressures $P < 16$ bar and low electric fields $E < 10^5$ V/m.

[1] P.C.Hendry,N.S.Lawson,P.V.E.McClintock,C.D.H.Williams and R.M.Bowley,*Phil.Trans.Roy.Soc(Lond)* A **332**,387(1990)

Cold Electron Attachment to Atomic Hydrogen on Liquid Helium Surface **26AP37**

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Surface state electrons (SSE) on liquid helium is applied to cold electron-atom/molecule collision experiment. In a two-dimensional mixture of SSE and adsorbed atomic hydrogen below 1 K, we found a chemical reaction reduces the SSE density. From the SSE density decay kinetics measurement, we found that the reaction is expressed as H + H + $e^- \rightarrow H^-$ + H. As a possible explanation, we propose a dissociative attachment mechanism to a highly rovibrationally excited hydrogen molecule which is an early product of atomic hydrogen recombination.

26AP38 First experimental observation of propagative oscillation modes of a helium-4 contact line.

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A helium-4 meniscus with finite contact angle and no contact-angle hysteresis on a solid substrate can be obtained thanks to pseudo-dewetting. Such a system offers a unique opportunity to study the dynamics of the oscillations modes of a meniscus in absence of viscous dissipation: we can generate localized distortions and analyze their propagation. We find that pulses do propagate along the contact line according to a dispersive relation which is in good agreement with theoretical predictions.