Session 21EP

The Role of BCS Coherence Factors and Meissner Screening in Transverse Phonon Scattering Near the Superconducting Transition in Aluminium. **21EP1**

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The theory for scattering of transversely polarised phonons, where BCS coherence factors are a dominant feature very near T_c, was examined. The theory was tested in a study of the attenuation of transverse ultrasound in the 150-300 MHz range near the superconducting transition in aluminium where a precipitous drop was observed over a few millikelvin just below T_c. This phenomenon was studied with sub-millikelvin resolution. Contrary to NMR relaxation, excellent agreement with BCS theory was found .

Modulation of I-V Curves of Nb Single and Double Junctions by 2D Scan of Magnetic Field **21EP2**

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Josephson current of superconducting junction can be modulated by an external magnetic field. From this modulation pattern of the Josephson current, uniformity of the tunnel barrier can be confirmed. The modulation of the Josephson current Ic of the superconducting junctions is usually observed by one-dimensional scan of the applied magnetic field. In this paper, using two pairs of the Helmholz coils, the external magnetic field H is scanned in two dimensions and the two-dimensional surfaces of the Ic-H dependence are first measured. In this research, we measure the modulation of the DC Josephson currents of Nb/AlOx/Nb junctions and Nb/AlOx/Nb/AlOx/Nb junctions by two dimensional scan of the external magnetic field.

21EP3 Electrical properties of a quasi-one-dimensional Nb_3Te_4 inserted with Indium

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The electrical resistivity of Nb_3Te_4 inserted with indium were measured in the temperature range from 0.5 to 300K. The superconducting transition temperature is enhanced from 1.8 to 3.3K by addition of In. The coherence lengths parallel to the c axis increase with increasing In concentration. We discuss the superconducting property of $In_XNb_3Te_4$.

21EP4 Anisotropic Electronic Structure and Orbital Analysis of Borocarbides

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The anisotropy of the Fermi velocities and the orbital character of various parts of the Fermi surface of rare earth (*R*) transition metal RT_2B_2C (*T*=Ni,Pd,Pt,..) are investigated by full potential relativistic band structure calculations. Their relationship to the anisotropy of the upper critical field and the coexistence of magnetism and superconductivity is discussed in the framework of multiband Eliashberg theory. Consequences for the puzzles of the T_c vs. density of states relation and the boron isotope effect are considered.

21EP5 Anomaly of Quasi-Particle Density of States in the Vortex State of $\mathbf{NbSe_2}$

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Magnetic field H dependence of the electronic specific heat coefficient γ was measured in various $NbSe_2$ crystals. In the sample with residual resistivity ratio of 100, $\gamma(H)$ is proportional to $\sqrt{H}$. This is quite different from conventional $\gamma \propto H$ behavior and rather similar to $\gamma(H)$ of superconductors with gap nodes, while the superconducting gap in $NbSe_2$ does not have nodes. From measurements on the sample containing columnar defects, we found that the γ anomaly is brought by quasi particles (QP's) outside of vortex cores. This result suggests that excess QP's are generated by Doppler energy shift caused by supercurrent around vortices. In $NbSe_2$, Doppler energy shift may exceed the non-zero minimum superconducting gap because of the anisotropy in the Fermi velocity and/or the superconducting gap.

Electronic State of $NbSe_2$ investigated by STM/STS **21EP6**

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Scannning tunneling microscopy/spectroscopy (STM/STS) and resistivity measurements were performed on $NbSe_2$ single crystals in which superconductivity and charge-density wave (CDW) coexist. We found a close correlation between residual resistivity ratio (RRR) and the resistive anomaly at the CDW transition, namely, RRR increases if the resistive anomaly becomes clearer. Topographic images at 4.5 K show 3×3 CDW superposed on atomic corrugations. Number of CDW domain boundary increases with decreasing RRR, while the CDW image and the tunneling spectrum within each domain are almost independent of RRR. These results suggest that CDW domain boundary works as carrier scatterer.

Superconducting Droplets: Nonlocal Conductance, Ballistic Effects and Re-entrant Superconductivity in Mesoscopic Amorphous Superconductors near the Critical Field **21EP7**

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We have studied magnetoresistance of short amorphous MoGe wires with all sizes down to $50\ nm$. Close to the superconducting transition, we have found multiple re-entries of the zero-resistance state over extended field intervals. This re-entrant behaviour is accompanied by striking long-range nonlocal effects, which provide direct evidence for the existence of a mixed state near the critical field, comprising normal and superconducting regions. We explain the results by the presence of submicron superconducting droplets, which are induced by quantum electron interference inside a disordered normal-metal matrix.

Transport Critical Current in Superconductor/Ferromagnet Trilayered films **21EP8**

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We have measured the critical current density, Jc, in rf-sputtered Nb/Co trilayered films, varying the superconducting Nb thickness and the orientation of applied fields. In contrast to the usual low-field dependence of Jc in conventional superconductors, Jc anomalously increases and shows a maximum at a low parallel applied field, being dependent on the domain states of ferromagnetic layer in contact with the superconducting one. These results indicate that the stray field of ferromagnetic layer with in-plane magnetization strongly influences the flux pinning in the superconducting film.

21EP9 Quasi-One-Dimensional FFLO State in Nb/Ni Layered System

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Last decade superconductor/ferromagnet (S/F) layered systems were the subject of extensive studies, searching the Fulde-Ferrell and Larkin-Ovchinnikov (FFLO) like state with spatial variations of the pair amplitude. We have prepared and investigated Nb/Ni bilayers and observed a non-monotonic $T_c(d_{Ni})$ behavior with a pronounced minimum of T_c at small thickness of the Ni layer. The role of different parameters of the S/F system, which influence the FFLO-state induced oscillations of $T_c(d_{Ni})$ is discussed. This work was partially supported by INTAS grant No. 99-00585 and RFBR grant No. 00-02-16328.

21EP10 Superconducting behaviors of Copper-Germanium alloys

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We have successfully made a series of Cu_xGe_{1-x} films spanning the weakly and strongly localized regimes. Several CuGe samples with $0.7 \geq x \geq 0.4$ demonstrate superconducting properties no matter in either two or three dimensions. Transition temperature T_c is about 0.4K. Upper critical magnetic field H_{c2} has been measured in these samples confirming that they are indeed superconductors. Near the zero field T_c, H_{c2} depends linealy on temperature and increases with increasing disorder. We will present their superconducting tunneling densities of states, $H_{c2}(T)$, and superconducting fluctuated magnetoresistances at very low temperatures such as low as one tenth of their T_c. We will discuss this observation in terms of current theoretical concept for the disorder induced superconductivity in CuGe samples.

21EP11 Electrical Transport, Magnetic, and Structural Properties of the Vortex Lattice in Superconducting V_3Si

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Electrical, magnetic, and structural properties of the vortex-lattice (VL) in single crystal V_3Si were studied by transport, bulk magnetometry and small-angle neutron scattering. Studies focused near the "peak effect" in critical current density that occurs just below the upper critical field of this weak-pinning system. History effects in transport are observed at temperatures below the peak, indicating a metastable vortex array. A well-defined VL is observed at fields and temperatures up to the low-side onset of the J_c peak, with no evidence of melting. High currents drive the vortex array to a stable state approaching that of Bardeen-Stephen free flux flow. Details will be presented. Research sponsored by the U.S.D.O.E.

Spin Polarized Vacuum Tunneling from a Conventional Superconductor **21EP12**

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Here we report on scanning tunneling spectroscopy of the Zeeman split density of states of a superconductor. Single crystals and MBE grown thin films of the conventional superconductor V_3Si were studied in magnetic fields up to 10 T and between temperatures of 2.3 K and 10 K. Zero field measurements reveal an unusual asymmetry of the tunneling conductance about the Fermi energy, with tunneling enhanced for filled with respect to empty quasi-particle states. In-field measurements expose a clear Zeeman splitting, enhanced (15% at 2.3 K and 65% at 4.3 K) compared to the expected $2\mu_B$B splitting. This enhancement will be discussed in the context of Fermi liquid effects.

Vortex Matter in NbN/AlN Superconducting Multilayers **21EP13**

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The vortex matter (VM) in NbN/AlN multilayers (ML) is investigated by transport measurements in fields applied parallel and perpendicular to the layers. The upper critical field shows a crossover from two to three-dimensional (2D-3D) superconductivity in parallel fields. Similarly to HTS, the irreversibility line (IL) shifts to lower temperatures with increasing anisotropy. The resistivity of the higher anisotropy ML scales with the normal component of the field, suggesting the presence of a 2D VM above the IL. The activation energy of the less anisotropic sample scales with the number of the superconducting layers, in agreement with 3D VM. The resitivity and IV characteristic are compared with the Bose-glass theory.

Far-infrared Optical Conductivity of Nb Thin Films **21EP14**

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A new method to characterize the optical constants of thin films[1] has been applied to Nb thin films (T_c = 9 K) depositted on Si substrates to determine the far-infrared optical conductivity $\sigma(\omega)$ at ω = 20 - 100 cm^{-1} and T = 4.5 - 15K. The $\sigma(\omega)$ spectra in the normal state (T = 15K) was found to be well described by the Drude model, while that in the superconducting state (T = 4.5K) was found to agrees well with the Mattis-Bardeen theory.

[1] H.Shibata *et al.* , Jpn. J. Appl. Phys. 40, 3163 (2001).

21EP15 Investigation of Flux Pinning Effect on Patterned Niobium Superconducting Films

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Flux pinning effects on niobium thin film having two-dimensional square array of submicron holes have been studied. Arrays with a variety of hole diameter and depth were first defined into SiN-coated Si-wafer by using electron beam lithography in conjunction with reactive ion etching. The patterned films were completed by DC sputtering of niobium film over the hole arrays. M-H loops measured by SQUID magnetometer and magnetoresistance curves measured by a four-probe method were used to interpret the flux pinning force as functions of hole diameter and depth.

21EP16 Giant parametric amplification of the nonlinear response in Nb

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Giant enhancement of the nonlinear response of a single crystal of Nb placed in an additional pumping ac magnetic field has been experimentally observed. The rectified signal from Nb ($T_c = 9.15$ K) has been measured as a function of temperature, dc field, the amplitude of ac field modulation, and of the pumping level of an additional ac magnetic field. The Nb sample was excited by an amplitude modulated ac field in the presence of an additional ac field at the double modulation frequency. Application of an additional pumping ac field leads to giant parametric amplification of the rectified signal. The rectified signal is about three order magnitude higher than the amplitude of the signal without parametric pumping. The amplitude of the rectified signal is an exponential function of the pumping amplitude at low pumping level when $H < H_{c2}$. Possible physical mechanisms of the observed phenomenon will be discussed.

21EP17 Nonlocality in superconducting metals: An ultra-high precision magnetic penetration depth study

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In previous reports the temperature dependence of the penetration depth $\lambda(T)$ in Al, the classic reference of nonlocal superconductors, has been found to be in disagreement with the expected behavior from the nonlocal BCS theory. Instead, in these studies $\lambda(T)$ was close to the local BCS prediction. Here we present high-precision measurements of $\lambda(T)$ in Al, Cd, and Zn down to 30 mK, which are in excellent agreement with the prediction of the nonlocal BCS electrodynamics without using adjustable parameters.

Effect of granularity on the insulator-superconductor transition in ultrathin Bi films **21EP18**

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At the insulator-superconductor transition (IST), the localization length is much higher than the superconducting coherence length, contrary to expectation for a "homogeneous" transition. This suggests the invalidity of a purely fermionic model for the transition. We also find that the Josephson coupling energies (E_J) and the charging energies (E_c) obey the relation $E_J < E_c$. This is again contrary to expectation, for the IST in a granular or inhomogeneous, system. Hence, a purely bosonic picture of the transition is also inconsistent with our observations. We discuss the implications.

3D-2D-Like Transition Above B_{c2} in Niobium Films **21EP19**

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Isotropic superconducting Nb-films thicker than the penetration depth appear to exhibit a magnetically anisotropic structure within the magnetic field range $B_{c2} \leq B_a \leq B_{c3}$, where B_a is the applied field. The anisotropic structure of the films consists of three layers: two superconducting surface layers and normal layer in between. Upon tilting the field with respect to the film surface, the magnetic behavior of vortices existing at these fields is found to be compatible with a 3D-2D-like dimensional crossover. Surface vortices residing on each of both film surfaces are coupled at fields almost parallel to the surface (3D), and decoupled at larger angles (2D) within the surface superconductivity state.

Josephson Junction Arrays on the Basis of Superconducting PtSi Films **21EP20**

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We present low-temperature transport measurements on Josephson junction arrays fabricated on the basis of superconducting polycrystalline PtSi films of thickness 6 nm. To fabricate a two dimensional array of superconductor–normal-metal–superconductor Josephson weak links, we patterned a square lattice of holes with a period of 600 nm by means of electron lithography and subsequent plasma etching. A periodic variation of the resistance of these arrays with a period corresponding to the magnetic flux quantum per unit cell, including a secondary minimum at the half-quantum points, has been observed.

21EP21 Observation of Insulator-Superconductor transition on solid inert gas and other substrates

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Observations of the insulator-superconductor transition in amorphous ultrathin films of Bi deposited on solid xenon are presented. The resistance separatrix is found to be close to $\mathrm{h}/4\mathrm{e}^2$ and the crossover thickness close to 25 Å for all substrates. $\mathrm{I}-\mathrm{V}$ studies and Aslamazov-Larkin analyses indicate superconductivity is inhomogeneous. Screening effects are observed, with the transition temperature increasing as the relative permeability of the substrate is increased, by studying films on quartz and Ge. The resistance separatrix that defines the transition remains unaffected. These results may be qualitatively understood in terms of a percolation type model.

21EP22 Superconducting Properties of 3-Dimensional Indium Wireframe in Opal Structure

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Artificial opal is a face centered cubic package of identical silica spheres with empty interstitials, which are available for infilling with In to form ensemble of nanograins with continuous bridges connecting adjacent nanoparticles. With the decrease of the cross-section of In component from 40 to 10 nm in the metal-dielectric nanocomposite the increase of the superconducting transition temperature (up to 4.2K) and the upper critical magnetic field (up to few tens of the bulk In value) were found out. The hysteresis of entry/exit magnetic field to/from In-opal has been observed and explained, tentatively, by the peculiarity of the magnetic flux dynamics in the lattice of In grains. RFFI 02-02-17685a.

21EP23 Microscopic study of low-κ type-II superconductors

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Thermodynamics and vortex lattices of low-κ type-II superconductors are studied numerically within the Eilenberger equations of superconductivity. Below some critical value $\kappa_c(T)$ of the parameter $\kappa = \lambda/\xi$, there is a first order transition at H_{c1} (type-IIa superconductivity) as a consequence of attractive vortex-vortex interaction. For $\kappa > \kappa_c$ phase transition is of the second order (type-IIb superconductivity). Phase boundary $\kappa_c(T)$ that separates type-IIa and type-IIb superconductivity has been calculated.

Superconducting Behavior of a Square Microhole Lattice on Pb Film **21EP24**

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The square microhole lattice on a Pb film has been prepared by evaporating a type-I superconductor Pb on a copper micromesh sieve with a 16.9-μm pitch. This corresponds to a matching field H_Φ of 72.5 mG. The sample magnetization has been examined by a SQUID magnetometer under a small field regime. We observe the matching peak, the step-wise change, and the enhanced hysteresis at $H = nH_\Phi$ in the sample magnetization. A particular feature is the anomalous matching effect at T=7.23 K. The matching peak has the same polarity against the field reversal. This cannot be understood in terms of the extended Little-Parks effect. We interpret that this arises from an attractive vortex interaction between the vortices for a low-κ (~ 0.46) superconductor. The magnetization of a polarized vortex domain caused by the attractive interaction may be dominant compared to the induced superconducting diamagnetism.

Josephson effect in superconducting junctions with different types of magnetic barrier between the superconductors **21EP25**

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Microscopic theory of Josephson effect in S-MB-S junctions (S denotes bulk superconductor, MB - magnetic barrier) with different types of MB is presented. The junctions with MB created by uniformly polarized ferromagnetic metal (F) or insulator-layer and also with MB created by FNF or FIF structures (N being the normal metal, I is the insulating layer) for arbitrary mutual orientation of the exchange field in the F layers are investigated. The conditions of the realization of π type of junctions are studied. The cases of ballistic and diffusive electron transport are investigated. For ballistic case the Andreev bound states are found and conditions of their existence for arbitrary pair-breaking effect in the S electrodes are studied.

Temperature Dependence of the Upper-Critical Field of Superconducting Thin Films **21EP26**

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We have measured the upper-critical field, Bc2, of superconducting Nb-Ti thin films, varying the temperature of the films in the perpendicular magnetic field. The thicknesses of the samples were 26 nm and 35 nm, and also their critical temperatures, Tc, were 5.88 K and 6.87 K respectively. As a result of this experiment, the values of slope dBc2/dT near Tc were -3.6 T/K for 26-nm-thick film and -3.4 T/K for 35-nm-thick film; these values were about twice that of Pauli limit. Zero-temperature upper-critical fields, which were estimated by extraporating Bc2 values to absolute zero, were 10.4 T and 12.2 T for the film with a thickness of 26 nm and 35 nm respectively; these values were less than that of bulk sample. The influence of film thickness on the upper-critical field of the superconducting thin films was discussed.

21EP27 Estimation of the Josephson Critical Current of a Single Grain: Percolation Model of the Resistive Transition

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The granular HTS is treated as a S-N mixture. Experimental data are used to determine the percolation threshold f_0 (the volume fraction of superconducting grains at zero resistance) and f_p (corresponding to the appearance of the first spanning superconducting cluster). The latter consists of percolating channels, each carrying the Josephson critical current J_{weak}. We demonstrate that, knowing f_0 and f_p as well as the morphology and orientation of the grains, one can derive realistic estimates of J_{weak}. This is realized by assuming a parallel resistive combination, one resistor being the spanning superconducting cluster, the other the nonspanning network. The former is treated as a percolation problem while the later is described within the effective-medium theory.

21EP28 Critical currents of strongly disordered ultra-thin superconducting films

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Quench-condensed films of various metals are well known systems for studying the superconducting state in presence of strong disorder. Critical currents of superconducting films of *Bi* and *Sn* with sheet resistances $< 500\Omega$ were found to vary with temperature according to the relation $I_c(T) = I_c(0)(1 - (\frac{T}{T_c})^4)$. The result was found to be independent of the substrate used. The observed dependence implies a variation of the superconducting gap $\Delta(T) \sim \sqrt{1 - (\frac{T}{T_c})^4}$, near T_c. This is different from the behaviour of a BCS type gap near T_c but consistent with some existing measurements on fabricated 2-D Josephson junction arrays. The $I - V$ characterisitics of these films also show hysteresis, indicating the presence of underdamped intergrain Josephson coupling. The values of the intergrain resistances and capacitances are estimated from the ratios of the observed retrapping and critical currents.

21EP29 Magnetoresistance Sign Change in Type-II Superconductors

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Resistive characteristics of pin-free superconductors with an edge barrier are studied. A model system representing an infinitely long strip of finite width W and thickness $d \ll W$ is employed. The numerical solution of the Maxwell-London equation derived in the hydrodynamic approach makes it possible to calculate both the voltage-current characteristics and magnetoresistance (MR) $R(H)$. It is revealed that positive MR behavior($dR/dH > 0$) actual within sufficiently low current range $I < I^*$ (I^* being the crossover current), changes the sign : $dR/dH < 0$ at $I > I^*$. This is due to asymmetry of the vortex distribution generated by the external magnetic field.

Proximity Effects in Nb-Cu Samples with Ultrafine Structure **21EP30**

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We have studied a proximity effect in samples prepared at extremely different cooling rates of liquid NbCu alloys and composed of nano- (20–30 nm) or microparticles of Nb in an almost Cu matrix. The critical temperature of rapidly cooled alloys is renormalized significantly in agreement with the theory of a proximity effect in superconducting properties of ultrafine Nb particles in a normal metal. These samples demonstrate a considerable super current at an initial Nb concentration down to about 10% and the electrical resistivity retains features of a flux flow regime in an abnormally wide range of an external magnetic field starting at the thermodynamic one of Nb.

Oscillations of the superconducting critical current in Nb-Cu-Ni-Cu-Nb junctions **21EP31**

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We report on experimental studies of critical current in Nb-Cu-Ni-Cu-Nb layered structures. The thickness of ferromagnetic Ni was varied from 10Å to 90Å, whereas, the rest of the parameters of the junction were kept constant. Strong oscillations of the critical supercurrent were observed with the thickness variation of Ni. Although such behavior has been predicted theoretically for long time, to the best of our knowledge, this is the first experimental evidence of this effect. Using known microscopic parameters of Ni, we found reasonable agreement between the period of oscillations and the decay of the measured critical current, and theoretical calculations.

Vortex States at Low Temperature and Disorder in Thick a-Mo_xSi_{1-x} Films **21EP32**

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In order to study the roles of disorder on the vortex phase diagram at low temperature T, we have measured the dc and ac complex resistivities for thick amorphous Mo_xSi_{1-x} films with various normal-state resistivities. For all the films studied, we can precisely determine the vortex-glass-transition line $B_g(T)$, which persists down to low enough T up to high fields near $B_{c2}(0)$, where $B_{c2}(0)$ is an upper critical field at T = 0. The finite quantum-vortex-liquid (QVL) phase at T = 0, $B_g(0) < B < B_{c2}(0)$, is commonly observed. The relative width of the T = 0 QVL phase, $[B_{c2}(0) - B_g(0)]/B_{c2}(0)$, is wider for more disordered films. This is consistent with the notion that the QVL phase is driven by strong quantum fluctuations, which are enhanced with increasing disorder.

21EP33 Theoretical Study of Phase Transition in Type II Superconductors with Pauli Paramagnetic Effect in High Magnetic Fields

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The H-T phase diagram of bulk type II superconductors with paramagnetic pair-breaking effect is studied using the Ginzburg-Landau model with a negative quartic term [1] but beyond the mean field approximation (MFA). Although MFA predicts a first order transition at H_{c2}, the presence of this MFA transition needs to be tested theoretically by including fluctuation effects because, as is well known, the ordinary second order transition at H_{c2} in MFA is lost by the fluctuation. Results of an analytic calculation and a Monte Carlo simulation in the lowest Landau level will be reported.

[1] K. Maki, Phys. Rev. 148, 362 (1966); M. Houzet and A. Buzdin, Phys. Rev. B 63, 184521 (2001)

21EP34 Pinning Properties and AC Susceptibilities in Superconducting Pb-Bi Alloys

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The relation between the irreversibility line and the pinning mechanism has not been clarified quantitatively. However, it is difficult to control the pinning strength in high-temperature oxide superconductors. The pinning strengths of the superconducting Pb-Bi alloys can be controlled easily by varying the Bi content. The magnetic relaxation and irreversibility field were studied for superconducting Pb-Bi alloys with different pinning strength. For a detailed investigation of flux creep phenomena in some specimens, we have also observed the flux creep rates. In this paper, we will try to investigate systematically the pinning properties and the fluxoid reversible motion in superconducting Pb-Bi alloys and to clarify the relation among the large decay of critical current density, the AC susceptibilities and pinning potential.

21EP35 Anomalous Magnetoresistance below the 2D Superconductor-Insulator Transition

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We study transport properties of disordered thin (4 nm) amorphous Mo_xSi_{1-x} films. With increasing field B at zero temperature, a transition from a superconducting to insulating phase takes place at a certain field B_c. The metallic quantum-vortex-liquid phase below B_c is not observed. Instead, we observe an anomalous peak in the magnetoresistance $R(B)$ at low B. $R(B)$ starts to rise from $B = 0$ and takes a small peak with large noise; it then falls to the resistance near $R = 0$ below B_c. The peak is not observed in parallel fields, indicating that the origin is due to vortices. The peak is no longer visible in thick (100 nm) films, suggesting that two dimensionality (2D) plays a role in the appearance of the anomalous peak.

Influence of a saturated helium-II film on a constant temperature detector **21EP36**

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Superconducting transition edge bolometers are senstive, but nonlinear, energy detectors and are widely used in low-temperature experiments. This paper discusses their application as a time-resolved helium atom beam detector. Measurements show that, even when the device is operated in constant temperature mode, the saturated superfluid helium film dramatically affects the responsivity of the system. An electro-thermal model that describes the observed responsivity to atom pulses under various conditions is presented.

A Scanning SQUID Microscope for Room Temperature Samples **21EP38**

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Scanning SQUID microscope based on both niobium and HTS junction dc SQUIDs has been developed. The SQUIDs are mounted inside the insulation vacuum of a specially designed helium dewar. A sapphire window with thickness of 60μm separates the SQUIDs from the room temperate sample. The stand-off distance between SQUID and the sample can be as low as 80μm, which is adjusted by a moving mechanism. The spatial resolution of the microscope is about 100-150μm and the magnetic field sensitivity is on the order of $10p\mathrm{T}/\sqrt{Hz}$. The SQUID sensor is read out using conventional dc SQUID electronics. A computer controlled x-y stage scans the sample below the microscope. Magnetic images of magnetic storage media, ferromagnetic and paramagnetic inclusions in geological and biological samples are being studied with the microscope. Nondestructive testing of different materials are also being performed.

Noise Properties of Serial SQUID Array Amplifiers for Transition Edge Sensor **21EP39**

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We report on the noise properties of serial SQUID (Superconducting Quantum Interference Device) arrays, which consist of many DC-SQUIDs connected in series. We have developed SQUID current amplifier for TES (Transition Edge Sensor) microcalorimeter with high current resolution of 10 $\mathrm{pA}/\mathrm{Hz}^{0.5}$ and large dynamic range of 60 dB. The use of the serial SQUID arrays for the current amplifier is effective in improving the current resolution without degrading the dynamic range. We have fabricated some serial SQUID arrays changing the number of DC-SQUIDs, and measured the noise.