Session 23BP

Coexistence of Superconducting Gap and Pseudogap in Underdoped Bi2212 **23BP1**

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The pseudogap in high T_c cuprates is an established phenomenon, although its origin is not clear yet. We have carefully studied the temperature dependence of tunneling spectra in underdoped and slightly overdoped Bi2212 single crystals. The underdoped spectra clearly show a pseudogap above T_c, while this gap features get very weak in slightly overdoped crystals. Without the pseudogap depression, the states in slightly overdoped spectra are always conserved. However, underdoped spectra do not conserve states even at temperatures when the material is in its superconducting state. More interestingly, we found that the conservation of states can be recovered by normalizing the superconducting spectra with the normal state pseudogap spectra. This clearly indicates the coexistence of pseudogap and superconducting gap.

Mechanism of hole carrier generation and pseudogap nature in doped La214. **23BP2**

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The generation of hole carriers in HTS is considered in the framework of model [JETP, 91 (2000) 579]. According to this model the hole conductivity starts up at the dopant concentration exceeding the percolation threshold for chain of -U centers. The conductivity (and superconductivity) takes place in the band formed by the oxygen pπ-orbitals hybridized with the pair orbitals of -U centers. It is shown that the inclusion of two-particle hybridization results in the temperature dependences of hole carrier concentration n(T)$\propto$T and resistivity R(T)$\propto$T. As far as the mechanism of superconducting gap suppression in HTS is the occupation of pair level with electrons, the superconducting gap (pseudogap) in small nonpercolative clusters containing short chains of -U centers has to open at T above T_c because of the large relative fluctuations of the number of particles between pπ-band and pair level in small clusters.

23BP3 Fermi surface and ARPES of CuO_2 planes – violation of Luttinger's theorem?

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We employ the dynamical cluster approach to the $2D$ Hubbard model in the intermediate coupling regime. For small to intermediate doping we observe strong deviations from conventional Fermi liquid behaviour and evidence for a violation of Luttinger's theorem. Without next-nearest neighbor hopping t' the calculated Fermi surface shows a crossover to a conventional Fermi liquid at larger doping while for physically sensible values of t' there remain strong deviations from the non-interacting Fermi surface even for large doping. Our spectra and Fermi surface data compare well with recent experiments on high-T_c compounds suggesting that certain pecularities observed experimentally may indeed be traced to a violation of standard Fermi liquid relations.

23BP4 Effects of thermal fluctuations and magnetic field in the SO(5) theory

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The SO(5) symmetry is expected as the result of the competition between magnetism and superconductivity orders. According to the RG theory, however, an O(n) isotropic fixed point becomes unstable for $n > 4$ in 3D because of thermal fluctuations. We have performed Monte Carlo simulations on a classical SO(5) model, which can describe the long-wave-length behaviors of the SO(5) theory. We have found, in contrast to RG theory, that the SO(5) symmetric point is stable when biquadratic coupling between AF and SC is repulsive, which is shown to be realized in high-Tc cuprates by the Gutzwiller projection. We derive a scaling theory for the bicritical phenomena which can be used test the SO(5) theory quantitatively in experiments. Under an external magnetic field, a first-order normal state to AF phase transition is predicted near the AF-SC phase boundary, which has been confirmed in organic superconductors.

23BP5 On the Limit of T_c in C_{60}-Based Superconductors

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Ionic superconductors ($C_{60}{}^{3-}$, $C_{60}{}^{3+}$) in the field-effect transistor (FET) are tried to explain in the unified picture with alkali-doped A_3C_{60} superconductors. The simplified extended BCS-like theory is presented in success in analyzing explicitly various roles of some kinds of phonons playing on the transition temperature T_c: the phonon to make the basic mechanism of weak-coupling s-wave superconductivity, the phonon to enhance T_c, and the phonon to adjust whether assisting or preventing superconductivity. Within the present theory for phonon-mediated superconductivity, the possibility of higher T_c and the limit of T_c are predicted and discussed in comparison with experimental results reported by Schön et al.[1].

[1] J.H.Schön et al., Science 288 (2000) 656; Nature 408 (2000) 549; Science 293 (2001) 2432).

Pseudogap phenomena in the BCS pairing model **23BP6**

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Recently, the pseudogap phenomena observed in the high-T_c cuprates have attracted much interest. It has been proposed by some authors that its origin may be attributed to the superconducting fluctuation in the normal state. Here, we investigate pseudogap phenomena realized in the BCS pairing model with a long but finite interaction range. We calculate the single-particle self-energy corrections by the superconducting fluctuation in all orders exactly in the temperature range where the superconducting fluctuation is Gaussian-like. The pseudogap behavior of the density of states is obtained in the substantially wide temperature ranges in the two-dimensional case. It is found that vertex corrections to the self-energy, which are discarded in the previous studies, are crucially important for the pseudogap phenomena in higher order calculations.

Novel Metallic and Superconducting States in Doped High-T_c Cuprates **23BP7**

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The current understanding of the nature of the novel pseudogapped metallic and superconducting (SC) states in doped high-T_c cuprates is reviewed taking into account recent theoretical and experimental results obtained for underdoped, optimally doped and overdoped cuprates. We prove that the pseudogap formation and superfluid condensation phenomena can be understood properly within the continuum model of carrier self-trapping and the novel two-stage Fermi-Bose-liquid model of superconductivity. It is argued that the pseudogap phenomena is irrelevant to superconductivity. The possibility of pseudogap formation above T_c and the coexistence of two preudogaps and true SC gap below T_c as well as doping and temperature dependences of these pseudogaps and SC gap are studied. The obtained results are consistent with numerous experiments.

Variational Monte Carlo Study on the Dependence of $\varepsilon_p - \varepsilon_d$ of the Two-Dimensional d-p model **23BP8**

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The superconducting condensation energy as a function of the energy difference ($\varepsilon_p - \varepsilon_d$) between the oxygen and copper site in the two-dimensional d-p model has been estimated by use of the variational Monte Carlo method. We have found that the superconducting condensation energy increases when $\varepsilon_p - \varepsilon_d$ increases. We also have calculated the numbers of the d- (n_d) and p-holes (n_p) and compared to those estimated from the NQR/NMR experiments. The obtained phase diagram, the superconducting condensation energy, which is correlated with the superconducting critical temperature, in the d-p model seem to be considerably agreement with those of the cuprate superconductors from the view point of n_d and n_p.

23BP9 Theory of Nernst Coefficient and Magnetoresistance in High-T_c Cuprates: the Role of Superconducting Fluctuations

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The Nernst coefficien (ν) in hole-doped compounds increases drastically below the pseudo-gap temperature, T^*. Here, we study this mysterious behavior of ν in terms of the FLEX+T-matrix approximation. We analyze the role of the vertex corrections (VC's) both for the electronic current and the heat one, which are indispencable to keep the conservation laws. According to the present analysis, the abrupt increase of ν below T^* is well understood as the reflection of the enhancement of the d-wave superconducting fluctuations (SCF), because the VC's due to the SCF make the total current $\vec{J}_k$ much singular. As a result, the striking behaviors of ν as well as the magnetoresistance below T^* are naturally understood in terms of the AF and SC fluctuation scenario based on the Fermi liquid theory.

23BP10 Sb NQR study of superconducting $YbSb_2$

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We have measured ^{121}Sb and ^{123}Sb NQR spectra and nuclear spin- lattice relaxation rate $1/T_1$ both in normal and superconducting states of $YbSb_2$. $1/T_1$ in the superconducting state has coherence peak just below the transition temperature and exponential temperature dependence at lower temperatures, which indicate occurrence of the s-wave superconductivity in $YbSb_2$.

23BP11 Unusual ferromagnetic behavior in UGe_2

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We have measured high pressure ac magnetic susceptibility ($\chi_{\rm ac}$) and dc magnetization on a ferromagnetic superconductor UGe_2, especially in a pressure region at which ferromagnetism (FM) and superconductivity (SC) coexist. As the pressure (P) increases above ~ 10 kbar, at which SC sets in, a peak temperature in $\chi_{\rm ac}(T)$ corresponding to the Curie temperature begins to deviate from a characterestic temperature ($T_{\rm m}$) below which spontaneous magnetization appears. This deviation increases with P, and even above pressures at which both FM and SC disappear, $T_{\rm m}$ remains at around 40 K. In addition, FC and ZFC magnetization separate below about $T_{\rm m}$. These results seem to suggest that tiny ferromagnetic clusters are formed below $T_{\rm m}$ and they behave as superparamagnetism. Thus, we conjecture that the FM at higher pressures is inhomogeneous, which may allow the coexistence of FM and SC in UGe_2.

^{115}In-NQR study of magnetic properties of $CeIn_3$ under pressure **23BP12**

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We report the pressure(P)-temperature phase diagram of antiferromagnetism and superconductivity in $CeIn_3$ based on the ^{115}In nuclear-spin-lattice-relaxation (T_1) measurements under P. We found that the localized magnetic character is robust against the application of P up to $P \sim 1.9$ GPa, beyond which the system evolves into an itinerant regime in which the resistive superconducting phase emerges.

Magnetic order in heavy electron system $CeRh_{1-x}Ir_xIn_5$ **23BP13**

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$CeRh_{1-x}Ir_xIn_5$ is an alloy of new heavy fermion compounds $CeRhIn_5$ and $CeIrIn_5$. $CeRhIn_5$ is an antiferromagnet (T_N= 3.8K) and $CeIrIn_5$ is a superconductor (T_c= 400mK). In the range of x=0.3-0.6 coexistence of antiferromagnetic order and superconductivity was reported. We have investigated the electronic states of the x=0.35 and 0.25 samples using ^{115}In-NQR and confirmed the antiferromagnetic order in both alloys from the measurement of spectrum and spin-lattice relaxation time.

Critical magnetic fluctuations induced superconductivity and residual density of states in $CeRhIn_5$ superconductor **23BP14**

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We propose the multiband extension of the spin-fermion model to address the superconducting d-wave pairing due to magnetic interaction near critical point. By solving the unrestricted gap equation with a general d-wave symmetry gap, we find that divergent magnetic correlation length ξ leads to the very unharmonic shape of the gap function with shallow gap regions near nodes. This unharmonic gap is extremely sensitive to the small amount of disorder and we propose that we can understand the large $N_{res}(0) = \lim_{T\to 0} C_p(T)/T$ value and its pressure dependence of the recently discovered $CeRhIn_5$ superconductor under pressure within this approach.

23BP15 High-temperature superconductivity: not due to cuprate-planes.

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The superconducting compound $Sr_2YRu_{1-u}Cu_uO_6$ (for $0.05 \leq u \leq 0.15$) has two types of layers: $YRuO_4$ doped on Ru sites with Cu, and $(SrO)_2$. It superconducts in its SrO layers with an onset temperature of ≈49 K, and with an absolute critical temperature of 23 K, which coincides with the Néel temperature T_N of the fluctuating Ru moments. Near 29.3 K, spin-glass fluctuations are observed. Interestingly, the doped Cu moments spin-order at ≈86 K. The $YRuO_4$ layers are ferromagnetic in their planes, but stacked antiferromagnetically, so that there is no field in the SrO layers. The SrO superconductivity of Cu-doped Sr_2YRuO_6 is analogous to the BaO-layer superconductivity of $PrBa_2Cu_3O_7$, and suggests that all cuprates superconduct p-type in their SrO or BaO layers, or in interstitial regions. We know of no credible evidence supporting the common viewpoint that the cuprate-planes superconduct.

23BP16 Effect of Adsorbed Molecules of Phenidone and Hydroquinone on the Critical Superconducting Parameters of Ceramics Y-Ba-Cu-O

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Hydroquinone (p-dihydroxybenzene) and phenidone (1-phenyl-3-pyrazoline) react effectively with Y-Ba-Cu-O ceramics and change its critical parameters. As the results: (1) Tc increases from 89.5 to 93 K; (2) fraction of the intergranular contacts engaged in the transport critical current conductivity increases; (3) total fraction of the superconducting phase increases; (4) transport critical current density decrease by a factor of 2.5-5. We suggest that an increase in Tc is associated with formation of Cu(III) in the ceramics lattice in the reaction course, and an increase in the number of intergranular contacts is due to the surface chemical reaction resulting in modification of the superconducting granules.

23BP17 Structural Sensitivity of Superconducting Properties of Mercury-Based Copper Oxides and Other Layered Systems

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We discuss the different factors which govern the unique physical properties of the mercurocuprate family $HgBa_2Ca_{n-1}Cu_nO_{2n+2+\delta}$. The relationships between structural and superconducting properties are discussed and particular attention is paid to layered structure. The dependence of a superconducting critical temperature for different members of mercurocuprate family is analyzed in terms of workable model of layered superconductors, taking into account possible charge redistribution. This lead to observable non-monotonic "bell"-shaped dependence of $T_c(n)$ and fits the experimental data well.

Electron-doped superconductivity in (Sr,Ca)CuO2 infinite-layer thin films **23BP18**

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The infinite-layer compound (Sr,Ca)CuO2 thin films have been prepared by off-axis rf magnetron sputtering. The c-axis lattice parameters of the infinite-layer phase are contracted with increase of deposition temperature, whereas the reversed changes in the a-axis lattice parameters are observed, suggesting the incorporation of oxygen vacancies in CuO2 planes. A superconducting transition with on-set at 40-50 K was obtained for the first time, induced by the electron-doping with suitable oxygen vacancies in CuO2 planes. Further increase of doping showed to destroy superconductivity.

The influence of superconductivity on the positronium in a void **23BP19**

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At present it has been established by experiment that the high-temperature superconductivity transition exerts a noticeable influence on positron annihilation effects. These effects are mainly connected with positrons trapped by lattice defects. The lifetime of such positrons decreases discontinuously at the superconductivity transition. In the present study this phenomenon is associated with an sharp formation of the energy gap when the superconductivity state arises in HTSC. We believe that the observed effect of the influence of superconductivity on the positron lifetime arises due to formation of a positronium in microvoids. When a superconductivity energy gap is formed the filling of the positronium level is decreased. Estimation of this phenomenon in HTSC carried out on the basis of the BCS theory gives the jump of the $\Delta\tau$ $\sim$1-10ps.

Superconductivity in NCCO thin films and effect of Gd and Ni doping **23BP20**

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In order to clarify the electronic states of electron-doped cuprates superconductor, $Nd_{2-x}Ce_xCuO_{4-y}$ (NCCO), $Nd_{1.8-x}Gd_{0.2}Ce_xCuO_{4-y}$ (NGCCO) and $Nd_{2-x}Ce_xCu_{0.998}Ni_{0.002}O_{4-y}$ (NCCNO) thin films were fabricated for Ce concentration range of $0.08 \leq x \leq 0.15$ by pulsed laser deposition technique on $SrTiO_3$ (100) substrate. The superconductor-insulator transition occurs at Ce concentration of $\sim$ 0.095 for NCCO, $\sim$ 0.105 for NGCCO and $\sim$ 0.11 for NCCNO. In all compositions, T_c gradually decreases as Ce concentration decreases. The presence of the superconductivity for $x \leq 0.12$ suggests the apparent presence of underdoped region of NCCO.

23BP21 Determination of structural changes of $YBa_2Cu_3O_{6.94}$ by X-Ray diffraction

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X-ray diffraction (XRD) patterns of the samples $YBa_2Cu_3O_{6.94}$ after slow heating from 300 K to 530 K (less than 1K/hour) and annealing at 530 K during one month demonstrate the decreasing of intensity of diffraction peaks and its broadening. Peak broadening is often assumed to results from coherent scattering domain sizes, its distribution, strain and disorder. Modelling of all possible contributions to XRD profiles were carried out. Usefulness of such approach for correlation of superconducting properties to actual structure is discussed.

23BP22 Pinning Properties of Gd-Ba-Cu-O Bulk Superconductor Fabricated by Cold Seeding Method

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Gd-Ba-Cu-O bulk superconductor was fabricated by the cold seeding method. We have optimized the growth conditions that make it possible to grow a single domain. The critical current density of the central part of the bulk was lower than the other parts in a lower magnetic field. However, the secondary peak effect was more remarkable. Such results are correlated with spatial fluctuation in the volume fraction of 211 phase as evidenced by the SEM observation of microstructure.

23BP23 Capacitive and Inductive Effects in Multi-Josephson Junction Model in High T_c Superconductors

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I-V characteristics of high T_c superconductors, such as $Bi_2Sr_2CaCu_2O_8$, are well described by use of the multi-Josephson junction model. There are capacitive and inductive effects as mechanisms of inter-layer couplings. By numerical simulation, I-V characteristics are investigated, including both effects. It is shown that the inductive effect makes phase differences of layers to behave coherently, while the capacitive effect works to form a pattern of phase-rotating layers. Both effects are equally important to get systematic changes of I-V characteristics from short junctions to long ones, and their dependence on the applied magnetic field.

Inhomogeneous electronic structures in heavily Pb-doped $Bi_2Sr_2CaCu_2O_y$ single crystals probed by low temperature STM/STS **23BP24**

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We have perfomed cryogenic STM/STS of heavily Pb-doped $Bi_2Sr_2CaCu_2O_y$ single crystals to investigate the two-phase microstructures possibly responsible for the flux pinning. The obtained STM/STS results at 4.3K clearly showed local inhomogeneity of gap structure Δ (Δ=20-60 meV) in a scale of several nm, suggesting the coexistence of sperconducting and pseudogap-like regions, even in the overdoped regime. We also comfirmed an abrupt change in Δ across the phase boundaries, indicating that they could act as effective pinning centers.

Cryogenic STM/STS observations of Pb-doped $Bi_2Sr_2CuO_y$ single crystals **23BP25**

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Cleaved ab-surfaces of Pb-doped $Bi_2Sr_2CuO_y$ (Bi2201) single crystals were probed by scanning tunning tunneling microscopy/spectroscopy (STM/STS) at cryogenic temperatures below T_c. The obtained STS spectra clearly indicate a d-wave like gap structure superimposed on inverse V-shaped background, similar to previous STS observations on pure Bi2201. Furthermore, we found that the gap value 2Δ was spatially non-uniform in a nm scale and ranged from 20 to 50 meV.

STM/STS studies on $YBa_2Cu_3O_{7-\delta}$ thin films treated with an atomic oxygen beam **23BP26**

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The surface electronic states of $YBa_2Cu_3O_{7-\delta}$ (YBCO) films are studied by using scanning tunneling microscopy/spectroscopy (STM/STS) at low temperature (T>8K). In order to improve the surface quality of YBCO, an atomic oxygen beam was utilized as a cleaning technique. The spatial dependences of the work function and the energy gap were measured by STM/STS. The origin of inhomogeneity of electronic states is discussed in the relation with the surface bound states due to d-wave pair potential.

23BP27 Comparative study of the transport properties of sub-micron bicrystal and ramp junctions

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A process has been developed that makes it possible to fabricate high quality sub-micrometer wide YBCO Josephson junctions using bicrystal or ramp junction technology. Junctions fabricated using this process allowed us to make comparative studies of sub-micron bicrystal and ramp junctions. We have especially studied junctions with one or both crystal axes oriented 45 degrees with respect to the barrier.

23BP28 STM Study of Vacancy Resonances in $Bi_2Sr_2CaCu_2O_{8+\delta}$

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Low temperature scanning tunneling microscopy (STM) of various samples of the high temperature superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ consistently reveals the presence of quasi-particle scattering resonances, similar both spectroscopically and spatially to those observed around Zn atoms in Zn-doped BSCCO. As the resonances appear at energies indicative of nearly unitary scattering ($\sim$0.5 meV) and are always accompanied by topographic depression of the surface Bi atom around which they are centered, we postulate that the source of scattering may be Cu vacancies in the CuO_2 plane. Such resonances should thus provide a simpler test case for theoretical models than those created by Zn or Ni substitution.

23BP29 Photoexcited Carrier Relaxation in a-axis Oriented $YBa_2Cu_3O_{7-\delta}$ Thin Films Measured by Femtosecond Time-Resolved Spectroscopy

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The photoexcited carrier relaxation dynamics in a-axis oriented $YBa_2Cu_3O_{7-\delta}$ (YBCO) thin films has been investigated by femtosecond time-resolved spectroscopy. Distinct responses along CuO_3 chain and c-axis of YBCO have been separated by the polarization-dependent femtosecond pump-probe measurements. At superconducting state, the transient reflectivity (ΔR/R) curves in c-axis direction are similar to those at normal state. However, the ΔR/R curves along CuO_3 chain at temperature below Tc become broad and its relaxation time of carriers is longer than one above Tc. The obvious difference of carrier relaxation processes between CuO_3 chain and c-axis is discussed.

Anomalous suppression of T_c in an over doped region of $TlBa_2Ca_2Cu_3O_{9-\delta}$ 23BP30

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Anomalous suppression of T_c has been found in an over doped region of $TlBa_2Ca_2Cu_3O_{9-\delta}$ superconductors. A heavily-over doped sample ($T_c \simeq 100$ K) was synthesized under high pressure. T_c was measured with decreasing the hole carriers. A dip of T_c was found before the doping state reaches to an optimally doped one ($T_c \geq 130$ K) i.e. in an over doped one. A dip was also found in La-214 system which is explained by stripe order. The anomalous behavior of T_c is discussed in terms of reconstruction of electric structure accompanied with Tl valence change (Tl^{3+} to $Tl^{(3-\delta)+}$) or effect of inhomogeneous carrier distribution between crystallography different CuO_2 layers as well as stripe order.

Symmetry Crossover of the Superconducting Coherent Peak and the Quasiparticle Band in High T_c Superconductors 23BP31

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The carrier density dependence of the superconducting coherent peak (pair breaking peak) was investigated by Raman scattering in $YBa_2Cu_3O_y$, $La_{2-x}Sr_xCuO_4$, Bi2212, and Bi2201. The symmetry of the coherent peak changes from B_{2g} (xy) to B_{1g} $(x^2 - y^2)$ as carrier density increases. The crossover point is the 60 K phase $(y = 6.63)$ in YBCO and the optimum carrier density in LSCO and Bi2212. In Bi2201 the clear crossover is not observed, but the B_{2g} (xy) coherent peak appears only at underdoping. It suggests that the pairing symmetry changes from $d(xy)$ to $d(x^2 - y^2)$ as carrier density increases. This crossover is related to the crossover of the low energy intensity suggesting that doped carriers make a quasiparticle band around $(\pi/2, \pi/2)$ at low carrier density and move to $(\pi, 0)$ as carrier density increases.

Nonmonotonic d-wave superconducting order parameter in electron doped cuprates 23BP32

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We report Raman scattering studies on $Nd_{1.85}Ce_{0.15}CuO_4$. The data is consistent with order parameter of the d-wave symmetry. As distinguished from the convensional monotonic d-wave superconducting gap, the present results require a *nonmonotonic* d-wave form of the order parameter. We find that in contrast with hole doped cuprates for $Nd_{1.85}Ce_{0.15}CuO_4$ the positions of the gap maxima are located closer to the nodes than to the Brillouin zone boundaries. The gap enhancement in the vicinity of the Fermi surface intersections with antiferromagnetic Brillouin zone emphasizes role of antiferromagnetic fluctuations and similarity in the origin of superconductivity for electron- and hole-doped cuprates.

23BP33 Four-fold symmetry of 90K-YBCO single crystals in magnetic fields

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We have measured the angular dependence of the resistivity $\rho(\theta)$ in 90K-YBCO single crystals, where θ is the angle between the direction of a magnetic field *H* and the current *I*. The obtained $\rho(\theta)$ shows the four-fold symmetry. On the other hand, Kwok et al. had observed only the two-fold symmetry in 90K-YBCO single crystals. The origin of the difference between the symmetry of each case is still not clear; however, We speculate that it comes from the difference of anisotropy which depends on the concentration of oxygen in CuO-chains.

23BP34 Difference in Ru ionic state between Ru1212 and Ru1222 from ESR measurements

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$RuSr_2GdCu_2O_8$ (Ru1212) is expected to give a good opportunity to understand a coexistence of ferromagnetism with superconductivity. However, a detailed magnetic structure in the RuO_2 layers is still controversial. In order to investigate the electronic state of Ru ions, we performed ESR measurements using polycrystalline samples of Ru1212 and its analogous $RuSr_2(Gd_{1.4}Ce_{0.6})Cu_2O_{10}$ (Ru1222). A resonance signal which indicates a ferromagnetic correlation between the Ru ions appears below T_M = 140K (Ru1212) and 175K (Ru1222). Our most interesting finding is that the signal can clearly be separated into two components only in Ru1212. This suggests that a charge segregation of Ru^{4+} and Ru^{5+} in the RuO_2 layers occurs in Ru1212, while an ionic valence of Ru^{5+} occupies in Ru1222.

23BP35 A Raman Scattering Study of Superconductivity in MgB_2

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Measurements of the in-plane and out-of-plane electronic Raman continuum in MgB2 single crystals show markedly different behaviour below T_c, indicative of a complex gap structure. In xx and xy polarisation configurations, a sharp pair-breaking peak is seen near 100 cm^{-1} but no scattering threshold forms directly below the peak. In zz and zx polarisations, a threshold is seen at 30 cm^{-1} but no pair-breaking peak appears. The gap structure seen in the Raman spectra is consistent with, and sheds light on, results from other techniques. Explanations for the polarisation dependence of the spectra are considered. This work was supported by the New Energy and Industrial Technology Development Organization.

LiBC and related compounds under high pressure **23BP36**

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We calculated the electronic and lattice properties of MgB_2 under high pressure (hydrostatic, uniaxial, *a*, *b*-axis) in the previous studies[1,2]. The electronic and lattice properties of LiBC and related compounds (MgB_2, MgC_2) under a variety of compression conditions are calculated at present study. The lattice properties are optimized automatically by the first-principles molecular dynamics (FPMD) method. The electronic properties of LiBC and related compounds (MgB_2, MgC_2) are also calculated. We investigate the change of the band structures under high pressure.
[1] K. Kobayashi and K. Yamamoto: J. Phys. Soc. Jpn. **70** (2001) 1861.
[2] K. Kobayashi and K. Yamamoto: J. Phys. Soc. Jpn. **71** (2002) 397.

Bonding Nature and Wave Function around the Fermi Level of MgB_2-related Compounds **23BP37**

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We present first-principle molecular-orbital calculations for the 39-K superconductor MgB_2 and related diborides using the DV-Xα method. The electronic structure of a slab cluster embedded in the Madelung potential is determined self-consistently in terms of charge transfer between Mg and B. In contrast with the previous band calculation, the negative charge of B is estimated to be 0.39. Our results, which include total and B 2p partial density of states, overlap population in the neighboring B-B and Mg-B bonds and wave functions around the Fermi energy E_F consisting of B $2p_{x,y}$ orbitals in the B planes, indicate the incomplete filling of the σ orbitals in MgB_2. We discuss possible ways to achieve higher transition temperatures in non-periodic systems such as surfaces and hetero-structures based on this study.

MgB_2: superconductivity and effects of pressure **23BP38**

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The Ginzburg-Landau theory of MgB_2 has been constructed taking into account the possibilities of different bands which superconduct: both σ- and π-bands or σ-alone. Then the microscopic theory of superconducting MgB_2 is proposed based on the strongly interacting σ-electrons and non-correlated π-electrons of borons. The kinematic and Coulomb interactions between the orbitally degenerated σ-electrons provide the superconducting state with the s^* -wave symmetry. T_c has a non-monotonic dependence on the distance *r* between the centers of σ- and π-bands. MgB_2 on a bell-shaped curve T_c *(r)* is identified in the overdoped region. The superconducting density of electronic states is in a satisfactory agreement with available experimental and theoretical data. The pressure effects are discussed.

23BP39 Specific heat of inhomogeneous superconductors as applied to MgB_2

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Temperature, T, dependences of the electronic specific heat C were calculated for spatially random inhomogeneous superconductor consisting of domains with different critical temperatures. The domain sizes are considered larger than the coherence length. The assumed disorder *simultaneously* smears the anomaly at T_c and leads to the $\propto T^2$ low-T asymptotics of $C(T)$. The latter can be observed at strong enough dispersions, otherwise the validity region of the power-law asymptotics becomes unobservable. In this case the transitional $C(T)$ dependence similar but not identical to the BCS one may be observed for the lowest attainable T. The discovered features reproduce well the variety of data for MgB_2.

23BP40 Physical properties of Be doped magnesium diboride

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The intermetallic compound magnesium diboride (MgB_2) exhibits the highest superconducting transition temperature(T_c=39K) of all metallic superconductors.
We report on the electrical transport and the magnetic properties for Be doped magnesium diboride. For sample preparation of $Mg_{1-x}Be_xB_2$, powdered magnesium , boron and powdered beryllium are mixed together and the mixture is press-formed into pellets. Pelletized samples are synthesied at 1623 K under 5.5 GPa with high pressure technique. We estimated the superconducting critical current J_c from magnetization curves of flux of $Mg_{1-x}Be_xB_2$

23BP41 A Simple Preparation of Superconducting MgB2 Thin Films by Composite -Target Sputtering System

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As-grown superconducting MgB2 thin films were prepared by usual simple R.F. sputtering. A two component target comprising of many small slices of B on a Mg disk was used. The films were deposited onto polished single crystal sapphire or SrTiO3 substrates at rather low temperatures ranging from 100 oC to 110 oC. For higher substrate temperature, we could not prepare a superconducting film. Five samples on SrTiO3 (111) substrate and one on sapphire showed zero resisitivity at about 15 K and onset at about 20 K. The overall feature of the transport phenomena was very different from measured feature in the prepared MgB2 bulk sample with much grain boundaries.

Dc and microwave fluctuational conductivity of anisotropic superconductors **23BP42**

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We present measurements of the dc and microwave excess conductivity above T_c in anisotropic superconductors, including cuprates and MgB_2. When temperature raises well above T_c, both the dc and microwave (24 and 48 GHz) excess conductivities drop much faster than predicted by the well-established gaussian theory. We introduce a spectral cutoff in the calculation of the finite-frequency fluctuational conductivity in order to suppress the contribution of high-momentum modes at high temperatures.
Calculations are presented for 3D, 2D and 1D superconductors at finite frequencies as well as in dc. We find that our data are well described by the model for appropriate dimensionalities.

Dendrites flux instability in superconducting MgB_2 film **23BP43**

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We show, using magneto-optical imaging that below 10 K the flux penetration in MgB_2 films is dominated by large dendritic structures abruptly entering the film. The formation of dendrites correlates with the large noise observed in magnetization data, which reduces the apparent J_c by nearly 50%. The instability is of thermo-magnetic origin as supported by computer simulations of vortex dynamics which reproduce the dendritic flux patterns. Dendrites nucleate near the film edge where a local magnetic field exceeds a threshold value of ≈ 12 mT at 4 K. The instability can be suppressed by thermal stabilization.

Determination of critical current density in flux creep state **23BP44**

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We propose a new method to determine critical current density (jc) for a superconductor with flux creep from the real part of AC susceptibility (ACS), which facilitates the determination of temperature dependent jc in a wide range. The relationship between jc of MgB2 and temperature at different criterions were determined by means of experimental real part of ACS curves throughout 5 to 38K at different DC fields Bd. Influence of criterion Ec on jc was studied by varying amplitude (Bac) and frequency (f) of AC field, arguing that it is not proper to obtain temperature dependence of jc by measuring only the peak temperature of imaginary part of ACS.

23BP45 Evidence of Bragg glass phase in high-$T_{\rm c}$ vortex states with columnar defects

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Although the Bose glass phase in high-$T_{\rm c}$ vortex states has been intensively studied, most attention has been paid to the region with dense and strong columnar defects so far. We numerically study the complementary region with sparse and weak columnar defects, and find a new phase characterized by a triangular Bragg peak and surrounded by the Bose glass phase. This new phase correnponds to the Bragg glass phase in high-$T_{\rm c}$ vortex states with point defects, and the phase transition to the Bose glass phase is of first order. In the case with point defects, the melting temperature $T_{\rm m}$ monotonously decreases as defects increase, while in the present case $T_{\rm m}$ increases as columnar defects increase up to a certain value. This qualitative difference can be explained by "partial trap" of flux lines to columnar defects.

23BP46 Preparation, scaling behavior of activation energy, and anisotropy of Hg-1212 HTS thin films

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We have successfully prepared high-quality epitaxial $(\mathbf{Hg_{0.9}Re_{0.1}})\mathbf{Ba_2CaCu_2O_{6+\delta}}$ HTS thin films without special handling during the preparation. The resistive transition have been investigated in magnetic fields up to 6 T parallel and perpendicular to the c-axis. We have determined the scaling behavior of the effective activation energy. Under variation of the angle θ between the field direction and the c-axis of the film with high angular resolution $(\Delta\theta \approx 0.1\,^\circ)$ the anisotropic properties of the vortex state and the depinning field of epitaxially grown **Hg-1212** films have been studied.The films exhibit sharp superconducting transitions at $T_c \simeq 120$ K with $\Delta T \simeq 2$ K. Also the films exhibit critical field anisotropy with a factor 7.67 with respect to the c-axis.

23BP47 Thermal melting and order–disorder transition in high-T_c superconductors

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Using Lindemann criteria and results of collective pinning theory, we investigate thermal melting of the vortex Bragg glass and the order–disorder transition from the Bragg glass to an amorphous vortex state in three-dimensional high-T_c superconductors. Accounting for both pinning-caused and thermal fluctuations of the vortex lattice, we calculate the boundaries separating the regions of single vortex, small bundle, and large bundle pinning in the temperature–magnetic field plane. This enables us to clarify how the melting line and the order–disorder line merge: For weak pinning these lines cross, with the melting line continuing above the crossing point, but for large quenched disorder in the vortex lattice it is quite possible that these two lines transform gradually into each other, forming one single transition line.

Magnetic Relaxation in Y-Ba-Cu-O Thin Films **23BP48**

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Distribution of a local field $B(x)$ on the surface of YBCO thin films in the mixed state and its time dependence is measured using a micro Hall-probe array. Analizing these data based on the flux diffusion equation, the model-independent activation energy U is obtained. Since the local current density J is defind to reproduce the field profile $B(x)$, $U(B, J)$ can be plotted in a 3-dimensional space. This 3-dimensional mapping gives us information on U as a function of B and J.

Microwave-Induced Zero-Current Crossings in $Bi_2Sr_2CaCu_2O_{8+y}$ Intrinsic Josephson Junctions **23BP49**

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Current-voltage characteristics in mesa-structured $Bi_2Sr_2CaCu_2O_{8+y}$ intrinsic junctions under in-plane magnetic fields reveal zero-current crossings (ZCCs) when microwave is applied. From measurements with controlled number of junctions ($N = 5 \sim 14$), we find that the number of ZCCs is just N in total of positive and negative bias sides; half of the $2N$ branches reported without microwave. Unlike Shapiro steps, the voltage step increases with microwave amplitude. Such features can be explained by considering the charging effect of superconducting layers and the pinning of triangular Josephson vortex lattice.

Interlayer Josephson Coupling for a Gas of Pancake Vortices **23BP50**

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The dependence of the Josephson interlayer coupling in layered superconductors on the magnetic field H is studied numerically in the limit of complete disorder of the positions of pancake vortices (pancake gas). The case is considered where the Josephson length essentially exceeds the intervortex distance (high magnetic field). We find that the spatial average $\langle \cos \varphi(\vec{r}) \rangle$ is proportional to $1/H^{1/2}$, where φ is the gauge-invariant phase difference between two layers. From the theory which interprets the magnetoabsorption resonances observed in layered superconductors as Josephson-plasma resonance, the experiment requires that $\langle \cos \varphi(\vec{r}) \rangle$ should be proportional to $1/H^{\alpha}$ with α between 0.7 and 1. The implication of our result for the interpretation of the magnetoabsorption resonances is discussed.

23BP51 Order parameter and pseudogap in electron doped high-temperature superconductors

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Recently, renewed interest in electron-doped high-temperature superconductors (HTS) has arisen from the question whether the phase diagram is symmetric with respect to electron/hole doping. The presently contradictory experimental status in favor of d- or s-wave symmetry of the superconducting order parameter for electron doped HTS is discussed. There are only few experimental reports on the pseudogap behavior of electron doped HTS. Here, we report on the observation of two different kinds of a normal state pseudogap in the electron doped HTS $La_{2-x}Ce_xCuO_4$ and $Pr_{2-x}Ce_xCuO_4$, one on the scale of the superconducting gap energy Δ, and one on the scale of the magnetic interaction energy J. Both gaps decrease resp. vanish with increased doping.

23BP52 3D Fermi-liquid ground state in a quasi-1D cuprate

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Interchain magnetotransport measurements have been performed on the quasi-1D cuprate $PrBa_2Cu_4O_8$ (Pr124). A T^2 resistivity in all three crystallographic directions and a large transverse magnetoresistance are observed at low T. Crossovers to states of reduced dimensionality are seen in both directions perpendicular to the CuO chains as field and temperature are increased, from which we are able to estimate the transfer integrals in Pr124 as $t_b^2 : t_a^2 : t_c^2 = 2500 : 2 : 1$. The results provide compelling evidence for a Fermi liquid ground state in the quarter-filled CuO chains in Pr124.

23BP53 Magnetic excitations investigated by ultrashort pulse excitation in high-Tc superconductors

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We have investigated the relaxation of elementary excitations in underdoped Bi2212 by ultrafast Raman spectroscopy. In x'y' symmetry, a broad feature has been observed around 2500 cm^{-1} in the Stokes side and assigned to B_{1g} two - magnon peak. In investigating the power dependence of the broad feature, we observed a super-linear behavior in B_{1g} symmetry, which is ascribed to the excess magnon population generated through the non-radiative relaxation across the CT gap. We observed a fast relaxation component around 0.4 ps and a long life time component greater than 20 ps for the B1g two-magnon peak.

Normal state resistivity of BSCCO single crystals: description with a two-barreers model **23BP54**

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We present multiterminal measurements of the resistivity tensor of BiSrCaCuO single crystal at various oxygen doping level d, ranging from under- (d=0.22) to slightly over-doped (d=0.27). Data are analized in term of a model which assumes two simultaneously present mechanisms for the out-of-plane conduction, markedly thermal activation and incoherent tunneling. Within this model we are able to describe data of normal state resistivity for all samples. Analysis of the parameters involved in the model is also presented.

c-axis YBCO: mid-infrared ab-plane response as a function of doping and temperature determined by attenuated total reflection **23BP55**

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The mid-infrared optical response of c-axis thin films of YBCO has been studied at a wavelength of 3.392microns using Otto-configuration attenuated total reflectance. The results are that the imaginary part of the dielectric function is temperature independent while the absolute value of the real part shows a moderate decrease with increasing temperature. A stronger dependence on doping is found and critical comparison is made with infrared normal reflectance data. In a generalised Drude analysis the scattering rate decreases with temperature and increases with decreased doping; this supports the notion of stronger coupling in the underdoped regime.

Ni Impurity Spin Fluctuations in $YBa_2(Cu_{1-x}Ni_x)_4O_8$ and $YBa_2(Cu_{1-x}Ni_x)_3O_{6.95}$ via Cu NQR **23BP56**

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We report a Cu NQR study of Ni impurity spin fluctuations in high T_c cuprate superconductors, $YBa_2(Cu_{1-x}Ni_x)_4O_8$ and $YBa_2(Cu_{1-x}Ni_x)_3O_{6.95}$, from measurement of Ni-induced Cu nuclear spin-lattice relaxation times. We found that the temperature dependence of the Ni spin correlation time is different from that of Kondo impurity in a conventional metal. e.g. Mn or Fe in Cu. Discussion will be made from viewpoints of an underscreening Kondo effect or an impurity in pseudo spin-gap state. This work was supported by New Energy and Industrial Technology Development Organization (NEDO).

23BP57 Phase fluctuation in pseudogap state of underdoped BSCCO thin film

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In oder to investigate the fluctuating state above T_C in underdoped BSCCO, a combine study by means of time-resolved pump-probe transmissivity measurement using femtosecond optiocal pulses and time-domain terahertz transmission spectroscopy have been carried out. Both experimental data showed the pseudogap opening below $\sim$210K, and can well explain a localized domain picture in which localized coherent domains with a pseudogap fluctuate with a lifetime shorter than 1ps and have an important role for the realization of macroscopic superconductivity state.

23BP58 Defects-Induced Thermal Instability in YBCO Films in Microwave Field

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The heat instability induced by linear defects is assumed to enhance the remarkable difference between microwave properties of YBCO single crystals and thin films due to extended strain fields near out-of-plane edge dislocations. We have shown that a single dislocation can not have a strong effect on R_s, but dislocation arrays, which were observed experimentally, can induce the thermal instability, if edge dislocations in the arrays are spaced closer than the heat relaxation length. Ordered dislocation structures provide much higher local temperature perturbation than randomly distributed dislocations.

23BP59 Specific Heat, Magnetic Susceptibility and Resistivity Of In-Doped $Sn_{0.8}Pb_{0.2}Te$

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We report experimental results on In-doped $Sn_{0.8}Pb_{0.2}Te$ solid solutions which are semiconductors with superconducting properties. We carried out simultaneous magnetic susceptibility and resistivity (four points) measurements from room temperature down to 1.5 K, as well as specific heat below 4.2 K, on poly-crystalline samples. All measurements indicate same critical temperature region, above which the specific heat exhibits a T^3 behavior, with $\theta_D = 80$K consistent with that of the constituent elements. Application of a magnetic field ($\sim$ 1 kG) lowers the temperature at which the specific heat anomaly occurs. The results suggest that the transition occurs in the bulk and is enhanced by the In impurities, even at high concentrations. This is understood to support the resonance scattering mechanism.

First finding of reentrant superconductivity driven by hyperfine interaction **23BP60**

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Compared to magnetically doped superconductors described by the theory of Abrikosov and Gorkov, electronic singlet ground state systems can have a much larger critical concentration of magnetic impurities, following the model of Keller and Fulde. The recent study of the superconducting Van Vleck paramagnet $La_{1-x}Pr_xTe$ revealed a critical Pr^{3+} concentration x close above 0.50. Surprisingly, in $La_{0.50}Pr_{0.50}Te$ the superconducting state with T_c = 0.20 K appeares not to be stable down to zero temperature. Instead, a reentrant transition to the normal state likely caused by the hyperfine enhanced magnetic moments of the ^{141}Pr nuclei occurs at about 0.02 K. Although these moments are not in a magnetically ordered ground state at T = 0.02 K, their contribution to Cooper pair breaking seems to be even stronger than of ferromagnetically ordered but non enhanced nuclear moments in type-I superconducting $AuIn_2$.

Nonlinear Conductivity in the Slightly Hole-Doped $Sr_{14-x}Ca_xCu_{24}O_{41}$ Ladder Compounds **23BP61**

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The slightly hole-doped spin-ladder compound $Sr_{14-x}Ca_xCu_{24}O_{41}$ has attracted much attention because a formation of some density wave state was suggested by the observation of the collective mode resonance in the microwave region. We studied the nonlinear dc conductivity along both the ladder and the rung directions, as a function of electric field. For $Sr_{14}Cu_{24}O_{41}$, we observed a definite nonlinearity even at a low electric field in the ladder direction, similar to observations in the sliding density wave state. Systematic studies with Ca substituted compounds suggest that the observed collective mode is easily destroyed with increasing amount of holes on the ladders, which may be characteristic of this new collective mode.

Single energy scale for magnetism and superconductivity in the HTSC $Ca_xLa_{1-x}Ba_{1.75-x}La_{0.25+x}Cu_3O_y$. **23BP62**

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The pairing mechanism in HTSC is believed to be due to magnetic interactions. Therefore, the critical temperature of superconductivity T_c, and of magnetic freezing T_g, in the superconducting state, should be intimately related. We show that this is indeed the case in $(Ca_xLa_{1-x})Ba(_{1.75-x}La_{0.25+x})Cu_3O_y$ where we determine T_g for various values of x and y using μSR. Both $T_c(x,y)$ and $T_g(x,y)$ collapses into a universal curve by making the coordinate transformation $T_c \rightarrow T_c/T_c^{\max}(x)$, and $y \rightarrow K(x)\Delta y$, where Δy is chemical doping measured from optimum, and K is a scaling parameter which relates chemical to charge doping. This indicates that a single energy scale controls both magnetic and superconducting transitions.

23BP63 Fast time-resolved measurements of c-axis quasiparticle conductivity in intrinsic Josephson junctions of 2212-BSCCO

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We present time-resolved four-point VI-characteristic measurements on 2212-BSCCO mesa structures, using a wide-band cryogenic amplifier measurement system. The measurements demonstrate the importance of self-heating on 50 ns time scales. Such heating is likely to have been very significant in many previously published measurements, where the reported nonlinear VI characteristics have been used to derive superconducting energy gaps. Our technique also allows us to investigate the relative importance of simple heating and nonequilibrium effects.

23BP64 Critical current of Na doped YBa2Cu3O7-y

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Na-doped sample YBa1.9Na0.1Cu3Oy +40molYBa2Cu3Oy (YBCO) were fabricated by the Melt-Textured Growth (MTG) method to study the effect of Na ion on critical current density of YBCO. The field and temperature dependence of critical current density,effective pinning energy U(T,Hdc,J) and irreversibility line Hirr(T) were determined by measurements of ac susceptibility (acs) for the samples. It is found that the doping Na ion plays a negative rule on flux pinning effect in YBCO sample. We argue that the appearance of the second peak in jc(Hdc) relation and the enhancement of anisotropy in the Na doped sample reported elsewhere is a further support to our conclusion.

23BP65 Stripes and superconductivity in the HTSC copper oxides

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Structural anomalies, at $T_2 \sim 240$K and $T_1 \sim 160$K, have been investigated for HTSC copper oxides by X-ray and neutron powder diffraction study. T_2 anomaly is attributed to formation of the stripe structure. T_1 anomaly is attributed to relaxation process during exchange of the electric charge between (Ba/Sr)0-layer and CuO_2-planes in the materials. The measurements of the ultrasonic sound attenuation at T_1 and T_2 confirm this conclusion.

Field- and Temperature-Dependent Magnetic Hysteresis in GBCO Ceramics **23BP66**

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Magnetic hysteresis measurements have been performed in GBCO ceramics, and effects of magnetic field, temperature and substitution were investigated. The hysteresis ΔM has been found to obey thermal activation type: $\Delta M \propto \exp[-T/T_0]$. The activation temperature T_0 varied around 20 K, which seemed to depend on the magnetic field as $H^{-1/n}$. Substitution tended to increase ΔM. These results have been examined in relation to flux pinning models along with the critical current densities.

Field Penetration and the Effect of Prehistory on the HTSC Demagnetization **23BP67**

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For correct investigating of the characteristics of HTSC critical state with large demagnetization, high bound barrier and volume pinning the technique of selective study of demagnetization, volume and bound pinning is developed. It is based on the sample volume scanning by external field with sample thickness changing. In YBaCuO and BiSrCaCuO monocrystal and polycrystal HTSC using Hall transducer(moving it along sample radius and axis) we found out the distinction in effect of demagnetization, bound barrier and volume pinning on processes of field penetration and distributing and on magnetic flux trapping. It was found that the effective demagnetization coefficient N passes the maximum when trapped magnetic field (TMF) increases. It was shown that if sample thickness is decreased TMF effect on the N is enlarged. Empirical model describing of TMF effect on N is developed.

Millimeter Wave and Microwave Electrodynamic Spectroscopy of $YBa_2(Cu_{1-x}Zn_x)_3O_y$ in the Meissner and Mixed State **23BP68**

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Study of the vortex core in high-T_c cuprates is quite interesting because new phenomena may be expected. Previously, we measured the magnetic-field dependence of the microwave surface impedance Z_S and revealed that the vortex core in pure $YBa_2Cu_3O_y$ (YBCO) is moderately clean. In this paper, we investigate Z_S for widely Zn-doped YBCO at various frequencies (0.5-100 GHz) and discuss the scattering mechanism of the quasiparticle in the vortex core by combining several different methods.

23BP69 *i*-soliton, fractional flux and breakdown of time reversal symmetry in multi-band superconductor

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We pointed out a soliton can be present in a multi-band superconductor [Phys. Rev. Lett. **88** (2002) 017002]. We named it *i*-soliton. It connects two different coherent states having different phases. The *i*-soliton traps a fractional flux inside a superconducting loop. These properties may realize a fractional flux quantum (FFQ) device beyond a single flux quantum(SFQ) decive. The *i*-soliton would be found in the multi-layer cuprate superconductor having crystallographically nonequivalent CuO_2 planes in one unit cell of which representative is $Cu_xBa_2Ca_3Cu_4O_y$ (Cu-1234).

23BP70 Flux Quantization in Superconducting Micro Disks

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Recently a novel vortex state appearing in a superconducting micro disk has been investigated and it is found theoretically that magnetic flux distribution in such a disk is determined by the boundary conditions (shape and size). In order to study the phenomena experimentally, we have observed the magentic flux distribution of a micro YBCO disk with 50 μm in diameter by a scanning SQUID microscope. Single quantanized vortices are observed in the disk and the number of vortices increases on increasing the applied magnetic field. These results suggest that the multi-vortex state appears in the disk.

23BP71 Vortex pinning enhancement in a magnetic-superconducting heterostructure

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Pinning of vortices in a high-temperature superconductor by the magnetic domain structure of a highly anisotropic ferromagnet is investigated by means of magnetic measurements in nanoscale period superconductor/ferromagnet (SC/FM) heterostructures. Two different samples consisting of highly epitaxial films of $YBa_2Cu_3O_7$ (SC) and $BaFe_{12}O_{19}$ (FM) are analyzed relative to a pure superconducting $YBa_2Cu_3O_7$ film. The irreversibility line obtained in the magnetic-field vs reduced-temperature phase diagram for each heterostructure is found to shift upwards when compared to the line corresponding to the pure superconducting sample. This effect is interpreted as an evidence for the enhancement of pinning of vortices in the SC layer by the magnetic domain structure in the FM layer.

Effect of Thermal Neutron Irradiation on the Pinning Properties of TSMG Sm-123 **23BP72**

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It was well studied by many groups that thermal neutron irradiation has an important role to improve the pinning properties and critical current densities of different types of superconductors. On the other hand, according to our knowledge, effect of thermal neutron irradiation on the pinning properties of Sm-123 samples was not studied before. In this report, we present the results of the effect of thermal neutron irradiation on the pinning properties and critical current densities of TSMG processed Sm-123 sample.

Phase diagram in highly anisotropic layered superconductors: crossing lattice melting transitions **23BP073**

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Recently, the crossing vortex lattice state in highly layered superconductors such as $\mathrm{Bi_2Sr_2CaCu_2O_{8+\delta}}$ has been explored both theoretically and experimentally by intensive studies in magnetic fields parallel to the superconducting $\mathrm{CuO_2}$ plane. We discuss it to establish the vortex phase diagram with emphasis on the spatial symmetry breaking. A possibility of the novel phase transition in the vortex liquid state will be argued and demonstrated experimentally.

Nature of the Vortex-Glass Order in the Type-II Limit **23BP74**

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In spite of extensive studies for a decade, the question of nature of the thermodynamic phase diagram of random high-T_c superconductors in magnetic fields remains unsettled. Here, I wish to address the question of the nature of the possible vortex-glass order in random type-II superconductors with point disorder in the unscreened limit. Extensive Monte Carlo simulations are performed for a three-dimensional lattice *XY* model which is more realistic than the gauge-glass model in that a uniform field threads the system and that the quenched randomness appears in the pinning energy. The existence of a stable vortex-glass order is established in the absence of screening. Various critical estimates assoicated wuth a continuous vortex-glass transition are estimated and are compared with those of the gauge-glass model. Destructive effects of screening on the vortex-glass order is also discussed.

23BP75 Antivortices in the mixed paramagnetic-orbital pair breaking regime

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We consider a thin superconducing layer with a magnetic field direction slightly tilted from the plane-parallel orientation. In such a situation, which generalizes the FFLO state, both paramagnetic and orbital pair-breaking effects must be taken into account. We minimize the quasiclassical free energy to obtain the stable order parameter stucture near the upper critical field, extending previous work [U.Klein et al. J. Low Temp. Phys. vol.118 91 (2000)] with regard to magnetic field contributions. We find two-dimensional periodic states, characterized by Landau quantum numbers $n > 1$ showing antivortices, e.g. a unit-cell with three order parameter zeros (two vortices and an antivortex) carrying totally a single flux quantum. The underlying physical mechanism is different from a recent prediction of antivortices in mesoscopic samples of triangular shape [L. F. Chibotaru et al. Phys. Rev. Lett. vol.86 1323 (2001)].

23BP76 Vortex States just below the Vortex-Glass Phase Probed by Voltage Noise

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We have measured the current-induced voltage noise in various fields H to study the vortex states of a thick amorphous Mo_xSi_{1-x} film. We focus on the field region between the Meissner and vortex-glass (VG) phase, where vortex states have not yet been clarified. Noise is largest in the Meissner phase ($H < H_{c1}$). With increasing H, noise falls near or below the background level; it then starts to rise at H_0, taking a broad peak in the VG phase, and falls again below the background level at a VG-to-liquid transition. We interpret H_0 as a characteristic field where order of VG starts to form. In the temperature T range studied the field region ($H_{c1} < H < H_0$) just prior to VG order grows monotonically on cooling. This is in contrast to the theory for clean systems which predicts $H_0 \rightarrow H_{c1}$ in the limit of T =0.

23BP77 Crystallisation and melting of the vortex system with a periodic pinning

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We present the results of the numerical simulations of the vortex system configurations in a quasi two-dimensional HTSC plate with different types of periodic pinninng. The simulation has been performed be means of a modified Monte-Carlo technique for the cases of square, triangular, rectangle, non-centered hexagonal, centered square and Kagome defects lattices. We have observed the systematic appearances of ordered vortex configurations (OVC) for every type of the defect lattices. Various structure and superstructure transitions of the vortex system have been observed at the increase and decrease of the applied magnetic field as well as at the changes of temperature. The appearances of OVC are accompanied by the peaks on the magnetization curves. But we have observed that some peaks are the results of shielding of the vortex entrance to the superconducting plate instead of the structure ordering transitions.

On the vortex mass in superconductors **23BP78**

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Vortex motion in a superconductor is considered at absolute zero temperature. Due to existence of collective modes of condensate oscillation, the vortex is shown to be a "relativistic-like" object, with a limiting velocity equal to the collective mode propagation velocity. Kinetic energy of this object is formed by the energy of superfluid condensate existing around the singularity line, and is due to creation of longitudinal electric fields. The rest mass of vortex obtained from the "relativistic" expression for condensate energy, is shown to exceed the mass of the vortex core.

Vortex fluctuations in the crossing lattice structure **23BP79**

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For the first time, we have derived the elastic free energy of the crossing vortex lattice, considering displacements of both pancake vortex stacks and Josephson vortices. The developed elastic theory has been applied to both, the equilibrium vortex configuration and also the vortex fluctuations. By using the Lindemann criterion the $H_c - H_{ab}$ phase diagram of the vortex lattice melting transition has been calculated. The results are in reasonable agreement with recent experimental data.

Vortex state of a 2D Josephson junction array at irrational frustration **23BP80**

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IV characteristics of a 2D Josephson junction array are studied experimentally at frustrations $f = (3 - \sqrt{5})/2$, 3/8, 8/21, 2/5, and 5/12, with a focus on the irrational frustration for which possible glassy natures without any intrinsic randomness have drawn particular interests for many years. For all five frustrations, the IV characteristics exhibit a scaling behavior, indicating a finite-temperature continuous superconducting transition. Scaling analyses show that the critical exponents for $f = (3 - \sqrt{5})/2$ are identical, within experimental errors, with those of $f =$ 8/21 and 2/5. The similarity in critical behaviors for three adjacent frustrations suggests that the vortex state at the irrational frustration is neither a vortex glass nor a high-order commensurate domains separated by domain walls as expected by some, but possibly a quasi-ordered state with the $f = 2/5$ structure as the principal structure.

23BP81 New Hall voltages in a planar pinning potential

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Two-dimensional vortex dynamics in a planar pinning potential (PPP) created by uniaxial or bianisotropic pinning planes in the presence of thermal fluctuations is considered on the basis of a Fokker-Planck equation. Explicit expressions for two new nonlinear anisotropic Hall voltages (longitudinal and transverse with respect to the current direction) are derived and analyzed. The physical origin of these odd (with respect to magnetic field reversal) voltages is caused by the subtle interplay between even effect of vortex guiding along the PPP and the odd Hall effect. As new odd voltages arise due to the Hall effect their characteristic scale is proportional to the Hall constant.

23BP82 Pinning Induced Instability of the Abrikosov Lattice Motion

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Abrikosov vortex lattice dynamics in a type-II superconductor with weak defects is studied taking into account gyroscopic (Hall) properties. It is demonstrated that the interaction of the moving lattice with weak defects results in the additional drag force with a nonmonotonic velocity dependence. It leads to a nonlinear I-V characteristic of the superconductor. The condition $dV/dF < 0,\ F$ is the total drag force, is shown to be only the necessary condition of the instability of the lattice translational motion with the velocity V under the action of the external force, F_{ext}. The inequality $dV/dF_{ext} < 0$ is more strict requirement than $dV/dF < 0$, but the instability with respect to some non-uniform perturbations appears even at the positive differential mobility $dV/dF_{ext} > 0$.

23BP83 The Antiferromagnetic Spin Fluctuation in Sr_2RuO_4

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Although Sr_2RuO_4 is suggested to be a spin triplet superconductor, neutron scattering experiments have not detected any evidence of FM spin fluctuations so far. Recently, I.I.Mazin *et al.* predicted that a magnetic response may appear at $(\frac{2\pi}{3}, \frac{2\pi}{3}, 0)$, and it was confirmed by neutron scattering measurement by Y.side *et al.* In the present paper, we report the energy and temperature dependences of the AFM fluctuations in detail, and discuss the role of the spin fluctuations to the spin triplet superconductivity.

Field-Temperature Phase Diagram of the 3-K Phase of Sr_2RuO_4 23BP84

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The eutectic system Sr_2RuO_4-Ru is referred to as the 3-K phase of the spin-triplet superconductor Sr_2RuO_4 (T_c =1.5 K) since the eutectic system has an enhanced T_c of ~ 3 K. We have established the field-temperature phase diagram of the 3-K phase for two field directions (H//ab and H//c) using resistivity data. We have found an upturn curvature in the $H_{c2}(T)$ curve for H//c and rather gradual temperature dependence of H_{c2} close to T_c. We propose that these charecteric features are explained, at least in a qualitative fashion, on the basis of theory that assumes surface superconductivity with a two-component order parameter at the interface between Sr_2RuO_4 and Ru inclusions.

Gap-like behavior of the c-axis dynamic conductivity in $Sr_2Ru_{1-x}Ti_xO_4$ 23BP85

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We report measurements of the out-of-plane reflectivity of pure and Ti-doped Sr_2RuO_4 single crystals investigated by infrared spectroscopy. The electronic part of the dynamic conductivity can be well described by a two-component model. In the superconducting samples ($x < 0.0015$) a sharp plasma edge with a small spectral weight develops below 140 K. The scattering rate γ shows a gap-like T-dependence, while higher doped samples (where superconductivity is suppressed) reveal an almost constant γ in the investigated temperature range $5\ \mathrm{K} < \mathrm{T} < 300\ \mathrm{K}$. We compare the observed charge gap, which still exists far above T_c (e.g. $T_c = 1.43$ K for $x = 0$), with investigations of the spin dynamics in the ruthenates and discuss them in the context of the pseudogap behavior in the cuprates.

Shubnikov-de Haas Oscillations in the Superconducting Fluctuation Region of κ-$(BEDT\text{-}TTF)_2Cu(NCS)_2$ 23BP86

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Shubnikov-de Haas oscillations in an organic superconductor κ-$(BEDT\text{-}TTF)_2Cu(NCS)_2$ are studied near the upper critical field of $H_{c2} \simeq 5$ T. Below 7.3 T, the oscillations suffer additional damping which is ascribable to the superconducting fluctuation effects. The damping is not observed in a pressure of 2 kbar. In this pressure, the superconductivity is suppressed and the H_{c2} becomes as low as 1 T. This clearly demonstrates that the additional damping observed at ambient pressure is relevant to the superconductivity.

23BP87 Electronic Heat Capacity of κ-(BEDT-TTF) $_4Hg_{3-\delta}X$ (X=Br, Cl)

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Low-temperature heat capacity measurements for single crystals of κ-(BEDT-TTF)$_4$Hg$_{3-\delta}$X$_8$ (X=Br, Cl) which are known as a strongly correlated organic system are performed. We observed interesting behavior in lattice heat capacity associated with the chain structure of mercury atoms in the anion layers. The electronic heat capacity coefficient, γ was found to be 3-4 times larger than those of well known 10 K class superconductors κ-(BEDT-TTF)$_2$Y. (Y=Cu(NCS)$_2$, Cu[N(CN)$_2$]Br). Large antiferromagnetic spin fluctuations which observed at low temperatures is considered as a reason for this large electron mass enhancement.

23BP88 Pressure effects in the Field-Induced Superconducting State of λ-(BETS)$_2$FeCl$_4$

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We investigate, by electrical transport, the field-induced superconducting state (FISC) in the organic conductor λ-(BETS)$_2$FeCl$_4$ at 1 Bar and 1.4 kBar of hydrostatic pressure. At 1 Bar and below 4 K, antiferromagnetic-insulator (AFI), metallic, and eventually superconducting (FISC) ground states are observed with increasing in-plane magnetic field. In the other hand, pressure stabilizes superconductivity (SC) which is followed by a SC to AFI transition upon cooling. Pressure also decreases the compensation field and considerably broadens the field dependence of the FISC state.

23BP89 Atomic size Josephson Junctions in field effect doped organic crystals

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The recent observation of a Fraunhofer pattern in the magnetic field dependence of the critical current $I_c(B)$ by H. Schön, B. Batlogg et al. is a crucial evidence for superconductivity in the surface of field effect doped organic crystals. We propose a microscopic origin for the Josephson junction due to steps in the interface layer, where the external electric field is shielded by a charge dipole and the local depletion of the charge density forms an atomic size weak link. In the light of this experiment, we show that for junctions between type II superconducting films the length l determining the period of $I_c(B)$ is significantly smaller than the penetration depth λ_L in the Meissner state due to flux penetration. In equilibrium the intervortex distance $a(B)$ enters, while in critical flux states induced by surface or bulk pinning l is independent of B. Further, the local magnetic field at the junction is affected by the geometry.

Penetration depth measurements of the borocarbides $LuNi_2B_2C$ and YNi_2B_2C **23BP90**

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Recent work on the non-magnetic borocarbide superconductors has shown the presence of low energy excitations in the vortex state, suggesting a possible anisotropic superconducting gap. We present measurements of the temperature dependence of the London penetration depth in the Meissner state of single crystals of $LuNi_2B_2C$ and YNi_2B_2C down to 1.3K using a high resolution radio frequency technique. Our results on samples with clean, prepared surfaces are in excellent agreement with a simple, isotropic, BCS weak-coupling, s-wave superconducting gap.

Measurement of an Anisotropic Superconducting Gap Parameter Resolved to a Single Fermi Surface Sheet: The de Haas-van Alphen Effect in YNi_2B_2C **23BP91**

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We have used the de Haas-van Alphen technique in the normal and superconducting states of YNi_2B_2C to measure the (angularly resolved) orbitally averaged superconducting gap parameter. The results show that the gap parameter is fourfold symmetric and highly anisotropic. This is the first time that superconducting gap anisotropies have been explored and resolved to individual sheets of the Fermi surface. Our results are not inconsistent with the suggestions of 's+g' symmetry in this material by Maki, Thalmeier and Won. In addition we have observed for the first time an excess damping due to screening by vortex motion in the peak effect region.

Vortex Lattice Evolution and Low-Field Reorientation Transition in $LuNi_2B_2C$ **23BP92**

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We present the results on VL evolution in as grown and annealed $LuNi_2B_2C$ single crystals by the decoration technique at a broad region of magnetic fields. We have observed the reorientation transition at magnetic field $H_1 \sim 250Gs$ in the annealed samples. The transition to square lattice in the annealed samples occurs at the lower value of magnetic field $H_2 \sim 600$ Gs. We have also found a strong anisotropy in the long-range VL orientational order in the vicinity of the transition field H_2. The observed VL behavior is discussed in frames of nonlocal London theory.

23BP93 Growth and study of $Ba_{1-x}K_xBiO_{3-y}$ single crystals: crystal structure and cation composition correlation

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Newly done results on the BKBO ($0.06 \leq x \leq 0.67$) single crystals growth of precise homogeneity composition, full cation analysis data, and structural aspects are reported. Structural studies have established a new low temperature phase for the superconducting BKBO compounds. The XRD data on BKBO crystals ($0.39 \leq x \leq 0.55$) demonstrate that superstructure reflections for the crystals exist already at room temperature, which stay constant down to 18K. The dependence of the pseudo-cubic lattice constant on both average bismuth valence and potassium content has been defined as an approximate function.

23BP94 Field Effect Doping to $SrTiO_3$

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Temperature and electric-field dependence of the current-voltage characteristics and charge-carrier mobility of an interface between $SrTiO_3$ and Al_2O_3 are reported. The measurements were performed on field-effect transistor (FET) structures, which were prepared on top of a $SrTiO_3$ single crystal by the deposition of aluminium source and drain contacts, a sputtered Al_2O_3 gate dielectric, and a gold gate electrode.