XVII Krajowa Konferencja Nadprzewodnictwa

Nadprzewodnictwo i inne stany emergentne
w układach z silnie skorelowanymi elektronami

25–30 października 2015 roku
Karpacz, Hotel Artus

Komitet Naukowy

M. Z. Cieplak (IF PAN, Warszawa)
R. Micnas (UAM, Poznań)
K. Rogacki (INTiBS PAN, Wrocław)
J. Spałek (UJ, Kraków)
A. Szytuła (UJ, Kraków)
K. I. Wysokiński (UMCS, Lublin)

Komitet Programowy

T. Domański (UMCS, Lublin)
D. Kaczorowski (INTiBS PAN, Wrocław) – przewodniczący
A. Kołodziejczyk (AGH, Kraków)
T. Kopeć (INTiBS PAN, Wrocław)
M. Maśka (UŚ, Katowice)
A. Oleś (UJ, Kraków)
R. Puźniak (IF, Warszawa)
S. Robaszkiewicz (UAM, Poznań)
K. Rogacki (INTiBS PAN, Wrocław)
W. Sadowski (PG, Gdańsk)
A. Ślebarski (UŚ, Katowice)
A. Zaleski (INTiBS PAN, Wrocław)

Komitet Organizacyjny

M. Samsel–Czekała (INTiBS PAN, Wrocław) – sekretarz
K. Filar (MLSPMiNT PAN, Wrocław)
D. Kaczorowski (INTiBS PAN, Wrocław)
M. Matusiak (INTiBS PAN, Wrocław)
A. Pikul (INTiBS PAN, Wrocław)
K. Rogacki (MLSPMiNT PAN,
INTiBS PAN, Wrocław) – przewodniczący
T. Zaleski (INTiBS PAN, Wrocław)

Tematyka

- Nadprzewodnictwo wysokotemperaturowe: zjawiska, mechanizmy, nowe materiały, zastosowania
- Nadprzewodzące układy nanorozmiarowe i niskowymiarowe
- Współistnienie nadprzewodnictwa i magnetyzmu, efekty bliskości
- Układy z silnie skorelowanymi elektronami: ciężkie fermiony, fluktuacje spinowe, fluktuacje ładunkowe
- Kwantowe przejścia fazowe, kwantowe zjawiska krytyczne
- Izolatory i semimetale topologiczne

Sponsorzy

- Instytut Niskich Temperatur i Badań Strukturalnych PAN
- Międzynarodowe Laboratorium Silnych Pól Magnetycznych i Niskich Temperatur PAN
- Instytut Fizyki PAN
- Wydział Fizyki Uniwersytetu im. Adama Mickiewicza w Poznaniu
- Wydział Fizyki, Astronomii i Informatyki Stosowanej Uniwersytetu Jagiellońskiego

Program konferencji

Niedziela, 25 października 2015 r.

16:30 – 18:30 *Rejestracja uczestników*

18:30 – 20:00 *Kolacja powitalna*

Poniedziałek, 26 października 2015 r.

9:00 – 9:20	*Otwarcie konferencji*
9:20 – 10:30	**Sesja I**
9:20 – 9:55	**PON–1 (Z)** J. Spałek „Unconventional superconductivity in strongly correlated systems: A brief overview”
9:55 – 10:30	**PON–2 (Z)** L. Krusin–Elbaum „Emergent surface superconductivity in the topological insulator Sb_2Te_3”
10:30 – 11:00	*Przerwa kawowa*
11:00 – 13:00	**Sesja II**
11:00 – 11:35	**PON–3 (Z)** A. Kaminski „Oddziaływania elektronowe w nowych i starych nadprzewodnikach”
11:35 – 12:10	**PON–4 (Z)** M. Mierzejewski, L. Vidmar, D. Golez, J. Bonca „Spektroskopia optyczna z rozdzielczością czasową nadprzewodników wysokotemperaturowych”
12:10 – 12:30	**PON–5 (A)** P. Starowicz „Electronic structure of the selected '11' iron chalcogenides investigated by ARPES”
12:30 – 12:45	**PON–6 (B)** A. Ptok „Unconventional superconductivity state in iron-based materials – specific heat study”
12:45 – 13:00	**PON–7 (B)** P. Wójcik, M. Zegrodnik, J. Spałek „Quantum size effect on FFLO state in superconducting nanostructures”
13:00 – 14:30	*Obiad*
14:30 – 16:00	**Sesja III**
14:30 – 15:05	**PON–8 (Z)** J. Jaroszynski „Zastosowanie wysokotemperaturowego nadprzewodnictwa w NHMFL”

15:05 – 15:25 **PON–9 (A)** R. Puzniak, V. Markovich, I. Fita, A. Wisniewski „Effect of reduced grain size on charge ordering and exchange bias in (Sm,Ca,Sr)MnO_3 manganites”

15:25 – 15:45 **PON–10 (A)** P. Przyslupski, M. Aleszkiewicz, K. Dybko, R. Minikayev, P. Dluzewski „Functional complex oxide nanostructures”

15:45 – 16:00 **PON–11 (B)** I. Zaytseva, O. Abal’oshev, P. Dłużewski, W. Paszkowicz, M. Kończykowski, L. Y. Zhu, C. L. Chien, and Marta Z.Cieplak „Magnetic field induced superconductor to dirty metal transition in Si/Nb/Si trilayers”

16:00 – 16:30 *Przerwa kawowa*

16:30 – 18:05 Sesja IV

16:30 – 17:05 **PON–12 (Z)** A. Szytuła „Nadprzewodnictwo w związkach międzymetalicznych lutetu”

17:05 – 17:20 **PON–13 (B)** G. Wojtasiewicz „Fault current limitation by 2G HTS superconducting transformer – experimental investigation”

17:20 – 17:35 **PON–14 (B)** N.–T. H. Kim–Ngan, M. Krupska, S. Sowa, M. Paukov, I. Tkach, L. Havela „Superconductivity in U–T alloys (T = Mo, Pt, Pd, Nb, Zr) stabilized in the cubic γ-U structure”

17:35 – 17:50 **PON–15 (B)** E. Maievskyi, M. Ciszek „The effect of magnetic history on AC loss minimum in BSCCO-2223 composite tape”

17:50 – 18:05 **PON–16 (B)** A. Los, B. Dabrowski, K. Rogacki „Critical currents anisotropy and pinning mechanism in $YBa_2Cu_{2.97}Mo_{0.03}O_x$ single crytals”

18:30 – 19:30 *Kolacja*

20:00 – 21:30 Sesja plakatowa I – „Eksperyment”

Wtorek, 27 października 2015 r.

9:00 – 10:30 **Sesja V**

9:00 – 9:35 **WTO–1 (Z)** B. A. Głowacki „Applied superconducting materials”

9:35 – 10:10 **WTO–2 (Z)** T. Janowski „Nadprzewodnikowe urządzenia elektroenergetyczne”

10:10 – 10:30 **WTO–3 (A)** J. M. Michalik, R. Córdoba, S. Sangiao, A. Fernandez–Pacheco, I. Serrano and J. M. De Teresa „Tungsten micro- and nanostructures fabricated with Focused-Beam-Induced-Processing techniques”

10:30 – 11:00 *Przerwa kawowa*

11:00 – 13:00 **Sesja VI**

11:00 – 11:35 **WTO–4 (Z)** M. Konczykowski „Phase diagram of iron-based superconductors tuned by irradiation induced disorder”

11:35 – 12:10 **WTO–5 (Z)** K. Conder „Nadprzewodzące chalkogenidki żelaza interkalowane metalami alkalicznymi”

12:10 – 12:30 **WTO–6 (A)** R. Szczęśniak „Nadprzewodnictwo wysokotemperaturowe: historia i perspektywy”

12:30 – 12:45 **WTO–7 (B)** F. Pérez-Rodríguez, R. Cortés–Maldonado, V. Chabanenko, A. Nabiałek, A. Wiśniewski „Effect of flux-line cutting on thermomagnetic avalanches in hard superconductors”

12:45 – 13:00 **WTO–8 (B)** K. Pomorski, A. Bednorz „Justification of the canonical quantization of the Josephson effect”

13:00 – 14:30 *Obiad*

14:30 – 16:00 **Sesja VII**

14:30 – 15:05 **WTO–9 (Z)** M. Z. Cieplak „Domieszki metali przejściowych w nadprzewodnikach żelazowych”

15:05 – 15:25 **WTO–10 (A)** A. Ciechan „Magnetism of strained and S-substituted FeTe: DFT study”

15:25 – 15:45 **WTO–11 (A)** A. P. Kądzielawa, A. Biborski, J. Spałek „Discontinuous transition of molecular-hydrogen chain to the quasi-atomic state”

15:45 – 16:00 **WTO–12 (B)** M. M. Wysokiński, J. Kaczmarczyk, J. Spałek „Nadprzewodnictwo w modelu sieci Andersona: rozwiązanie funkcji falowej Gutzwillera”

16:00 – 16:30 *Przerwa kawowa*

16:30 – 18:05 Sesja VIII

16:30 – 17:05 **WTO–13 (Z)** A. Szewczyk, T. Zajarniuk, M. U. Gutowska, P. Wiśniewski, D. Kaczorowski, M. I. Pashchenko, V. A. Bedarev, S. L. Gnatchenko,| L. N. Bezmaternykh, V. L. Temerov, A. A. Prokhorov, L. F. Chernysh „Czy magnetyczne przejście fazowe w aluminoboranach ma charakter przemiany kwantowej?”

17:05 – 17:20 **WTO–14 (B)** R. J. Radwanski, D. M. Nalecz, and Z. Ropka „Three localized f electrons in UPd_2Al_3, UGa_2, UGe_2”

17:20 – 17:35 **WTO–15 (B)** M. Abram, M. M. Wysokiński, J. Spałek „Microscopic model of magnetism in UGe_2: criticalities and realistic parametrization”

17:35 – 17:50 **WTO–16 (B)** G. Górski „Irreducible Green Functions Method applied to nanoscopic systems”

17:50 – 18:05 **WTO–17 (B)** P. Stefański „Probing a fractional Josephson junction with a quantum dot”

18:30 – 19:30 *Kolacja*

20:00 – 21:30 Sesja plakatowa II – „Teoria”

Środa, 28 października 2015 r.

9:00 – 10:30	**Sesja IX**
9:00 – 9:35	**ŚRO–1 (Z)** K. I. Wysokiński, M. Rogatko „Nadprzewodnictwo w holograficznym świecie (... i w obecności ciemnej materii)”
9:35 – 10:10	**ŚRO–2 (Z)** A. Wójs „Ułamkowe skyrmiony w układach kwantowego efektu Halla ”
10:10 – 10:30	**ŚRO–3 (A)** T. A. Zaleski, T. K. Kopeć „Coherence and spectral weight transfer in the dynamic structure factor of cold lattice bosons”
10:30 – 11:00	*Przerwa kawowa*
11:00 – 18:30	*Czas wolny*
18:30 – 21:30	*Uroczysta kolacja*

Czwartek, 29 października 2015 r.

9:00 – 10:30 **Sesja X**

9:00 – 9:35 **CZW–1 (Z)** R. Micnas „Bozonowo-fermionowy model rezonansowy dla niekonwencjonalnych nadcieczy”

9:35 – 10:10 **CZW–2 (Z)** W. Tabiś „Korelacje ładunkowe i ich wpływ na własności elektronowe wysokotemperaturowych nadprzewodników”

10:10 – 10:30 **CZW–3 (A)** M. M. Maśka, V. G. Rousseau, N. Trivedi „Phase coherence in the boson–fermion model”

10:30 – 11:00 *Przerwa kawowa*

11:00 – 13:00 **Sesja XI**

11:00 – 11:35 **CZW–4 (Z)** T. Story „Półprzewodniki IV-VI jako materiały topologiczne”

11:35 – 12:10 **CZW–5 (Z)** J. Tworzydło „Krawędź Kitaeva w nadprzewodnikach topologicznych”

12:10 – 12:30 **CZW–6 (A)** B. Wiendlocha „Superconductivity and resonant levels in doped semiconductors”

12:30 – 12:45 **CZW–7 (B)** O. Pavlosiuk, D. Kaczorowski and P. Wiśniewski „Putative topological superconductors LuPdBi, LuPtBi and YPtBi; electronic and thermodynamic properties”

12:45 – 13:00 **CZW–8 (B)** G. Rut, A. Rycerz „Transport pseudodyfuzyjny i magnetoprzewodność dysku Corbino w dwuwarstwowym grafenie”

13:00 – 14:30 *Obiad*

14:30 – 16:00 **Sesja XII**

14:30 – 15:05 **CZW–9 (Z)** T. Klimczuk, G. Prathiba, I. Kim, J. Strychalska, T. Park „Efekt ciśnienia chemicznego w $SmNiC_2$”

15:05 – 15:25 **CZW–10 (A)** A. Ślebarski, M. M. Maśka and M. Fijałkowski „Nadprzewodnictwo w obecności nieporządku atomowego związków La o strukturze podobnej do skutterudytu”

15:25 – 15:45 **CZW–11 (A)** R. Lemański „Przewodnictwo elektryczne w fazach uporządkowanych ładunkowo”

15:45 – 16:00 **CZW–12 (B)** K. J. Kapcia, A. Amaricci, S. Robaszkiewicz, M. Capone „Charge-orderings with insulator–metal transition in the infinite dimensional extended Hubbard model”

16:00 – 16:30 *Przerwa kawowa*

16:30 – 18:05 Sesja XIII

16:30 – 17:05 **CZW–13 (Z)** A. Błachowski, K. Komędera, A. K. Jasek, J. Żukrowski, K. Ruebenbauer „Od magnetyzmu do nadprzewodnictwa w związkach żelaza – badania metodą spektroskopii mössbauerowskiej”

17:05 – 17:20 **CZW–14 (B)** L. M. Tran, S. Denholme, M. Fujioka, P. Wiśniewski, Z. Bukowski, Y. Takano, A. J. Zaleski „Hydrostatic pressure enhanced superconductivity in $Eu(Fe_{0.81}Co_{0.19})_2As_2$”

17:20 – 17:35 **CZW–15 (B)** V. L. Bezusyy, D. J. Gawryluk, M. Berkowski, A. Malinowski, and M. Z. Cieplak „Evolution of the transport properties of doped iron chalcogenide $FeTe_{0.65}Se_{0.35}$”

17:35 – 17:50 **CZW–16 (B)** A. Krzton–Maziopa, E. Pomjakushina, K. Conder „Superconducting properties of iron selenides intercalated with bulky molecular spacers”

17:50 – 18:05 **CZW–17 (B)** M. Majka, J. Kozak „Nadprzewodnikowe ograniczniki prądu zwarciowego dla sieci elektroenergetycznej”

18:30 – 19:30 *Kolacja*

Piątek, 30 października 2015 r.

9:00 – 10:30 **Sesja XIV**

9:00 – 9:35 **PIĄ–1 (Z)** J. Karpinski, S. Katrych, K. Rogacki, A. Pisoni, R. Gaal, N. D. Zhigadlo and L. Forro „$Ln_4Fe_2As_2Te_{1-x}O_4$ (Ln = Pr, Sm, Gd): Superconducting properties and structure”

9:35 – 9:55 **PIĄ–2 (A)** A. Kołodziejczyk, K. Rogacki, Ł. Bochenek, T. Cichorek, B. Wiendlocha, J. Toboła, S. Kaprzyk, R. Zalecki „First superconducting itinerant ferromagnet Y_9Co_7”

9:55 – 10:15 **PIĄ–3 (A)** T. Domański, I. Weymann, M. Barańska „Constructive feedback of the superconductivity on the Kondo state in quantum dots”

10:15 – 10:30 **PIĄ–4 (B)** M. Zegrodnik, J. Kaczmarczyk, J. Spałek „Superconductivity in the t-J-U-V model: Gutzwiller wave function solution”

10:30 – 11:00 *Przerwa kawowa*

11:00 – 13:00 **Sesja XV**

11:00 – 11:35 **PIĄ–5 (Z)** B. Dabrowski „Strongly-correlated corner-shared networks of 3d transition metal and oxygen”

11:35 – 12:10 **PIĄ–6 (Z)** T. Cichorek „Stany emergentne w izolatorze Kondo $CeOs_4As_{12}$”

12:10 – 12:30 **PIĄ–7 (A)** V. H. Tran, Z. Bukowski „The coexistence of superconductivity and charge density wave in $LaCu_{1-x}Ag_xSb_2$”

12:30 – 12:45 **PIĄ–8 (B)** M. J. Winiarski, B. Wiendlocha, P. Wiśniewski, D. Kaczorowski, T. Klimczuk „Superconductivity in $(Sc,Y,Lu)V_2Al_{20}$ cage compounds – an experimental and theoretical study”

12:45 – 13:00 **PIĄ–9 (B)** G. Michałek, T. Domański, B. R. Bułka, K. I. Wysokiński „Nonlocal Andreev reflection in three-terminal hybrid devices”

13:00 – 14:30 *Obiad*

Sesja plakatowa I – „Eksperyment”

E–1 J. Sosnowski „Critical current analysis in fast neutrons irradiated HTc multilayered superconductors”

E–2 W. Słysz, M. Guziewicz, A.Klimov, R.Puźniak, M. Juchniewicz, M. A. Borysiewicz, R. Kruszka, M. Węgrzecki, A. Łaszcz, A. Czerwiński, R. Sobolewski „Proximitized NbN/NiCu superconductor/ferromagnet nano-bilayers for single photon detection”

E–3 E. I. Kuchuk, V. V. Chabanenko, I. Abaloszewa, A. Nabiałek, V. F. Rusakov „The relief of magnetic induction in hard SC at thermomagnetic avalanches”

E–4 A. Abaloszew, I. Abaloszewa, M. Konczykowski, M. A. Tanatar, R. Prozorov „Vortex pinning and creep in single crystals BaKFeAs with intrinsic and irradiation-induced disorder”

E–5 P. Gierłowski „Superconducting niobium cavity for penetration depth and surface resistance measurements”

E–6 W. M. Woch, M. Chrobak, M. Kowalik, R. Zalecki, J. Przewoźnik, C. Kapusta „Magnetoresistance and irreversibility fields of bismuth based 1G tape”

E–7 M. Chrobak, M. Kowalik, W. M. Woch, R. Zalecki „Thermal fluctuations of YBCO based 2G tape”

E–8 M. Kowalik, A. Szeliga, W. Tokarz, W. M. Woch, M. Chrobak, R. Zalecki „Critical currents and full penetration fields of YBCO based 2G tape”

E–9 M. Chrobak, W. M. Woch, M. Kowalik, R. Zalecki, J. Przewoźnik, C. Kapusta „Magnetic properties of *c*-axis oriented YBCO thin film”

E–10 W. M. Woch, M. Chrobak, M. Kowalik, R. Zalecki, J. Niewolski „Magnetoconductance of $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_x$ bulk superconductor in the fluctuation region”

E–11 M. Kowalik, R. Zalecki, W. M. Woch, M. Chrobak „Critical current of BiSCCO 2:2:2:3 films on silver substrate”

E–12 R. Zalecki, W. M. Woch, M. Kowalik, A. Kołodziejczyk „Penetration depth measurements in the yttrium based bulk high-temperature superconductors”

E–13 H. Lochmajer, M. Matusiak, G. Urbanik, P. Przyslupski, K. Rogacki „Superconductivity and ferromagnetism in $La_{0.67}Sr_{0.33}MnO_3/YBa_2Cu_3O_7$ nanoheterostructures”

E–14 A. K. Jasek, K. Komędera, A. Błachowski, K. Ruebenbauer, K. Rogacki „Charge modulation in $SmFeAsO_{0.91}F_{0.09}$ superconductor seen by Mössbauer spectroscopy”

E–15 K. Komędera, A. K. Jasek, A. Błachowski, K. Ruebenbauer, J. Żukrowski, A. Krztoń–Maziopa „Structural disorder in $A_xFe_{2-z}Se_2$ superconductors studied by Mössbauer spectroscopy”

E–16 Z. Bukowski, A. Niemiec, L. M. Tran, A. Zaleski „Superconductivity, structural and magnetic phase transition in Ru-doped $CaFe_2As_2$”

E–17 J. Korczak, A. Krzton–Maziopa „Effect of anion substitution on superconducting properties of hybrid iron selenides”

E–18 O. Pavlosiuk, D. Kaczorowski, P. Wiśniewski „Magnetic and transport properties of topologically nontrivial half-Heusler phases RPdBi (R = Ho, Dy, Gd)”

E–19 G. Gajda, A. Morawski, A. Presz, R. Diduszko, T. Cetner, D. Gajda „The critical parameters (J_c and T_c) of the Ce, Nd oxides and carbon encapsulated in boron doped MgB_2”

E–20 D. Gajda, A. Morawski, A. Zaleski, M. Rindfleisch, M. Tomsic, M. S. A. Hossain, S. X. Dou, T. Czujko, W. Haßler, K. Nenkov „Critical current density in $C_4H_6O_5$ doped MgB_2 wires at 4.2 K and 20 K”

E–21 M. Łapiński, M. Prześniak–Welenc, N. Szreder, B. Kościelska, W. Sadowski „Electrical transport in copper-doped lithium titanate thin films prepared by sol-gel method”

E–22 J. Strychalska, M. Roman, B. Wiendlocha, W. Sadowski, T. Klimczuk „La_3Co – superconductivity on the edge of ferromagnetism”

E–23 K. Domieracki, D. Kaczorowski „Superconductivity in noncentrosymetric $ThIr_2Si_2$”

E–24 A. P. Pikul, G. Chajewski, P. Wiśniewski, M. Samsel–Czekała, D. Kaczorowski „Superconductivity in YPt_2Si_2”

E–25 S. Sowa, N.–T. H. Kim–Ngan, M. Krupska, M. Paukov, I. Tkach, L. Havela „Superconducting transition in U–Pt and U–Pd alloys”

E–26 J. Juraszek, Z. Henkie, T. Cichorek „Superconducting properties of the filled skutterudite compound $LaOs_4As_{12}$”

E–27 A. Malinowski, V. L. Bezusyy, P. Nowicki „Magetoresistance, Kohler’s rule and thermopower in the normal-state of $La_{1.85}Sr_{0.15}CuO_4$ doped with Ni”

E–28 B. Idzikowski, N. Pierunek, Z. Śniadecki „Magnetocaloric effect in disordered $Y_{1-x}Gd_xCo_2$ ($0 \le x \le 1$) compounds”

E–29 Ł. Bochenek, T. Cichorek „Low-temperature angular magnetoresistance of the Kondo insulator $CeOs_4Sb_{12}$”

E–30 T. Klimczuk, M. Roman, A. Cevallos, L. Schoop, R. J. Cava „Physical properties of NbSeI”

E–31 M. Krupska, N.–T. H. Kim–Ngan, S. Sowa, Z. Tarnawski, A. G. Balogh „Interdiffusion and ion beam mixing effect in bi-layer Fe_3O_4/Fe/MgO(001) films”

E–32 D. Szewczyk, J. Mucha, P. Stachowiak, P. Vanderbemden „Thermal properties of Ti-doped Cu-Zn soft ferrites”

Sesja plakatowa II – „Teoria”

T–1 M. Fidrysiak „Longitudinal spin excitations and microscopic origin of magnetic ordering in iron-pnictides”

T–2 G. Harań, D. Grzybowska „Superconducting instability of the non-centrosymmetric system”

T–3 B. Kuśmierz, A. Wójs „Quantum Hall many-body repulsion ground states from the two-body pseudopotential”

T–4 T. Woźniak, M. Bieniek, P. Potasz, A. Wójs „Electronic properties of 2-dimensional bilayer bismuth topological insulator”

T–5 W. R. Czart, S. Robaszkiewicz „Phase diagrams of the Penson–Kolb–Hubbard model with repulsive pair-hopping interaction”

T–6 K. J. Kapcia, W. R. Czart „The extended Hubbard model with pair-hopping interaction in the limit of very narrow bandwidth”

T–7 P. Tomczak, P. Jabłoński, M. Tomczak „Probing the Kosterlitz–Thouless transition in 1D Heisenberg antiferro-magnet based on the topological properties of its ground state”

T–8 S. Głodzik, T. Domański „Influence of electron pairing on the sub- and superradiance in quantum dots”

T–9 A. Kobiałka, T. Domański „T-shape quantum dot with the Majorana bound state”

T–10 V. Apinyan, T. K. Kopeć „BCS pairng, BKT superfluidity and BEC in the strongly correlated excitonic systems”

T–11 D. Makieła, M. M. Maśka „Spontaneous currents in bosonic rings”

T–12 V. M. Travin, T. K. Kopeć „Phase transitions of bosons in optical lattices with a micture of single and pair hoppings”

T–13 S. A. Anufriiev, T. A. Zaleski „Phase diagram of mixtures of ultracold bosons in optical lattices”

T–14 B. Grygiel, K. Patucha, T. A. Zaleski „Optical conductivity of ultra-cold bosons in optical lattices”

T–15 K. Patucha, B. Grygiel, T. A. Zaleski „Role of bandwidth and energy gap in formation of ground state of bosons in artificial magnetic fields”

T–16 S. Cortés–López, F. Pérez–Rodríguez „Infrared response of a multilayer stack composed of laminar-superconductor and dielectric”

T–17 V. Chabanenko, E. Kuchuk, C. Romero–Salazar, O. A. Hernández–Flores, F. Pérez–Rodríguez, I. Abaloszewa, A. Nabiałek „The role of rough flux front penetration in critical state stability of type II superconductors”

T–18 A. P. Durajski, R. Szczęśniak, K. M. Skoczylas „The temperature dependence of energy gap in thin film electron-doped cuprates”

T–19 A. M. Duda, E. A. Drzazga, R. Szczęśniak „Influence of the anisotropy on the superconducting critical temperature”

T–20 E. A. Drzazga, A. M. Duda, R. Szczęśniak, M. W. Jarosik „Superconducting properties of the alloy of tin and copper”

T–21 K. Pomorski, P. Prokopow „Physical description of unconventional Josephson junctions”

T–22 A. Tomski, J. Kaczmarczyk „Gutzwiller wave function solution for finite systems: superconductivity in the Hubbard model”

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T–29 K. Bieniasz, M. Berciu, A. Oleś „Orbital Polarons in $KCuF_3$”

Referaty – poniedziałek

Unconventional superconductivity in strongly correlated systems: A brief overview

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I briefly overview the properties of superconductors in which the electronic correlations play an important, if not predominant role. This class encompasses high-T_c cuprate systems, heavy-fermion materials, and organic compounds. In all of them the superconductivity is either intertwined with metal-insulator transition of the Mott-Hubbard type or tightly connected with magnetism and the presence of quantum critical points. On the basis of selected examples I shall try to make a distinction between the systems in which the pairing is induced by the quantum spin fluctuations as opposed to those in which real space pairing is induced by the combined effect of interelectronic correlations and exchange interactions.

Relation to experiment for the case of the high-T_c superconductors is discussed in a semiquantitative manner and for the heavy fermion in qualitative terms. Role of the system dimensionality and of coupling to the lattice in determining a realistic value of the critical temperature is raised at the end.

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Emergent surface superconductivity in the topological insulator Sb_2Te_3

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Surfaces of three-dimensional topological insulators have emerged as one of the most remarkable states of condensed quantum matter where exotic electronic phases of Dirac particles should arise. Here I will report on our discovery of surface superconductivity in the topological insulator Sb_2Te_3 with transition to zero resistance induced through a minor tuning of growth chemistry that depletes bulk conduction channels. The depletion shifts Fermi energy towards the Dirac point as witnessed by a factor of 300 reduction of bulk carrier density and by the largest carrier mobility (~ 25,000 $cm^2V^{-1}s^{-1}$) found in any topological material. Direct evidence from transport, the unprecedentedly large diamagnetic screening, and the presence of ~ 25 meV gaps detected by scanning tunneling spectroscopy reveal the superconducting condensate to emerge first in surface puddles at unexpectedly high (above 50 K) temperatures, with the onset of global phase coherence at ~ 9 K. I will discuss how global coherence is mediated by interpuddle diffusion of quasiparticles and how the rich structure of this state lends itself to manipulation via growth conditions and the material parameters such as Fermi velocity and mean free path.

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Interaction of electrons with collective excitations in conventional and unconventional superconductors

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Interaction of electrons with collective modes plays a central role in theory of conventional superconductors and many models of unconventional superconductors. In cuprates for example, presence of such interaction was discovered almost two decades ago [1, 2], however there is no consensus as to its origin [2–5]. It is not even known whether it is responsible for driving the pairing or a mere spectator of the superconducting transition. One of the reasons for this situation is lack of momentum resolved data from classical superconductors that would serve as a baseline for identifying the physical nature of the coupling interaction and its role in the pairing mechanism. In this talk we will present such data from classical BCS superconductor MgB_2 [6, 7] and review the old and new properties of the collective mode present in cuprates. In the classical superconductor, the coupling of the electrons to the phonon mode responsible for pairing remains almost unaffected across the critical temperature. This is unlike the situation in cuprates, where the signature of coupling to the collective mode vanishes above T_c. We also discovered new low energy spectral feature in MgB_2 that is most likely a signature of coupling to the Leggett mode – a relative phase excitation of the two suprefluids present in this material.

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Ultrafast relaxation of charge carriers in high-temperature superconductors

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We discuss time-resolved optical spectroscopy which has recently been applied with unprecedented time resolution to the prototypical case of superconducting copper oxides with a doping concentration close to that necessary to attain the largest critical temperature [1]. It demonstrates that, already on the 10 fs timescale, the electron dynamics is fully captured by the effective interaction with bosonic fluctuations. This extremely fast timescale together with our calculations within the two dimension t-J model, strongly point to short-range spin fluctuations as the universal class of bosons mediating the electronic interactions in doped copper oxides.

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Electronic structure of the selected „11” iron chalcogenides investigated by ARPES

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We investigated $Fe_{1+x}Te_{1-y}S_y$, $Fe_{1+x}Te_{1-y}Se_y$ and $Fe_{1-x}Ni_\delta Te_{1-y}Se_y$ by means of angle resolved photoemission spectroscopy (ARPES) and density functional theory.

Studies of a $Fe_{1+x}Te_{1-y}S_y$ superconductor revealed a presence of a flat band located at 3–5 meV above the chemical potential (μ), which covers about 3% of the Brillouin zone volume. It is an evidence of Van Hove singularity. ARPES measurements in different geometries delivered constraints for the orbital characters of the bands in $Fe_{1+x}Te_{1-y}S_y$. It is proved experimentally that the character of the flat band is d_z^2 in the Γ point, while LAPW+LO calculations for undoped FeTe do not show d_z^2 orbital characters close to the Fermi energy.

An interesting behavior of Ni doped $Fe_{1+x}Te_{1-y}Se_y$ motivated us to investigate its electronic structure. We found that Ni doping shifts μ upwards, decreases the hole-like Fermi surface volume near the Γ point and possibly leads to a Lifshitz transition, when the inner hole pocket band is displaced below μ. The situation for electron pockets at the M point is not clarified. However, we can conclude that Ni doping should increase the electron count and lower hole concentration in the system.

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Unconventional superconductivity state in iron-based materials – specific heat study

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In the BCS conventional superconductors, the Cooper pairs have zero total momentum. On the other hand, in strong magnetic fields and very low temperatures, a phase with nonzero total momentum can be preferred by the system. This hypothetical phase was put forward by two independent groups: Fulde and Ferrell, and Larkin and Ovchinnikov both in 1964 [1,2]. Only in the last decade, systems meeting the right conditions for an experimental verification of this phase have appeared, such as the heavy fermion systems, organic and iron-based superconductors [3,4].

In experiments on the ordered phases (such as superconducting or magnetic), measurements of the anomalies in the specific heat C are one of the most sensitive tools [5]. In this presentation, we show a proposal for an experimental signature of the FFLO phase in multi-band iron-based superconductors [6]. Moreover, we will show the versatility of this method applied to a one band system plagued by finite size effects [7].

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Quantum size effect on FFLO state in superconducting nanostructures

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We study the Fulde-Ferrel-Larkin-Ovchinnikov (FFLO) phase in metallic nanostructures and examine its interplay with the quantum size effect. For metallic nanofilms we demonstrate that the range of the magnetic field for which the FFLO state is stable oscillates as a function of the film thickness. The multiband effects lead to a division of the FFLO phase stability region into subregions number of which depends on the number of bands participating in the formation of the paired state [1]. We also consider the case of a metallic cylindrical nanowire and demonstrate that the orbital effect, which so far has been regarded as detrimental to the FFLO phase formation, can in fact induce the nonzero-momentum paired state [2]. Namely, in the external magnetic field the two-fold degeneracy with respect to the orbital magnetic quantum number is lifted, what leads to a Fermi wave vector mismatch between the subbands with opposite orbital momenta in the paired state. This mismatch can be compensated by the nonzero total momentum of the Cooper pairs results in the formation of the FF phase. With the increasing magnetic field a series of FF stability regions appear, in between which the standard BCS superconducting phase is stable.

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Application of high temperature superconductivity in MagLab Tallahassee FL

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Thirty years after the discovery of high temperature superconductivity (HTS), its nature remains unclear while practical applications are rather sparse. It seems, however, that at least in the applications area some groundbreaking progress is observed. In particular, construction of high field low temperature HTS electromagnets for research seems to be very close to reality. All-superconducting (YBCO tape +Nb_3Sn +NbTi) 32 tesla magnet for users has just reached 27 T and awaits for remaining segments. A small YBCO coil added 4.5 T to the 31 T resistive magnet background produced a total record field of 35.5 T showing feasibility of an even higher field. In parallel we work on a different approach: all-YBCO no-insulation magnet constructed in SuNAM Korea reached 26 T. We work also on magnets for nuclear magnetic resonance (NMR) based on BISCO 2223 and 2212 wires. Although scientific magnets are not the most popular things in life, success in this area may increase confidence in large-scale applications, such as electricity generation, transmission, machinery etc. Other potential applications we work with are HTS circuits for US Navy ships demagnetization, and trapped field in bulk YBCO. The latter project with Univ. of Cambridge and Boeing Corp. – resulted in the world record of 17.6 T trapped field in ~ 30 K with potential applications in suspension, NMR, neutron and X-ray spectroscopy. I will also talk about our work on superconducting wires, tapes and cables including broad characterization and studies on pinning mechanisms. If time permits, I will also review our intensive research on iron-based superconductivity in NHMFL.

Effect of reduced grain size on charge ordering and exchange bias in (Sm,Ca,Sr)MnO_3 manganites

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Magnetic studies of nanoparticles (NPs) with reduced grain size are exciting since properties of the particle core differ significantly from those of the shell and core-shell interaction leads to unexpected effects.

The narrow-bandwidth $Sm_{1-x}Ca_xMnO_3$ exhibits a highly distorted perovskite $GdFeO_3$-type structure that is favorable for the charge localization but detrimental for double exchange interactions. With decreasing particle size from 60 to 15 nm for $Sm_{0.43}Ca_{0.57}MnO_3$ and from 80 to 20 nm for $Sm_{0.27}Ca_{0.73}MnO_3$, the relative volume of the ferromagnetic (FM) phase increases monotonously, while the CO phase progressively weakens and disappears completely in $Sm_{0.43}Ca_{0.57}MnO_3$ NPs of average 15 nm particle size.

The exchange bias field and the coercive field of $Sm_{0.1}Ca_{0.9}MnO_3$ NPs depend in a non-monotonic way on cooling magnetic field, while the asymmetry of remanence magnetization increases monotonously with the increase of cooling field.

The basically AFM electron doped manganite $Sm_{0.1}Ca_{0.6}Sr_{0.3}MnO_3$ in the ground state exhibits a heterogeneous spin configuration consisting of the *C*-type AFM phase with the Néel temperature $T_{N-C} \approx 150$ K, the *G*-type AFM phase with the Néel temperature $T_{N-G} \approx 70$ K, and a FM-like phase with very weak spontaneous magnetic moment. The phase separation, into two different AFM phases and a FM-like phase at the temperatures below T_{N-G}, leads to unusual magnetic properties.

Functional complex oxide nanostructures

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Complex oxide heterostructures demonstrate fascinating physical properties such as high temperature superconductivity, ferro- and antiferromagnetism, ferroelectricity, multiferroicity and even strong spin orbit interaction. Progress in oxide thin film deposition method allows to integrate these materials with different electric properties in complex oxide heterostuctures.

The combination of superconducting, magnetic, ferroelectric, mutiferroic and strong spin-orbit interaction material (e.g. ferroelectric-strong spin orbit interaction, superconducting-multiferroic, ferromagnetic-ferroelectric) in one artificial hetrostructure allows to design new nanostructures with novel functionalities.

Here we describe properties of $BaTiO_3/La_{0.7}Sr_{0.3}MnO_3$, $YBCO/La_{0.7}Sr_{0.3}MnO_3$, $YBCO/BiFeO_3$ and $SrIrO_3/BaTiO_3$ heterostructures deposited on different substrates by means of high pressure sputtering method. Transport and microstructural analysis will be presented.

Magnetic field induced superconductor to dirty metal transition in Si/Nb/Si trilayers

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It is well established that upon the reduction of the thickness of superconducting film the film resistance increases and the superconductivity is suppressed. In addition, in strongly-disordered thin films the external magnetic field induces superconductor-insulator transition (SIT). However, there exists a large class of weakly disordered materials, in which the presence of magnetic field leads to a state of disordered („dirty") metal, not to an insulator. In this work we examine the nature of such a transition in thin niobium films.

The Nb films, in a form of Si/Nb/Si trilayers, with Nb thickness *d* varying from 50 nm down to 1.1 nm, and a fixed Si thickness of 10 nm, are grown by magnetron sputtering. As *d* is reduced, the structure of the films changes from polycrystalline to amorphous, and the Hall coefficient evolves from positive to negative [1]. In the presence of the external magnetic field a crossing point of the resistance isotherms, characteristic for a SIT transition, is observed. However, the detail magnetoresistance and *I-V* measurements reveal that the transition proceeds to the state of „dirty" metal.

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Nadprzewodnictwo w związkach międzymetalicznych lutetu

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Metaliczny lutet wykazuje własności paramagnetyczne do najniższych temperatur, jednak pod ciśnieniem 45 kbar przechodzi w stan nadprzewodzący z temperaturą krytyczną 0.022 K. Własności nadprzewodzące związków lutetu są dotychczas słabo zbadane, co w dużej mierze związane jest z faktem, iż temperatury krytyczne są rzędu mK lub kelwinów. W referacie zaprezentowane zostaną wyniki dla nowoodkrytego nadprzewodnika LuSnGe [1]. Uzyskane wyniki zostaną porównane z danymi dla innych związków lutetu. Związek LuSnGe krystalizuje w rombowej strukturze (grupa przestrzenna *Cmcm*). Zależność temperaturowa namagnesowania, oporu elektrycznego oraz ciepła właściwego wykazały, że w temperaturze 0.74 K następuje przejście do stanu nadprzewodzącego. Badania w zewnętrznym polu magnetycznym wykazały, że jest to nadprzewodnik II rodzaju z krytycznymi polami $B_{C1} < 8$ mT i $B_{C2} \approx 40$ mT. Wyznaczone wartości londonowskiej długości wnikania $\lambda = 2.83 \cdot 10^{-5}$ cm^2 oraz długości korelacji $\xi = 0.91 \cdot 10^{-5}$ cm^2 dają wartość parametru Ginzburga–Landaua $\kappa_{GL} = \lambda/\xi = 3.12$ potwierdzający nadprzewodnictwo II rodzaju.

Uzyskane wyniki porównano z właściwościami innych związków lutetu. W związkach tych można wyróżnić dwie grupy różniące się wartościami temperatur krytycznych. Do pierwszej należy zaliczyć związki z wysokimi wartościami temperatur krytycznych np. $LuNi_2B_2C$ (T_c = 16.5 K), $Lu_2Fe_3Si_5$ (T_c = 6.1 K), $LuMn_6X_8$ X = = S (2 K), Se (6.2 K). Własności tych związków są dobrze zbadane, co umożliwia wyciągnięcie informacji o przyczynach wystąpienia stanu nadprzewodzącego. Drugą grupę np. $LuPd_2Si_2$ tworzą związki o niskich temperaturach krytycznych (0.67 K). Porównanie własności tych grup może być pomocne przy poszukiwaniu nowych materiałów o własnościach nadprzewodzących.

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Fault current limitation by 2G HTS superconducting transformer – experimental investigation

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Transformers represent one of the oldest and most mature elements in a power transmission and distribution network. The new superconducting transformers are smaller and lighter than conventional ones and they have lower power losses too. Also, the new 2G superconducting tapes with high resistivity in the normal state allow to build transformers with high short-circuit strength. The short-circuit current limiting feature of the superconducting transformer, which is the most important benefit of replacing conventional windings by superconducting ones, provides protection and significantly reduces the wear and tear of circuit breakers and other substation power equipment.

This paper describes the design and experimental investigations results of a model of a 1-phase, 10 kVA superconducting transformer with windings made of 2G HTS tape. A special regard is given to the ability of the device's superconducting winding to limit the short-circuit current, in particular its resistivity in normal state at a temperature of 77.

Superconductivity in U–T alloys (T = Mo, Pt, Pd, Nb, Zr) stabilized in the cubic γ-U structure

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Thermodynamic properties of the orthorhombic α-U phase have been thoroughly investigated, since this phase is stable at room temperature, e.g. it exhibits superconductivity below 0.78 K. The properties of the high-temperature body-centered cubic γ-U phase is much less known, except of a few articles in the 60s reporting that it reveals a superconducting ground state around 2 K.

By using ultrafast cooling (with the cooling rate up to 10^6 K/s) we could stabilize the γ-U phase alloys with a reduced amount of the required T dopant content (T = Mo, Pt, Pd, Nb, Zr). The pure cubic γ-U phase is revealed in the splat-cooled alloys with 15 at.% Mo and Pt doping, while 15 at.% Nb doping yields the γ^0-U phase. In the U–Zr system, higher Zr concentrations (30 at.% Zr) are necessary [1,2].

All U–T splats become superconducting with T_c in the range of 0.6 K – 2.1 K [3,4]. The bulk character of superconductivity can be concluded for some of the splats when comparing specific heat anomaly at T_c with the BCS theory prediction.

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The effect of magnetic history on AC loss minimum in BSCCO-2223 composite tape

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We investigate AC losses in BSCCO-2223 superconducting composite tape due to coaxial AC and DC magnetic fields subjected perpendicular to the plane of the sample tape. Such superposition of magnetic fields leads to the reduction of magnetic losses and appearing so-called „loss valley".

Measurements were provided with a sinusoidally varying magnetic fields at frequency of 31 Hz, amplitudes up to 100 mT and superimposed DC-bias magnetic field up to 50 mT in liquid nitrogen. The effect of electromagnetic „history" on the AC loss minima was revealed. Presented results can be interpreted by existence of „pinned" magnetic field in the volume of superconductor.

Increase of critical currents and peak effect in Mo substituted Y123 single crystals

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Due to high critical temperature (T_c = 93 K) and significant critical current densities ($j_c > 10^{-5}$ A/cm^2) $YBa_2Cu_3O_7$ (Y123) is one of the most promising superconductors for applications at liquid nitrogen temperatures. However, this material exhibits large critical current anisotropy $\gamma \approx 10$ resulting from different pinning strengths of vortices for field oriented perpendicular or parallel to the superconducting CuO_2 planes. Moreover, the intrinsic pinning centers present in Y123 become less effective at higher temperatures due to increasing superconducting coherence length. To enhance pinning force at higher temperatures we have partially substituted Mo for Cu in the chain region of the Y123 crystal structure by creating pinning centers with larger dimension, which have been identified as the dimmers of MoO_6. The size of distortion, which is produced by such Mo_2O_{11} clusters, is close to the superconductor's coherence length near nitrogen boiling temperature. Moreover, these three-dimensional pinning centers are also effective as weakly interacting, randomly distributed extended point-like defects. The results obtained clearly demonstrate that the critical current densities in Y123 can be considerably increased and the anisotropy reduced by novel substitution methods and annealing's, which create intrinsic nano-sized defects in the right setting of the crystals structure.

Referaty – wtorek

Applied superconducting materials

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Electron-phonon coupling is one of the most common interaction in superconducting material ranging from Nb_3Sn, MgB_2, iron-based superconductors and high temperature cuprates such as $YBa_2Cu_3O_{7-\delta}$ and $HgBa_2Ca_2Cu_3O_{8+\delta}$. However an importance of the electron phonon coupling constant λ_{ep} should not be underestimated for characterisation of the electronic properties of superconducting materials, but it is important that the flux quantisation and pinning mechanism are hold responsible for the applicability of the superconducting materials. I will also discuss how the interrelation between critical temperature (as well as irreversibility field) of superconductors together with available cryogenics will play a decisive role in accessibility of applied superconductors.

Superconducting power devices

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The electric energy generated in power plants all over the world is transformed at least three times by transformers in power systems. Despite their high efficiency, power transformer lose represent about 5% of the overall generated energy. Most of those losses occur in copper windings. Attempts to use transformer windings made with low-temperature superconductors (LTS – NbTi) which were carried out in the 1970's, as well as windings made with high-temperature superconductors (HTS-BSCCO) were not successful.

The new possibilities became available after the appearance of second generation HTS conductors (2G HTS) The layer of the superconducting material in the HTS 2G tapes is about 1 μm thick. The base of high resistivity and a thermal stabilizer determine the thickness of the tape (0.05 ÷ 0.10 mm). Such cables can be used in high-power AC devices.

The main reason of small interest in superconducting transformers is the high price of such a device as compared to conventional transformers. The overall capacity of transformers installed in a power network is about 5 times higher than all the power stations which work in all the power systems in the world. The costs of transformers and the power lost in is a substantial percentage of the costs of energy.

More advanced are working on the Superconducting Fault Current Limiters (SFCL) and Superconducting Magnetic Energy Storage (SMES).

Tungsten micro- and nanostructures fabricated with Focused-Beam-Induced-Processing techniques

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Focused-Beam-Induced-Processing (FBIP) techniques are of great interest for fabrication of nanostructures. Superconductor-ferromagnetic in-plane nanocontacts have been created with focused-electron/ion-beam-induced deposition techniques for studies of Andreev Reflection. The experiments have also allowed the determination of the superconducting gap of the W-based nanodeposits grown with focused ion beam [1]. Also circuit repairing and modifications performed with FBIP are of interest for fabrication of microdevices such as ultrasensitive SQUID susceptometer capable of operating over an extremely wide frequency range (0.001 Hz – 1 MHz) at extremely low temperatures (13 mK) and offers new possibilities in the study of thin films or even monolayers of nanosized magnets, and has potential applications in diverse fields such as quantum computing, high-density information storage or on-chip magnetic refrigeration [2].

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Phase diagram of iron-based superconductors tuned by irradiation induced disorder

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Composition–temperature (x-T) phase diagram of canonical iron-based superconductors $Ba(FeAs_{1-x}P_x)_2$ superconductors present fundamental interest for understanding of the mechanism of superconductivity. Upon isovalent substitution of As by P, temperature of spin density wave (SDW) transition decreases and dome of superconducting phase appears. In the region of intersection of SDW transition line with superconducting dome several phenomena attract attention:

- Normal state exhibit non Fermi-liquid behavior.
- Magnetism and superconductivity are supposed to coexist on microscopic scale.
- Putative quantum critical point (QCP) is hidden under superconducting dome.

I will present the investigation by electronic transport and magnetization of the phase diagram under the effect of disorder controlled by energetic particle irradiation. The main results of this work are: (1) Downward shift of entire SDW transition line and extension of linear resistivity vs. temperature region points out to the displacement QCP under the effect of disorder. (2) Significant change of the vortex matter properties can be identified at the crossover from antiferromagnetic to paramagnetic normal state. This may be related to the different nature of the vortex core. (3) Lifshitz type transition at the origin of SDW state is robust against the disorder.

Work realized in collaboration with: Yuta Mizukami, Takasada Shibauchi, fromTokyo University, and Shigeru Kasahara, Yuji Matsuda from Kyoto University, Japan.

Alkali metal intercalated iron chalcogenide superconductors

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Since discovery in 2010 iron chalcogenide superconductors $A_xFe_{2-y}Se_2$ (where A = K, Rb, Cs, Tl/K, and Tl/Rb) have attracted a great attention. This was so significant that according to the „Research fronts 2013" the topic „Alkali-doped iron selenide superconductors" was the number one within the whole physics science. Although the chemical formula is relatively simple, the compounds are showing very complex relationships between the structure, magnetism and superconductivity. In particular it was shown that that the existing iron vacancies order in the structure is linked with a long-range magnetic order. Further, in the $A_xFe_{2-y}Se_2$ single crystals an intrinsic mesoscopic phase separation at temperatures below about 500 K was found. In one of these phases the magnetic order is suppressed and superconductivity appears below the transition temperature $T_c \approx 30$ K. The second phase remains magnetic until the lowest temperatures. Various experimental techniques were used for investigations of the intrinsic phase separation. Results of these studies together with reports concerning synthesis, crystal growth, and structure investigations will be shortly reviewed.

High-temperature superconductivity: history and perspectives

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Obtaining the superconducting critical temperature with the value comparable to the value of room temperature is one of the fundamental objectives of solid state physics. In the paper, we discuss the history of experimental and theoretical discoveries that clearly influenced the development of high-temperature superconducting state physics. With regard to the current and future research, we focus our attention on inducing the superconducting state in cuprates and the compounds rich in hydrogen [1–4].

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Effect of flux-line cutting on thermomagnetic avalanches in hard superconductors

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We have developed a theoretical formalism for studying thermomagnetic avalanches (magnetization jumps) in hard superconductors. The formalism is based on the elliptic flux-line-cutting critical-state model [1] for describing the nonlinear relation between the electrical current density and the electric field, induced inside the superconductor as an external magnetic field is varied either in magnitude or direction. With such a model, the Maxwell equations coupled to the equation of heat diffusion have been numerically solved without using any condition for the critical state instability. Our formalism has been employed to reproduce the remanent-magnetization jumps by a transverse field applied to a NbTi cube. The jumps are due to the sudden reorientation of the magnetic induction inside the superconductor into the direction of the transverse magnetic field. Such a reorientation occurs because of the instability of the critical spatial distribution for the angle of the magnetic induction.

This work was supported by SEP-CONACYT (grants 166382 and 183673) and VIEP-BUAP.

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Justification of the canonical quantization of the Josephson effect

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Quantum devices based on Josephson effect in superconductors are usually described by a Hamiltonian obtained by commonly used canonical quantization. However, this recipe has not been yet rigorously justified. We show that this approach is indeed correct in certain range of parameters. We find the condition of the validity of such quantization and the lowest corrections to the Josephson energy as presented in [1].

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Transition-metal substitutions in iron-based supercoductors

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Doping of carriers by elemental substitution is a very efficient method to induce superconductivity in iron-based superconducting (IBS) systems. A particular type of substitution, that of transition-metal (TM) elements substituted into Fe-site, results in interesting evolution of many system properties, which are not quite well understood yet. While some theoretical models predict that the TM substitutions introduce localized states close to the impurity site, the other studies suggest, instead, that the band modification by these impurities depend on the strength of impurity potential, producing either a rigid band shift (accompanied by carrier doping) in case of week potential, or localized states in case when impurity potential is strong [1].

In this talk I will first review the recent studies on the TM substitutions into IBS systems. Insightful in this respect are angle-resolved photoemission (ARPES) studies of TM doped $BaFe_2As_2$ pnictide compound, which support the idea on the influence of impurity potential on the carrier doping [2]. I will then turn attention to TM substitution of iron chalcogenide system. While the ARPES results for this material are not available, our recent transport studies indicate that effects of impurity-induced localization may occur in this system, affecting strongly the superconductivity [3].

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Magnetism of strained and S-substituted FeTe: DFT study

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Superconductivity in the antiferromagnetically (AFM) ordered FeTe emerges under the Se or S substitution into Te sites in the bulk material and under tensile stress applied to FeTe thin films. The aim of our DFT calculations was to examine correlations between magnetism and superconductivity of FeTe [1–3]. The results reveal AFM double-stripe order with the $(\pi,0)$ wave vector for pure FeTe at ambient pressure, which turns in to the single-stripe order with the (π,π) nesting vector for all superconducting samples. The obtained magnetic transitions are caused by the variations of the average chalcogen position in the unit cell. The analyzed normal-state properties of such systems allow a detection of the well resolved nesting-driven fluctuations only for the superconducting samples, consistent with their AFM ground states. The results indicate that superconductivity is strongly related to fluctuations with the (π,π) nesting vector.

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Discontinuous transition of molecular-hydrogen chain to the quasi-atomic state

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We obtain in a rigorous manner a transition from a stable molecular hydrogen nH_2 single chain to the quasiatomic two-chain $2nH$ tate [1]. We devise the method composed of an exact diagonalization in the Fock space combined with ab initio adjustment of the single-particle wave function in the correlated state. The transition is strongly discontinuous and appears even for relatively short chains, $n = 3 \div 6$. The signature of the transition as a function of applied force is a discontinuous change of the equilibrium intramolecular distance. The corresponding change of the Hubbard ratio U/W reflects the Mott–Hubbard-transition aspect of the atomization. Universal feature of the transition relation to the Mott criterion for the insulator-metal transition is also noted. The role of coupling to the lattice [2] in determining the value of T_C for metallic hydrogen is also estimated.

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Superconductivity in the Anderson lattice model: Gutzwiller wave function solution

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We apply the variational method based on the diagrammatic expansion for Gutzwiller wave function (DE-GWF) to the Anderson lattice model for description of the heavy fermion systems. In the paramagnetic phase the formation of f band out of initially localized states, and high effective masses are obtained [1].

Within this approach, we also propose a microscopic origin of superconductivity as purely driven by strong electronic correlations. The stability of superconductivity against paramagnetism is determined. The nature of superconductivity reflects some of the features observed for heavy fermion superconductors, e.g. leading d-wave symmetry of the order parameter and reasonably low value of the condensation energy [2].

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Does a magnetic phase transition in aluminoborates have a quantum character?

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$RAl_3(BO_3)_4$ aluminoborates (R is a rare earth) are intriguing materials, crystallizing in the trigonal *R*32 structure. The R ions are the only ones owning a non-zero magnetic moment. The aluminoborates show a large magnetoelectric effect, strongly dependent on R. No phase transitions were found in them in the range 300–2 K, thus, the specific heat studies down to 50 mK were performed for the Dy and Tb borates. As the result, at ~ 0.5 K, a phase transition was discovered and interpreted as related to ordering of the *R* magnetic moments. The transition temperature was found to lower under influence of magnetic field applied along different directions. Magnetization studies revealed the magnetization curves typical of ferromagnets, which, in relation with the field-induced lowering of the transition temperature, makes this behavior atypical. The possible explanations of this effect by proximity of a quantum critical point and an influence of quantum fluctuations, as well as by a competition between the dipole-dipole and exchange interactions leading to appearance of a modulated structure will be discussed.

Three localized f electrons in UPd_2Al_3, UGa_2, UGe_2

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UPd_2Al_3 exhibits superconductivity coexisting below T_{SC} of 2 K with the antiferromagnetic state (T_N = 14 K) with substantial U magnetic moment. UGa_2 is unique uranium compound being ferromagnet with T_C = 125 K. UGe_2 is unique uranium compound becoming superconductor from ferromagnet with T_C = 52 K. There is a long debate on the role played by *f* electrons, itinerant or localized, and a number of localized *f* electrons. One of present authors (RJR) has claimed at the very beginning on the existence of three localized *f* electrons, i.e. of the U^{3+} ion in UPd_2Al_3 with crystal-field states, in contrary to strong opposition of the „itinerant" community or of „two-localized-*f*-electrons" community. Recently M. Wysokinski, Abram & Spałek (Phys. Rev. B 91 (2014) 081108R) claim that in UGe_2 **all** *f* electrons are itinerant. Thus, here we put a question why, and if, the situation in UGe_2 is different. Apart, there is a view that a use of the single-ion CF to conducting compounds is errorneous (Klamut, Central Commission BCK-V-0-819/2003). In contrary to reproach of K. Wysokinski (2003) that RJR sees features of the crystal field everywhere even there where they surely do not have large meaning I admit that indeed I search for the crystal field everywhere. I only say that in 2015 many experimentalists see the crystal field very often.

Microscopic model of magnetism in UGe_2: criticalities and realistic parametrization

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We extend our recent microscopic model of the full magnetic phase diagram of UGe_2 [1–3] by including intersite hybridization and *f*-electron hopping. This allows us to model realistically the influence of external pressure on the system behavior. We show that such relatively simple microscopic model, based on the Anderson lattice model, is sufficient to explain a number of experimentally measured phenomena, namely the position of both classical and quantum critical points on the phase diagram and the right sequence of phases when either pressure or magnetic field are applied [4].

Although, our work [1–3] has been principally devoted to the description of UGe_2, it can be also useful for investigation of band ferromagnetism appearing in the Anderson lattice model when applied to other ferromagnetic mixed-valence heavy fermion systems.

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Irreducible Green Functions Method applied to nanoscopic systems

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The equation of motion method (EOM) for Green functions is one of the tools used in the analysis of quantum dot system coupled with metallic and superconducting leads. We investigate modified EOM, based on differentiation of double-time temperature dependent Green functions both after primary time *t* and secondary time *t'*. Our EOM approach allows us to obtain the Abrikosov–Suhl resonance both in the particle–hole symmetric case but also in the asymmetric cases. We will apply the irreducible Green functions technique to analyses the EOM for dot system. This method give a workable decoupling scheme breaking the infinite set of Green function equations. We apply this technique for calculating the density of the states and the differential conductance of single-level quantum dot with Coulomb repulsion attached to two metallic leads (N–QD–N) or one metallic and one superconducting leads (N–QD–SC). Our results are compared with the experimental data and previous calculations.

Probing a fractional Josephson junction with a quantum dot

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We consider theoretically a junction between two topological superconducting wires, mediated by a quantum dot. The wires are modelled by Kitaev chains tuned into topological phase, which possess unpaired Majorana states at their ends. The Majorana states closer to the dot convert into Dirac fermion *d* inside the dot, forming fractional Josephson junction. The dot is additionally coupled to the normal leads. It is also assumed, that when the topological wires are short, the unpaired Majorana end states can hybridize inside the wire forming an extended Dirac fermion f_α. The junction is investigated via electron transport between the dot and normal leads. We discuss the superconducting phase dependence of the spectral density of the dot and its conductance, as well as parity effects induced by the gate voltage acting on the dot. In particular we show the competition between the formation of the fermion *d* inside the dot and fermion f_α inside the wire α. It is manifested by the dependence of the Majorana peak width, arising from unpaired Majorana end state in the wire α', on the hybridization pairing strength inside the wire α. Moreover, the value of this width possesses characteristic 4π periodicity with respect to the change of the superconducting phase difference between the wires. We prove that these unusual features are reflected in the conductance through the dot and suggest the possible experiment to spot the presence of Majorana fermions.

This work has been supported by the National Science Centre under the contract DEC-2012/05/B/ST3/03208.

Referaty – środa

Superconductivity in the holographic World (and the presence of dark matter)

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The AdS/CFT or gauge-gravity duality provides a way to access strong coupling field theoretical problem using string theoretical ideas. After discussing main ideas of the famous anti-de Sitter conformal field theory duality (AdS/CFT) I shall discuss a few examples of the application of these ideas to construct strong coupling equivalent of the Ginzburg–Landau like theory of superconductivity with *s*-wave and *p*-wave symmetry of the order parameter. We are mainly interested in the signatures of the dark matter (as characterized by its coupling α to the ordinary matter) in the measured properties of superconductors like transition temperature T_c, upper critical magnetic field [2], etc. We have found that in the probe limit the effect of α on T_c depends on the symmetry of the order parameter and the gravitational background. In general the modifications are more severe for Yang-Mills *p*-wave model of superconductor than on *s*-wave one or Maxwell vector *p*-wave [3].

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Fractional skyrmions in quantum Hall systems

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We will review the physics of skyrmions in ferromagnetic quantum Hall states of 2D electrons in a high magnetic field. Skyrmions are remarkable topological vortex-like spin structures, carrying electric charge, angular momentum, and massive spin, and their emergence as lowest energy charged quasiparticles in a ferromagnetic ground state causes its spin depolarization. It also supports spin-flip excitations with energies below the single-electron spin splitting (Zeeman gap) which can be probed by (e.g.) Raman spectroscopy.

Skyrmions have also been predicted in ferromagnetic fractional quantum Hall (FQH) systems, such as Laughlin incompressible liquid at the Landau level filling factor $\nu = 1/3$. Understanding of the FQH effect involves various exotic emergent topological particles, such as fractionally charged quasiparticles, composite fermions (CFs), nonabelian anyons, or Majorana fermions. In particular, the incompressibility of the many known FQH ground states results from the formation of essentially free CFs from strongly correlated electrons – through binding quantized vortices of the many-body wave-function as a result of Coulomb interaction in a Landau level.

Fractional skyrmions emerge as topological spin textures in the CF ferromagnets. Owing to different form and reduced energy scale of effective CF interaction, the hypothetical fractional skyrmions are fragile objects, suppressed by even fairly weak Zeeman effect.

We predict (theoretically) the existence of minimal fractional skyrmions in the excitation spectrum near $\nu = 1/3$, and argue that they have recently been detected in Raman scattering experiments [1].

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Coherence and spectral weight transfer in the dynamic structure factor of cold lattice bosons

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Ultracold atoms have been used to create novel correlated quantum phases allowing to address many solid-state physics problems using the quasi-particle concept, which is the foundation of our understanding of many-body quantum systems. For bosons, the simplest kinds of excited states involve two particles and they are connected to the dynamic structure factor $S(\mathbf{q}, \omega)$, measured using Bragg spectroscopy, similarly to the angle-resolved photoemission spectroscopy (ARPES) in solid state physics – a major tool in the study of high-T_c cuprates. Here we show that spectral weight transfer between low and high energies is an intrinsic property of the strongly correlated Bose system in close analogy to the doped Mott-Hubbard electronic insulator. Furthermore, the appearance of sharp coherence peaks in the superfluid phase of the cold bosons closely resembles the formation of sharply defined quasiparticle excitations below T_c in cuprates suggesting an intimate connection between the intrinsic nature of these seemingly different systems.

Referaty – czwartek

Boson-Fermion resonant model for nonconventional superfluids

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We review briefly the properties of a mixture of mutually interacting bosons (bound fermion pairs) and itinerant fermions on a lattice (the boson–fermion model). The boson–fermion (BF) model with resonant interaction is a basic model for superconductivity that has been adopted to explain high-T_c superconductivity and the BCS–BEC crossover in ultra-cold fermionic atomic gases. Several authors have considered the BF scenarios in the investigation of superconductivity mechanism, exploring heterogeneity of the electronic structure of cuprate HTS, especially in the pseudogap phase, either in the momentum space (Fermi arcs model) or in the real space (charge and spin inhomogeneities) [1–5]. Here, firstly, we analyze the BF model with isotropic and anisotropic pairing of extended *s* and $d_{x2\text{-}y2}$ -wave symmetries for a 2D square lattice within the mean field and the Kosterlitz–Thouless scenario. The characteristics of this (hard-core) boson-fermion mixture are determined as a function of position of the local pair level and the total particle concentration. Secondly, the superfluid transition temperature from the pseudogap state and phase diagrams of a 3D and quasi-2D boson-fermion resonant model are computed within a self-consistent T-matrix approach [2,5]. The salient features of BCS–BEC crossovers for various fillings and across the superfluid–insulator transition in the BF model are analyzed. The results are discussed in the context of a two-component scenario of preformed pairs and unpaired electrons for high-T_c superconductors. They are also connected to the resonant superfluidity in cold atomic Fermi gases with a Feshbach resonance.

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Charge order and its connection with the electronic transport in the high-T_c cuprate superconductors

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Charge-density-wave (CDW) correlations within the quintessential CuO_2 planes have been argued to either cause or compete with the superconductivity in the cuprates, and they might furthermore drive the Fermi-surface reconstruction in high magnetic fields implied by quantum oscillation (QO) experiments for $YBa_2Cu_3O_{6+\delta}$ (YBCO) [1] and $HgBa_2CuO_{4+\delta}$ (Hg1201) [2]. Although, the observation of bulk CDW order in YBCO was a significant development [3], it reminded imperative to establish if the pristine electronic transport properties of the cuprates are compatible with such an ordered state. The results of resonant X-ray scattering and the electronic transport measurements on a model cuprate Hg1201 (T_c = 72 K) will be presented [4]. In the measured hole-doping level, both the short-range CDW and Fermi-liquid transport appear below the same temperature of about 200 K. Furthermore, the smaller CDW modulation wave vector observed for Hg1201 is consistent with the larger electron pocket implied by both QO [2] and Hall-effect [5] measurements, which suggests that CDW correlations are indeed responsible for the low-temperature QO phenomenon.

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Phase coherence in the boson-fermion model

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We consider a coupled boson-fermion model in two dimensions, that describes itinerant fermions hybridizing with localized bosons composed of pairs of tightly bound opposite–spin fermions. We trace out the fermionic degrees of freedom and perform a classical Monte Carlo simulation for the effective classical Hamiltonian of boson phases. We find that the fermions not only generate an effective long-range temperature-dependent boson-boson coupling that generates a finite phase stiffness, but remarkably the phase stiffness is considerably more robust than that described by the XY model. Our analysis further shows that the inter-vortex interaction in the effective model is a power law rather than logarithmic as in the XY model. Results for the effctive quantum-classical model are compared to fully quantum simulations based on the Stochastic Green Function algorithm for the original boson-fermion model. Our results are relevant for resonance superfluids in the BCS–BEC crossover regime and also certain aspects of the high temperature superconductivity.

IV–VI semiconductors as topological materials

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In IV–VI narrow-gap semiconductors $Pb_{1-x}Sn_xTe$ and $Pb_{1-x}Sn_xSe$ chemical composition, temperature, and hydrostatic pressure induced band inversion effect is observed with SnTe- and SnSe-rich rocksalt alloys and compounds exhibiting the inverted band ordering at four L-points of the Brillouin zone. In these cubic materials no topological states protected by time-reversal symmetry are expected. Following the theoretical proposal, a new class of topological materials, topological crystalline insulators (TCI), was discovered in IV–VI crystals by angle-resolved photoemission spectroscopy with crystalline (mirror-plane) symmetry warranting the topological protection [1]. In TCI materials the topological transition can be controlled by band gap and crystal distortion engineering [2,3]. Recently, new two-dimensional topological phases were proposed for TCI materials: 2D TCI state in SnTe (001) and quantum spin Hall insulator in SnSe (111) and SnTe (111). New directions in this field are also related to carrier-induced ferromagnetism observed in $Sn_{1-x}Mn_xTe$ and superconductivity found in SnTe and $Sn_{1-x}In_xTe$.

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Kitaev edge modes of topological superconductor

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We consider a two-dimensional superconductor with spin-triplet *p*-wave pairing, which supports chiral or helical Majorana edge modes. For a strongly anisotropic system both chiral and helical edge states are protected by the translational symmetry. The presence of disorder breaks this symmetry, however we still find an algebraic decay of thermal conductance, marking absence of localization. We explain this phenomenon by contrasting the edge modes of the two- dimensional system with the one-dimensional Kitaev chain. We also stress the role of average symmetry present in the system.

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Superconductivity and resonant levels in doped semiconductors

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Resonant levels (RL) may be formed by special impurity atoms in semiconductors, at energies, where in the absence of neighboring atoms a real bound state would be formed. One of the manifestations of RL is a sharp peak of the impurity's density of electronic states at the resonance energy. Recently, RL gained attention as they may significantly improve thermoelectric properties of semiconductors [1,2], which was observed, e.g. for Tl doped PbTe, In doped SnTe or Sn doped Bi_2Te_3. Among other intriguing physical properties, some of these materials exhibit low temperature superconductivity, like PbTe:Tl or SnTe:In. For the case of PbTe:Tl, the charge Kondo effect and negative-U Anderson model have been proposed as an explanation for the occurrence of superconductivity [3]. This, however, requires that Tl is in the mixed valence state, Tl^+ and Tl^{3+},which is not supported by the XANES and EXAFS measurements, as well as contradicts the first principles calculations [1,2]. In present work, using KKR–CPA calculations, we show unusual electronic structure of the „resonant" systems and we try to verify whether the electron-phonon interaction may be strong enough to be responsible for the superconductivity in these systems.

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Putative topological superconductors LuPdBi, LuPtBi and YPtBi; electronic and thermodynamic properties

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We present electronic transport and thermodynamic properties of single crystals of the half-Heusler phases: LuPdBi, LuPtBi and YPtBi having theoretically predicted band inversion requisite for non–trivial topological properties. All three compounds become superconducting below critical temperatures of 1.8, 0.9 and 0.86 K, with zero-temperature upper critical fields of 2.3, 1.1 and 1.7 T, respectively. Although all superconducting transitions are well reflected in the electrical resistivity and magnetic susceptibility data, no corresponding anomalies can be seen in the specific heat, alike reported for related antiferromagnetic superconducting half-Heusler phases. In LuPdBi and YPtBi temperature dependences of the electrical resistivity suggest existence of two parallel conduction channels: metallic and semi-conducting, with the latter making negligible contribution at low temperatures. Their magnetoresistances show weak antilocalization effects in small magnetic fields. In fields above 2 T, the magnetoresistances become linear and do not saturate in fields up to 9 T, where they exceed 200%. The linear magnetoresistance is observed up to room temperature. Below 10 K, it is accompanied by single Shubnikov-de Haas oscillations revealing charge carriers with small effective masses and Berry phases close to 1/2 expected for Dirac-fermion surface states, thus corroborating topological nature of these materials.

Pseudodiffusive transport and magnetoconductance of bilayer graphene Corbino disk

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Using the transfer matrix in the angular momentum space we investigate the impact of trigonal warping on magnetotransport and scaling properties of a ballistic bilayer graphene in the Corbino geometry [1]. Although the conductivity exhibits a one-parameter scaling [1–3], the shot noise characteristics, quantified by the Fano factor F and the third charge transfer cumulant R, remain pseudodiffusive. This suggests that the pseudodiffusive transport is not defined based on the universality of conductance.

The effect of enhanced conductance due to the trigonal warping is maximized at a magnetic field B_{res} proportional to the skew interlayer hopping integral and inversely proportional to the size of the system. Above the critical field B_{res} the average magnetoconductivity asymptotically drops along with the magnetic field as B^{-1}, approaching the pseudodiffusive value $\sigma = 8\mathrm{e}^2/\mathrm{h}$. The conductance as well as higher charge transfer cumulants exhibit oscillations with beats of a period proportional to $(B/t_0)^{1/2}$ which can be utilized as a way of estimating t_0. In the high field limit the interference effects predicted for $t_0 = 0$ [4] should emerge once again.

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Chemical pressure effect in $SmNiC_2$

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A series of $Sm_{1-x}Ln_xNiC_2$, where Ln = La and Lu, were synthesized by arc-melting method and annealed for 2 weeks at 850°C. Powder x-ray diffraction was used to analyze sample purity and the lattice parameters were calculated using LeBail refinement method. Physical properties were measured by means of magnetic susceptibility, electrical resistivity and heat capacity.

$SmNiC_2$ is a ferromagnet with relatively high Curie temperature (T_C = 17 K). Since Sm is located almost in the middle of the lanthanides, it gives unique opportunity of chemical doping by large La as well as small Lu metal. This way increase (La doping) or decrease (Lu doping) in the unit cell volume is expected, which might be seen as negative or positive „chemical" pressure.

The phase diagram reveals a sudden decrease of the charge density wave formation temperature (T_{CDW}) from 150 K for $SmNiC_2$ to 55 K for $Sm_{0.75}La_{0.25}NiC_2$. The Curie temperature decreases with both La and Lu substitution in $Sm_{1-x}Ln_xNiC_2$. Interestingly ferromagnetism is observed for $Sm_{0.13}Lu_{0.87}NiC_2$ and Curie temperature T_C = 3.5 K was estimated from the Arrot plot. Further increase of La reveals superconductivity and the highest $T_{sc} \sim$ 3K is obtained for pure $LaNiC_2$.

Superconductivity in the presence of disorder in skutterudite-related La-based compounds

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The effect of atomic disorder on superconducting properties has inspired a great deal research, with discovery of unconventional superconductivity in heavy fermion compounds and associated quantum critical behavior. There are known strongly correlated superconductors that show evidence of nanoscale disorder, meaning that the sample exhibits electronic inhomogeneity over the length scale of the coherence length. Such substantial nanoscale electronic disorder is typical, e.g., for $PrOs_4Sb_{12}$ [1], $CePt_3Si$ [2] or $CeIrIn_5$ [3]. Our investigation of the filled cage superconductors $La_3M_4Sn_{13}$ with M = Rh and Ru have shown evidence of two superconducting phases; an inhomogeneous superconducting state below T_c^* and the „normal" superconducting phase below $T_c < T_c^*$ [4], while the T_c^* effect is not observed in $LaCo_4Sn_{13}$. We present a comprehensive thermodynamic and high pressure electrical resistivity study of these new materials to explain the superconductivity in the presence of disorder.

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Electrical conductance in charge-density-wave phases

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We analyze electrical conductance of strongly correlated electron systems in ordered phases. Using the Dynamic Mean Field Theory (DMFT) formalism we find rigorously the temperature dependent Density of States (DOS) at half filling in presence of both local (on site coupling U) and non-local (intersite coupling V) interactions.

At $T = 0$ the system is ordered to form the checkerboard pattern and the DOS has the gap Δ at the Fermi level E_F. With an increase of T the DOS evolves in various ways that depend on U and V. In particular, for $V = 0$ and $U > U_{cr}$ the gap persists for any T. However, if $U < U_{cr}$, two additional subbands develop inside the gap. They become wider with increasing T and at a certain temperature T_{MI} they join with each other at E_F. Since above T_{MI} the DOS is positive at E_F, we interpret T_{MI} as the transformation temperature from insulator to metal.

Having calculated the temperature dependent DOS we study thermodynamic properties of the system starting from its free energy F. Then we find how the order parameter d and the gap Δ change with T and we construct the phase diagram, where we display regions of stability of four different phases: ordered insulator, ordered metal, disordered insulator and disordered metal (see Ref. [1]).

Finally we calculate *dc-conductivity* and show that its temperature dependence is not typical, as it increases with temperature in the metallic phase.

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Charge-orderings with insulator–metal transition in the infinite dimensional extended Hubbard model

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Charge orderings are relevant to a broad range of important materials, including manganites, cuprates, magnetite, several nickel, vanadium and cobalt oxides, heavy fermion systems (e.g. Yb_4As_3) and numerous organic compounds [1–5]. We present studies of the extended Hubbard model with both (i) the effective on-site interaction U and (ii) the intersite density-density interactions W (nearest-neighbors and next-nearest neighbors). In the analysis of the phase diagrams and thermodynamic properties of this model we have adopted the approaches, which treat the on-site interaction term exactly and the intersite interactions within the mean-field approximation [2–5]. We studied the finite bandwidth limit of the model using diagonalization method by Lanczos algorithm within the dynamical mean field theory [1–3]. Our investigation of the general case show that, depending on values of the interaction parameters and electron concentration/chemical potential, the system can exhibit not only several homogeneous charge ordered metallic and insulating phases, but also various phase separated states.

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From magnetism to superconductivity in iron compounds: Mössbauer spectroscopy studies

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Interplay between magnetism and superconductivity in iron-based parent compounds and superconductors is to be discussed in light of the Mössbauer spectroscopy results.

Iron arsenide FeAs develops antiferromagnetic transversal incommensurate spirals with the hyperfine field varying along the spiral in a fashion resembling 3*d* symmetry. The reason for that is a competition between localized covalent coupling of spins and itinerant magnetism. Upon transformation into layered structure like $BaFe_2As_2$ one obtains incommensurate longitudinal spin density wave (SDW) within Fe–As layers. Layered compounds could be transformed into superconductors varying electron density close to the Fermi level and varying distance between layers. Superconductivity is accompanied by the loss of the iron magnetic moment. Optimally doped „122" superconductor $Ba_{0.6}K_{0.4}Fe_2As_2$ (T_{SC} = 38 K) exhibits a modulation of the charge (electron) density which leads to the development of charge density wave CDW (nematic order) and what is more to the modulation of electric field gradient EFG. The charge modulation is sensitive to the superconducting transition, so distribution of the „covalent" electrons is perturbed by the itinerant electrons forming Cooper pairs.

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Hydrostatic pressure enhanced superconductivity in $Eu(Fe_{0.81}Co_{0.19})_2As_2$

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$Eu(Fe_{0.81}Co_{0.19})_2As_2$, belonging to the widely investigated Fe-based superconducting family, was previously shown to be a superconductor with multiple phase transitions [1,2]. At reduced temperatures, $Eu(Fe_{0.81}Co_{0.19})_2As_2$ undergoes a Spin-Density Wave transition at $T_{SDW} = 80$ K, then orders antiferromagnetically at $T_N = 16$ K and finally, below $T_c = 5.5$ K, reaches the superconducting region. However the most remarkable property of this compound is Field Induced Superconductivity, where the T_c can be increased up to 7 K by applying an external magnetic field.

In this contribution we will focus on the physical properties of $Eu(Fe_{0.81}Co_{0.19})_2As_2$ measured under hydrostatic pressure. Our measurements show, that *via* hydrostatic pressure it is possible to enhance the T_c. Moreover, by the simultaneous application of both hydrostatic pressure and an external magnetic field, the T_c was further increased up to about 10 K.

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Evolution of the transport properties of doped iron chalcogenide $FeTe_{0.65}Se_{0.35}$

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We describe the study of the *ab*-plane resistivity and Hall effect in $Fe_{1-y}M_yTe_{0.65}Se_{0.35}$ single crystals with M = Co or Ni, and y up to 0.2 [1]. In case of each dopant two types of crystals, with different crystalline quality, are prepared by Bridgman's method using different cooling rates, fast or slow [2]. The low-temperature Hall coefficient R_H changes sign to negative for crystals with y exceeding 0.135 (Co) and 0.06 (Ni), consistent with the electron doping induced by these impurities. However, the R_H remains positive for all samples at high T, suggesting that remnant hole pockets survive the doping, but the holes become localized at low T in heavily doped crystals. Superconducting transition temperature (T_C) approaches zero for y = 0.14 (Co), and 0.03 (Ni), while the resistivity at the T_c onset is only weakly affected by Co doping, but it increases strongly for the Ni. These results suggest that in case of Co impurity the T_c suppression may be attributed to electron doping. On the other hand, the Ni substitution, in addition to electron doping, induces strong localization effects at small impurity contents. Remarkable differences between the transport properties of slow and fast-cooled crystals are also observed, and will be discussed.

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Superconducting properties of iron selenides intercalated with bulky molecular spacers

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Single crystals of alkali metal intercalated iron chalcogenides manifest reversible nanoscale phase separation at low temperatures which affects their superconducting properties. The observed phase separation is difficult to be controlled during synthesis when conventional high temperature crystal growth is used but can be avoided by employing „soft chemistry" low temperature solvothermal methods. Already the first attempts realized in solutions of alkali metals in ammonia resulted in a whole list of compounds with significantly improved $T_c \sim 40 – 46$ K, but with limited superconducting volume fractions between 0.5 and 30%. Further developments enabled synthesis of intercalated materials with nearly 100% shielding fractions. The solvothermal approach gives the unique opportunity for a subtle tuning of the superconducting properties of layered iron selenides by a change of the type and amount of the co-inserted organic guest molecules. At present the adducts of alkali metals and ammonia, lithium amide or both of them, pyridine, ethylenediamine and hexamethylenediamine were investigated. All of them show a clear enhancement of the critical temperature accompanied by a large expansion of the tetragonal unit cell compare to the parent compound.

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Superconducting fault current limiters for the electric power system

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Superconducting fault current limiters (SFCLs) are the most attractive devices for the power network, because limiters can be used to limit the short current in electrical network [1,2]. The operation of a SFCL is based on the sudden transition from the superconducting state to the normal state by exceeding the critical current I_c of the material. This transition from the superconducting to the normal state take a very short time, so fast that we are able to limit the first current peak to a threshold value which not exceed three to five times the rated current. These limiters use the variation of resistivity during the transition. The rapid increase of resistance and impedance of the SFCL reduces the short current in the circuit.

This paper presents the design and the calculated electrical parameters of the medium voltage class SFCL prototypes made in Electrotechnical Institute. The coreless superconducting fault current limiter consists of three windings: a primary and secondary windings made of SF12050 tape and a parallel connected primary copper winding. All windings are inductively coupled and intended to work in liquid nitrogen.

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Referaty – piątek

$Ln_4Fe_2As_2Te_{1-x}O_4$ (Ln = Pr, Sm, Gd): Superconducting properties and structure

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In the frame of our studies new family of high T_c pnictides superconductors has been synthesized. Single crystals and polycrystalline samples of $Ln_4Fe_2As_2Te_{1-x}O_4$ (Ln = Pr, Sm, Gd) have been grown under high pressure of 3 GPa at 1400–1500°C. In as grown undoped crystals T_c = 25 K has been determined by magnetic and resistivity measurements. As result of fluorine doping T_c of crystals or polycrystalline samples increased up to 45 K for $Gd_4Fe_2As_2Te_{1-x}O_{4-y}F_y$ and 40 K for $Sm_4Fe_2As_2Te_{1-x}O_{4-y}F_y$. The structure consists of the alternating Fe_2As_2 and Pr_2O_2 layers in the *c* direction separated by tellurium atoms. It has close resemblance to the LnFeAsO structure. Lattice constants *a* and *b* are slightly larger (by = 0.04 Å) while *c* is considerably larger (by = 21.3 Å). The Te site reveals about 10% of vacancies, which can be source of doping in as grown crystals without intentional doping. Electrical resistivity has been measured on FIB shaped crystals in magnetic fields up to 16 T. The H_{c2} anisotropy γ = 16 near T_c is larger than γ = 7 for Ln 1111 and decreases at lower temperatures.

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First superconducting itinerant ferromagnet Y_9Co_7

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This paper presents a review of the experimental results [1–3] and the electronic band structure calculations [3,4] of Y_9Co_7 which proof the intermetallic compound is the first very weak itinerant ferromagnetic superconductor [5]. Recently, the specific heat, magnetization measurements and electrical transport properties of the compound were reinvestigated through careful low-temperature measurements performed on one and the same high-quality polycrystalline sample [1].

Several electronic quantities and parameters characterizing the superconducting and normal state were calculated within the Ginzburg–Landau–Abrikosov–Gorkov theory [2]. The data reveals clean limit superconductivity in Y_9Co_7. A few other results are also shortly reviewed and discussed with special attention on ultraviolet photoemission spectroscopy and their comparison with our band structure calculations [3].

The results show the local coexistence of a weak itinerant ferromagnetic order with a Curie temperature of $T_C \approx 4.5$ K and BCS-like superconductivity below $T_S \approx 2.95$ K [1,2].

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Constructive feedback of the superconductivity on the Kondo state in quantum dots

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The strongly correlated quantum impurity deposited on interface between the metallic and superconducting reservoirs absorbs the electron pairing that substantially affects the many-body Kondo effect. Interplay between the correlations and such proximity induced pairing can broaden the Kondo resonance upon increasing a coupling to the superconducting reservoir. We explain this effect within the Anderson impurity model, generalizing the Schrieffer-Wolf perturbative approach and using the numerical renormalization group calculations. We provide evidence that the Kondo resonance broadening is due to the quantum phase transition and propose experimental methods for verifying this counter-intuitive behavior.

Superconductivity in the t-J-U-V model: Gutzwiller wave function solution

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The stability of the d-wave superconducting phase is analyzed within the t-J-U-V model on the square lattice with electron transfer amplitudes between the nearest and next nearest neighbors. The results have been obtained with the use of the diagrammatic expansion Gutzwiller wave function (DE–GWF) method [1,2], which is numerically very efficient and allows for a detailed analysis of the phase diagram as a function of relevant parameters (such as U, V, J, δ). The contribution to the condensation energy originating from particular terms of the Hamiltonian are studied for different values of the band filling. Also, the calculated nodal Fermi velocity is compared with the experimental data corresponding to the cuprate superconductors.

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Strongly-correlated corner-shared networks of 3*d* transition metal and oxygen

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Transition metal (M) oxides forming 3-dim and 2-dim corner-shared networks build of the MO_6 octahedra exhibit some of the most spectacular physical properties known, which are derived from strong correlations among charge, spin and orbital degrees of freedom of the 3*d* electrons. I will review some of these characteristics in perovskites AMO_{3-d} starting from the ferroelectric M = Ti (d^0), colossal magnetoresistive and multiferroic M = Mn (d^3 and d^4), superconducting M = Cu (d^9). I will use a simple description of these materials based on the crystal field theory, which allows development of the essential parameters describing properties and establishing design rules for predicting new properties and designing new compounds. The unique properties of perovskites arise from their unusual chemical versatility and structural intricacy, which can be tailored through selection of specific A-site cations, their fractions, ionic sizes and valences, spin states, and electronic orbital orderings, as well as the content and vacancy ordering of oxygen. Perovskites exhibit unique oxygen non-stoichiometry, which can be used to sensitively vary the valence state of transition metals and, as such, control the properties; for example, T_c in high-temperature superconductors. However, oxygen non-stoichiometry can be also used to tune the ionic sizes of transition metals at the synthesis temperature to produce novel perovskites or to extend solubility limits of known materials with useful properties. I will show how these methods can be used to obtain remarkable perovskite and hexagonal manganites.

Emergent states in the Kondo insulator $CeOs_4As_{12}$

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In materials where the Kondo effect is particularly strong, a dense lattice of magnetic moments and conduction electrons form a coherent narrow band that gives rise to several unusual properties such as heavy-fermion superconductivity. In a few cases, however, highly renormalized *f* electrons, hybridized with conduction electrons, form a completely filled band of quasiparticles with excitation gap in the millivolt range.

The filled skutterudite $CeOs_4As_{12}$ is a rare example of a so-called Kondo insulator. For this cubic 4*f*-electron compound, the electrical resistivity increases by more than two orders of magnitude upon cooling below about 130 K. Remarkable that an applied magnetic field (up to $B = 14$ T) strongly reduces the resistivity leading to metallic behavior at $T < 3$ K. These observations together with a magnetic-field-induced anisotropy of insulator-metal transition show that the ground state of $CeOs_4As_{12}$ arises from hybridization between the conduction and 4*f* electrons.

However, in striking contrast to the Kondo effect scenario that predicts a closing of the hybridization gap in finite fields, we have observed a lowering of the electronic specific heat towards zero values in the limit $T = 0$. This unusual behavior may point at a formation of topologically nontrivial states in $CeOs_4As_{12}$ which were indeed suggested by some theoretical considerations.

In collaboration with R. E. Baumbach, Ł. Bochenek, M. Gutowska, Z. Henkie, M. B. Maple, A. Szewczyk, and R. Wawryk.

The coexistence of superconductivity and charge density wave in $LaCu_{1-x}Ag_xSb_2$

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The coexistence and/or interplay between superconductivity (SC) and collective effects are ones of intriguing issues in condensed matter physics. This is because non-phononic mechanism and the existence of exotic electron pairing may frequently occur in coexistent states. The intermetallic $LaCuSb_2$ and $LaAgSb_2$ compounds, both crystallizing in the tetragonal $ZrCuSi_2$-type structure (space group *P*4/*nmm*), but they do exhibit distinct ground states. The first compound was reported to be superconducting below 0.9 K [1], while the latter without superconductivity and shows two charge density wave (CDW) transitions at 207 K and 185 K [2]. In order to look for the coexistence of SC and CDW order we grown single crystals of $LaCuSb_2$, $LaAgSb_2$ and $LaCu_{0.55}Ag_{0.45}Sb_2$ and measured specific heat and electrical resistivity. The obtained results have revealed that the CDW state occurs in $LaCu_{0.55}Ag_{0.45}Sb_2$. We observe CDW transitions at 200 K and 167 K, accompanied by very large thermal hysteresis. The $LaCu_{0.55}Ag_{0.45}Sb_2$ does show superconductivity also below T_c = 0.56 K, being a little lower than that of our $LaCuSb_2$ of 0.93 K. Some basic thermodynamic parameters describing superconducting and normal states in the coexisting SC/CDW compound will be presented and compared to those of the parent compounds.

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Superconductivity in (Sc, Y, Lu)V_2Al_{20} cage compounds – – an experimental and theoretical study

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Polycrystalline samples of ternary cage aluminides ScV_2Al_{20}, YV_2Al_{20}, LaV_2Al_{20}, and LuV_2Al_{20} were synthesized using the arc-melting technique. Structural studies using powder x-ray diffraction and Rietveld refinement confirmed the $CeCr_2Al_{20}$-type crystal structure composed of icosahedral Al–R cages and revealed only trace amounts of impurities.

Experimental investigations including magnetic susceptibility, specific heat and resistivity measurements reveal superconducting transition at 0.6, 0.61, and 1.03 K for Lu-, Y-, and Sc-containing sample, respectively. Superconductivity in LaV_2Al_{20} was not observed down to 0.4 K.

Electronic structures of all compounds were calculated. A detailed analysis of electron-phonon coupling based on recently reported phonon calculations for (Sc, La)V_2Al_{20} [1] allows to calculate the T_c of ScV_2Al_{20} with excellent agreement with experimental data and explains the lack of superconducting transition in LaV_2Al_{20}.

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Nonlocal Andreev reflection in three-terminal hybrid devices

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We generalize Büttiker formalism [1] to probe the competition between normal electron transfer (ET) and crossed Andreev reflection processes (CAR) in a three terminal hybrid system, composed of a quantum dot (QD) tunnel coupled to one superconducting (S) and two normal reservoirs [2]. For sufficiently strong coupling to S electrode the relevant non-local resistance changes sign from the positive (dominated by ET) to the negative (dominated by CAR) value with an increase of driving voltage. We show that amplitude of various local and non-local resistances and even their sign can be easily controlled upon varying coupling to the S electrode and tuning the QD level by an applied gate voltage.

Our theoretical predictions substantially differ from the existing experimental data obtained for three-terminal planar junctions [3] due to the Andreev bound states induced by the proximity effect in the subgap spectrum of the QD.

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Plakaty – poniedziałek

Critical current analysis in fast neutrons irradiated HTc multilayered superconductors

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High temperature oxide superconductors characterized by the multilayered crystal structure are very promising materials from the applied point of view. Successful application of these materials in power devices as cryocables, electromagnets is however strongly dependent on their transport current capacity. Critical current is in fundamental way related to the pinning interaction of pancake vortices and capturing centers, created in the superconducting accelerators just by the fast neutrons irradiation. This question will be considered in the paper. It will be given detailed analysis of the pinning potential barrier shape for various kinds of the pinning centers. The pinning force will be then determined taking into account the statistics of the occupation of the fixed number of the nano-defects by pancake vortices of varying with magnetic field concentration. The current-voltage characteristics are then calculated and compared with experimental data measured on Bi-based HTc superconducting sample. Good agreement has been received then between experiment and theoretical model, from which the pinning parameters can be deduced. The interaction between surrounding planes will be in the paper considered too. These considerations concern the case of the current flow in the *a*-*b* planes of the HTc layered superconductors. In the second part of the paper it will be analyzed important case of the current flow in the *c*-axis direction, which is determined by the Josephson's effects. The formation and properties of the intrinsic Josephson's junctions will be considered. Finally short presentation of the model of the high voltage superconducting cryocable constructed by Author, using HTc superconducting tapes, will be given, device very sensitive to above effects. The experiences of the Author during his stay at JINR in Dubna, concerning these topics will be discussed too.

Proximitized NbN/NiCu superconductor/ferromagnet nano-bilayers for single photon detection

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Superconducting single-photon detectors (SSPDs) based on resistive hotspot formation in a superconducting nanostripe upon optical photon absorption are presently regarded as the best high-performance, ultrafast photon counters

One of the possible approaches towards the SSPD performance improvement is modification of a super-conducting material. In our case, we implement superconductor/ferromagnet (S/F) nano-bilayers consisting on nm-thick NbN/NiCu and NbTiN/NiCu films

In our presentation, we discuss structural properties of our S/F bilayers with the main emphasis on the epitaxy of the individual films and the quality of the S-F interface (TEM cross-sections with the atomic-level resolution). Electron transport of patterned bilayers, such as resistance and critical current density dependences on temperature, and current-voltage characteristics, were studied and compared to those of uncovered S layers.

The relief of magnetic induction in hard SC at thermomagnetic avalanches

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We present the results of analysis of magneto-optical images obtaining during developing thermomagnetic avalanches in superconductors (SC). There are some new peculiarities in behavior of magnetic flux.

1. As a result of avalanche, during its entrance (or exit) to the superconductor's volume, paramagnetic (or diamagnetic) circular currents in diamagnetic (or paramagnetic) regions of the SC appear, which determine the local reversal of magnetic induction profile.

2. It was found that the velocity of the avalanche front has a maximum in the initial stage and then decreases oscillating manner with increasing depth of penetration into the SC. The frequency of the oscillation is about 1 kHz, depending on the physical characteristics of the SC.

3. The tilt angle of the profile of the magnetic induction at the front of the avalanche remains constant during the movement of the avalanche, i.e. the critical current of the front does not change.

4. The destruction of the critical state of SC disc due to the thermomagnetic avalanches in the case of magnetic flux trapping occurs with the formation Meissner hole.

Vortex pinning and creep in single crystals BaKFeAs with intrinsic and irradiation-induced disorder

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We investigated vortex pinning and creep on pristine and irradiated optimally doped $Ba_{1-x}K_xFe_2As_2$ single crystals ($x \sim 0.4$–0.6). Miniature Hall sensor array technique was used to measure spatial distribution of the magnetic field on the sample surface and of it evolution with time. Crossover from a strong pining regime by large, nanometer size defects, to a weak collective pinning was observed after introduction of point-like disorder by low-temperature electron irradiation. Irradiation with swift heavy-ions produced correlated disorder and Bose-glass type pining regime with almost field independent critical current and rectangular magnetization loops. Angular variation of magnetic hysteresis implies localization of vortices on heavy-ion induced columnar defects. Importantly, introduction of artificial pinning centers of both types did not suppress the omnipresent and quite substantial at all temperatures flux creep. Analysis of the irreversible magnetization time evolution recorded in a wide range of temperatures allowed determination of current-dependence of the effective energy barrier and identification of the particular flux creep regimes.

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Superconducting niobium cavity for penetration depth and surface resistance measurements

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We present the design of a cylindrical superconducting microwave cavity, working at 19.9 GHz. The TE_{011}-mode niobium cavity, remaining in high vacuum during the measurements, is embedded into a copper enclosure, allowing a cool-down of the entire assembly to 4.2 K. The measured sample is glued on a sapphire rod with a diameter of 2 mm, whose temperature can be independently controlled between 5 K and 100 K.

Microwave measurements are performed by a vector network analyzer (VNA) in the reflection mode, i.e. the S_{11} component of the complex scattering matrix S is measured. Microwaves are supplied to the cavity via a semirigid cable. The loaded Q factor and the shift of the resonance position are measured during a temperature sweep, followed by calculating of the unloaded Q_0 factor and the unloaded resonance frequency f_0 by means of the Kajfez procedure [1]. The values of the superconducting penetration depth λ and of the surface resistance R_s are calculated approximating the single crystal sample by an oblate spheroid of appropriate size, using a procedure described by Klein et al. [2].

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Magnetoresistance and irreversibility fields of bismuth based 1G tape

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The temperature dependencies of magnetoresistance were measured. The critical temperature of the tape was found to be $T_c = 110.2$ K and the narrow transition width to the superconducting state was observed. The width of the transition was defined as follows: $\Delta T = T_{90} - T_{10}$. The magnetic field dependence of the transition width was fitted using the formula: $\Delta T = CH^m + \Delta T_0$. The reversibility fields were calculated and their temperature dependence was discuss within the Ginzburg–Landau strong coupling limit approach.

Thermal fluctuations of YBCO based 2G tape

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The thermal fluctuations of commercial second generation (2G) tape were studied near the critical temperature T_c = 92 K. The detailed analysis of the temperature dependence of resistivity measurements was made in the temperature ranging from the zero resistance critical temperature up to 200 K. Take advantage of these measurements the thermal fluctuations of conductivity were analyzed using Aslamazov–Larkin microscopic approach and the critical exponents were calculated within the transition temperature.

Critical currents and full penetration fields of YBCO based 2G tape

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The critical currents of commercial second generation (2G) tape were obtained by the transport as well as form the a.c. susceptibility measurements using the Bean model. These critical currents were compared with data declare by the manufacturer. The full penetration fields were extracted from the virgin curves of the magnetization measured as a function of the applied magnetic field for several temperatures. The magnetization measurements as a function of the angle between direction of the applied magnetic field and the plane of the tape show shape anisotropy as well as the angle dependencies of demagnetization factor.

Magnetic properties of *c*-axis oriented YBCO thin film

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The *c*-axis orientation $YBa_2Cu_3O_\delta$ thin film was prepared directly on MgO substrate by the pulse laser deposition. The thickness of the film was 170 nm. The superconducting critical temperature was $T_{c50\%} = 89$ K and the width of superconducting transition was $\Delta T = 1.6$ K. The temperature dependencies of magnetoresistance were measured and the reversibility fields were calculated.

Magnetoconductance of $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_x$ bulk superconductor in the fluctuation region

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The temperature dependencies of the magnetoresistance of $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_x$ bulk superconductor were measured near the critical temperature $T_c = 107.1$ K. The thermal fluctuations were studied using the following formula of conductance: $\Delta\sigma = K\varepsilon^{-\lambda}$, where $\varepsilon = T - T_c/T_c$, λ is the critical exponent and K is a constant. The temperature dependence of excess conductivity is defined within the Ginzburg-Landau mean field approximation as:

$$\Delta\sigma = \frac{1}{R(T)} - \frac{1}{R_R(T)},$$

where $R(T)$ is the measured resistivity and $R_R(T)$ is the resistivity obtained by the linear extrapolation of the resistivity data from room temperature down to the onset temperature. The critical exponents in the vicinity of the critical temperature were determined and their magnetic field dependencies were analysed.

Critical current of BiSCCO 2:2:2:3 films on silver substrate

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The $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_\delta$ films were obtained directly on silver substrates by the sedimentation processes. The thicknesses of the films are of the order of several tens micrometers. The temperature dependencies of the a.c. susceptibility of the films were measured and analyzed. The critical current were calculated from the absorption part of a.c. susceptibility using the Bean's model. The temperature dependencies of the critical currents were fitted using the Ginzburg–Landau strong coupling limit approach.

Penetration depth measurements in the yttrium based bulk high-temperature superconductors

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The magnetic field penetration depths of bulk $YBa_2Cu_3O_y$ superconductor with the critical temperature 90 K were determined from the A.C. susceptibility measurements. When the sample is in the Meissner state, the dispersive component of A.C. susceptibility as well as its temperature dependence reflects the changes of the penetration depth at various temperatures. In the ceramic superconductors the penetration depths are the order of a few micrometers and they are comparable to the grains size of the ceramics. The influence of the applied magnetic field on the A.C. penetration depth was studied via the measurements taken for the zero-field-cooled as well as for the field-cooled samples.

Superconductivity and ferromagnetism in $La_{0.67}Sr_{0.33}MnO_3/YBa_2Cu_3O_7$ nanoheterostructures

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Nanosized FM/SC heterostructures are an attractive model system for studying unusual proximity effects and the interaction between magnetism and superconductivity in low-dimensional structures. We report recent results on heterostructures composed of ferromagnetic $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) and superconducting $YBa_2Cu_3O_7$ (YBCO) multilayers. The thickness, number and configuration of LSMO and YBCO layers were changed in a systematic way to modify the nature and intensity of the interaction between the layers. The transport and magnetic properties were investigated in a wide temperature range (2 to 400 K) and in fields up to 14 T. Upper critical field and superconducting critical current densities were measured for as made and by FIB structured samples. We have observed an influence of the magnetic LSMO layer on the superconducting properties of the adjacent YBCO layer and vice versa. The Nernst effect was studied in the mixed state revealing the characteristic temperature dependence of the Nernst signal which seems to be correlated with variation of the upper critical field. The STM images were made to allow proper interpretation of the results.

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Charge modulation in $SmFeAsO_{0.91}F_{0.09}$ superconductor seen by Mössbauer spectroscopy

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The $SmFeAsO_{0.91}F_{0.09}$ belongs to the '1111' family of the iron-based superconductors and exhibits null resistivity below 40 K. A magnetic susceptibility starts to drop from the almost zero value at 40 K, but never reaches ideal diamagnetic state. Mössbauer spectra exhibit singlet broadened by CDW (charge density wave) and EFGW (electric field gradient wave). Hence, some incommensurate electron density modulation occurs for the *s*-states (CDW) and higher angular momentum states (EFGW). Some magnetic spectral broadening occurs below 28 K. The evolution of CDW and EFGW at superconducting transition is quite different in comparison with '122' $Ba_{0.6}K_{0.4}Fe_2As_2$. For the '122' compound the shape of EFGW broadens reversibly and shape of CDW is getting narrower reversibly. Here, one observes the opposite effect i.e. the shape of EFGW is getting very narrow across transition, while the shape of CDW broadens. The shape of either CDW or EFGW is very similar well below and well above transition. It means that the condensate has no influence on the charge modulation while separated by sufficiently broad energy gap. Strong perturbation of EFGW at transition suggests significant contribution of the higher angular momentum states to the superconducting condensate.

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Structural disorder in $A_xFe_{2-z}Se_2$ superconductors studied by Mössbauer spectroscopy

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Two intercalated iron-chalcogenide superconductors $Li_x(C_5H_5N)_yFe_{2-z}Se_2$ (T_{SC} = 40 K) and $Cs_xFe_{2-z}Se_2$ (T_{SC} = 25 K) in the as-prepared and annealed state have been investigated by the Mössbauer spectroscopy. Samples despite showing almost single phase X-ray patterns are in fact multi-phase systems on the microscopic scale. There is a superconducting fraction in the regions of the Fe–Se sheets almost free of vacancies, and magnetically ordered fraction in the regions with (ordered) iron vacancies. Some iron occurs between sheets in the form of the high spin trivalent iron and metallic α-Fe clusters. Hence, one has superconducting and magnetic regions within the same material – spatially separated. In order to obtain superconductivity one needs to order intercalated species by annealing. Larger separation of the Fe–Se sheets as provided by $Li_x(C_5H_5N)_y$ intercalation in comparison with Cs_x leads to increase of the superconducting transition in agreement with the hypothesis of the nearly two-dimensional superfluid density.

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Superconductivity, structural and magnetic phase transition in Ru-doped $CaFe_2As_2$

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A series of polycrystalline samples of $CaFe_{2-x}Ru_xAs_2$ ($0 \le x \le 2$) has been synthesized by solid state reaction. Single crystals of $CaFe_2As_2$ were grown using tin flux technique, and single crystals of $CaFe_{2-x}Ru_xAs_2$ ($0.04 \le x \le 0.10$) were grown by self-flux method using FeAs flux. The crystal structure of $CaFe_{2-x}Ru_xAs_2$ was studied using powder X-ray diffraction. The physical properties were investigated by the magnetic susceptibility and electrical resistivity measurements in the temperature range 2–300 K and in magnetic fields up to 9 T.

It has been found that in the $CaFe_2As_2$–$CaRu_2As_2$ system solid solutions exist over the whole compositional range. The temperature of the tetragonal-to-orthorhombic phase transition in $CaFe_{2-x}Ru_xAs_2$ has been observed to decrease with increasing ruthenium content (x) and simultaneously the antiferromagnetic order (Spin Density Wave) is suppressed. For $x = 0.06$ both transitions have not been observed. For the higher ruthenium content, $x > 0.06$, a transition from the tetragonal (T) to the collapsed tetragonal (cT) form is observed. In the range of $0.02 \le x \le 0.1$ the transitions to the superconducting state have been detected. The largest fraction of superconducting phase is found for ruthenium content $x \approx 0.05 – 0.06$. This is the first observation of superconductivity in this system.

Effect of anion substitution on superconducting properties of hybrid iron selenides

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Iron selenide is well-known superconductor with the simplest layered structure, characterized by critical temperature of about 8 K, that can be relatively easily modified by substitution on anion site or by intercalation of alkali metals, or organic molecular spacers between Fe-Se layers. Anion substitution clearly changes parameters of the unit cell and critical temperature, that can be explained by deformation of FeSe tetrahedron in crystal structure [1]. The intercalation of organic molecular spacer between Fe–Se sheets brings more spectacular results: critical temperature can be enhanced about 4 times in comparison to the parent compound [2]. In this work we have combined both of these modifications and prepared intercalated hybrid materials to study the relation between superconductivity and crystal structure.

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Magnetic and transport properties of topologically nontrivial half-Heusler phases RPdBi (R = Ho, Dy, Gd)

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Several dozen rare-earth containing half-Heusler phases that crystallize in the noncentrosymmetric cubic MgAgAs-type structure have recently been proposed, according to electronic structure calculations, as plausible 3D topological insulators [1]. We have accentuated searching for compounds, which demonstrate unusual fusion of superconductivity, magnetic order and topologically non-trivial electronic state.

Single crystals of half-Heusler compounds RPdBi (R = Ho, Dy, Gd) grown by self-flux method, were studied by means of magnetization, electrical transport and heat capacity measurements in wide ranges of temperature and magnetic field. RPdBi order antiferromagnetically at Néel temperatures T_N = 1.9 K, 3.7 K and 12.8 K, respectively. At temperatures below ≈100 K magnetoresistivity of all compounds is negative and with no sign of saturation in magnetic fields up to 9 T.

Below T_c = 0.7 K the superconductivity was found in HoPdBi. Polarized neutron diffraction on HoPdBi single crystal shows that propagation vector is (½,½,½), which corresponds to theoretical predictions for an antiferromagnetic topological insulator [2]. Shubnikov–de Haas oscillations, with non zero phase factor indicating that HoPdBi may hosts Dirac fermions, were observed at T below 7 K. These findings make HoPdBi a new platform for studing the interplay between superconductivity, magnetic order and topological states.

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The critical parameters (J_c and T_c) of the Ce, Nd oxides and carbon encapsulated in boron doped MgB_2

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The results of the irreversibility field and critical temperature change induced by the 1–3 at.% additions of the cerium and neodymium oxide to the carbon encapsulated boron magnesium diboride cylindrical sample is presented. The cylindrical samples were paced in the Nb foil, the packed of the wrapped samples were then placed inside stainless steel hermetic container and HIP-ed at 1 GPa argon gas pressure at 740°C for 40 minutes. For the comparison of the HIP treated and normal pressure annealed samples the analogical types of the samples have been prepared without the high pressure annealing. All the samples have been prepared, annealed and microstructurally analyzed at the Institute of High Pressure Physics in Warsaw. The measurements of the critical temperature and the hysteresis loop were done at International Laboratory of High Magnetic Fields and Low Temperatures Wrocław, using a vibrating magnetometer (VSM) up to 14 T. We show results critical current density (J_c) and pinning force, XRD and SEM analysis.

Critical current density in undoped MgB_2 wires at 4.2 K and 20 K

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Treatment of hot isostatic pressure leads to increase of density and the number of connections between the grains, creates additional pinning centers, improves the uniformity of superconducting material, allows for smaller grains, reduces the size of the voids. We will present the results of critical current density (J_c), the pinning force density (F_p), and analysis of the (F_p) density. The multicore monel-sheathed type MgB_2 wires manufactured by continuous in tube forming and filling e.g. (CTFF) method by Hypertech Inc. Ohio, USA. Such multicore wires samples of in situ type with Nb barrier and Cu stabilizer with the monel sheaths have been subsequently hot isostatic pressed at Institute of High Pressure Physics at 0.1 MPa – to 1 GPa in argon gas pressure medium at temperatures of 700°C for annealing time 15 min. The critical current measurements have been performed in magnetic fields up to 14 T. The critical temperature was measured using four-probe resistive method using AC current (5 mA, 14 Hz) at International Laboratory of HMF & LT by using PPMS Model 7100.

Electrical transport in copper-doped lithium titanate thin films prepared by sol–gel method

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Lithium titanate is a type-II spinel oxide superconductor with transition temperature $T_c = 13$ K. However above T_c lithium titanate shows metallic behaviour and can be used e.g. as electrodes for rechargeable lithium-ion batteries. Since the discovery of superconductivity in lithium titanate many scientific attention has been devoted to improve the transition temperature by doping by other atoms. Substitution of Ti atoms in lithium titanate by for example Al, B, Cr, Ge, Mn, Ni or V has no effect in enhancement of T_c. Only Cu dopant gives hope to increase of the transition temperature.

In this work, the results of structural and electrical studies of copper doped lithium titanate have been presented. The samples were prepared by sol-gel method. Lithium acetate, butoxytitanium and ethanol were used as the reagents. Additionally copper nitrate was added as a Cu dopant source for preparation of $LiTi_{2-x}Cu_xO_4$. Thin films were deposited on quartz glass substrates by a spin coating technique at a rate of 120 rps and then were calcinated under argon atmosphere at various temperature in a range from 500°C to 600°C for 20 hours.

Crystallization temperature and thermal stability were measured by simultaneous thermogravimetric analysis (TG) and differential scanning calorimetry (DSC) with mass spectroscopy (MS). Electrical parameters were calculated on the basis of impedance spectroscopy method (IS).

La_3Co – superconductivity on the edge of ferromagnetism

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A polycrystalline sample of La_3Co was synthesized by arc-melting of stoichiometric amount of lanthanum (purity 99.9%) and cobalt (purity 99.95%) and annealed at 500ºC for three weeks. We report results of the dynamic and static magnetic susceptibilities, electrical resistivity and heat capacity to characterize its superconducting and normal-state properties. Our measurements confirmed bulk superconductivity ($T_c \sim 4.5$ K) and indicate that La_3Co is a moderately or strong coupling type-II superconductor with $\lambda_{ep} = 0.82$, $\Delta C/\gamma T_c = 1.83$. We estimated upper and lower critical field values to be 3.5 T and 17.6 mT, respectively. Using these values, we calculated a superconducting coherence length $\xi(0) = 10$ nm, a Ginzburg–Landau superconducting penetration depth $\lambda_{GL}(0) = 162$ nm, and the Ginzburg–Landau parameter $\kappa = 16.7$.

Superconductivity in noncentrosymetric $ThIr_2Si_2$

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The thorium-based silicide $ThIr_2Si_2$ crystallizes with an orthorhombic crystal structure of the $CaBe_2Ge_2$-type (space group *P*4/*nmm*) that lacks an inversion center. Its low-temperature physical properties were studied by means of magnetization, electrical resistivity and heat capacity measurements, performed down to 0.35 K in magnetic fields up to 1 T. The compound was found to exhibit bulk superconductivity below T_c = 2.1 K with an upper critical field of about 0.15 T. The experimental data indicates that $ThIr_2Si_2$ is probably a weakly-coupled type-II BCS superconductor.

Superconductivity in YPt_2Si_2

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The RT_2M_2 intermetallic phases (where R is a lanthanide or actinide, T – a transition or noble metal, and M – a *p*-electron element) are known to crystallize in two derivatives of the tetragonal $BaAl_4$-type structure: a non-centrosymmetric primitive one of the $CaBe_2Ge_2$-type (space group P4/nmm) and a body-centered one of the $ThCr_2Si_2$-type (space group *I*4/*mmm*). As shown by Shelton et al. [1], the primitive unit cell consistently favors superconductivity over the body-centered one (at least in experiments performed above 1.1 K). The aim of our work was to examine this relationship between crystal structure and physical behavior in an extended series of Y-, La-, and Th-based RT_2M_2 phases. Here we present preliminary results obtained for YPt_2Si_2.

A polycrystalline button of YPt_2Si_2 was prepared by arc melting. Subsequently, half of it was annealed at 850ºC for one week. X-ray powder diffraction revealed that both the as-cast fragment and the annealed one crystallize with the $CaBe_2Ge_2$-type structure (the lattice parameters for the latter are: a = 4.1594(1) Å and c = 9.8039(3) Å). Magnetic susceptibility, electrical resistivity and specific heat measurements, performed down to 0.35 K, showed that the as-cast sample becomes superconducting below about 1.7 K, while the annealed one at about 1.6 K, in agreement with the previous report [1]. Quantitative analysis of the magnetic susceptibility and specific heat data showed that the superconductivity in YPt_2Si_2 has a bulk character. Experiments performed in magnetic fields revealed that the transition can be suppressed by applying about 0.1 T for the as-cast specimen, and about 0.05 T for the annealed one.

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Superconducting transition in U–Pt and U–Pd alloys

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Using splat cooling technique with the cooling rate of 10^6 K/s we are able to maintain the high-temperature cubic γ-U phase down to room temperature in the U–T systems (T = Mo, Pd, Pt) by 15 at.% T doping. The U–T alloys with T doping in the intermediate range of 5-6 at.% consist of both orthorhombic α-U and cubic γ-U phase.

The superconducting transition in U–6 at.% Mo revealed by a smooth decrease below 1.4 K and a sharp drop at 0.78 K in the resistivity, while a single sharp drop was revealed at T_c = 0.69 K for U–5 at.% Pd and U–5 at.% Pt [1]. With applying magnetic fields, the resistivity drops move to lower temperatures. The critical magnetic fields at zero temperature (m0Hc) is estimated to be about 2 T for those alloys.

The superconductivity transitions were revealed by only one broad peak at T_c in the $C(T)$ curves. The specific-heat jumps are much smaller than the calculated values from the BCS theory. Namely, for U–6 at.% Mo the estimated jump is only around 55% of the BCS value. In the case of U–5 at.% Pt, it is still smaller (22%).

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Superconducting properties of the filled skutterudite compound $LaOs_4As_{12}$

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Among various La-filled skutterudite compounds, $LaRu_4As_{12}$ (T_c = 10.45 K) displays several features that point at two-band superconductivity (TBSC), although the cubic crystal structure does not favour multiple superconducting gaps. A compelling evidence for more than one energy gap holds for (I) a nonlinear-magnetic-field (B) dependence of the specific heat in the zero-temperature limit, (ii) a positive curvature of the $B_{c2}(T)$ dependence, and (iii) a deviation of the electronic specific heat from the one-gap α model [1]. A distinction of TBSC effects is often difficult, particularly when temperature dependences of the quantities are examined. In contrast, B-dependent effects are more often different and thus more often allow a reliable distinction between both phenomena.

Here, we present results of comparative study on closely related $LaOs_4As_{12}$ that has been recognized as conventional one-band superconductor (T_c = 3.2 K) [2]. In particular, we have investigated a B dependence of the electronic specific-heat coefficient, i.e., $\gamma(B)$ in the limit $T = 0$. Owing $B_{c2} \approx 0.7$ T and due to $T = 0.38$ K being the lowest temperature accessible in our experiments, a $\gamma(B)$ dependence can be investigated in a rather narrow field range. However, up to about $B = 0.1$ T we have observed a linear behavior of $\gamma(B)$, indicative of an isotropic s-wave superconductivity in $LaOs_4As_{12}$. Thus, this finding supports TBSC rather than anisotropy effects as a viable cause of the observed anomalies in $LaRu_4As_{12}$ adopting the same filled skutterudite crystal structure.

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Magetoresistance, Kohler's rule and thermopower in the normal-state of $La_{1.85}Sr_{0.15}CuO_4$ doped with Ni

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We present the results of detailed measurements of Hall effect, magnetoresistance (MR) and thermopower in Ni-doped $La_{1.85}Sr_{0.15}CuO_4$ (LSCNO). The transport measurements have been carried out on the thin films of LSCNO, up to $y = 0.08$ Ni content, prepared by the laser ablation method.

Above 20 K, MR is small and positive both when the magnetic field is perpendicular and parallel to the current direction. In the very limited T-region, where resistivity ρ varies approximately as T^2, the orbital MR appears to fulfill „modified Kohler's rule", where the influence of large residual resistivity, ρ_{res}, in LSCNO, is eliminated by replacing resistivity at zero field, ρ_0, with $\rho_0 - \rho_{res}$.

At low temperatures, MR becomes large and negative. The relatively weak field-orientation dependence suggests that negative low-T MR of LSCNO has a spin-related origin.

Doping with Ni ions, known to be strong scattering centers, causes that the inflection point in the $\rho(T)$ curve comes out in the temperature measurement window at T_{infl} and the known „T-linear" resistivity is observed in a limited region of the LSCNO phase diagram. T_{infl} decreases with y, while another characteristic point – the temperature T_θ at which inverse Hall angle, $\cot\theta_H$, deviates from its known T^2 dependence, increases with increasing y. A similar trend – increasing with y – is observed in the y-dependence of temperature at which thermopower S has its maximum. Since the two characteristic temperatures, T_{infl} and T_θ, have the opposite trends vs. Ni doping, they cannot denote the same (pseudogap) energy scale, contrary to the literature suggestions.

Magnetocaloric effect in disordered $Y_{1-x}Gd_xCo_2$ ($0 \le x \le 1$) compounds

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Magnetocaloric effect (MCE) is defined as the adiabatic temperature change ΔT_{ad} or the isothermal magnetic entropy change ΔS_m, as a function of temperature and magnetic field. MCE is used in magnetic refrigeration which is becoming a new alternative to conventional cooling methods.

YCo_2 parent compound with an $MgCu_2$-type Laves phase structure (*Fd*-3*m* space group) is an exchange-enhanced Pauli paramagnet on the verge of fulfilment of Stoner criterion. Ferromagnetic state can be induced for instance by topological and/or chemical disorder [1]. The influence of Gd substitution and quenched-in disorder on the magnetic properties of $Y_{1-x}Gd_xCo_2$ ($0 \le x \le 1$) compounds is studied mainly by the use of vibrating sample magnetometry. Magnetic entropy changes $\Delta S_m(T,\mu_0 H)$ and refrigerant capacity RC parameter were determined on the basis of $M(H)$ curves as important factors of merit in evaluating the cooling efficiency. Changes in all MCE parameters with structural ordering (after isotrhemal annealing procedure) are clearly visible. For instance, for $Gd_{0.6}Y_{0.4}Co_2$ compound with Curie temperature $T_C = 282$ K in as-quenched state, RC is equal to 122 J/kg, while for annealed sample ($T = 700$°C, $\tau_a = 60$ min) it decreases to 104 J/kg. Structural disorder significantly broadens the magnetic transition and the temperature dependence of magnetic entropy changes in investigated compounds.

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Low-temperature angular magnetoresistance of the Kondo insulator $CeOs_4Sb_{12}$

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The filled skutterudite $CeOs_4Sb_{12}$ is a rare example of a Kondo insulator [1]. This cubic 4f-electron system undergoes a phase transition at $T \approx 0.8$ K as observed in transport and thermodynamic properties. Most likely, a low-lying phase transition is of spin-density-wave (SDW) type. Additionally, transport measurements revealed a magnetic-field-(B)-induced insulator-metal transition below 20 K. Very recently, $CeOs_4Sb_{12}$ has been proposed as a candidate for a topological insulator [2].

We present results of the electrical resistivity $\rho(T)$ and the transverse angular magnetoresistance AMR measured for $CeOs_4Sb_{12}$ along the main crystallographic directions down to $T = 0.1$ K and up to $B = 14$ T. Based on $\rho(T)$ measurements performed for an electrical current aligned along B, we have established a B–T diagram that reveals a large anisotropy of an ordered phase. For the [111] direction, SDWs are extended up to about 2.5 K ($B = 14$ T). For the [100] direction, SDWs do not exist above 1 K and are suppressed in $B \geq 9$ T. While distinct anomalies in the AMR for [111] coincide very well with characteristics of the B–T diagram, surprisingly, there are no signatures of the phase transition for the [100] direction. Forthcoming AMR experiments for [110] should disclose parameter(s)/mechanism(s) giving rise to unusual low-T properties of $CeOs_4Sb_{12}$.

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Physical properties of NbSeI

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The chalcogenide NbSeI was obtained by annealing stoichiometric elements sealed in an evacuated quartz tube at 680°C for 4 days. Crystallographic structure was determined by powder X-ray diffraction. NbSeI forms in cubic (F-43m) crystal structure with separated Nb clusters as previously reported in ref. [1]. Physical properties were tested by magnetic susceptibility and specific heat capacity measurements from 1.9 K to 300K.

Magnetic susceptibility obeys Curie–Weiss low in the whole measured temperature range and estimated effective magnetic moment is about 0.2 μ_B/Nb and the Curie–Weiss temperature, θ_{CW}, is very close to zero, suggesting absence of magnetic interactions between Nb clusters.

Low temperature specific heat measurements of NbSeI derives the Sommerfeld parameter and the Debye temperature, $\gamma = 11$ mJ mol^{-1}K^{-2} and $\Theta_D = 200$ K, respectively.

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Interdiffusion and ion beam mixing effect in bi-layer Fe_3O_4/Fe/MgO(001) films

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Magnetite have been considered as one of promising materials for spintronic applications at room temperature. We are interested in controlling and modeling of interfaces of magnetite thin film systems with optimal structures and desired properties. Ion beam analysis techniques are employed to investigate the film composition, layer structure, interface properties and stability of the bi-layer magnetite-on-Fe films grown on MgO(001) substrates by MBE techniques. Several bi-layer Fe_3O_4/Fe/MgO(001) films with different layer thickness in the range of 25–100 nm were prepared and investigated. We underline the thermal interdiffusion during the film growth and the ion beam mixing effect upon irradiation by 1 MeV Ar^+ and Kr^+ ion beam with different ion influences in the range of 10^{15}–10^{17} ions/cm^2.

Our results confirm that one could always obtain the stoichiometric Fe_3O_4 layer on the film surface in such magnetite-on-Fe film systems. Annealing and ion irradiation induced a very large interface zone having a spinel and/or wustite formula, but the pure magnetite layer could be well preserved upon ion irradiation with small doses. It indicates a high stability of the stoichiometric Fe_3O_4 layer of the bi-layer magnetite films.

Thermal properties of Ti-doped Cu–Zn soft ferrites

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A great majority of widely used ferrite ceramics feature a relatively high temperature of order-disorder phase transition in their magnetic subsystem. However, for some particular applications, a low value of T_c is required. Here we report the results of thermal properties investigations carried out on particular bulk Ti-doped Cu-Zn ferrite ceramics. The temperature dependence of the specific heat and of the thermal conductivity, determined in the temperature range 2–300 K, do not exhibit peculiar feature at the magnetic transition temperature. The low temperature value of the magnetic phase transition and good thermal parameters make the investigated ferrite ceramics applicable as magnetic wave producers in devices designed for magnetization of high-temperature superconducting ceramics. The final conclusion was supported by some theoretical considerations.

Plakaty – wtorek

Longitudinal spin excitations and microscopic origin of magnetic ordering in iron-pnictides

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I evaluate the longitudinal spin excitations (LSEs) as a probe of microscopic origin of magnetic ordering in iron-pnictide parent compounds, which is motivated by recent observation of sizable LSEs in $BaFe_2As_2$ and NaFeAs [1]. The adopted interpretation of LSEs as bottom of particle-hole (P–H) continuum points unambiguously toward significant contribution of itinerant electrons to magnetism and calls into question local-moment model approaches to these materials. This scenario is, however, difficult to reconcile with optical spectroscopy, suggesting that P-H excitations should be observed at larger energies than LSEs seen experimentally.

I propose a distinct mechanism contributing to LSEs at low energies, based on multi-magnon excitations, which is not energetically related to P–H continuum. The LSEs within three model approaches, including anisotropic Heisenberg model, two-band excitonic model, and effective non-linear σ-model, are investigated. Within the effective model, it is found that the multi-magnon contribution to the total low-energy spectral weight can be bounded from below by 2.5% for $BaFe_2As_2$ if the system is close to a magnetic quantum phase transition as suggested by a subclass of frustrated local-moment J_1–J_2 model approaches to iron-pnictides. The obtained range of LSEs is of the same order as reported ~ 5.7%, which indicates that sizable LSEs are not inconsistent with local-moment magnetism.

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Superconducting instability of the non-centrosymmetric system

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A non-centrosymmetric superconducting groundstate can be identified as the one characterized by the highest critical temperature T_C. This issue had been discussed within the Fermi gas and the weak-coupling superconductivity scenario by Frigeri et al. [1]. The applied in Ref. [1] method ignored the spin-orbit coupling induced change of the density of states at the Fermi level and lead to a conclusion of an approximate lack of the T_C suppression for the singlet *s*-wave state and the triplet *p*-wave state defined by the order parameter $\mathbf{d}(\mathbf{k})$ parallel to the spin-orbit coupling vector $\gamma(\mathbf{k})$, and displayed a strong suppression of the states determined by $\mathbf{d}(\mathbf{k})$ nonparallel to $\gamma(\mathbf{k})$. We reexamine the issue of the effect of the parity breaking spin-orbit coupling on the superconducting instability temperature taking into account the basic features of the induced band evolution: the increased band width and the redistribution of the spectral weights in the density of states. We show, within the tight-binding model, a general tendency of the spin-orbit coupling to suppress the critical temperature of the spin singlet and triplet states. For the weak-coupling systems we report a development of the spin-orbit coupling induced sharp T_C maxima for the band fillings which lead to the Fermi level singularities of the density of states. Finally, we note that the suppression of the triplet uniform states developed due to the interband particle--particle interactions is comparable to that of the intraband states for the intermediate-coupling superconductors.

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Quantum Hall many-body repulsion ground states from the two-body pseudopotential

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The fractional quantum Hall effect (FQHE) is one of the most interesting phenomena in the solid state physics. Wave functions of electrons confined to the lowest Landau level, relevant for the description of this effect are seeked among complex antisymmetric polynomials. One of the most famous example of such polynomial is Laughlin wave function. It describes $\nu = 1/3$ state and can be viewed as a ground state of Hamiltonian generated by two-body short-repulsion interaction.

One can consider general trial wave functions, generated by the k-body short-repulsion. Such series, among the Laughlin state ($k = 2$) consists of the Moore-Read „Pfaffian" ($k = 3$) state, believed to be a good description of $\nu = 5/2$ state and Read–Rezayi parafermion ground states ($k = 4$), witch is considered as a description of $\nu = 13/5$ state. We examine, whether such wave functions generated by this particular, nonphysical interactions can be mimicked by the two-body repulsion.

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Electronic properties of 2-dimensional bilayer bismuth topological insulator

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Topological insulators (TI) [1] are fascinating new materials, which posses many properties interesting for both applied and fundamental physics. Even though in last decade this materials were thoroughly studied, there is only limited number of real 2D materials where this effect was proved to exist.

In the following work we study electronic and structural properties of bilayer bismuth Bi (111). First we compare electronic structure for infinite system obtained from density functional theory and tight-binding model after Liu, Allen [2]. Then we study properties of nanoribbons in function of width and edge termination. Then we compare properties of nanoribbons with quantum dots spectra. Next the effect of magnetic field on electronic spectrum is presented, where special attention is paid to the evolution of topologically protected edge states. Disorder effects are investigated within tight-binding approach. kp model is derived around Gamma point and solved for perfectly circular system.

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Phase diagrams of the Penson–Kolb–Hubbard model with repulsive pair-hopping interaction

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We study the extended Hubbard model with pair hopping interaction J, i.e. the Penson–Kolb–Hubbard (PKH) model. This report focuses mainly on the properties of the PKH model in the case of repulsive J ($J < 0$) which may stabilise superconductivity with eta pairing. We examine the effects of on-site density–density U interaction on the mutual stability of magnetic, charge-ordered and superconducting states including s-wave and eta-pairing. In the phase diagrams homogeneous as well as phase-separated states are taken into account. The analysis is performed for finite temperatures within the (broken symmetry) Hartree–Fock approximation for arbitrary interaction parameters ($J < 0$ and U) and electron concentration ($0 < n < 2$) on the $d = 2$ square lattice. The results are compared with those obtained earlier for the Penson–Kolb model as well as for the PKH model with attractive J ($J > 0$) which may stabilise s-wave superconductivity.

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The extended Hubbard model with pair-hopping interaction in the limit of very narrow bandwidth

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The extended Hubbard model with pair-hopping interaction, i.e. the Penson–Kolb–Hubbard model, is one of the conceptually simplest phenomenological models for studying correlations and for description of superconductivity in narrow-band systems with short-range, almost unretarded pairing. We present studies of the model within the broken-symmetry Hartree–Fock approximation (HFA) in the narrow bandwidth regime (for square lattice) and compare these results with exact ones in the atomic limit. We examine the effects of on-site density–density interaction on the mutual stability of magnetic and superconducting states including *s*-wave and eta-pairing. Our investigation of the general case, depending on values of the interaction parameters and electron concentration, show that results obtained within both approaches are consistent, although for the finite single electron hopping phases with magnetic long-range order also occur.

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Probing the Kosterlitz–Thouless transition in 1D Heisenberg antiferromagnet based on the topological properties of its ground state

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A Kosterlitz-Thouless phase transition in the ground state (GS) of an antiferromagnetic spin-½ Heisenberg chain with nearest (J_1) and next-nearest-neighbor interactions (J_2, $\lambda = J_2/J_1$) is reinvestigated once more from a different perspective: taking into account a scalar product $\langle\psi_{GS}(\lambda)|\ \psi_{GS}(\lambda)\rangle$ an unequivocal correspondence between its components and topological objects. One can classify these objects according to whether any two of them can be transformed into each other in a conti-nuous way (the same homotopy class). A finite size scaling of the „connection" term $\langle\psi_{GS}(\lambda),\lambda|\psi_{GS}(\lambda)\rangle$ with respect to chain length (16, 18, 20, 22, 24 spins) calculated for each class of above mentioned objects leads to the critical value of λ with an accuracy of half percent (this is not the scaling of the Berry phase).

Influence of electron pairing on the sub- and superradiance in quantum dots

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We discuss an interplay between the proximity-induced electron pairing and a transfer of the spectral weight between three vertically coupled quantum dots. By tuning the quantum dots using the external gate potentials the resulting spectrum (and transport properties) reveal the broad and narrow lineshapes, reminiscent of the superradiant and subradiant contributions known in quantum optics. In the tunneling heterostructures comprising the superconducting electrodes they are additionally affected by the electron pairing. We analyze the mutual interrelation between these phenomena and point out feasible methods to observe them experimentally.

T-shape quantum dot with the Majorana bound state

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We study the electronic spectrum and transport properties of the quantum dot coupled between the metallic reservoirs and the side-attached quantum wire, hosting at its edges the Majorana type quasiparticles. Quantum interference involving these exotic quasiparticles induces some characteristic features that can be experimentally probed in measurements of the differential tunneling conductance. We investigate such properties both, for the coupled and uncoupled pair of the Majorana quasiparticles.

BCS pairng, BKT superfluidity and BEC in the strongly correlated excitonic systems

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We present in this paper an unified view on the excitonic phase transitions in the two-dimensional (2D) and three-dimensional (3D) strongly correlated excitonic systems. For the 3D and 2D case, we have found that in the high density limit the BCS pairing mechanism is dominating in the system, while in the low density limit and at the very low temperatures the system undergoes the Bose-Einstein (for 3D case) condensation [1], or the Berezinskii –Kosterlitz–Thouless (BKT) superfluid phase transition to the vortex–antivortex bound ground state (for 2D case) [2]. We show that the BEC and BKT transition temperatures are much lower than the transition temperature of the excitonic pair formation state called the „excitonic insulator" (EI), which is an intermediate state, typical for both 3D and 2D excitonic systems. By considering the electron gauge transformation, we have introduced the new bosonic variables associated with the particle wave function. We have shown that strong bosonic phase fluctuations suppress considerably the hybridization gap present in the usual pairing mechanism and we obtain the gapless DOS structure in the macroscopic phase coherent regime [3]. For the 2D case, we have shown that the excitonic BEC regime is possible only in the case of $T = 0$ and we calculated the BEC transition probability function in that case [4].

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Spontaneous currents in bosonic rings

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Nonequilibrium dynamics of noninteracting bosons on one-dimensional and finite width ring-shaped lattices is studied by means of the Kinetic Monte Carlo method. The system is approximated by the classical XY model (the kinetic term is neglected) and the Monte Carlo simulations are performed for the planar classical spins.

We study the dynamics that follows a finite-time quench to zero temperature. If the quench is slow enough the system can equilibrate and finally reaches the ground state with uniform spin alignment at zero temperature. However, if the quench is faster than the relaxation rate, the system can get locked in a current-carrying metastable state characterized by a nonzero winding number. We analyze how the zero-temperature state depends on the quench. We also study the time evolution of the phase––phase correlation function during the quench.

The most obvious candidates for experimental realization of the system under consideration are cold atom systems with noninteracting or weakly interacting bosonic atoms in a ring-shaped optical lattice or arrays of Josephson junctions.

Phase transitions of bosons in optical lattices with a micture of single and pair hoppings

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We have considered Bose condensate in the optical lattice with a mixture of single and pair hoppings. Our study is the extension of work [1] where authors have considered optical lattice in the ground state and our goal was study of Bose condensation for arbitrary temperatures. In order to calculate free energy of the system and determine phase transition lines between disordered and ordered phases, the Laplace transform method [2–3] has been applied. We identified several possible scenarios for phase diagrams with phase transition of first and second order. The results have been obtained both analytically (from the Landau expansion of the free energy) as well as by the use of the numerical methods of calculation. Finally, we have discussed our results and proposed further ideas of the extension of the problem, e.g. by inclusion of multi-body interaction between bosons.

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Phase diagram of mixtures of ultracold bosons in optical lattices

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Ultracold atomic gases in optical lattice give a remarkable opportunity to simulate complicated many-body physics in relatively simple and highly controlled systems. In this work a behavior of mixture of two species of bosons in optical lattice is studied. Such systems have been investigated both experimentally [1,2] and theoretically [3,4], but even the basic characteristics like the phase diagram have not been unambiguously determined. Presence of two order parameters for each species of bosons may lead to phase separation or coexistence of the competing orders. In the present paper, a thorough analysis of the phase diagram of a mixture of two coupled atomic gases is performed using mean-field approximation by the means of both analytical and numerical methods. Landau expansion is used to determine the multiplicity (bi or tetra) of multicritical points [5]. The resulting phase diagram is presented for various parameters of the extended Bose-Hubbard model Hamiltonian. It is shown that first order phase transitions occurs in the specific regions of phase diagram.

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Optical conductivity of ultra-cold bosons in optical lattices

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We study the optical conductivity of ultra-cold bosonic systems in optical lattice using quantum rotor approach. The method allows us to go beyond the mean-field approximation and track the behavior of the current-current correlation function along the phase transition between the Mott insulator and superfluid state. In the phase-ordered state, a discrete ingredient appears resulting from long-range coherence in the system. We present the frequency dependence of both the real and imaginary part of the optical conductivity for various lattice geometries.

Role of bandwidth and energy gap in formation of ground state of bosons in artificial magnetic fields

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We study the properties of ultra-cold bosons in optical lattice in arbitrary gauge potentials. Using quantum rotor approach we are able to go beyond mean-field approximation thus taking into account subtleties of the band structure introduced by the artificial magnetic field. This allows us to elucidate the interplay of the subbands widths and energy gaps on the formation of the coherent state. As a result, we are able to pinpoint the elements of the band structure, which are crucial to proper theoretical description of the synthetic magnetic field in a lattice bosonic system. This leads us finally to a method to approximate Hofstadter butterfly spectrum with simpler band structure for a wide range of magnetic fluxes.

Infrared response of a multilayer stack composed of laminar-superconductor and dielectric

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Layered high-temperature superconductors behave as negative-refractive-index metamaterials [1]. Because of their inherent anisotropy, the effective permittivity components parallel and perpendicular to the superconducting planes possess different infrared Josephson plasma frequencies. Consequently, there exists a wide frequency interval where those permittivity components have different sign and, therefore, the refractive index is negative. We theoretically study the reflectivity and transmissivity of multilayer stacks with alternating high-temperature superconductor and dielectric slabs. Their infrared spectra are calculated by using the transfer-matrix method. It was found that both reflectivity and transmissivity exhibit narrow pass bands associated with two types of Fabry–Perot resonances, one in the superconductor and the other in the dielectric slab. The resonances inside the superconductor appear just above the lower Josephson plasma frequency, namely in the negative-dispersion band. When both types of Fabry–Perot resonances are close each other, the infrared spectra are characterized by clearly-separated strong peaks due to the quantization of the Bloch phase within the total length of the multilayer stack.

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The role of rough flux front penetration in critical state stability of type II superconductors

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Thermo-magnetic avalanches – a critical state instability – are commonly observed in type-II superconductors (SC). The key quantity that characterizes the flux stability is the applied field $\mu_0 B_{fj}$ where the first flux jump occurs [1, 2]. Important features at fields less than $\mu_0 B_{fj}$ are a monotonously decreasing critical current density, as function of the magnetic induction, and flat flux fronts penetrating into the SC. According to our magneto-optical studies, the magnetic profiles have a rocky-mountain-like slop due to stochastic jumps of the flux bundles which form a rough front [3]. This is fundamentally different from the model situations in the theory of thermomagnetic avalanches. We simulate non-uniform flux distributions in infinity cylinder, within the framework of an elliptic critical-state theory, considering a periodical position dependence of the critical current density. In this announcement the role of non-uniform flux front relief on the upper shielding limit of full critical state stability is discussed.

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The temperature dependence of energy gap in thin film electron-doped cuprates

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We investigate the dependence of the superconducting energy gap (G) on the temperature (T) for the electron-doped high-temperature superconductors. The following compounds, in the form of the thin films, have been taken into consideration: $La_{2-x}Ce_xCuO_4$ (LCCO), $Pr_{2-x}Ce_xCuO_4$ (PCCO), and $Nd_{2-x}Ce_xCuO_4$ (NCCO). It was found that function $G(T)$ deviates from the BCS prediction more, if a concentration of cerium assumes the lower values. For the lowest concentration (in the case of LCCO and NCCO), the function $G(T)$ is not quite like the BCS curve, which is connected with the existence of the residual Nernst region. Next, it has been pointed out that the NCCO superconductor becomes structurally unstable for the maximum concentration of cerium, which is leading to the anomalous dependence of the energy gap on the temperature and the induction of the wide Nernst region.

Influence of the anisotropy on the superconducting critical temperature

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In the paper, the properties of the anisotropic superconductors have been discussed on the basis of MgB_2, H_2 and CaC_6 [1–6].

Next, the dependence of the critical temperature on the anisotropy of the electron-phonon interaction and the depairing electron correlation has been studied.

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Superconducting properties of the alloy of tin and copper

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The thermodynamic properties of the superconducting state in $Sn_{1-x}Cu_x$ alloy on the value of the parameter x have been described. The Eliashberg functions from the paper P. W. Watson and D. G. Naugle have been taken into consideration [1].

The Eliashberg equations on the imaginary and real axis have been solved. In first step, the values of critical temperature have been determined. Next, the order parameter and the wave function renormalization factor have been derived. The conducted analysis allows us to determine the dimensionless parameters: R_Δ, R_C, and R_H.

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Physical description of unconventional Josephson junctions

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The mathematical description of unconventional Josephson junctions in various formalisms is given. In particular one can obtain unconventional Josephson junction by placement of nonsuperconducting or ferromagnetntic strip on the top of superconducting strip. The existence of field-induced junctions opens up possibilities for very easy manufacture of electronic devices that show no dissipation and have very simple architecture. They can be created by putting ferromagnetic or ferroelectric material on top of a superconductor. Their properties can be tuned in a continuous manner. The transition from the weak-link regime to the tunneling regime is demonstrated by [1].

This permits building tunable single Josephson junctions, arrays and matrices of Josephson junctions, SQUIDs, current limiters, qubits and a broad range of logical gates as given in [2]. Apart from the applications the new family of Josephson junctions also provides opportunities for studying the fundamental physics of magnetism and vortices.

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Gutzwiller wave function solution for finite systems: superconductivity in the Hubbard model

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We study the superconducting phase of the Hubbard model using the Gutzwiller variational wave function (GWF) and the recently proposed [1] diagrammatic expansion technique (DE–GWF). We consider a finite system even though one of the key advantages of DE–GWF is the ability to work in the thermodynamic limit, which allows for an analysis of subtle effects like Fermi surface deformations [1] and leads to an improved accuracy with respect to the variational Monte Carlo (VMC) results [2–3].

Using the finite-system implementation of DE–GWF we study the accuracy of the results as a function of the system size (which is practically unrestricted). This analysis is used to verify the validity of the finite-size scaling used in VMC.

The presented research is a first step towards applying the DE–GWF method in inhomogeneous situations and studying systems with impurities, stripe phases, etc.

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Correlation-induced *d*-wave superconductivity within the Anderson–Kondo lattice model

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We discuss the appearance of the *d*-wave superconductivity and its coexistence with magnetism within a fully microscopic Anderson–Kondo lattice model derived from Periodic Anderson model. The pairing originates from a competition between the Kondo interaction and the *f*–*f* superexchange. We use the so-called statistically consistent Gutzwiller approximation. The coexistence regimes of antiferromagnetism with superconductivity are determined and appear in the vicinity of the Kondo-insulating quantum critical point. We compare our results with those obtained in the Kondo-lattice limit, where the starting *f*-electrons are localized, as well as discuss the valence change accompanying the onset of superconductivity.

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High-pressure superconductivity in yttrium: The strong-coupling approach

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In the framework of the Eliashberg formalism, the properties of the superconducting state inducing in yttrium for the pressure at p_1 = 26 GPa and p_2 = 31 GPa ($[T_C]p_1$ = 7.9 K and $[T_C]p_2$ = 9.27 K) have been determined. It has been proven that the value of the Coulomb pseudopotential is high and increases with the increasing pressure: $[\mu^*]p_1$ = 0.181 and $[\mu^*]p_2$ = 0.251. Next, the order parameter ($\Delta(T)$), the thermodynamic critical field ($H_C(T)$), the specific heat in the superconducting state ($C^S(T)$), and the specific heat in the normal state ($C^N(T)$) have been calculated. It has been proven that the values of the dimensionless parameters: $R_\Delta \equiv 2\Delta(0)/k_BT_C$, $R_C \equiv (C^S(T_C) - C^N(T_C))/C^N(T_C)$, and $R_H \equiv \equiv (T_CC^N(T_C))/H_C^2(0)$, significantly deviate from the predictions of the classical BCS theory: $R_\Delta \in \langle 3.97, 4.13\rangle$, $R_C \in \langle 2.16, 2.41\rangle$, and $R_H \in \langle 0.153, 0.153\rangle$. The electron effective mass is high for both pressures: $\left[m_e^*\right]_{p_1}^{T=T_C} = 2.16\, m_e$ and $\left[m_e^*\right]_{p_2}^{T=T_C} = 2.64\, m_e$, where the symbol m_e denotes the electron band mass.

Strain effects on electronic structure of $Fe_{0.75}Ru_{0.25}Te$

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The recent DFT-based study [1] of structural and electronic properties of hypothetical Ru-doped iron chalcogenides have suggested that these systems exhibit the same topology of the Fermi surface (FS) as that of FeSe, differing only in the subtle FS nesting features. The calculations predict that the ground states of the solid solutions $Ru_xFe_{1-x}Se$ and $Ru_xFe_{1-x}Te$ are the single- and double-stripe antiferromagnetic, respectively. The superconductivity in iron chalcogenides is believed to be mediated by spin fluctuations in single-stripe magnetic phase, thus the Ru-doped FeSe is a good candidate for a new superconducting iron-based material.

In this presentation, an interplay between structural parameters and magnetism of $Fe_{0.75}Ru_{0.25}Te$ alloy is discussed based on the results of DFT-based calculations.

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Electronic structure and physical properties of non-centrosymmetric superconductor Th_7Co_3

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The non-conventional superconductors are the subject of ongoing theoretical and experimental investigations. We should underscore that among of these materials, the high-T_C cuprates, the FeAs-based compounds and heavy fermion superconductors have been studied in more detail, during the last years. Recently, there are many works in which it is suggested that the lack of the inversion symmetry could lead to the mixed state of the spin-singlet and spin-triplet configurations of the superconducting pairs, and as a consequence, an assymetric spin-orbit coupling (ASOC) is enhanced, which removes the degeneracy related to the spin, and the parity conservation will be violated by the Pauli principle. In the present work we examine the superconductor Th_7Co_3 with the critical temperature of order 1.9 K. This superconductor crystallizes in a hexagonal structure (space group $P6_3mc$). Due to the absence of the inversion symmetry center and the electronic correlations are presumably weak, it is highly desired to explore physical properties both, theoretically and experimentally, and furthermore to compare the obtained results. The results of magnetization, electrical resistivity, and specific heat measurements of Th_7Co_3 are presented. The thermodynamic characteristics of the superconducting state are evaluated. The self-consistent band structure calculations for the compound Th_7Co_3 were performed too, in which the effect of the ASOC is pronounced, i.e. the degeneracy of the spin-up and spin-down bands is removed.

Effect of doping on magnetic properties of magnetocaloric series $(Fe_{1-x}Mn_x)_2P_{1-y}Si_y$

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We present results of ab-initio calculations for the $(Fe_{1-x}Mn_x)_2P_{1-y}Si_y$ series, where we investigate the effect of doping on magnetic properties of these materials. Such compounds, which belong to the Fe_2P class of magnetocaloric materials are now extensively studied, due to their potential in magnetic cooling. In a Fe_2P type unit cell transition metals occupy two inequivalent Wyckoff sites (namely 3*f* and 3*g* position). We have shown, that the preference of occupation of particular Wyckoff site by iron or manganese lead to different dependence of magnetic properties such as magnetic moment or estimated magnetic transition temperature with respect to absolute substitution of iron by manganese. Our results correspond well with recent experimental data.

Localized *d* electrons in K_2CoF_4, $SrMnO_3$, $LaCoO_3$

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K_2CoF_4, $SrMnO_3$ and $LaCoO_3$ are considered as prototype oxides with strong electron correlations, not well theoretically described so far. A theoretical problem is related with the role played by *d* electrons. First two compounds are antiferromagnets with moments associated with 3*d* electrons in the incomplete shell. Despite of the incomplete 3*d* shell they are insulators. In standard LDA calculations *d* states are obtained on the Fermi level pointing to their itinerant/metallic behavior. We advocate for a substantial physical adequacy of the crystal-field approach to compounds containing open 3*d*/4*f*/5*f* shell (we have extended it to the Quantum Atomistic Solid State theory QUASST) where some number of *d*/*f* electrons is localized forming atomic-like strongly-correlated electronic systems. We reconcile the crystal-field approach with a modification of the standard LDA calculations by introducing U term. It means that our first-principles strongly-correlated crystal-field approach seems to have a common idea with LDA+U calculations. From really first-principles calculations we have evaluated a full set of the crystal-field coefficients accounting for lattice and local distortions for all these compounds. They are real potentials, in the atomic scale, in contrary to pseudo-potentials usually introduced in modern theories. We calculated spin and orbital moment and its direction in the crystal.

Orbital Polarons in $KCuF_3$

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We present a calculation of the spectral properties of a single charge doped at the Cu(3d) sites of the Cu–F plane in $KCuF_3$. A superexchange model, designed to represent the orbital physics in $KCuF_3$, is developed [1] and the problem is treated by generating the equations of motion for the Green's function by means of subsequent Dyson expansions [2] and solving the resulting set of equations. We then compare this method to the Self Consistent Born Approximation (SCBA) used before for this kind of problem [3], and further corroborate the results by calculating analytically the first couple of moments. We find our methods in good agreement for the ground state, although the equations of motion method is both more dependable and more flexible, since it is a systematic expansion with precise control of elementary physical processes, which is underlined by its good agreement with the sum rules, in contrast to SCBA.

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