XX Krajowa Konferencja Nadprzewodnictwa

Nowe fazy, koncepcje i zastosowania

Lublin, 22 - 26 maja 2022 r.

XX Krajowa Konferencja Nadprzewodnictwa

„Nowe fazy, koncepcje i zastosowania”

„New phases, concepts and advances”

Lublin, 22–26 V 2022

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Szanowni Państwo,

Niecały rok po odkryciu w 1986 roku nadprzewodników wysokotemperaturowych odbyło się w Warszawie pierwsze ogólnopolskie spotkanie badaczy zjawiska nadprzewodnictwa i nadprzewodzących materiałów. Współprzewodniczącymi jednodniowego spotkania byli Dyrektorzy dwu Instytutów Akademii Nauk, profesorowie Jan Klamut (INTiBS we Wrocławiu) i Henryk Szymczak (IF PAN w Warszawie). Po 35 latach spotykamy się już po raz dwudziesty w ramach tego cyklu. Dotychczas konferencje odbywały się na średnio co 22 miesiące. Grupa lubelska organizuje ją po raz czwarty, ale pierwszy raz miejscem spotkania jest miasto Lublin. Mamy nadzieję, że czterodniowa konferencja będzie dobrą okazją do wymiany poglądów na temat tego ważnego zjawiska oraz przyczyni się do odnowienia kontaktów naukowych osłabionych przez pandemię COVID-19 i nawiązania nowych form współpracy.

Życzymy Państwu miłego pobytu i owocnych dyskusji naukowych,

Organizatorzy

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- Instytut Fizyki Uniwersytetu M. Curie-Skłodowskiej
- Oddział Lubelski Polskiego Towarzystwa Fizycznego

Lista konferencji nadprzewodnictwa / List of conferences on superconductivity

1. I Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Warszawa, kwiecień 1987 r.

2. II Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Kraków, 28-29 stycznia 1988 r.

3. III Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Wrocław, 21-22 października 1991 r.
   (organizator: Instytut Niskich Temperatur i Badań Strukturalnych PAN we Wrocławiu)

4. IV Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Poznań, 1993 r.
   (organizatorzy: Instytut Fizyki Molekularnej PAN
   i Uniwersytet im. Adama Mickiewicza w Poznaniu)

5. V Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Kazimierz Dolny, 22-25 stycznia 1995 r.
   (organizator: Instytut Fizyki Uniwersytetu Marii Curie-Skłodowskiej w Lublinie)

6. VI Międzynarodowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Zakopane, 23-28 września 1996 r.
   (organizatorzy: Instytut Fizyki Uniwersytetu Jagiellońskiego
   i Akademia Górniczo-Hutnicza w Krakowie)

7. VII Krajowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Międzyzdroje, 01-03 września 1997 r.
   (organizator: Instytut Fizyki Politechniki Szczecińskiej)

8. VIII Krajowe Sympozjum Nadprzewodnictwa Wysokotemperaturowego,
   Gdańsk-Sobieszowo, 07-10 września 1999 r.
   (organizator: Wydział Fizyki Technicznej i Matematyki Stosowanej Politechniki Gdańskiej)

9. IX Szkoła Nadprzewodnictwa Wysokotemperaturowego,
   Krynica-Czarny Potok, 10-14 czerwca 2001 r.
   (organizatorzy: Instytut Fizyki Uniwersytetu Jagiellońskiego
   i Akademia Górniczo-Hutnicza w Krakowie)

10. X Krajowa Szkoła Nadprzewodnictwa
    „Nadprzewodnictwo wysokotemperaturowe i inne zjawiska w perowskitach”,
    Warszawa, 06-10 czerwca 2004 r.
    (organizator: Krajowa Sieć Naukowa „Silnie skorelowane fermiony
    - od nadprzewodnictwa do kolosalnego magnetooporu”, Instytut Fizyki PAN w Warszawie)

11. XI Krajowa Szkoła Nadprzewodnictwa
    „Zjawiska kolektywne i ich współzawodnictwo”,
    Kazimierz Dolny, 25-29 września 2005 r.
    (organizator: Krajowa Sieć Naukowa „Silnie skorelowane fermiony
    - od nadprzewodnictwa do kolosalnego magnetooporu”,
    Instytut Fizyki Uniwersytetu M. Curie-Skłodowskiej w Lublinie)

12. XII Krajowa Szkoła Nadprzewodnictwa
„Układy skorelowanych elektronów wczoraj i dziś”,
Ustroń, 14-18 września 2006 r.
(organizator: Instytut Fizyki Uniwersytetu Jagiellońskiego w Krakowie)

13. XIII Krajowa Szkoła Nadprzewodnictwa
„Nadprzewodnictwo, uporządkowanie spinowe i ładunkowe”,
Lądek Zdrój, 06-10 października 2007 r.
(organizator: Instytut Niskich Temperatur i Badań Strukturalnych PAN we Wrocławiu)

14. XIV Krajowa Szkoła Nadprzewodnictwa
„Nadprzewodnictwo i niejednorodne układy skondensowane”,
Ostrów Wielkopolski, 13-17 października 2009 r.
(organizatorzy: Instytut Fizyki Molekularnej PAN, Uniwersytet A. Mickiewicza w Poznaniu)

15. XV Krajowa Szkoła Nadprzewodnictwa
„Sto lat nadprzewodnictwa”,
Kazimierz Dolny, 09-13 października 2011 r.
(organizator: Instytut Fizyki Uniwersytetu M. Curie-Skłodowskiej w Lublinie)

16. XVI Krajowa Konferencja Nadprzewodnictwa
„Niekonwencjonalne nadprzewodnictwo i układy silnie skorelowane”,
Zakopane, 07-12 października 2013 r.
(organizatorzy: Instytut Fizyki Uniwersytetu Jagiellońskiego
i Akademia Górniczo-Hutnicza w Krakowie)

17. XVII Krajowa Konferencja Nadprzewodnictwa
„Nadprzewodnictwo i inne stany emergentne w układach z silnie skorelowanymi elektronami”,
Karpacz, 25-30 października 2015 r.
(organizator: Instytut Niskich Temperatur i Badań Strukturalnych PAN we Wrocławiu)

18. XVIII Krajowa Konferencja Nadprzewodnictwa
Krynica Morska, 08-13 października 2017 r.
(organizator: Wydział Fizyki Technicznej i Matematyki Stosowanej Politechniki Gdańskiej)

19. XIX Krajowa Konferencja Nadprzewodnictwa
„Niekonwencjonalne nadprzewodnictwo i silnie skorelowane układy elektronowe”,
Bronisławów, 06-11 października 2019 r.
(organizator: Instytut Fizyki PAN w Warszawie)

20. XX Krajowa Konferencja Nadprzewodnictwa
„Nowe fazy, koncepcje i zastosowania”,
Lublin, 22-26 maja 2022 r.
(organizator: Instytut Fizyki Uniwersytetu M. Curie-Skłodowskiej w Lublinie)

Professor Roman Micnas (1947-2022)

With deep sorrow we learned that Prof. Roman Micnas, a distinguished Polish physicist, passed away on 13 January 2022. He was born in Nowice on November 4th, 1947. He graduated with MSc from Adam Mickiewicz University (AMU) in 1970, where he also received PhD degree in 1978, Habilitation (Dr hab.) degree in 1988, and became a Professor of physics in 1990. In the Faculty of Physics of AMU he was the head of Solid State Theory Division in years 1998-2018.

He published a number of important contributions to the theory of condensed matter physics. In his works he covered mainly the theory of superconductivity, strongly correlated materials, magnetism, phase transitions, and ultracold atoms on optical lattices. His main achievement consists in development of the theory of superconductivity with local electron pairing. In this field he published a number of seminal works, including the highly cited review article: Rev. Mod. Phys. **62**, 113-173 (1990), with Julius Ranninger and Stanisław Robaszkiewicz as the co-authors. He published over 140 articles in various fields of physics, *inter alia* together with Karl Alex Müller. Roman Micnas gave over 60 invited talks at international conferences and he promoted six doctoral students.

Professor Micnas paid long term research visits to the University of Linköping, Sweden (collaboration with K. A. Chao); ICTP Trieste, Italy; University of Grenoble; the Institute Laue-Langevin, Grenoble; CNRS Grenoble, France (collaboration with J. Ranninger). In total, as a visiting professor he stayed in 15 scientific institutions in Sweden, Brazil, France, Italy, Germany, Switzerland and USA.

For his development of theory of superconductivity with local electron pairing he was awarded, together with Stanisław Robaszkiewicz, the Marie Skłodowska-Curie Scientific Prize of the Polish Academy of Sciences (PAS) in 1989. In 1994 he became Corresponding Member of PAS, and in 2016 - Ordinary Member. He served a number of important functions in PAS, among others he was a member of Committee for Physics of PAS, and since 2015 a Dean of Division III of Exact Sciences and Earth Sciences of PAS. He was a member of several scientific societies: Polish Physical Society, European Physical Society, American Physical Society and American Association for Advancement of Science. He coorganized 35 national and international conferences, among others the cycle of the European Conferences „*Physics of Magnetism*", which he organized and co-chaired since 1993.

Professor Roman Micnas took very active part in the whole series of National Conferences on Superconductivity both as a member of the Scientific Committees and as a lecturer. He actively contributed to the success of these Conferences and the superconductivity research in Poland.

We shall remember him as an excellent scientist and a very friendly Member of our Community.

Tadeusz Domański[a], Tomasz Kostyrko[b], Andrzej M. Oleś[c], and Karol I. Wysokiński[a]

[a] *Faculty of Mathematics, Physics and Computer Science, M. Curie-Skłodowska University, Lublin*
[b] *Faculty of Physics, Adam Mickiewicz University, Poznań*
[c] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, Kraków*

SCIENTIFIC PROGRAMME

Sunday (22 May 2022)

from 15:00 Registration

17:00 - 19.00 Sightseeing tour of the Castle and Old Town of Lublin

19:00 - 20.00 Supper

20:00 - 20.15 Tadeusz Domański [M. Curie-Skłodowska University, Lublin]
Conference opening

20:15 - 21:00 Wiesław Ignacy Gruszecki [M. Curie-Skłodowska University, Lublin] ..... W.I
Dlaczego warto zadbać aby żółta plamka w naszym oku była naprawdę żółta?

Monday (23 May 2022)

Chair *Karol I. Wysokiński*

09:00 - 09.45 Józef Spałek [Jagiellonian University, Cracow] W.01
A brief perspective in high temperature superconductivity

09:45 - 10:15 Artur Malinowski [Polish Academy of Sciences, Warsaw] W.02
Pseudogap in underdoped cuprate seen in longitudinal magnetoresistance

10:15 - 10:45 Coffee break

Chair *Andrzej M. Oleś*

10:45 - 11:15 Wojciech Tabiś [AGH University of Science and Technology, Cracow] W.03
Cuprates - the perspective of electronic transport

11:15 - 11:45 Tomasz Cichorek [Polish Academy of Sciences, Wrocław] W.04
Two-band superconductivity in electron-irradiated $PrOs_4Sb_{12}$ and $CeCu_2Si_2$ studied by local magnetization measurements

11:45 - 12:15 Andrzej Szewczyk [Institute of Physics, Polish Academy of Sciences, Warsaw] W.05
Magnetic phase transition in $TbAl_3(BO_3)_4$ below 700 mK - quantum and classical features

12:15 - 12:45 Karolina Górnicka [Gdańsk University of Technology, Gdańsk] W.06
Superconductivity in Os-based Laves compounds

13:00 - 15:00 Lunch

Chair *Krzysztof Rogacki*

15:00 - 15:30 Andrzej M. Oleś [Jagiellonian University, Cracow] W.07
Hubbard subbands in the infinite-layer nickelate

15:30 - 16:00 Jacek Herbrych [Wrocław University of Science and Technology, Wrocław] W.08
Hund excitations in orbital-selective Mott insulators

16:00 - 16:30 Marcin M. Wysokiński [MagTop, Warsaw] W.09
Non-Abelian Berry phase induced entanglement between qubits in QED cavity

16:30 - 17:00 Coffee break

Chair *Roman Puźniak*

17:00 - 17:30 Bartłomiej Wiendlocha [AGH University of Science and Technology, Cracow] W.10
Strong-coupling superconductivity of $SrIr_2$ and $SrRh_2$: Phonon engineering of metallic Ir and Rh

17:30 - 18:00 Artur Durajski [Częstochowa University of Technology, Częstochowa] W.11
Ternary superhydrides: in search of low-pressure high-temperature superconductor

18:00 - 18:30 Tomasz Kostyrko [A. Mickiewicz University, Poznań] W.12
Theory of superconductivity with local electron pairing: history and perspectives

18:30 - 18:50 Andrzej Szytuła [Jagiellonian University, Cracow] W.13
Chwila wspomnień po 36 latach

19:00-20:00 Supper

20:00-21:00 Poster session

Tuesday (24 May 2022)

Chair *Tomasz Dietl*

09:00 - 09.45 Marta Z. Cieplak [Institute of Physics, Polish Academy of Sciences, Warsaw] W.14
Interplay of various order parameters and disorder in iron chalcogenides

09:45 - 10:15 Tomasz Klimczuk [Gdańsk University of Technology, Gdańsk] W.15
Superconductivity in the Heusler-type intermetallic compounds

10:15 - 10:45 Coffee break

Chair *Andrzej Ślebarski*

10:45 - 11:15 Andrzej Wiśniewski [Institute of Physics, Polish Academy of Sciences, Warsaw] W.16
Properties of (Nb,Pb,In)/NbP - superconductor Weyl semimetal junctions

11:15 - 11:45 Grzegorz Jung [Ben Gurion Univ. Negev, Israel & Institute of Physics PAS, Warsaw] W.17
Chiral molecule mediated proximity effect

11:45 - 12:15 Paweł Starowicz [Jagiellonian University, Cracow] W.18
Electronic structure of the heavy fermion superconductor Ce_3PdI_{11} with two inequivalent crystallographic positions of Ce atoms

12:15 - 12:45 Damian Rybicki [AGH University of Science and Technology, Cracow] W.19
Badanie żelazowo-arsenowych nadprzewodników wysokotemperaturowych z wykorzystaniem promieniowania synchrotronowego

13:00 - 15:00 Lunch

Chair *Andrzej Szytuła*

15:00 - 15:30 Paweł Jakubczyk [University of Warsaw, Warsaw] W.20
Stability of the Fulde-Ferrel-Larkin-Ovchinnikov phases in Fermi mixtures: role of the Lifshitz point

15:30 - 16:00 Maciej Fidrysiak [Jagiellonian University, Cracow] W.21
Spin and charge quantum excitations in high T_c cuprates

16:00 - 16:30 Tomasz Polak [A. Mickiewicz University, Poznań] W.22
Coexistence of two kinds of superfluidity

16:30 - 17:00 Coffee break

Chair *Marta Z. Cieplak*

17:00 - 17:20 Mateusz A. Gala [AGH University of Science and Technology, Cracow] W.23
The interplay between lattice distortion and superconductivity in cuprate superconductors

17:20 - 17:40 Gabriel Kuderowicz [AGH University of Science and Technology, Cracow] W.24
Origin of the phonon soft mode in Heusler compound $LiPd_2Ge$

17:40 - 18:00 Marlena Dziurawiec [Wrocław University of Science and Technology, Wrocław] W.25
Equilibrium and nonequilibrium criticality in the one-dimensional XY model with long-range interactions

18:00 - 18:20 Bartosz Krajewski [Wrocław University of Science and Technology, Wrocław] W.26
Phenomenology of spectral functions in disordered spin chains at finite temperature

18:20 - 18:40 Hadi Cheraghi [M. Curie-Skłodowska University, Lublin] W.27
Floquet dynamical phase transitions

19:00-20:00 Supper

20:00-21:00 Poster session

Wednesday (25 May 2022)

Chair *Wojciech Sadowski*

09:00 - 09.45 Tomasz Dietl [MagTop, Warsaw & Tohoku University, Sendai (Japan)] W.28
Exchange interactions in magnetically doped semiconductors

09:45 - 10:15 Maciej M. Maśka [Wrocław University of Science and Technology, Wrocław] W.29
Topological superconductivity driven by self-organized spin structures

10:15 - 10:45 Coffee break

Chair *Andrzej Wiśniewski*

10:45 - 11:15 Nicholas Sedlmayr [M. Curie-Skłodowska University, Lublin] W.30
Instability of Majorana states in Shiba chains due to leakage into a topological substrate

11:15 - 11:45 Marcin Mierzejewski [Wrocław University of Science and Technology, Wrocław] W.31
Interaction-induced Majorana edge states in multiorbital chains

11:45 - 12:15 Mircea Trif [MagTop, Warsaw] W.32
Yu-Shiba-Rusinov qubit

12:15 - 12:45 Kacper Wrześniewski [A. Mickiewicz University, Poznań] W.33
Dynamical quantum phase transition in a mesoscopic superconducting system

13:00 - 15:00 Lunch

Chair *Marcin Mierzejewski*

15:00 - 15:30 Andrzej Ptok [Institute of Nuclear Physics, Polish Academy of Sciences, Cracow] W.34
Ab initio study of chiral phonons

15:30 - 16:00 Krzysztof Wójcik [M. Curie-Skłodowska University, Lublin] W.35
Interplay of strong correlations and superconductivity in double quantum dots

16:00 - 16:30 Jan Barański [Military University of Aviation, Dęblin] W.36
Quench dynamics of Fano-like resonances in double quantum dot systems

16:30 - 17:00 Coffee break

Chair *Radosław Szczęśniak*

17:00 - 17:30 Aksel Kobiałka [University of Basel, Switzerland] W.37
Sublattice extension of the Rashba nanowire model

17:30 - 17:50 Małgorzata Strzałka [Wrocław University of Science and Technology, Wrocław] W.38
Nontrivial spin textures in superconducting two-dimensional materials

17:50 - 18:10 Surajit Basak [Institute of Nuclear Physics, Polish Academy of Sciences, Cracow] W.39
Shiba states in systems with density of states singularities

18:10 - 18:30 Grzegorz Górski [University of Rzeszów, Rzeszów] W.40
Magnetic field effect on transport properties of double quantum dot coupled to Majorana wire

18:30 - 18:50 Maksymilian Kliczkowski [Wrocław University of Science and Technology, Wrocław] W.41
Artificial neural network solution to problems of many body correlated systems

20:00-21:00 Conference dinner

Thursday (26 May 2022)

Chair *Józef Spałek*

09:00 - 09.45 Dariusz Kaczorowski [Polish Academy of Sciences, Wrocław] W.42
Mixed singlet-septet Cooper pairing in half-Heusler superconductors

09:45 - 10:15 Roman Puźniak [Polish Academy of Sciences, Warsaw] W.43
Enhancement of superconducting state properties and crystallinity degradation as a result of chemical substitutions, under pressure, and after hydrogenation in Fe-Te-Se single crystals

10:15 - 10:45 Coffee break

Chair *Maciej M. Maśka*

10:45 - 11:15 Krzysztof Rogacki [Polish Academy of Sciences, Wrocław] W.44
Superconductivity by dislocation bundles in $SrTiO_3$

11:15 - 11:45 Kamil Kolincio [Gdańsk University of Technology, Gdańsk] W.45
Spin chirality produced by thermal spin fluctuations

11:45 - 12:15 Sylwia Gutowska [AGH University of Science and Technology, Cracow] W.46
Anisotropy of superconducting gap of Pb-Bi alloy

12:15 - 12:45 Ryszard Radwański [Center of Solid State Physics & Pedagogical University, Cracow] W.47
Quantum Atomistic Solid State Theory: $CeRh_2Si_2$, K_2CoF_4, $LaCoO_3$, Sr_2VO_4, Ba_2IrO_4, Sr_2RuO_4

12:45 - 13:00 Closing remarks

13:00 - 15:00 Lunch

POSTER SESSION

P-01 I. Abaloszewa, M.Z. Cieplak, A. Abaloszew, L.Y. Zhu, C.-L. Chien
Thermomagnetic instabilities in Nb films

P-02 S. Altanany, I. Zajcewa, M.Z. Cieplak,
Berezinski-Kosterlitz-Thouless transition in ultrathin niobium films

P-03 B. Baran, R. Taranko, T. Domański,
Subgap dynamics of double quantum dot system

P-04 E.E. Oyeka, M.J. Winiarski, A. Błachowski, K.M. Taddei, T.T. Tran,
^{57}Fe Mössbauer study of a potential skyrmion host $Fe(IO_3)_3$

P-05 B. Camargo, A. Alaferdov, B. Kerdi, W. Escoffier,
Graphite's magnetoresistance anomaly outside the quantum limit

P-06 V. Chabanenko, A. Nabiałek, R. Puźniak,
Avalanche dynamics of magnetic flux in the Nb-Ti superconducting tube

P-07 E.A. Drzazga-Szczęśniak, A.Z. Kaczmarek,
The selected superconducting properties of electron- and hole-doped graphene

P-08 P. Gierłowski, B. Cury Camargo, I. Abaloszewa, A. Abaloszew,
M. Jaworski, K. Cho, R. Prozorov, M. Kończykowski,
Superconducting properties of electron-beam irradiated $Ba_{1-x}K_xAs_2F_2$

P-09 M. Hendzel, M. Fidrysiak, J. Spałek,
Mottness in many-particle reinterpretation of chemical bonding

P-10 A.Z. Kaczmarek, E.A. Drzazga-Szczęśniak,
The superconducting energy gap in the hole-doped graphene beyond the Migdal's theory

P-11 K. Komędera, I. Biało, W. Tabiś, D. Tolj, N. Barišić,
Mössbauer spectroscopy study of $K_2FeCu_3S_4$ murunskite

P-12 S. Królak, K. Górnicka, M.J. Winiarski, T. Klimczuk,
Possible weak localization in a layered oxypnictide $La_3Cu_4P_4O_2$

P-13 A. Krzywicka,
Pairing mechanism at finite temperatures in bosonic systems

P-14 R.J. Radwański, D.M. Nałęcz, Z. Ropka,
Charge, spin-orbit and crystal-field electronic states in $CeRh_2Si_2$

P-15 P. Sobota, R. Idczak, A.P. Pikul,
Superconductivity in $(NbTa)_{0.67}(MoHfW)_{0.33}$ high entropy alloy

P-16 K. Pryga, B. Wiendlocha,
Electronic structure and superconductivity in Co-Ni-Cu-Rh-Ir-Zr2 high entropy alloy

P-17 P. Sobota, R. Idczak, T. Pikula, D. Gnida, A.P. Pikul,
Superconductivity in High Entropy Alloys with Th

P-18 M. Rosmus, N. Olszowska, Z. Bukowski, P. Starowicz,
Electronic Structure and Dirac Cone Dispersion in Cobalt Doped $CaFe_2As_2$

P-19 D. Szczęśniak,
Quasiparticle tunneling in Josephson junctions via in-gap states

P-20 H. Świątek, L.S. Litzbarski, M.J. Winiarski, I. Oshchapovskyy, T. Klimczuk,
Crystal structure and superconductivity in ternary $Y_2Pd_{1.25}Ge_{2.75}$ intermetallic

P-21 J. Wronowicz, M. Mierzejewski, J. Hebrych,
Level statistics and integrability breaking in chains with long-rang interactions

P-22 T. Zajarniuk, A. Szewczyk, M.U. Gutowska, W. Szuszkiewicz, E. Lhotel,
H. Szymczak, R. Puźniak, A. Prokhorov,
The intriguing nature of phase transition in $DyAl_3(BO_3)_4$ aluminoborate

P-23 I. Zajcewa, M. Chrobak, M.Z. Cieplak,
Coulomb blockade effect in highly underdoped LSCO thin films

LECTURES

XX-TH CONFERENCE ON SPERCONDUCTIVITY
"New phases, concepts and advances"
Lublin, 22-26 May 2022

Opening lecture **W-I**

Dlaczego warto zadbać aby żółta plamka w naszym oku była naprawdę żółta?

Wiesław Gruszecki

Katedra Biofizyki, Uniwersytet Marii Curie-Skłodowskiej w Lublinie

Oko - narząd wzroku człowieka jest organem dostarczającym największą część informacji o otaczającym nas świecie, umożliwiając efektywne, bezpieczne i twórcze funkcjonowanie. Ze względu na fakt, iż oko ludzkie wyposażone jest w miliony fotoreporterów wrażliwych na promieniowanie o różnej długości fali, nasze widzenie jest nie tylko precyzyjne ale również umożliwiające rozróżnianie tysięcy barw. Funkcjonowanie oka ludzkiego w ekstremalnie szerokim zakresie intensywności światła wymaga połączenia wysokiej czułości fotoreceptorów z ich foto-stabilnością. Okazuje się, że te przeciwstawne wymagania są niezwykle trudne do pogodzenia. W tym celu w ludzkim narządzie wzroku funkcjonują mechanizmy regulacyjne kontrolujące intensywność strumienia fotonów docierających do fotoreceptorów, wśród nich zwężanie i rozszerzanie źrenicy oka, które można przyrównać do działania przesłony aparatu fotograficznego. Najnowsze badania pokazują, iż analogiczną rolę na poziomie molekularnym pełnią luteina i zeaksantyna, barwniki karotenoidowe zlokalizowane w plamce żółtej siatkówki oka. Mechanizm ten, określony przez badaczy mianem *żaluzji molekularnych* blokuje przechodzenie fotonów do fotoreceptorów przy silnym świetle, ułatwiając ich transmisję w warunkach niskiego natężenia promieniowania. Na znaczenie aktywności tego mechanizmu wskazuje fakt, iż niedobory barwników plamki żółtej prowadzą do nieodwracalnej utraty wzroku. Podczas wystąpienia zaprezentowane zostanie funkcjonowanie *żaluzji molekularnych* w oku człowieka. Przedstawione będą również rekomendacje dotyczące diety wpływającej na wysoki poziom barwników plamki żółtej w siatkówce. Korzystanie z tych rekomendacji pomoże słuchaczom zapewnić sobie sokoli wzrok przez długie lata życia!

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Plenary lecture **W-01**

A brief perspective in high temperature superconductivity

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High temperature superconductivity encompasses the cuprates, nickelates, iron compounds, and the hydrogen-sulphur compounds. The first three groups of compounds involve in the pairing electrons, which are strongly to moderately correlated [1], whereas in the last class of systems specific phonon excitations, connected to hydrogen bonding, play a crucial role [2].

In this overview I concentrate first on the (semi)quantitative theory of high-T_c superconductivity in the cuprates based on our original variational approach beyond the renormalized mean field theory. Selected equilibrium and dynamic-excitation properties are analyzed briefly. General questions regarding the pseudogap and two-dimensional character of those systems are raised.

In the second part of the talk selected basic physical properties of the nicklates [3] and hydrogen-sulphur systems [4] are briefly characterized. At the end, some basic questions such as reduced system dimensionality, nonstandard chemical bonding, and the Mottness, are discussed.

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Invited lecture **W-02**

Pseudogap in underdoped cuprate seen in longitudinal magnetoresistance

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We present the results of in-plane magnetotransport study of slightly underdoped cuprate $La_{1.85}Sr_{0.15}CuO_4$ (LSCO15) with Ni impurity. Increasing Ni content y causes a sharp drop in longitudinal magnetoresistance (LMR), detected in LSCO15, to broaden and move towards higher temperatures. Temperature $T_{mLMR}(y)$ of this local maximum in LMR coincides with temperature $T_{dev}(y)$, below which ideal resistivity from the parallel-resistor model deviates from its T^2-dependence and not from the T-linear one. A direct comparison with the hole doping evolution of pseudogap (PG) in $La_{2x}Sr_xCuO_4$, possible through the mobile-carrier concentration extracted from the thermopower measurements, allows to equate both characteristic temperatures $T_{mLMR} \simeq T_{dev}$ with PG opening temperature $T^\star$. The rate of PG closing by magnetic field parallel to the CuO2 plane, in measurements up to 9 T, is consistent with the spin-paramagnetic effect and yields PG closing field B_{pc} close to the second critical field Bc2 predicted for superconducting gap with the help of WerthamerâĂŞHelfandâĂŞHohenberg theory.

The low-field data allow also to predict that B_{c2} in T=0K limit decreases in the system from 83 T to 56 T when y increases from 0 to 0.035. Examination of the spin part in magnetic susceptibility reveals that increased Stoner factor can be partially responsible for the enhancement of the Pauli paramagnetic effect. Increasing Ni content separates the relevant Zeeman energy scales, $g\mu_B B_{c2}$ and $g\mu B B_{pc}$ (g=2), both decreasing with increasing y, from the pseudogap thermal energy scale $k_B T^\star$, equal to them for $y = 0$ but increasing with increasing y.

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Invited lecture **W-03**

Cuprates - the perspective of electronic transport

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Despite immense efforts, the cuprate Fermi surface (FS) has been unambiguously determined in only two distinct, low-temperature regions of the phase diagram: a large hole-like FS at high and, at moderate doping, a small electron-like pocket associated with charge-density-wave (CDW) driven FS reconstruction stabilized by high magnetic fields. I will present systematic resistivity, magnetotransport, and Hall effect measurements for a number of cuprates in a wide temperature and charge-carrier range. Our electronic transport results indicate a significant change of the carrier density upon crossing from the overdoped to underdoped regime. [1–3] This change corresponds to the localization of one hole per primitive unit cell CuO_2. Furthermore, the detailed observation of the evolution of the transport coefficients across the cuprate phase diagram indicate that the decrease of the density of states at the FS, reflects the formation of disconnected Fermi-arcs, but is not a consequence of a true reconstruction of the FS driven by a phase transition. [4] The transport properties directly steam from the Fermi-arc evolution with doping and temperature, where arcs states remain essentially unchanged, and from the scattering rate that is dominated by the Umklapp process. Finally, I will present the arguments for a phase transition associated with the enhancement of the CDW order by high magnetic fields and low temperatures in the underdoped regime of the cuprate phase diagram. [4]

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Invited lecture **W-04**

Two-band superconductivity in electron-irradiated $PrOs_4Sb_{12}$ and $CeCu_2Si_2$ studied by local magnetization measurements

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The heavy-fermion and multiband superconductor $PrOs_4Sb_{12}$ with broken time-reversal symmetry, spontaneously developing on passing through the critical temperature $T_c \simeq 1.85$ K, is a leading candidate to display chiral superconductivity. Based on measurements of the temperature dependence of the lower critical field $H_{c1}(T)$, we have recently found evidence for the order parameters composed of a sign-changing smaller gap and a large isotropic *s*-wave gap [1].

To develop a detailed understanding of multicomponent superconductivity in $PrOs_4Sb_{12}$, we have extended measurements of $H_{c1}(T)$ down to temperatures as low as 7 mK utilizing a 2DEG Hall magnetometry. We observe a sudden increase in $H_{c1}(T)$ deep in the superconducting state, indicative of a rare case of two nearly decoupled bands. Furthermore, a non-saturating and concave behaviour of $H_{c1}(T)$ below about 0.45 K clearly points at a sign-changing symmetry of the smaller gap. Equally remarkable is a high sensitivity of this characteristic to electron irradiation. Indeed, a concentration of artificial atomic defects as small as a few 0.1% results in both a saturation of $H_{c1}(T)$ at $T < 0.15$ K and a strong suppression of the anomalous enhancement below $\simeq 0.25T_c$, consistent with a destruction of an unconventional order parameter due to the smaller gap. Possible symmetries of the smaller gap as well as results of a comparative study on the two-band isotropic *s*-wave homologue $LaRu_4As_{12}$ (T_c = 10.4 K) [2, 3] will be discussed in the context of a putative chiral spin-triplet pairing state in $PrOs_4Sb_{12}$.

In addition, we report in- and out-of-plane $H_{c1}(T)$ dependencies of the prototypical heavy-fermion material $CeCu_2Si_2$ ($T_c \simeq 0.58$ K, S-type), for which two-band and fully gapped superconductivity has been recently observed. For both [100] and [001] directions, we found clear anomalies (at $\simeq 0.36T_c$ and $\simeq 0.39T_c$, respectively) followed by moderate enhancements. Unlike to $PrOs_4Sb_{12}$, however, both $H^a_{c1}(T)$ and $H^c_{c1}(T)$ curves saturate in the limit $T = 0$, being more consistent with an $s_{\pm}$-wave scenario than a $d_{xy} + d_{x^2-y^2}$ band-mixing paring model. Besides, the effect of electron-irradiation on the anomalous enhancement of $H_{c1}(T)$ at $T \ll T_c$ will be shown.

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Lecture W-05

Magnetic phase transition in $TbAl_3(BO_3)_4$ below 700 mK - quantum and classical features

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Specific heat, C_B, and magnetization, M, of a $TbAl_3(BO_3)_4$ single crystal were studied for temperatures, T, from 50 mK to 300 K, with emphasis on the $T < 1$ K range, where a phase transition was found at 0.68 K. Nuclear, lattice and critical (C_{cr}) contributions to C_B were separated. We found that: (i) the phase transition shifts to lower T with increase in magnetic field $\mathbf{B}_{||}$, parallel to the easy magnetization axis, (ii) $C_{cr} \sim T^{y_0}$, and (iii) the Grüneisen ratio, Γ, defined as:

$$\Gamma = -\frac{1}{T}\frac{(\partial S/\partial B)_T}{(\partial S/\partial T)_B} = -\frac{(\partial M/\partial T)_B}{C_B(T)} = \frac{1}{T}\left(\frac{\partial T}{\partial B}\right)_S \tag{1}$$

(S is entropy) diverges as a function of $B_{||}$ for $B_{||}$ approaching a critical value of 0.6 T. The dependences of both C_{cr} and Γ on T (especially scaling of the latter for $B_{||} \geq 0.30$ T), as well as the dependence of Γ on $B_{||}$ are characteristic of the systems, in which the classical phase transition line is influenced by quantum fluctuations, QF, and ends at a quantum critical point. By analyzing the y_0 and Γ values, we assessed the dynamical critical exponent z to be $0.82 \leq z \leq 0.96$. Based on these results, we suppose that QF dominate the behavior of the system and destroy the long range order, i.e., we suppose the transition to have a quantum character.

The interpretation that this is the transition to the ferromagnetic ordering of Tb^{3+} magnetic moments is the most natural, intuitive, and supported by the studies of M. However, such a classical transition should be smeared and shifted to higher T by $B_{||}$, while we observe the opposite effect. Such effect was observed in systems, in which not only the exchange interactions but also magnetic dipolar interactions were essential. However, the possibility, that the transition is related to any other kind of ordering, e.g., a multipolar ordering, can not be ruled out *a priori*.

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Lecture W-06

Superconductivity in Os-based Laves compounds

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Laves phase compounds belong to the class of Frank - Kasper phases showing topologically close-packed structures. They are categorized primarily into three parent members: the C14 hexagonal $MgZn_2$ - type ($P63/mmc$), the C15 cubic $MgCu_2$ - type ($Fd-3m$) and the C36 hexagonal $MgNi_2$ - type structures ($P63/mmc$). The discussion on the special properties of Laves phases started in the 1920s and 1930s. Laves's work gave the first valuable insight into the characteristics of this class of materials.Especially in the last 30 years AB_2 - type Laves phase compounds have been a subject of particular interest in solid state physics due to the variety of their physical properties. Today, over a thousand binary and ternary Laves phase intermetallics have been synthesized and characterized, of which about 60% contain a rare earth metal atom.

Motivated by describing the Os-based Laves superconductors, we synthesized and tested ROs_2 materials (R = Lu, Y, Sc). The bulk nature of the superconducting transitions for $LuOs_2$, YOs_2, and $ScOs_2$ is evident from the visible anomalies at T_c = 3.47 K, 4.55, and 5.36 K, respectively. The heat capacity experiment revealed that all compounds are moderately coupled type-II superconductors.

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Invited lecture **W-07**

Hubbard subbands in the infinite-layer nickelate

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Starting from an effective two-dimensional (2D) two-band model for infinite layer nickelates [1], consisting of bands obtained from d and s–like orbitals, we investigate whether this model can be mapped onto a single-band Hubbard model. With exact diagonalization and the Lanczos algorithm we determine the electron density distribution $\{n_d, n_s\}$ in an eight-site 2D cluster. One finds a competition between low-spin and high-spin states in undoped nickelate [2]. Screening of interactions within the s band redistributes electrons over the bands and destroys antiferromagnetism. The holes realize doping $\delta = 1 - n_d$ in partly filled lower Hubbard band (LHB) of the correlated $x^2 - y^2$ band, and considerable spectral weight is then transferred from the upper Hubbard band (UHB) to the unoccupied part of the LHB (i.e., above the Fermi level). The mechanism of such a spectral weight transfer is well known in a doped Mott insulator [3] and explains why the weight of the LHB increases beyond that expected for the correlated d band at half filling. The largest weight transfer emerges at reduced Coulomb interaction $U_d = 4$ eV and moderate screening of 50%. The Hubbard bands form in the correlated $x^2 - y^2$ band and the weight transfer occurs only when the strongly correlated band is partly filled.

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Lecture W-08

Hund excitations in orbital-selective Mott insulators

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Strongly-correlated electron systems are at the heart of many modern condensed matter physics phenomena. The celebrated Mott insulators, originating in the strong electron-electron correlations, are still extensively studied in the context of the high-temperature superconductivity of cuprates. On the other hand, the complicated multiorbital Fermi surface of iron-based superconductors can lead to novel phenomena not present in "standard" Mott physics. A nontrivial example of the latter is the orbital-selective Mott phase (OSMP), where Mott-localized and itinerant electrons coexist. In this talk, I will show that additional energy scales present in the multiorbital systems, i.e., the Hund interaction, lead to novel bands in the single-particle spectrum of the system. I will primarily discuss that one gets multiple Hund and Hubbard modes instead of the upper- and lower-Hubbard band known from the single-orbital Hubbard model. Finally, I will present the optical conductivity data, which can serve as a simple experimental tool to probe such phenomena.

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Lecture W-09

Non-Abelian Berry phase induced entanglement between qubits in QED cavity

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Geometric phases, generated by cyclic evolutions of quantum systems with degenerate groundstate providing qubit basis, offer realization of the non-Abelian statistics. As compared to dynamic gates, non-Abelian geometric control over such a qubit should benefit from tolerance to fluctuations. On the concrete example of dynamically driven hole-spin 3/2 immersed in QED cavity in Ref. [1] we have shown that the interplay between the non-Abelian Berry phases generated by local time-dependent electrical fields and the shared photons allows for fast manipulation, detection, and long-range entanglement of the qubits. Moreover, we have demonstrated that owing to its geometrical structure, such a scheme is indeed robust against external noises. Additionally, we have confirmed that the found mechanism also applies to quantum dot qubits [2] where single gate holonomic operations are executed by cyclic control of the position of confining potential.

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Lecture W-10

Strong-coupling superconductivity of $SrIr_2$ and $SrRh_2$: Phonon engineering of metallic Ir and Rh

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The two title compounds, $SrIr_2$ and $SrRh_2$, are so-called Laves phases which superconduct with T_c = 6.1 K and 5.4 K, respectively. Their crystal structure is closely related to the underlying monoatomic *fcc* phases of elemental M = Ir and Rh, with the tetrahedrons of M as the main building blocks. Further on, we see similarities between SrM_2 and elemental M on the microscopic level. The electronic structure of the Laves phase is roughly speaking the charge-doped electronic structure of the elemental metal, as Sr is a charge reservoir. Also the phonon spectra show similarities between those two systems. In spite of these similarities, both groups of materials have strikingly different superconducting properties, as Ir and Rh are poorly-superconducting materials with T_cs of 0.3 K and 0.003 K, respectively. The aim of our work was to explain how the insertion of Sr into the Ir/Rh network changes the poorly superconducting metals into strongly coupled superconductors, as small electron doping effect is not sufficient to explain that. What we have found may be labeled as *phonon engineering* as the modifications in phonon spectra occurred to be the key ingredient in making the Laves phases the strongly coupled superconductors. Eventhough Sr has a smaller atomic mass than Ir or Rh, its presence in the structure influences propagation of phonons in the network of M tetrahedrons, leading to a substantial lowering of frequencies of selected phonon branches, enhancing the electron-phonon interaction and multiplying T_c. Moreover, this mechanism seems to be quite general and explains strong-coupled superconductivity of other related Laves phases.

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Lecture W-11

Ternary superhydrides: in search of low-pressure high-temperature superconductor

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Motivated by the recent experimental discovery of high-temperature carbonaceous sulfur hydride (C-S-H) [1], we have systematically explored the superconductivity of a carbonaceous lanthanum hydride (C-La-H) ternary compound in the pressure range of 50-250 GPa. Based on first-principles calculations and strong-coupling Migdal-Eliashberg theory, we find that a hitherto unreported LaC_2H_8 ternary system is dynamically and thermally stable above 70 GPa in a clathrate structure with space group $Fm\bar{3}m$ and exhibits a superconducting critical temperature in the range of 69-140 K [2]. The obtained results have important implications for tuning pressure and T_c through appropriate doping and in the future, they may contribute to the discovery of superconducting materials at ambient conditions.

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Invited lecture **W-12**

Theory of superconductivity with local electron pairing: history and perspectives

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The theory of superconductivity with local electron pairing [1, 2] was founded chiefly by the Polish authors: Roman Micnas and Stanisław Robaszkiewicz and their co-workers, beginning since early 1980'. The approach is based on the assumption that the basic properties of the superconductors can be explained using an effective short ranged dispersionless attraction between electrons. Although the first works in this field appeared yet before discovery of superconductivity in cuprate oxides, the original motivation for its development was to study the properties of a hypothetical high-temperature superconductors with electronic attraction due to the coupling of electrons to some high energy bosonic excitations, e.g. excitons or optical phonons. The generic models used in the theory are: the Hubbard Hamiltonian with a negative on-site or intersite attraction, the periodic Anderson model, and the boson-fermion model. The theory proved to be useful, e.g. in discussion of the universal properties of unconventional superconductors as described by so-called Uemura plots, in an analysis of the BCS-Bose crossover, and in an explanation of the pseudogap in the underdoped cuprate superconductors. In a limit of a very strong on-site electron attraction the theory describes superconductors with local electron pairs. In the latter case some accurate, explicit formulas for various superconducting characteristics of the system were obtained, which can be used for testing the general theory. In this talk I plan to present a short historical account of the development of the theory, its main advantages and limitations, its present day reception and some recent applications.

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Lecture W-13

Chwila wspomnień po 36 latach

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W bieżącym roku mija 36 lat od odkrycia zjawiska wysokotemperaturowego nadprzewodnictwa. Pragnę przypomnieć okoliczności tego odkrycia w szczególności w Polsce, które doprowadziły do konsolidacji i rozwoju środowiska prowadzącego badania w tej tematyce. Efektem tego było powstanie cyklicznego Krajowego Sympozjum ”Nadprzewodnictwo Wysokotemperaturowe”. W tym roku jest to już 20 spotkanie. Warto przypomnieć te ”gorące dni”. ”Piękno nauki na tym polega, że tyle jest zjawisk nieprzewidywalnych” (Paul Chu, Ching-wu).

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Plenary lecture **W-14**

Interplay of various order parameters and disorder in iron chalcogenides

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Since the discovery of iron-based superconductors over a decade ago large efforts are directed towards uncovering the primary order parameter determining the properties of these materials. However, the abundance of various low-temperature phases observed experimentally suggests that there may be no single order parameter, instead, many degrees of freedom, including nematic, spin, charge, or orbital degrees of freedom, are strongly intertwined. In addition, these materials are prone to various forms of disorder, which influences the nature of the ground state.

In this talk, I will summarize several years of our studies of iron chalcogenide system, $FeTe_{1-x}Se_x$, in which the disorder is introduced intentionally by two different methods, substitution of transition metal element, Ni, into Fe-site, and by changing the crystallization rate during the crystal growth. This last method introduces either excess, or deficiency of the Fe, what affects both the crystal quality, and superconductivity, with the surprising result that the superconductivity is enhanced in crystals of inferior crystallographic properties [1]. Over the years, we have used various experimental probes to understand this behavior, including transport [2], photoemission [3], and, most recently, magnetization and angular magnetoresistance experiments. I will combine the results of these experiments and discuss how the interplay of nematicity, spin fluctuations, and disorder-induced doping affects ground state properties of this system.

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Invited lecture **W-15**

Superconductivity in the Heusler-type intermetallic compounds

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Although discovered more than a century ago, the Heusler material classes remain an exciting and active research area. Interestingly, there are more than 1000 reported compounds in this family, and only 35 of them are superconductors.

In this lecture, recently reported Heusler-type superconductors: $MgPd_2Sb$ [1], $LiPd_2Ge$ [2], $LiPd_2Si$ [3], $LiGa_2Rh$ [4] and $LiGa_2Ir$ [5] will be presented.

$MgPd_2Sb$ is the first Mg-based a Heusler-type compound in which superconductivity is revealed. The number of valence electrons for $MgPd_2Sb$ is VEC = 27 and falls exactly at the maximum of the proposed T_c vs. VEC [6]. For $LiPd_2Ge$ and $LiPd_2Si$ the number of valence electrons is 25, and for the other two Li-based superconductors ($LiGa_2Rh$ and $LiGa_2Ir$) VEC = 16. While the last two materials are type-II superconductors, $LiPd_2Ge$ is a rare case of an intermetallic compound for which type-I superconductivity is observed. Theoretical calculations of the phonon structure indicate the possibility of the so-called soft modes in $LiPd_2Ge$, which lead to the amplification of the electron-phonon coupling and consequently to the occurrence of superconductivity in this family.

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Invited lecture **W-16**

Properties of (Nb, Pb, In)/NbP - superconductor/Weyl semimetal junctions

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Recently, an idea of introducing superconductivity in topological materials has been developed owing to the possibility of non-zero momentum Cooper pairing. One of the consequence of the non-zero momentum pairing is the possibility of formation of zero-energy modes that are equivalent to Majorana fermions which show potential for practical realization of fault-tolerant topological quantum computation. While there is still a long way to build such quantum computer, one needs to find an optimal material platform for its construction. In particular, introducing nonzero superconducting order parameter into topological materials by inducing superconductivity through the proximity effect enables to employ presently achievable Weyl semimetals and conventional superconductors.

In our studies of interface transmission, the (001) surface of NbP single crystal was covered by several hundred nm thick metallic layers of either Pb, or Nb, or In. Upon cooling of the devices during which the metals become superconducting, all three types of junctions show conductance increase, pointing out the Andreev reflection as a prevalent contribution to the subgap conductance. In the case of Pb-NbP and Nb-NbP junctions, the absolute value of the conductance is much smaller than that for the bulk crystal, indicating that the transmission occurs through only a small part of the contact area. An opposite situation occurs in In-NbP junction, where we observe very high and narrow peak at zero bias. The conductance at the peak reaches the bulk value indicating that almost whole contact area is transmitting and, additionally, a superconducting proximity phase is formed in the material. We interpret this as a result of indium diffusion into NbP, where the metal atoms penetrate the surface barrier and form very transparent superconductor-Weyl semimetal contact inside. However, further diffusion occurring already at room temperature leads to degradation of the effect, so it is observed only in the pristine structures. Despite of this, our observation directly demonstrates possibility of inducing superconductivity in Weyl semimetal.

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Invited lecture **W-17**

Chiral molecule mediated proximity effect

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The proximity effect is well understood in the superconductor to normal metal contacts, however, its understanding is quite limited in systems involving organic molecules. In this presentation we discuss the organic molecules mediated proximity effect between classical BCS superconducting thin film and normal metal nanoparticles. For low-temperature superconducting Nb thin films, a peculiar inverse proximity effect has been observed in which the critical temperature and the critical current increase upon the attachment of organic molecules topped with gold nanoparticles. Concomitantly, in the tunneling density of states of the gold NPs, depending on the molecule-mediated coupling strength, either zero-bias peaks or the proximity gaps appear. For strong molecular coupling, the proximity gaps are induced in Au NPs.

Chiral molecules are known to exhibit the chiral induced spin selectivity effect appearing, among others, as chiral-induced magnetization and spin-selective transport. The replacement of straight molecules with chiral ones leads to new features in the proximity effect between conventional BCS superconductors and normal metal nanoparticles. Scanning tunneling spectroscopy shows that the singlet-pairing s-wave order parameter of Nb is significantly altered upon adsorption of chiral polyalanine alpha-helix molecules on its surface. The tunneling spectra exhibit zero-bias conductance peaks embedded inside gaps or gap-like features, suggesting the emergence of unconventional triplet-pairing components with either d-wave or p-wave symmetry at the Nb organic-molecules interface, as corroborated by simulations. These results may open a way for realizing simple superconducting spintronics devices.

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Invited lecture **W-18**

Electronic structure of the heavy fermion superconductor Ce_3PdIn_{11} with two inequivalent crystallographic positions of Ce atoms

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We studied the electronic structure of the antiferromagnetic heavy-fermion superconductor Ce_3PdIn_{11} by means of angle-resolved photoemission spectroscopy (ARPES) and density functional theory (DFT). The ARPES measurements were conducted at T = 6 K using photon energy of 122 eV, corresponding to Ce 4d-4f resonance, which enhances the spectral contribution of Ce 4f electrons. The Fermi surface mapped in the experiment appeared quite complex with some branches similar to those observed before in related $CeTIn_5$ and Ce_2TIn_8 (T = Co, Rh, Ir, Pd) systems. The ARPES spectra reflected strong hybridization between 4f and conduction band electrons which leads to enhanced effective masses of 4f quasiparticles. Analysis of the spectral width as a function of binding energy revealed features characteristic of Fermi liquid state. The ARPES spectrum related to the $f^1_{7/2}$ final state showed an energy splitting of 50 meV, which may originate from crystalline electric field effect.

The DFT calculations made using Korringa-Kohn-Rostoker method allowed to reproduce qualitatively the dispersions and parts of the Fermi surface seen in the experiment. The total Bloch spectral function and its projection on atomic orbitals reflected contributions of different atoms to the valence band. In particular, distinct features were found due to the Ce atoms located at the crystallographic 2g and 1a sites, what implies different hybridization effects related to the two Ce atom sublatices in the Ce_3PdIn_{11} unit cell.

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Lecture W-19

Badania żelazowo-arsenowych nadprzewodników wysokotemperaturowych z wykorzystaniem promieniowania synchrotronowego

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Na seminarium przedstawię wyniki pomiarów żelazowo-arsenowych nadprzewodników wysokotemperaturowych z wykorzystaniem promieniowania synchrotronowego (Solaris i Elettra) metodami XANES (X-ray absorption near edge structure) oraz XLD (X-ray linear dichroism). Wyniki pomiarów techniką XLD na krawędzi $L_{3,2}$ Fe w rodzinie związków $Eu(Fe_{1x}Co_x)_2As_2$ wskazują na różne obsadzenie orbitali d_{xz} and d_{yz} żelaza, co prawdopodobnie wiąże się ze zjawiskiem nematyzmu, który jest obserwowany w tych materiałach [1]. Zaprezentuję również wyniki pomiarów techniką XANES (na krawędziach Fe oraz As) na związkach dwóch rodzin tzw. 112 i 122, różniących się m.in. strukturą krystaliczną, w funkcji domieszkowania Fe (Ni lub Co).

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Invited lecture **W-20**

Stability of the Fulde-Ferrell-Larkin-Ovchinnikov phases in Fermi mixtures: role of the Lifshitz point

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I will discuss the issue concerning stability of the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) superfluid phases to thermal and quantum fluctuations, emphasizing the role of the Lifshitz point present in the mean-field phase diagram of the system. On general grounds I will argue that in isotropic systems such a phase diagram cannot be stable to fluctuations in any dimensionality below d=4. I will discuss the possibility of stabilizing the FFLO states in layered three-dimensional setups.

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Invited lecture **W-21**

Spin and charge quantum excitations in high-T_c cuprates

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Observation of robust quantum spin and charge excitations in doped copper-oxide high-temperature superconductors (HTSC) suggests their relevance to HTSC phenomenology and calls for investigation of the microscopic mechanism preventing them from Landau overdamping. We address this problem using **V**ariational **W**ave **F**unction (VWF) scheme, combined with expansion in the inverse number of fermionic flavors ($1/\mathcal{N}_f$), in brief VWF+$1/\mathcal{N}_f$ [1–5]. Our approach is benchmarked against determinant quantum Monte-Carlo results, and applied to interpret the resonant inelastic x-ray scattering data for La- and Bi-based cuprates.

By employing the Hubbard model with long-range Coulomb interaction, we demonstrate that observed spin- and charge excitation spectra may be quantitatively reproduced across the HTSC phase diagram, with doping-independent model parameters [1, 3, 5]. Adequacy of t-J and t-J-U-(V) models is also delineated [4].

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Lecture W-22

Coexistence of two kinds of superfluidity

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Bosonic lattice systems with extended interactions constitute a unique platform to study new phases of matter. This work presents an analysis of the Bose-Hubbard model with density-induced tunneling. The U(1) quantum rotor method in the path integral effective action formulation is used. This approach enables the discovery of a second kind of superfluidity in physical systems: pair superfluidity, thus adding to the phases of matter. It also sheds light on the properties of single-particle Bose-Einstein condensation (BEC) in optical lattice systems with higher inter-particle correlations. The derived effective phase Hamiltonian includes the residue of many-body correlations, providing information about phase transitions between the normal state and single-particle and pair superfluids at finite temperatures. The thermodynamical properties of the system are investigated. The impact of density-induced tunneling on single-particle BEC is also analyzed. The density-induced term supports single-particle coherence at high densities and low temperatures, improving the single BEC critical temperature. It is also responsible for dissipative effects, which are independent of the system's thermal properties.

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Lecture W-23

The interplay between lattice distortion and superconductivity in cuprate superconductors

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The interplay between the crystallographic structure and superconductivity in the cuprates has been extensively explored for over three decades [1]. It is now a well-known fact, that the cuprates exhibit large differences in T_c's despite similar generic structure. For instance, the maximal critical temperature for two single-layered cuprates $La_{2-x}Sr_xCuO_4$ (LSCO) ($T_{c,max}$ = 35 K) and $HgBa_2CuO_{4+\delta}$ (Hg1201) ($T_{c,max}$ = 95 K) differs by approximately 60 K. Understanding why seemingly similar cuprates have such significantly different critical temperatures can provide clues regarding the mechanism of superconductivity in these materials. However, the main difficulty in searching for the source of these differences comes from the fact, that it requires comparison of different compounds, thus consideration of the variation in the defect concentration, doping mechanism [2], details of the Fermi surface, etc. In contrary, uniaxial pressure allows one to induce small changes in the lattice geometry and test in detail the influence of the crystallographic structure on superconductivity in a single sample, keeping the disorder and defect concentration unchanged.

I will present our preliminary results of the electronic and structural studies performed on single crystals of the hole-doped LSCO and electron-doped $Nd_{2-x}Ce_xCuO_4$ (NCCO) under external uniaxial pressure. Our results demonstrate that even small uniaxial stress applied along *a*-axis noticeably influences the electronic properties and superconductivity, as observed by resistivity measurements. Furthermore, I will discuss the impact of uniaxial pressure on the lattice parameters, determined using X-ray diffraction (XRD). Our studies demonstrate that uniaxial pressure is an ideal tool to explore the interplay between the structure and superconductivity.

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Lecture W-24

Origin of the phonon soft mode in Heusler compound $LiPd_2Ge$

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Recently discovered superconducting Heusler compound $LiPd_2Ge$ [1] is a weakly coupled type-I superconductor with a transition temperature T_c=2 K. It exhibits an unusual feature in the phonon spectrum namely an unstable soft mode near the wavevector $\mathbf{q} = (1/3, 1/3, 0)$ (i.e. harmonic phonon frequencies become imaginary). Isostructural and isoelectronic $LiPd_2Si$ and $LiPd_2Sn$ show similar phonon anomalies, but the softening in $LiPd_2Ge$ is the strongest and it coincides with the highest calculated T_c for this series of compounds which suggest it enhances superconductivity. Soft modes in the phonon spectrum were observed in other Heusler structures, however their origin is rarely discussed. In this work we have systematically studied possible reasons for the appearance of the soft mode by examining the Fermi surface nesting, structural distortion, structure modulation and the potential energy surface. We found that the strongly anharmonic double-well potential appears in the system, however only for the collective atomic displacements, which coincide with the unstable phonon eigenvectors.

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Lecture W-25

Equilibrium and nonequilibrium criticality in the one-dimensional XY model with long-range interactions

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Long-range order can exist at finite temperature in a one-dimensional system, provided that there exists slowly decaying long-range interaction. This allows, in particular, for a finite temperature transition to a superfluid state in a thin ring. If the critical point is approached sufficiently quickly, topological defects can be created in the form of states with non-zero winding number. This nonequilibrium dynamics is described by the Kibble-Żurek (KZ) mechanism.

In this talk the nonequilibrium dynamics across the phase transition will be discussed for the one-dimensional XY model with long-range interaction that decays as $r^{-\alpha}$. This model can be obtained as an effective model for non-interacting bosons with long-range hoppings. We use the kinetic Monte Carlo method to simulate the dynamics for different cooling rates. We argue that the long-range character of the interaction introduces a new length scale, which affects the KZ scaling relations.

It has been suggested that for $\alpha = 2$ a Berezinskii-Kosterlitz-Thouless-type transition to the superfluid state exists in this model [1]. We analyze this particular case in a detailed way. Since in this case the properties scale logarithmically with the system size, it is numerically very demanding to obtain results in the thermodynamic limit. Nevertheless, using massive computations we were able to predict the temperature dependence of the superfluid stiffness.

Finally, a nontrivial problem of periodic boundary conditions for systems with long-range interactions will also be discussed.

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Lecture W-26

Phenomenology of Spectral Functions in Disordered Spin Chains at Infinite Temperature

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Quantum many-body systems in the presence of quenched disorder exhibit many intriguing features, which range from the emergence of anomalously slow dynamics to the possibility of a phase transition into a many-body localized (MBL) phase, where the slow dynamics still persists up to detectable timescales. However, a simple and universal theory that may explain this dynamics at different disorder strengths is still missing.

Recently [1], we have introduced a phenomenological theory that may explain some of these features. The theory accurately explains the low-frequency part of the spectral function in a wide range of disorders. The linchpin of this theory is the premise of a proximity of the interacting system (random field Heisenberg spin chain) to the noninteracting limit, in which the system is an Anderson insulator. Taking the spin imbalance (experimentally relevant observable measured in several experiments by the I. Bloch's group) as an example, we demonstrate that the proximity to the local integrals of motion of the Anderson insulator determines the dynamics of the observable at infinite temperature. In finite interacting systems, our theory quantitatively describes its integrated spectral function without assuming the existence of an MBL phase.

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Lecture W-27

Floquet dynamical quantum phase transitions

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The concept of dynamical quantum phase transitions (DPQTs) [1] observed in some experimental works [2–4] have been introduced as the similarity between the equilibrium partition function of a system and Loschmidt amplitude i.e., the overlap between an initial state and its time-evolved one. Whilst the equilibrium phase transitions are described by nonanalyticities in the thermal free energy, the DQPTs are marked by the nonanalytical behavior of dynamical free energy during its temporal real-time evolution. Remarkably, it is predicted that a signature of the DQPT for a quantum system can emerge in the topological structure which can be perfectly characterized by a dynamical topological order parameter in one- [5] and two-dimensional [6] identified precisely by the discontinuities of the Pancharatnam geometric phase during the time evolution of the systems.

On the other side, the study of time-dependent quantum systems in the framework of the Floquet theory [7], i.e., evolving quantum systems under the time-periodic Hamiltonians, is one of the most attractive areas of developing nonequilibrium research. Merging two theories, DQPTs and Floquet systems, leads to creating Floquet DQPTs (FDQPTs) [8, 9] where the dynamics occur periodically without decaying in time.

Here I want to speak about FDQPTs for both pure and mixed state one-dimensional p-wave superconductors with a time-driven pairing phase and their relationships with the dynamical topological order parameter.

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Plenary lecture **W-28**

Exchange interactions in magnetically doped topological semiconductors

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Over last decades, we have been witnessing more and more stronger interplay of magnetism and superconductivity. After an introduction to dominant exchange mechanisms between transition metal spins in conventional and topological semiconductors, I will turn to a worthwhile controversy concerning the sign and magnitude of the interband analogue of the RKKY interaction in topological systems.

A consensus has recently emerged that the enhanced interband spin susceptibility in topological materials leads to a strong and foremost ferromagnetic coupling between transition-metal ions [1,2], the interaction referred to as the Van Vleck mechanism [3]. We have called this insight into question and demonstrated theoretically that in the absence of carriers the superexchange is the dominant exchange mechanism in magnetically-doped topological insulators [4]. In particular, we have shown, using band structure parameters [5] and the methodology elaborated earlier [6], that the interband susceptibility is conquered by a self-interaction term that does not contribute to the strength of the spin-spin interaction between different magnetic ions [4].

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Invited lecture **W-29**

Topological superconductivity driven by self-organized spin structures

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We study the temperature-dependent self-organization of magnetic moments coupled to itinerant electrons in a finite-size low-dimensional nanostructures proximitized to a superconducting reservoir. At low temperatures, an effective RKKY-type interaction between the localized magnetic moments, that is mediated by itinerant electrons, leads to their helical ordering. This ordering, in turn, affects the itinerant electrons, inducing the topologically nontrivial superconducting phase that hosts the Majorana modes. The calculations demonstrate that the topological state can exist at least for a chain of magnetic atoms [1] and for a ladder [2]. It is interesting that in the case of a ladder an unconventional topological phase transition with neither gap closing nor a change of symmetry is possible. This contradicts common assumptions that topological phase transitions in topological superconductors are accompanied by a closing of the topological gap or a change of the symmetry of the system.

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Invited lecture **W-30**

Instability of Majorana states in Shiba chains due to leakage into a topological substrate

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We revisit the problem of Majorana states in chains of scalar and magnetic impurities deposited on a superconductor with a mixed s-wave and p-wave pairing. We use several new analytical and semi-analytical tools that allow one to determine the topological character of impurity Shiba chains. We show that the magnetic impurity chains exhibit well-localized Majorana states when the substrate is trivial, but these states hybridize and get dissolved in the bulk when the substrate is topological. Most surprisingly, and contrary to previous predictions, the scalar impurity chain does not support fully localized Majorana states except for very small and nely tuned parameter regimes, mostly for a non-topological substrate close to the topological transition. Our results indicate that a purely p-wave or a dominant p-wave substrate are not good candidates to support either magnetic or scalar impurity topological Shiba chains.

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Invited lecture **W-31**

Interaction-induced Majorana edge states in multiorbital chains

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Topological phases of matter are among the most intriguing research directions in Condensed Matter Physics. It is known that superconductivity induced on a topological insulator's surface can lead to exotic Majorana modes, the main ingredient of many proposed quantum computation schemes. In this context, iron-based high critical temperature superconductors are among the main candidates to host such exotic phenomenon. Moreover, it is commonly believed that the Coulomb interaction is vital for the magnetic and superconducting properties of these systems. Our studies bridge these two perspectives and show that the Coulomb interaction can also drive a trivial superconductor with orbital degrees of freedom into the topological phase [1]. Namely, we show that above some critical value of the Hubbard interaction, identified by the change in entropy behaviour, the system simultaneously develops spiral spin order, a highly unusual triplet amplitude in superconductivity, and, remarkably, Majorana fermions at the edges of the system.

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Invited lecture **W-32**

Yu-Shiba-Rusinov Qubit

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Magnetic impurities in s-wave superconductors provide a viable platform for realizing a topological quantum computer based on Majorana zero modes. However, the coherent manipulation of quantum degrees of freedom in these systems remains an open challenge. For this purpose, in this talk I will describe a new type of quantum bit, a Yu-Shiba-Rusinov qubit (YSRQ), stemming from two nearby magnetic impurities on a superconductor, and demonstrate that the coherent rotation and the read out of the qubit states is possible by exploiting the dynamics of the impurity spins [1]. We establish a protocol for the generation of Rabi oscillations induced by the dynamics of the magnetic impurities, which is robust for a wide range of experimentally feasible parameters. The precession of the magnetic impurities also generates a feedback torque acting on the impurity, which in turn modifies its resonance frequency depending on the YSRQ state [2]. I will show that it is possible to utilize this effect to read out the YSRQ via the well-established scanning tunneling microscopy-electron spin resonance (STM-ESR) techniques. If time permits, I will briefly discuss an alternative for YSRQ manipulation and detection based on super-currents [3]. YSRQs can be integrated naturally with topological qubits based on Majorana zero modes, allowing the possibility of transferring quantum information coherently between them and facilitate future implementations of a universal set of quantum gates.

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Invited lecture **W-33**

Dynamical quantum phase transition in a mesoscopic superconducting system

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We study the transport and dynamical properties of a hybrid mesoscopic system, consisting of a magnetic impurity, such as a quantum dot or a molecule, embedded between the metallic and superconducting leads. This system allows for the exploration of a singlet-doublet phase transition, which emerges depending on the intrinsic parameters of the system. To inspect the signatures of this phase transition, we focus on the quench dynamics triggered by two different protocols. The first one is performed in the coupling strength between the impurity and the superconducting lead, while the other one is associated with the shift of the orbital energy level. We thoroughly analyze the time-dependent charge occupancy, on-dot pairing correlations and transient currents. Furthermore, we determine the Loschmidt echo and demonstrate that non-analytic features in the return rate reveal signatures of dynamical quantum phase transitions [1]. Such dynamical phase transitions are found to occur periodically at critical times, which coincide with the corresponding local extrema of the pairing correlation function.

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Invited lecture **W-34**

Ab initio study of the chiral phonons

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Hexagonal and kagome lattices exhibit extraordinary electronic properties. Such distinctive features are a consequence of additional discrete degrees of freedom associated with a valley or the occurrence of electronic flat-bands. Combination of both types of lattices, observed in CoSn-like compounds, leads not only to the topological electronic behavior, but also to the emergence of chiral phonon modes. Here, I will present our results of the study of CoSn-like compounds in the context of the emergence of chiral phonons [1]. Previous theoretical studies demonstrated that the chiral phonons can be found in ideal two-dimensional hexagonal lattices [2, 3]. However, it turns out that in the case of CoSn-like systems with the P6/mmm symmetry, the kagome lattice formed by *d*-block element (Co-like) is decorated by the additional *p*-block atom (Sn-like). This results in a two dimensional triangular lattice of atoms with non-equal masses and the absence of chiral phonons in the kagome plane. Contrary to this, the interlayer hexagonal lattice of *p*-block atoms is preserved and allows for the realization of chiral phonons. Additionally, we discuss the properties of these chiral phonons in several class of materials, like magnetic topological insulators $T\mathrm{Bi}_2\mathrm{Te}_4$ (T =Mn,Fe) [4], binary compounds ABi (A =K,Rb,Cs) [5], orthorhombic YAlSi [6].

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Lecture W-35

Interplay of strong correlations and topological superconductivity in double quantum dots

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One of the most intensely researched types of superconductors are so called topological superconductors, hybrid 1-dimensionsal nanowires supposedly hosting p-wave superconductivity in their bulk and Majorana bound states (MBS) at their ends. In a quest for irrefutable proof of their existence transport measurements on quantum dot attached to the end of such wire has been proposed and realized, showing some signatures of nontrivial topology [1], but no decisive proof of the presence of MBS. On the other hand, in various systems at low temperatures strong electronic correlations give rise to rich phase diagrams, comprising also unconventional phases [2]. In this contribution we bridge these two fields with theoretical investigations of the signatures of MBS in the spin and charge transport through a T-shaped double quantum dot coupled to the topological superconductor [3]. Addressing the Kondo regime by means of numerical renormalization group calculations we demonstrate a series of predictions complementary to conventional 0-bias peak in the spectral density observed in MBS candidates.

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Lecture W-36

Quench dynamics of Fano-like resonances in double quantum dot systems

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We explore the electron dynamics of a system composed of double quantum dots embedded between metallic and superconducting leads in a "T-shape" geometry. In nanoscopic systems where electron transfer between electrodes can be realized via different paths, interference effects play an important role. For the double quantum dot system in chosen geometry interference of electrons transferred between electrodes via interfacial quantum dot (QD_1) and electrons scattered on side dot (QD_2) gives rise to Fano-like interference. If such a system is additionally coupled to a superconducting electrode, along well understood Fano resonance additional resonance appears on the opposite side of Fermi level.

In recent work [1], we showed that this resonance occurs solely as a result of the local pairing of non-scattered electrons with scattered ones. In the present presentation considering the quench dynamics, we explore how much time is required for the formation of each of these resonances.

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Lecture W-37

Sublattice extension of the Rashba nanowire model

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Interplay between superconductivity, spin orbit coupling and magnetic field can lead to realization of the topological phase. Majorana bound states (MBS) emerging at the ends of a one dimensional nanowire are one of its manifestations [1, 2]. Signatures of these states have been observed, e.g. in superconductor-semiconductor hybrid nanostructures or adatom chains. During this talk, We will present a few cases where the MBS can emerge outside of the usual topological regime, due to the impact of the sublattice on the topology of Oreg-Lutchyn model of Rashba nanowire. It is done by expanding the Rashba nanowire model with dimerized sublattice similar to SSH model [3] or with antiferromagnetic sublattice [4]. In the first case, the dimerization-induced topological superconductivity allows for forming of additional topological *branch*. In the second case, an additional topological *branch* emerges due to the antiferromagnetic order allowing Majorana bound states to exist close to half-filling, obviating the need for either doping or gating the nanowire to reach the low density regime or even external magnetic field. We will discuss results in context of topological phase diagrams showing the beneficial impact on the robustness of MBS.

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Lecture W-38

Nontrivial spin textures in superconducting two dimensional materials

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Nontrivial spin structures in 2D materials, like stripes, vortices and skyrmions, can lead to unconventional magnetic or transport phenomena. Moreover, in recent years such systems have attracted considerable interest due to their relevance to topological superconductivity. Natural 2D topological superconductors are rather elusive and therefore it is desired to engineer systems which can host topological states. One of the promising routes is to place a 2D nontrivial spin structure on top of a superconducting substrate.

The "traditional" stabilization mechanism for topological spin structures is based on the Dzyaloshinski-iâĂŞMoriya interaction in noncentrosymmetric magnets. Here, we demonstrate that another mechanism, itinerant frustration, can also lead to 2D helical spin structures. This mechanism is inherent to itinerant magnets in which the spin and charge degrees of freedom of electrons are coupled. The coupling induces an effective magnetic interactions, which tend to twist the spin configurations [1]. Using the spin-fermion model with proximity-induced superconductivity it will be shown that by tuning the electron concentration and pairing magnitude the spin structures can be controlled. In particular, we will demonstrate that for some system geometries such a system can host Majorana zero modes.

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Lecture W-39

Shiba states in systems with density of states singularities

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Magnetic impurity placed in a superconductor can lead to the emergence of a pair of bound states, symmetric in energy with respect to the Fermi level, known as the Yu-Shiba-Rusinov (YSR) [1–3] states. The properties of the YSR bound states depends strongly on the density of states (DOS) at the Fermi level. Here I will show our recent study of the properties of YSR bounds states in systems with DOS singularities (Dirac point, van Hove singularity, and flat band singularity), more specifically we considered honeycomb, kagome, and Lieb lattices [4]. The position of the singularities were tuned to both at the Fermi level and away from the Fermi level to uncover the properties of YSR states in those systems. It was observed that although all the properties are generic regardless of the type of lattices, the properties can change drastically if the system contains more than one non-equivalent sublattices (e.g. Lieb lattice). The value of critical magnetic coupling (J_c) was found to enhance or reduce depending on the sublattice it resides in. To explain the scenario more clearly, I will also present the differences in the local DOS and coherence lengths for different sublattices for Lieb lattice.

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Lecture W-40

Magnetic field effect on transport properties of double quantum dot coupled to Majorana wire

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We theoretically investigate the influence of external magnetic field on the spectral and transport properties of double quantum dot (DQD) system coupled to the Majorana wire. We assume that one quantum dot (QD1) is coupled to a conventional superconductor (SC) and normal metallic lead (N), while the second one (QD2) is coupled to a topological superconductor (TSC) hosting Majorana bound states. The coupling of QD1 with SC generates the Andreev bound states (ABS) in a quantum dot, which constitute an additional sub-gap transport channel in the SC-QD1-N system. On the other hand, the coupling of QD2 with TSC leads to generation of the Majorana zero mode (MZM) in the QD2. A hallmark of Majorana bound states is that these states cannot be removed from zero energy by local perturbation. We study the coexistence of ABS and MZM in the coupled double quantum dot system. The non-zero inter-dot coupling leads to mutual penetration of ABS and MBS in quantum dots [1, 2]. Value changes of the external magnetic field lead to the modification of the spectral function of QD1 and QD2. We also analyze the influence of the magnetic field on the zero-bias conductance and the differential conductance of DQD system.

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Lecture W-41

Artificial neural network solution to problems of many body correlated systems

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While trying to describe the physics of many-body correlated systems it has been quickly realized that the exponential complexity of the problems makes it often exceptionally hard to find an accurate solution. However, even though the complexity of quantum correlations encoded in the many-body wave function is in principle required to get an exact form of the solution, in reality often a much smaller segment of the corresponding Hilbert space alone is sufficient to characterize it adequately. Since the techniques offered by Machine Learning (ML) are aimed at extracting important features from huge datasets, they seem to be perfect tools for efficient finding the best representation of quantum states.

During the talk, it will be demonstrated how those tools can be used to dramatically reduce the complexity of a quantum state representation. In particular, we will show how the novel Artificial Neural Network quantum state representation [1–3], previously based on the Variational Monte Carlo approach, can be incorporated as an inner part of the reinforcement learning scheme. Results for the lower spectrum of spin one-half Hamiltonians will be presented with the insight deliberation on further possibilities offered by this method. In particular, the implementation of the Restricted Boltzmann Machine-type network to study a many-body quantum system coupled to classical degrees of freedom will be discussed.

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Plenary lecture **W-42**

Mixed singlet-septet Cooper pairing in half-Heusler superconductors

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In the ordinary picture of superconductivity, electrons with spin $s = 1/2$ form Cooper pairs whose spin structure is singlet ($S = 0$) or triplet ($S = 1$). However, when the electronic structure near the Fermi level is characterized by fermions with angular momentum $j = 3/2$, e.g., due to strong spin-orbit interaction, novel pairing states such as even-parity quintet ($J = 2$) and odd-parity septet ($J = 3$) are allowed. Prime candidates for such exotic pairing are half-Heusler compounds, which exhibit unconventional superconducting properties [1–4]. Recently, we have shown that superconductivity in the non-centrosymmetric bismuthide LuPdBi can be described by a mixture of isotropic even-parity singlet and anisotropic odd-parity septet pairing, whose ratio can be tuned by electron irradiation [5]. By means of magnetotransport and penetration depth measurements, we found that carrier concentrations and impurity scattering both increase with irradiation, resulting in a nonmonotonic change of the superconducting gap structure. Our findings shed new light on our fundamental understanding of unconventional superconducting states in topological materials.

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Invited lecture **W-43**

Enhancement of superconducting state properties and crystallinity degradation as a result of chemical substitutions, under pressure, and after hydrogenation in Fe-Te-Se single crystals

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We have already shown that the almost ideal single crystal of $FeTe_{0.65}Se_{0.35}$ exhibits a greater width of superconducting transition and a considerably smaller value of the critical current density in comparison with non-uniform sample of the same compound [1]. Resistivity results confirmed that the inhomogeneous spatial distribution of ions and presence of small hexagonal-like phase in chalcogenides with nanoscale phase separation seem to enhance the superconductivity in this system [2]. Under ambient pressure the weakening of superconducting state properties was observed in $Fe_{0.994}Ni_{0.007}Te_{0.66}Se_{0.34}$ crystal, with disorder introduced by Ni substitution, as compared with those in $Fe_{0.99}Te_{0.66}Se_{0.34}$. For $Fe_{0.994}Ni_{0.007}Te_{0.66}Se_{0.34}$, the x-ray diffraction studies have revealed a degradation of crystal quality under applied elevated pressure. Superconducting state properties of single phase $Fe_{0.99}Te_{0.66}Se_{0.34}$ crystal, such as the upper and lower critical fields, were found to be poorer, at both ambient and hydrostatic pressure, than those observed for $FeTe_{0.5}Se_{0.5}$ crystals exhibiting pronounced nanoscale phase separation. Comprehensive studies of impact of pressure on crystal structure and on superconducting state properties confirmed that enhancement of superconductivity under pressure correlates with appearance of mosaicity [3]. It was shown that thermal diffusion of hydrogen into the crystals causes significant structural changes, leads to degeneration of crystal quality, and significantly alters superconducting properties, especially enhances the critical current density [4]. After hydrogenation, a strong correlation was noticed between the structural changes and changes in the parameters characterizing the superconducting state.

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Invited lecture **W-44**

Superconductivity by dislocation bundles in $SrTiO_3$

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$SrTiO_3$ (STO), although a wide gap insulator, has long been known to be a material that easily turns into a metallic and superconductive state at extremely low levels of doping. This raised a number of questions regarding the coexistence and interdependence of metallicity/superconductivity and polar properties in this material. In the report we will show that metallicity and superconductivity in STO are not bulk properties, as it seemed, but they occur in dislocations clustered in bundles of the size of the superconducting coherence length. We have investigated STO single crystals in which only the dislocation cores were selectively doped with electrons by the electro-reduction method. During this process, reduced Ti ions and oxygen vacancies are created, and although only 10^{14-15} oxygen atoms per cm^3 were removed from the entire crystal, doping the dislocation network in the surface of single crystals was sufficient to induce a macroscopic state of superconductivity with $T_c \simeq 0.2$ K. In order to explain superconductivity in STO, we propose a model that assumes the coexistence of metallic dislocation cores with polaronic insulating regions that enable polaronic coupling within bundles with a diameter of 40-50 nm. Our research clearly shows that superconductivity in STO is realized in metallic filaments along the dislocations and is not of a volume nature [1].

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Invited lecture **W-45**

Spin chirality produced by thermal spin fluctuations

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The term *chirality* originates from the word $\chi\varepsilon\iota\rho$ in ancient Greek language. This term is used for description of objects which, like a human hand, are distinguishable from their mirror reflection. In magnetic materials, this term refers to the geometrical arrangement of spins, arising from magnetic moments being canted from parallel or antiparallel orientation. The resulting scalar spin chirality is defined as triple spin correlation expressed as their mixed product: $S_i \cdot (S_j \times S_k)$. This quantity affects the motion of quantum-mechanical electrons and thus builds a bridge between the microscopic details of the electronic structure and off-diagonal transport responses such as Hall and Nernst effects. Apart from the materials with static spin-chiral orderings, including skyrmionic systems, the finite scalar spin chirality can be produced by the average arrangements of thermally fluctuating spins. This phenomenon can be observed even in the paramagnetic state, at temperatures exceeding the magnetic ordering point, as we demonstrate in a system being a highly metallic ferromagnet with breathing kagomÃl' lattice [1].

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Lecture W-46

Anisotropy of superconducting gap of Pb-Bi alloy

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The Pb-Bi family of superconducting alloys has been known for many years, and due to their high critical field and relatively high critical temperature, these materials are widely used as superconducting junctions, and have recently been intensively studied as potential nuclear coolers in generation IV nuclear reactors.

Despite a number of experimental studies on these alloys, up to now their electronic and phonon structure has not been studied. We focus on the $Pb_{0.64}Bi_{0.36}$ alloy, which forms in *hcp* structure and is the strongest-coupled classical superconductor with a critical temperature $T_c = 8.6$ K and the electron-phonon coupling constant $\lambda = 2.0$. We compare its properties to elemental Pb, which crystallizes in the fcc structure and has lower $T_c = 7.2$ K and $\lambda = 1.5$. By using density functional perturbation theory the electron-phonon interactions are studied and we explain why Pb-Bi alloy is such a strongly coupled superconductor and how it is related to its hexagonal crystal structure. The calculations are supported by measurements of specific heat, magnetic susceptibility and resistivity. The measured temperature dependence of the magnetic critical field suggests that Pb-Bi is not a single-gap superconductor. To analyze this we have calculated the k-dependent superconducting gaps by solving anisotropic Eliashberg equations, as well as by using density functional theory for superconductors. Our results confirm that Pb is a two-gap superconductor and show that Pb-Bi has a strongly anisotropic three-band-gap structure.

Acknowledgments This work was supported by the National Science Centre (Poland), project number 2017/26/E/ST3/00119, EU Project POWR.03.02.00-00-I004/16 and PLGrid infrastructure.

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Lecture W-47

Quantum Atomistic Solid State Theory: $CeRh_2Si_2$, K_2CoF_4, $LaCoO_3$, Sr_2VO_4, Ba_2IrO_4 and Sr_2RuO_4

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The developed Quantum Atomistic Solid-State Theory (QUASST) starts theoretical description of a solid containing open d/f shell atoms from analysis of the charge and low-energy electronic structure of 3d/4f/5f/4d/5d ions. This low-energy electronic structure is determined by crystal-field and spin-orbit interactions.

In $CeRh_2Si_2$, a Kondo-lattice intermetallic and antiferromagnet, we proved, by detailed analysis of temperature dependence of the low-temperature specific heat, the realization of the trivalent charge state of practically all cerium ions. In the magnetic state, below T_N of 36 K, the Kramers doublet ground state becomes split opening a spin gap reaching 6 meV at T= 0 K. The observed magnetic moment is basically of the atomic origin. In K_2CoF_4 we study the formation of the local Co magnetic moment by means of the crystal-field and spin-orbit interactions concluding the foundamental importance of the the spin-orbit interactions, though they are very weak in case of $3d$ ions. The formation of the Co moment in K_2CoF_4 will be discussed in comparison to $LaCoO_3$, in which Co looses its magnetic moment due to strong crystal-field interactions. Similar situation occurs for Sr_2VO_4 which shows a very weak magnetic state despite of the V^{4+} state with one spin S=1/2. Sr_2VO_4 is nice manifestation of the foundamental role of the spin-orbit coupling in $3d$ ions, though its value is only 30 meV. The spin-orbit coupling causes almost perfect compensation of the spin moment by the orbital moment. Ba_2IrO_4 is oxide with $5d$ ion (Ir). It is antiferromagnet with T_N = 240 K. There is discussion about the charge state of the iridium being part of a very general problem about relation between formal and realized charge and valence state. In contrary to Ba_2IrO_4 Sr_2RuO_4 does not order magnetically down to lowest temperatures, but at 1.5 K exhibits superconductivity. Apart of theoretical problem related to the occurrence of the superconductivity there is problem why Ru ion looses its magnetic moment.

We claim that i) the conventional crystal-field interactions should be evaluated the first for any meaningful description of magnetic and electronic properties of any $3d/4f/5f$ compound, ii) in a $3d/4f/5f$ compound there exists the discrete electronic structure at the energy scale below 1 meV, iii) the $3d$ electrons exhibit a substantial localized character forming strongly-correlated $3d^n$ configurations, and iv) the standard band structure calcuations, in the eV-energy scale, should be complemented with this discrete low-energy atomic-scale electronic structure.

POSTER PRSENTATIONS

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Poster **P-01**

Thermomagnetic instabilities in Nb films

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In this work, we provide a systematic study of the magnetic field penetration process and avalanche formation in niobium films of different thicknesses deposited on glass substrates. The research was carried out by means of direct visualization of the magnetic flux using magneto-optical imaging. The experimental data were compared with theoretical predictions for the development of thermomagnetic instabilities in the form of dendritic flux avalanches in thin films [1]. Analysis of the temperature and thickness dependence of threshold magnetic field, H_{th} and of threshold flux penetration length, l_{th} allows the evaluation of the thermal and superconducting parameters of the studied films, such as heat transfer coefficient from the superconducting film and substrate, thermal conductivity, critical current density.

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Poster **P-02**

Berezinski-Kosterlitz-Thouless transition in ultrathin niobium films

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The transition to the superconducting (SC) state in 2 dimensional (2D) films is believed to be described by Berezinski-Kosterlitz-Thouless (BKT) theoretical model, which assumes that the thermal unbinding of the vortex-antivortex pairs occurs at certain temperature, TBKT, leading to the specific evolution the nonlinear exponent of the current-voltage (I-V) characteristics. However, many recent studies suggest that this description is restricted to the case of homogeneous films. Since this films are prone to various types of disorder, which may lead to inhomogeneity, it is important to understand how disorder modifies the I-V behavior, so that the description in terms of the BKT model becomes invalid.

Here we study the influence of disorder on the superconducting (SC) transition in ultrathin niobium (Nb) films of various thickness, ranging from 2.5 nm up to 10 nm, in the absence of external magnetic field. The films are sandwiched between two thin silicon layers for protection against oxidation. In thick films we observe the behavior predicted by the BKT model, including well-defined jump in the superfluid density at the TBKT. However, with the decrease of film thickness the behavior evolves, so that in thinnest film no TBKT may be identified, suggesting breakdown of the film into SC islands, immersed in the metallic, non-SC background.

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Poster **P-03**

Subgap dynamics of double quantum dot system

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Recent development of the time-resolved spectroscopies (to picosecond precision) allows to probe dynamical processes imposed by the intrinsic effects or driven by the external potentials, giving an insight into the characteristic energy-scales realized in a system of our interest. We study them here in a nanoscopic heterostructure, the double quantum dot embedded between the superconducting and metallic electrodes. We analyze the response of such setup to: (i) abrupt voltage applied across the junction, (ii) sudden change of the quantum dot energy levels, and (iii) their periodic driving. We explore the evolution of the Andreev bound states (originating from the superconducting proximity effect) and discuss their signatures observable in the time-dependent charge currents. We discuss the efficiency of relaxation processes and investigate the Rabi-like quantum oscillations, their beating patterns, and multi-photon features showing up in the tunneling conductance.

Besides numerical computations, we have also developed the auxiliary procedure based on a machine learning algorithm that reliably yields the Andreev conductance for an arbitrary set of model parameters.

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Poster **P-04**

^{57}Fe Mössbauer study of a potential skyrmion host $Fe(IO_3)_3$

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A design strategy for skyrmion host candidates based on combinations of magnetic spin in asymmetric building units having stereoactive lone-pair electrons and polar lattice symmetry has been proposed [1].

$Fe(IO_3)_3$ crystallizes in the polar chiral hexagonal lattice with space group $P6_3$. The combined structural features of the macroscopic electric polarization along the c-axis stemming from the coalignment of the stereoactive lone-pairs of the IO_3^- trigonal pyramid and the magnetic Fe^{3+} cation residing on the 3-fold rotation axis were selected to promote asymmetric exchange coupling. We find evidence of a predicted skyrmion phase at $14\text{K} \leq T \leq 16\text{K}$ and $2.5\text{T} \leq \mu_0 H \leq 3.2\text{T}$ driven by Dzyaloshinskii-Moriya interaction [1].

^{57}Fe Mössbauer spectroscopy studies of $Fe(IO_3)_3$ were performed. In a paramagnetic state, the spectra have a shape of the narrow single line typical for high-spin Fe^{3+}. Relatively small line-width and lack of measurable electric quadrupole splitting indicate that Fe^{3+} occupy one crystallographic position and the nearest surrounding of Fe^{3+} ions is only subtly distorted. Spectra obtained at 12K and 5K show a six-line structure due to the Zeeman hyperfine magnetic splitting [1]. ^{57}Fe Mössbauer studies confirm that the phase transition at $T_N = 17\text{K}$ is completely magnetically driven, not structural.

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Poster **P-05**

Graphite's magnetoresistance anomaly outside the quantum limit

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At high magnetic fields, graphite exhibits a correlated insulating phase. Such a feature usually manifests as an anomalous, sharp increase of the material's resistance at temperatures below 10 K and magnetic fields above 35 T. This high resistance state (HRS), also called a "magnetoresistance anomaly", is believed to be associated with a c-axis density wave transition, triggered by a 3D - to - 1 D dimensional crossover when the material is deep in the quantum limit.

In this work, through the study of thin, exfoliated graphite flakes, as well as mechanically-treated mesoscopic samples with high charge carrier concentration, we demonstrate that such an electronic phase transition survives even in the Landau quantization regime. This result, which is at odds with the conventional theoretical description for the HRS, enables a different approach when studying magnetic-field-induced features in graphite. In particular, we report the possibility of a non-monotonic variation of the electronic g factor in graphite around the magnetic fields conventionally associated with the HRS.

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Poster **P-06**

Avalanche dynamics of magnetic flux in the Nb-Ti superconducting tube

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The theoretical analysis of dynamic phenomena in doubly connected bulk superconductors is very problematic, so experimental studies in this case play a primary role [1–4].

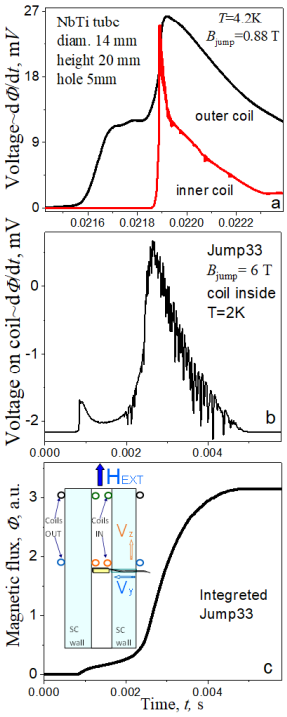

Figure 1: Pulses of voltages induced during flux avalanche in the coils inside and outside the tube (a,b) and magnetic flux vs time t (c).

We report some observations of spatial and time variations of flux penetration of thick-walled cylindrical NbTi tubes of hard superconductor at thermomagnetic avalanches. Hall probe at the center of the sample was used in order to observe flux jumping. Different pick-up coils (insert in Fig.1c) were used for tracking the changes of the magnetic flux [3]. Nucleation and propagation of thermomagnetic avalanche in different cross-sections of the sample, in the wall of the tube and in the inner area were studied in the range of magnetic fields (H_{ext}) between 1 and 9 T, where the avalanches take place. The structure of magnetic flux $\Phi(t)$ and $\mathrm{d}\Phi/\mathrm{d}t$ (t) avalanche (Fig.1a,b,c) as well as changes of field and temperature (T) dependences of magnetic flux have been analyzed. Complicated fine structure of the magnetic flux penetrated into the inner area of tube has been detected (Fig.1b). Physical nature of observed effects will be discussed.

The registration of the signal of the disturbance at different levels along the height of the tube (insert to Fig. 1c) and in external and inner coils made it possible to estimate simultaneously the propagation velocity of the disturbance along (V_{z}) and orthogonally (V_{y}) to the magnetic induction line. The speed of avalanche propagation along the magnetic field is ten times higher than that in perpendicular direction.

Contact measurements of impulse of electric field E_{aval} on the surface of a superconductor resulting from the flux avalanche dynamics has been carried out. As calculations show, the value of the normal component of current $\sigma_{\mathrm{aval}} \times E_{\mathrm{aval}}$ on the surface in a pulse exceeds the value of the critical current of the material even if the conductivity $\sigma_{\mathrm{aval}} \approx \sigma_{\mathrm{ff}}$, where σ_{ff} is flux flow conductivity.

The work presents new aspects of the dynamic response of the superconducting screen, discuss details and updates existing (known) data.

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Poster **P-07**

The selected superconducting properties of electron- and hole-doped graphene

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Doping is one of the most prominent techniques to alter original properties of materials. Herein, the effects of electron- and hole-doping on the selected superconducting properties of graphene are considered. In details, the Migdal-Eliashberg formalism is employed to analyze specific heat and critical magnetic field in the representative cased of graphene doped with nitrogen and boron, respectively. It is found that electron doping is much more favorable in terms of enhancing the aforementioned properties than its hole counterpart. These findings are appropriately summarized by the means of the dimensionless thermodynamic ratios, familiar in the Bardeen-Cooper-Schrieffer theory. To this end, the perspectives for future research on superconductivity in graphene are drawn.

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Poster **P-08**

Superconducting properties of electron-beam irradiated $Ba_{1-x}K_xAs_2F_2$

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The '122' iron-based superconductor $Ba_{1-x}K_xAs_2F_2$, ($x = 0.53$), was electron-beam irradiated at 2.5 MeV and a fluence of 11.74 C/cm^2 and later annealed at a number of increasing temperatures in order to investigate the influence of the annihilation process of structural disorder (mostly point defects), created by e-beam irradiation, on the superconducting properties of the sample, especially on its London penetration depth λ_{ab}. We have applied two experimental methods: magneto-optic and microwave measurements carried out by means of a cylindrical cavity. Our results demonstrate an almost full recovery of the superconducting transition temperature T_c after annealing and show that our data follow the experimental Uemura-relation [1] ($T_c \sim 1/\lambda_{ab}^2 \sim n_s/m^*$), discovered initially for high-T_c superconductors, better than expected and reported by other authors [2], despite some instabilities observed in our sample.

Acknowledgments This work was supported in part by the National Science Center, Poland, research project no. 2014/15/B/ST3/03889.

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Poster **P-09**

Mottness in many-particle reinterpretation of chemical bonding

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We analyze [1] two-particle binding factors of H_2, LiH, and HeH^+ molecules/ ions with the help of our original exact diagonalization *ab intio* (EDABI) approach [2]. The interelectronic correlations are taken into account rigorously within the second quantization scheme with a restricted basis of renormalized single-particle wave functions, i.e., with their size readjusted in the correlated state. We define the many-particle covalency and ionicity factors in a natural manner in terms of the microscopic single-particle and interaction parameters, also predetermined within our method. We discuss limitations of those basic characteristics and introduce the concept of atomicity (*Mottness*), corresponding to the Mott and Hubbard criterion concerning the localization threshold in those many-particle systems. This addition introduces atomic ingredient into the electron states and thus eliminates a spurious behavior of covalency with the increasing interatomic distance, as well as provides a physical reinterpretation of the bonding.

Acknowledgments This work was supported by Grants OPUS No. UMO-2018/29/B/ST3/02646 and No. UMO-2021/41/B/ST3/04070 from Narodowe Centrum Nauki

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Poster **P-10**

The superconducting energy gap in the hole-doped graphene beyond the Migdal's theory

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In the present communication, we analyze the role of the non-adiabatic effects on the superconducting energy gap in the hole-doped graphene. By employing the Eliashberg formalism beyond Migdal's theorem, we present that the non-adiabatic effects strongly influence the superconducting energy gap in the exemplary boron-doped graphene. In particular, the non-adiabatic effects, as represented by the first order vertex corrections, supplement Coulomb interaction and suppress the superconducting state. In summary, the obtained results confirm previous studies on the superconductivity in the two-dimensional materials and show that the corresponding superconducting phase may be governed by the non-adiabatic effects.

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Poster **P-11**

Mössbauer spectroscopy study of $K_2FeCu_3S_4$ murunskite

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In this contribution, we report our study of murunskites ($K_2FeCu_3S_4$), novel materials that, upon doping, could potentially host high T_c superconductivity at ambient pressure. In many aspects, these materials can be viewed as interpolation between cuprates and ferropnictides, with the lattice structure similar to that of pnictides and the electronic valence structure analogous in many ways to cuprates. Furthermore, as in the case of cuprates, the parent compounds of murunskites show antiferromagnetic ordering (at approximately 100 K) [1], which makes them a unique playground to investigate the interplay between lattice, spin, and orbital ordering with strong electronic correlations, and in particular superconductivity [1].

To understand the antiferromagnetic ground state of murunskites, we performed systematic Mössbauer spectroscopy measurements in $K_2FeCu_3S_4$. We collected a set of spectra in the temperature range between 4.2 K and 300 K, using a transmission geometry and the 14.41 keV resonant line of ^{57}Fe. Our study suggests the appearance of two magnetic Fe sublattices, ordered up to about 40 and 100 K, respectively. Furthermore, the complex magnetic structure revealed by Mössbauer studies together with recent DFT calculations [1] suggest that the magnetic structure of murunskites differs significantly from that of ferropnictides.

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Poster **P-12**

Possible weak localization in a layered oxypnictide $La_3Cu_4P_4O_2$

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Transition metal oxypnictides constitute a vast family of materials, in which electron-correlation induced phenomena often arise, such as high T_c superconductivity. Most thoroughly researched, owing to their exceptionally high critical temperatures, remain Fe-based layered oxypnictides, such as $LaFeAsO_{1-x}F_x$. Among iron-free compounds, their nickel-based counterparts are the most similar, both structurally and in terms of physical properties. Within the $RE_3Ni_4Pn_4O_2$ (RE stands for rare earth, Pn for P or As) family, superconducting compounds form only with nonmagnetic La and are characterized by T_cs of 2.2 K and 2 K for $La_3Ni_4P_4O_2$ [1] and $La_3Ni_4As_4O_2$ [2], respectively.

Polycrystalline $La_3Cu_4P_4O_2$ sample was synthesized from freshly dried La_2O_3, La shavings, Cu and pre-synthesized CuP_2 powders by solid-state reaction method. Structural data were obtained utilizing X-ray diffraction, combined with LeBail refinement that confirmed sample purity and a tetragonal crystal structure (space group I4/mmm, no. 139). In order to further characterize transport and thermal properties of $La_3Cu_4P_4O_2$, resistivity and heat capacity measurements were performed in the temperature range 1.9 âĂŞ 300 K. Our data show a minimum in the resistivity at T = 13.5 K, which can be ascribed to a possible presence of weak localization.

Acknowledgments Work at GUT was supported by the National Science Centre (Poland) UMO-2017/27/B/ST5/03044.

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Poster **P-13**

Pairing mechanism at finite temperatures in bosonic systems

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The pure Bose-Hubbard model, a staple of optical lattice-related research that describes bosonic condensation, is examined in finite temperatures. Advanced analytical methods are used, most importantly path integrals and quantum rotors. A first-order trace approximation is commonly applied while integrating over bosonic fields to obtain a phase-only model. Here, a second-order trace approximation is considered instead. This extension leads to an effective phase model with two types of superfluid: standard Bose-Einstein condensation and additional temperature-driven bosonic pair condensation. This effective model is further treated with a self-consistent harmonic approximation, in order to compare the two superfluids.

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Poster **P-14**

Charge, spin-orbit and crystal-field electronic states in $CeRh_2Si_2$

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We point out the scientific importance of the increasing evidence for the existence of the discrete low-energy meV-energy states in compounds containing atoms with the incomplete $4f$ shell.

In $CeRh_2Si_2$, which is intermetallic and considered a Kondo-lattice antiferromagnet, we have proved, by detailed analysis of temperature dependence of the low-temperature specific heat, the realization of the trivalent charge state of practically all cerium ions. In the magnetic state, below T_N of 36 K, the Kramers doublet becomes split, and a spin gap opens reaching 6 meV at T= 0 K. [1]

The good description below T_N of 36 K (=3 meV) confirms that CEF states in $CeRh_2Si_2$ are remarkably thin (in the energy scale, their width is smaller than 0.3 meV) and that practically all Ce atoms/ions contribute to the experimental low-temperature specific heat.

We conclude that hybridization/mixed-valence phenomena are very weak in $CeRh_2Si_2$. Such a conclusion is quite strong scientifically owing to often found anomalous behavior of Ce ions in intermetallics.

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Poster **P-15**

Superconductivity in $(NbTa)_{0.67}(MoHfW)_{0.33}$ high entropy alloy

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High entropy alloys (HEA), i.e. solid solutions of five or more principal elements mixed in equimolar or near-equimolar ratios and forming well-defined, simple, close packed structures [1], are currently one of the most intensively studied materials for potential applications. They often exhibit excellent mechanical, chemical and physical properties, such as strength comparable to that of metallic glasses and ceramics [2], high fracture toughness [3], and corrosion resistance [4]. From the point of view of solid-state physics, one of the most interesting phenomena discovered in HEAs is superconductivity, which was first reported for $Ta_{34}Nb_{33}Hf_8Zr_{14}Ti_{11}$ (T_c = 7.3 K, H_{c2} = 82 kOe) by Koželj et al. [5] and later also for several other systems (for review see Ref. [6]).

In our search for new HEA superconductors with Ti, Zr or Hf, we have recently synthesized a novel high entropy alloy $(NbTa)_{0.67}(MoHfW)_{0.33}$. In this paper, we report on the formation and crystal structure of that alloy, studied by XRD and EDXS analysis, and on its physical properties, studied by low-temperature magnetic, electrical resistivity and specific heat measurements. It was found that the alloy crystallizes in the W-type structure (space group Im-3m, lattice parameter a = 3.287 Å) and is a type-II superconductor with the critical temperature $T_c \approx 4.79$ K and upper critical field $H_{c2}(0) \approx 14.5$ kOe. Despite that XRD and SEM/EDS studies showed presence of only one phase in bulk and uniform atom distribution, the magnetic, specific heat and resistivity measurements are pointing to significant internal disorder in the studied compound.

Acknowledgments This work was co-financed by the National Science Center (Poland) in the frame of OPUS 20 grant (project no. 2020/39/B/ST5/01782).

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Poster **P-16**

Electronic structure and superconductivity in Co-Ni-Cu-Rh-Ir-Zr2 high entropy alloy

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High entropy alloys (HEAs) are a class of novel intermetallic compounds consisting of five or more elements that generally, despite their complex composition, crystallize in rather simple crystal structures. Since their discovery there has been significant scientific interest in them as some possess extraordinary mechanical properties, meaning that a superconducting HEAs may be useful for applications under extreme conditions. Up to this date only a handful of such HEAs have been reported. Among them is a $CuAl_2$-type superconductor $Co_{0.2}Ni_{0.1}Cu_{0.1}Rh_{0.3}Ir_{0.3}Zr_2$ with a HEA-type transition metal site, which was discovered in 2021 [1]. As of this date the mechanism of superconductivity in this compound hasn't been studied in details.

Here we perform *ab initio* calculations in order to study the electronic structure of this HEA, as well as the related binary compounds, using a number of complementary methods, that is KKR-CPA, plane-wave pseudopotential, and full-potential linearized augmented plane-wave. We determine the electronic band structure, densities of states and McMillan-Hopfield parameters. The local distortions of the crystal structure are studied through the supercell relaxation. The spin-orbit coupling effects are analyzed as well. From the experimental specific heat and calculated band structure the electron-phonon coupling parameter is estimated, suggesting the conventional character of pairing interactions. This observation is now verified by the ongoing computations of the electron-phonon interaction functions.

Acknowledgments This work was supported by the National Science Centre (Poland), project No. 2017/26/E/ST3/00119.

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Poster **P-17**

Superconductivity in High Entropy Alloys with Th

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High Entropy Alloys can be classified as solid solutions of 5 or more metals with non-negligible concentration of each element (min. 5at.%). They form well-defined, simple and often single-phased closed-packed structures [1]. They are characterized by exceptional mechanical toughness and chemical resistance, which distinguishes them from other groups of alloys. Since the discovery of superconductivity in HEA [2] research on new HEA systems has intensified, in the hope of finding more superconducting alloys. Recently, the superconducting system with uranium was reported [3] leading to an increased interest in HEA systems with actinides.

We report successful synthesis of HEA systems with Th:$(NbTa)_{0.67}(MoWTh)_{0.33}$ and $(NbTa)_{0.67}(HfWTh)_{0.33}$. The XRD and low temperature magnetic measurements show that there are two multiphase systems characterized by $T_c \approx 5.5$ K and 3.5 K respectfully. In addition, we present results of SEM imaging, electrical resistivity and specific heat measurements.

Acknowledgments This work was co-financed by the National Science Center (Poland) in the frame of OPUS 20 grant (project no. 2020/39/B/ST5/01782)

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Poster **P-18**

Electronic Structure and Dirac Cone Dispersion in Cobalt Doped $CaFe_2As_2$

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We investigated the electronic structure of the cobalt doped $CaFe_2As_2$ compound using the ARPES technique at UARPES beamline of the Solaris synchrotron. Measurements were carried out on samples of three different compositions, the parent compound $CaFe_2As_2$, weakly doped $CaFe_{1.93}Co_{0.07}As_2$, and strongly doped $CaFe_{1.85}Co_{0.15}As_2$. These samples correspond to all the states that form the phase diagram. The parent compound and the weakly doped sample correspond to the region in which the samples are in antiferromagnetic orthorhombic states, while the strongly doped sample is in the paramagnetic tetragonal part of the phase diagram. For both doped samples, superconductivity and spin density waves (SDW) are observed. The tested samples show two types of electron structure depending on the doping level. For the antiferromagnetic phase, a characteristic flake structure related to SDW is observed, while the structure in the paramagnetic phase consists of concentric hole bands around the Γ point and electron bands around the X point. We did not observe a significant change in the band structure under the influence of cobalt doping within the orthorhombic phase. For a low doping level, the existence of Dirac cones was observed, which is analogous to those observed in the $BaFe_2As_2$ compound [1]

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Poster **P-19**

Quasiparticle tunneling in Josephson junctions via in-gap states

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In the present communication the quasiparticle tunneling in the Josephson junctions (JJ) is considered with respect to the in-gap states appearing within the insulating barrier. In details, a simple theoretical model is discussed to allow general and in-depth description of the quasiparticle tunneling in relation to the intrinsic properties of the JJ and potential external fields. In this context, special attention is given to the localization properties of the in-gap states and the related tunneling rates. The presented observations are expected to provide means to probe JJ barrier toward better understating of the decoherence mechanisms in the the selected superconducting qubit modalities.

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Poster **P-20**

Crystal structure and superconductivity in ternary $Y_2Pd_{1.25}Ge_{2.75}$ intermetallic

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A high-purity intermetallic germanide $Y_2Pd_{1.25}Ge_{2.75}$ was synthesized via arc-melting by deliberately tuning the composition out of the ideal 2:1:3 ratio. The crystal structure was determined to be of a disordered AlB_2-type (space group P6/mmm), with lattice parameters a = 4.2217(1) Å and c = 3.9340(1) Å.

Resistivity measurements showed typical metallic behavior with a transition to superconducting state taking place at T_c = 3.27 K - a value that is slightly higher than the 3 K previously reported for the stoichiometric compound Y_2PdGe_3 [1].

The specific heat measurements confirmed bulk character of superconductivity, with a normalized specific heat jump determined to be $\Delta C_p/\gamma T_c$ = 1.38. The calculated values of Sommerfeld coefficient and Debye temperature were γ = 5.0(5) mJ mol^{-1} K^{-2} and θ_D = 220.3(3) K, once again higher than for Y_2PdGe_3 [1].

The sample exhibited characteristic type-II superconductor behavior of magnetic susceptibility, with a clear divergence of the FC and ZFC curves below T_c and a shielding fraction approaching 100% at the lowest temperatures. The lower and upper critical field values were calculated to be 2.7(1) mT and 2.94(5) T, respectively.

Additional magnetization measurements conducted under pressure up to 0.55 GPa showed T_c shifting to lower values, at a rate of -0.17 K/GPa.

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Poster **P-21**

Level statistics and integrability breaking in chains with long-rang interactions

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We discuss the spin dynamics and level statistics in the XXZ chain with long-range exchange interaction which decays in the real space as $1/r^{\alpha}$, where r denotes the distance between two lattice sites. We focus on the easy plain regime with the anisotropy parameter $\Delta < 1$. In the limiting case $\alpha \to \infty$, the studied model reduces to the standard XXZ chain for which the spin transport is known to be ballistic. Although for finite α the asymptotic spin dynamics is diffusive, we demonstrate that one may tune the anisotropy parameters so that one still observes a quasiballistic transport for arbitrary $\alpha > 2$. Our results demonstrate correlations between the level statistics and the anomalous tendency of the quantum spin chain to the quasiballistic spin transport.

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Poster **P-22**

The intriguing nature of phase transition in $DyAl_3(BO_3)_4$ aluminoborate

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Rare earth aluminoborates $RAl_3(BO_3)_4$ (R - rare earth ion) demonstrate interesting physical properties, e.g., a very strong magnetoelectric effect [1]. They are promising materials for the laser techniques [2].

The $DyAl_3(BO_3)_4$ crystal studied, crystallizing in a trigonal symmetry, described by the R32 space group, was grown by spontaneous solution-melt crystallization method. Magnetic properties of the dysprosium aluminoborate originate from the $4f$-electrons of the Dy^{3+} ions which sit in a trigonal lattice. According to the Hund$'$s rules the dysprosium ion has a $^6H_{15/2}$ ground state, which splits into doubles under influence of the crystal electric field in aluminoborates.

The phase diagram of $DyAl_3(BO_3)_4$ was constructed for 2 K >T $\geq$ 50 mK. It was found that, under influence of increasing external magnetic field, B, the temperature of the transition decreases, albeit the studies of the magnetization of the $DyAl_3(BO_3)_4$ compound showed that the appearing order has a ferromagnetic character with magnetic moments directed along the c axis.

An analogy between the dysprosium borate and the lithium rare-earth fluorides LiRF, which helps to understand the physical nature of the magnetic phase transition in $DyAl_3(BO_3)_4$, will be presented.

Acknowledgments This work was supported partially by the National Science Centre, Poland, under project No.2018/31/B/ST3/03289

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Poster **P-23**

Coulomb blockade effect in highly underdoped LSCO thin films

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Superconductor-insulator transition (SIT) could be observed in strongly inhomogeneous systems, such as granular superconducting films or Josephson junction arrays, which may be understood as a set of superconducting islands immersed in the metallic matrix. In this case, the SIT depends sensitively on the ratio of two energies: energy of Josephson coupling E_J (that corresponds to the coupling between superconducting islands, allowing Cooper pair transport) and charging energy E_C, which, in turn, depends on two other parameters: distance between superconducting areas and the resistance of the nonsuperconducting matrix. The evolution from $E_J/E_C \gg 1$ to $E_J/E_C \leq 1$ leads to characteristic crossover from superconducting-like current-voltage characteristics (IVC), to insulating-like IVC.

Here we examine the inhomogeneous nature of strongly underdoped $La_{2-x}Sr_xCuO_4$ (LSCO) films by the measurements of IVC in two strained LSCO films. We show that with the decreasing temperature films evolve, from superconducting state with transition broadened by thermal vortex activation, to an insulating state, in which Coulomb blockade effect, together with backbending of the $I-V$ curve, is evidenced. However, in contrast to Coulomb blockade effect observed in case of Josephson junction arrays, we observe this feature in the absence of magnetic field. Our result indicates that Cooper pairs survive even at lowest temperatures in the insulating regime, what suggests that the pairing mechanism is most likely of local character.

Program XX Krajowej Konferencji Nadprzewodnictwa, Lublin 22-26 maja 2022 r.

	Niedziela/Sunday 22.05.2022	Poniedziałek/Monday 23.05.2022	Wtorek/Tuesday 24.05.2022	Środa/Wednesday 25.05.2022	Czwartek/Thursday 26.05.2022
7.00 – 9.00		Śniadanie/Breakfast	Śniadanie/Breakfast	Śniadanie/Breakfast	Śniadanie/Breakfast
Chairperson		*K. I. Wysokiński*	*T. Dietl*	*W. Sadowski*	*J. Spałek*
9.00-9.45		**J. Spałek**	**M.Z. Cieplak**	**T. Dietl**	**D. Kaczorowski**
9.45-10.15		**A. Malinowski**	**T. Klimczuk**	**M. Maśka**	**R. Puźniak**
10.15 – 10.45		Kawa/Coffee break	Kawa/Coffee break	Kawa/Coffee break	Kawa/Coffee break
Chairperson		*D. Kaczorowski*	*A. Ślebarski*	*A. Wiśniewski*	*M. Maśka*
10.45 – 11.15		**W. Tabiś**	**A. Wiśniewski**	**N. Sedlmayr**	**K. Rogacki**
11.15 – 11.45		**T. Cichorek**	**G. Jung**	**M. Mierzejewski**	**K. Kolincio**
11.45 – 12.15		**A. Szewczyk**	**P. Starowicz**	**M. Trif**	**S. Gutowska**
12.15 – 12.45		**K. Górnicka**	**D. Rybicki**	**I. Weymann**	**R. Radwański**
					Zamknięcie/Closing
13.00 – 15.00		Obiad/Lunch	Obiad/Lunch	Obiad/Lunch	Obiad/Lunch
Chairperson		*K. Rogacki*	*A. Szytuła*	*M. Mierzejewski*	
15.00 – 15.30		**A.M. Oleś**	**P. Jakubczyk**	**A. Ptok**	
15.30 – 16.00		**J. Herbrych**	**M. Fidrysiak**	**K. Wójcik**	
16.00 – 16.30		**M. Wysokiński**	**T. Polak**	**J. Barański**	
16.30 – 17.00		Kawa/Coffee break	Kawa/Coffee break	Kawa/Coffee break	
Chairperson		*R. Puźniak*	*M.Z. Cieplak*	*R. Szczęśniak*	
17.00 – 17.30	***Zwiedzanie wzgórza zamkowego i Starego Miasta w Lublinie/ Sightseeing tour of the Castle and Old Town of Lublin***	**B. Wiendlocha**	17^{00} **M. Gala**	17^{00} **A. Kobiałka**	
17.30 – 18.00		**A. Durajski**	17^{20} **G. Kuderowicz**	17^{30} **M. Strzałka**	
18.00 – 18.30		**T. Kostyrko**	17^{40} **M. Dziurawiec**	17^{50} **S. Basak**	
		A. Szytuła	18^{00} **B. Krajewski**	18^{10} **G. Górski**	
			18^{20} **H. Cheraghi**	18^{30} **M. Kliczkowski**	
19.00 – 20.00	Kolacja/Supper	Kolacja/Supper	Kolacja/Supper		
20.00 – 20.15	***Powitanie/Welcome*** **T. Domański**	**Sesja posterowa**	**Poster session**	**Uroczysta kolacja Conference dinner**	
20.15 – 21.00	***Wykład inauguracyjny /Opening lecture*** **W.I. Gruszecki**	**Poster session**	**Sesja posterowa**		