Institute of Physics

Programme & abtracts

International Symposium

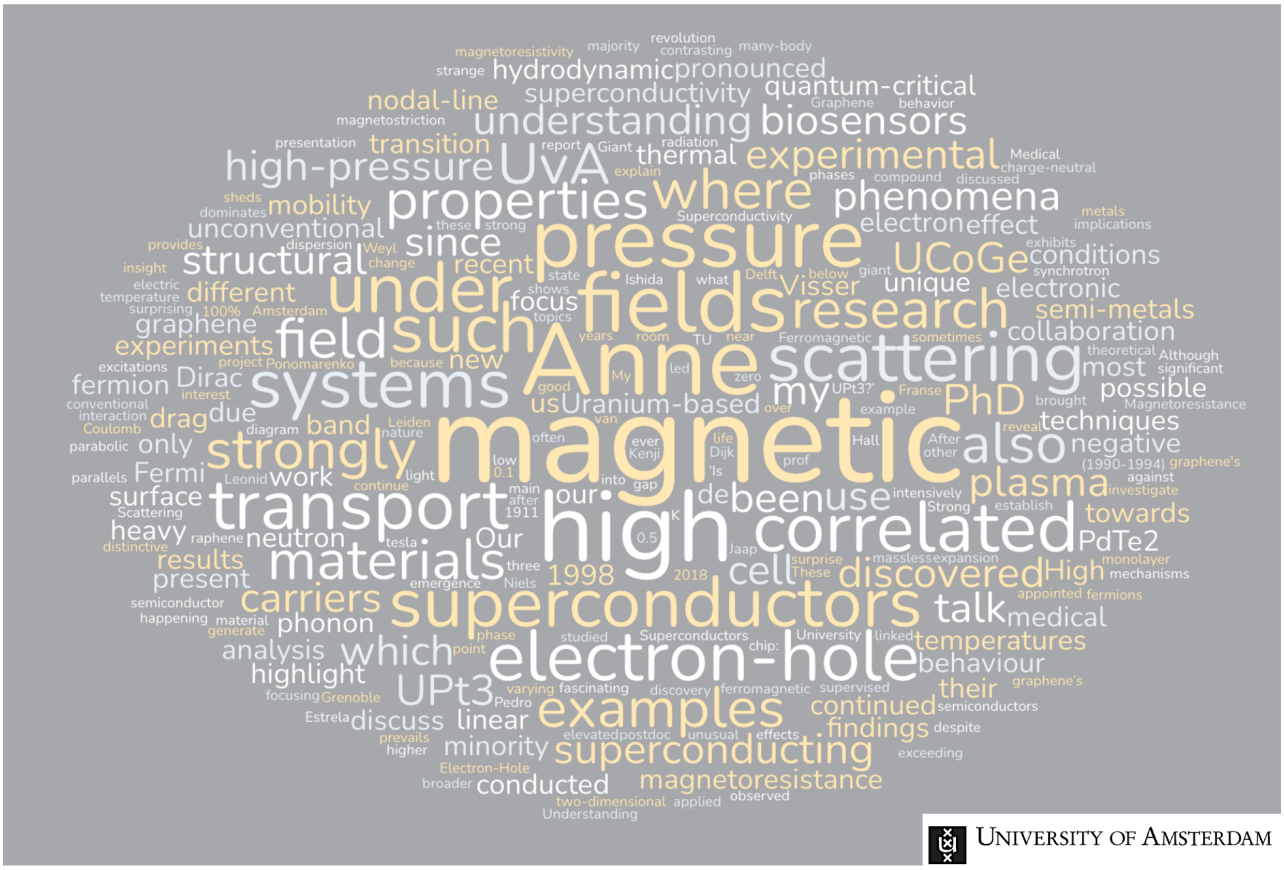
18 October 2024

Burcht van Berlage

Amsterdam



Strong correlations, unconventional superconductivity and topological materials

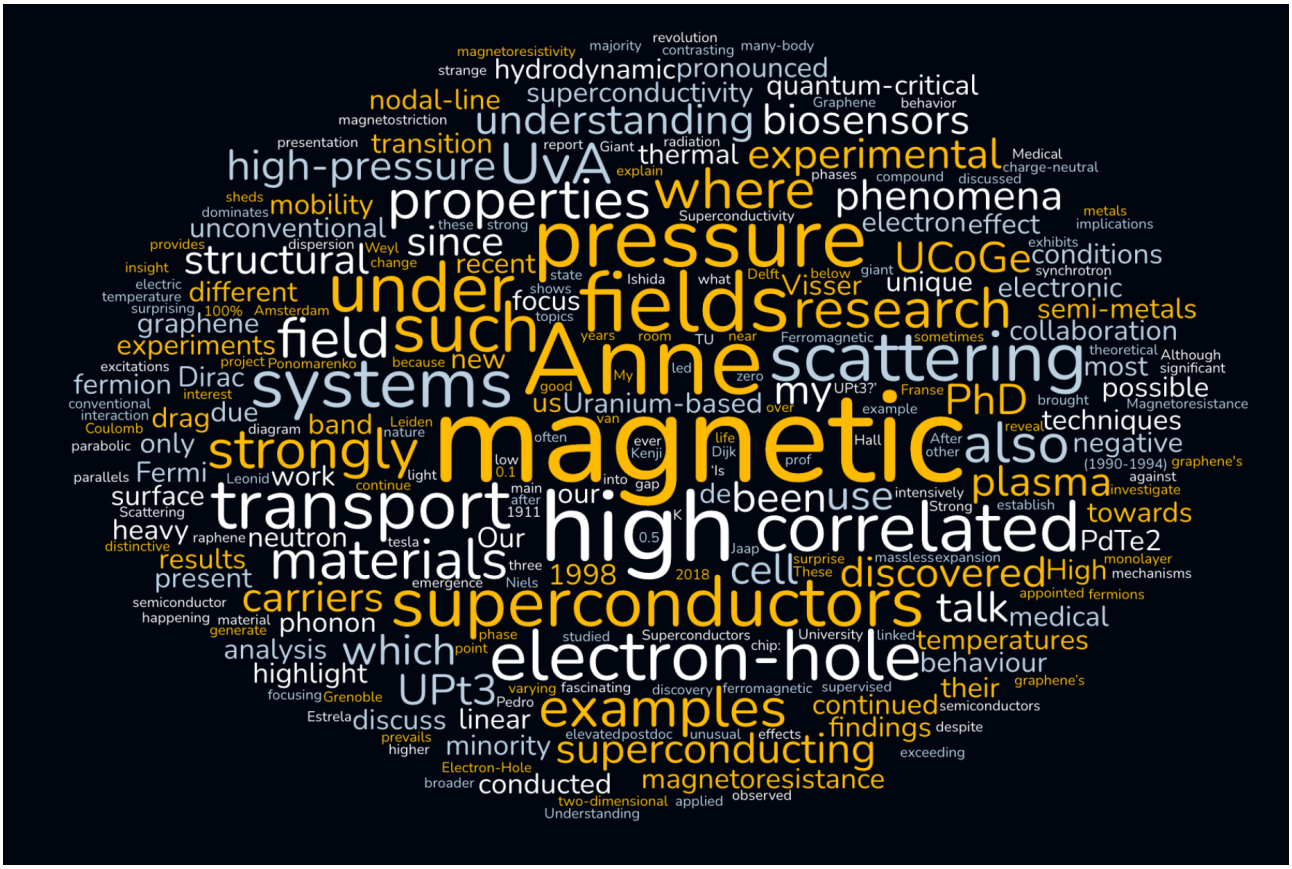


To mark the retirement of Anne de Visser

Scientific programme:

09:15	opening & welcome, Mark Golden
Morning session:	chair Klaus Hasselbach
09:30- 10:00	Niels van Dijk (TU Delft)
10:00- 10:30	Leonid Ponomarenko (University of Lancaster)
10:30-10:45	coffee
10:45 – 11:15	Pedro Estrela (University of Bath)
11:15 – 11:45	Steffen Wiedmann (Radboud University, Nijmegen)
11:45 – 12:15	Alix McCollam (University College Cork)
12:15 – 13:45	lunch
Afternoon session:	chair Carley Paulsen
13:45 – 14:15	Klaus Hasselbach (Institut Néel, Grenoble)
14:15 – 14:45	Kenji Ishida (Kyoto University)
14:45 – 15:00	break
15:00 – 15:30	Ayako Ohmura (Niigata U.) & Takashi Naka (Ryukyu University)
Social programme:	chair Mark Golden
15:45 – 16:30	short (5 min.) timeslots with theme 'what Anne meant for me' from students & colleagues
16:30	Anne has the last word
17:00 – 19:00	drinks and snacks

The following word cloud has been generated from the titles and abstracts of this symposium:



1st morning session

Is there life after UPt_3?

Niels van Dijk, TU Delft

My PhD research project at the University of Amsterdam (1990-1994) was supervised by Anne de Visser and prof. Jaap Franse. The main focus of my research was to establish the superconducting phase diagram of the strongly correlated electron compound UPt_3 by thermal expansion and magnetostriction experiments. This material shows unconventional superconductivity below 0.5 K, with three different superconducting phases for varying temperatures and magnetic fields. The nature of the superconducting state has over the years led to continued experimental and theoretical interest. After my PhD I continued as a postdoc on neutron scattering of strongly correlated systems in Grenoble and was appointed at TU Delft to investigate magnetic and structural materials with neutron scattering and synchrotron radiation techniques. The collaboration with Anne de Visser on UPt_3 and other topics will be discussed.

Strong Electron-Hole Scattering and Giant Magnetoresistance in Graphene

Leonid Ponomarenko, University of Lancaster

Graphene, a two-dimensional semiconductor with zero band gap, exhibits unique electronic properties due to its linear band dispersion and massless Dirac fermions. At elevated temperatures, thermal excitations generate an electron-hole plasma in graphene, where electron-hole scattering dominates, contrasting with conventional semiconductors where phonon scattering prevails. This strong electron-hole interaction results in hydrodynamic behaviour, with implications for transport phenomena such as the Hall effect and magnetoresistance.

In this presentation, I will discuss our findings on the hydrodynamic electron-hole plasma in monolayer graphene, focusing on the emergence of unusual transport properties near the Dirac point. We report a surprising negative mobility of minority carriers due to Coulomb drag in the electron-hole plasma, where majority carriers drag minority carriers against the applied electric field. This negative mobility is most pronounced at room temperature, despite significant phonon scattering. Our experiments also reveal giant parabolic magnetoresistance at low magnetic fields, exceeding 100% at 0.1 tesla, and a transition to linear magnetoresistivity under higher magnetic fields, linked to many-body effects.

These results highlight graphene's distinctive quantum-critical transport behavior, with parallels to phenomena observed in strange metals and Weyl systems. Understanding these properties not only sheds light on charge-neutral graphene's transport mechanisms but also provides insight into broader quantum-critical systems.

2nd morning session

Medical analysis on a chip: a revolution happening

Pedro Estrela, Department of Electronic & Electrical Engineering, University of Bath

Although doing a PhD with Anne on strongly correlated electron systems, the training on experimental techniques, critical thinking and problem solving enabled me to pursue a career on a very different direction: biomedical technologies (a loosely correlated non-electron system?) and, in particular, point-of-care medical diagnostic devices.

The pregnancy test and the glucose meter are classic examples of biosensors that had a clear impact in people's lives. More recently, everyone became familiar with COVID-19 self-tests.

The provision of healthcare is changing, with a tendency towards telemedicine whenever possible. But such changes are only truly effective with new biosensors that patients can use in a simple way. In this talk we will highlight several examples of biosensors for a range of diseases and conditions. Miniaturisation, together with the use of nanotechnologies and artificial intelligence, makes it possible to have full medical laboratories on a small chip.

Quantum Materials in High Magnetic Fields- Stretching and compressing nodal-line semi-metals

Steffen Wiedmann, Radboud Universiteit, Nijmegen

The interplay between topology and electronic correlations imparts robustness and order to quantum materials. Experiments conducted under extreme conditions, such as high magnetic fields are crucial for the determination and understanding of the unique properties of quasi-particles and the material's Fermi surface. In my talk, I will present recent findings on the tunability of the magneto-resistance and Fermi surface of nodal-line semi-metals under uniaxial strain.

Uranium-based heavy fermion superconductors in high magnetic fields

Alix McCollam, University College Cork

Anne has made huge contributions to the present knowledge of uranium-based heavy fermion superconductors, and particularly to their behaviour in high magnetic fields. I will discuss the importance of this family of materials, and the steps towards the current state-of-the-art in their high magnetic field characterisation and understanding. As key examples, I will focus on UPt_3 and UCoGe, where Anne's work was seminal and continues to shape the field.

Afternooon session

UPt_3 reloaded

Pablo Garcia-Campos[1], Dai Aoki[2,3], Klaus Hasselbach[1]
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[2)] Université Grenoble Alpes, CEA, IRIG, PHELIQS, 38000, Grenoble, France
[3)] Institute for Materials Research, Tohoku University, Ibaraki 311-1313, Japan

UPt_3,HEAVY FERMIONS AND SUPERCONDUCTIVITY was the title of Anne's PhD thesis. I will tell a few following chapters, some we shared, of the never ending story of UPt_3.
UPt_3, 1 Uranium and 3 Platinum, is the only crystalline material presenting two successive superconducting transitions in zero applied magnetic field, thus it has to have a very special kind of superconductivity with similar properties as superfluid ^{3}He, the paradigm for unconventional superconductivity.
When a superconductor is cooled below the transition temperature a homogeneous superconducting condensate of electrons forms and the magnetic field threading the superconductor is compressed into magnetic flux tubes (vortices), each carrying a single quantum of flux (h/2e), the Heisenberg constant and 2e the Cooper pair charge. Vortices behave as microscopic parallel aligned bar magnets and thus repel each other.
We use scanning Superconducting Quantum Interference Device (SQUID) microscopy to compare the magnetic stray field of vortices in UPt_3 in the high temperature, A (below 0.53 K) and low temperature, B phase (below 0.48 K). We observe mobile half quantum vortices merging into single quantum vortices in the B phase only.
Upon cooling under a slightly increased magnetic field to the B phase, regions containing many vortices are separated from region with no vortices. The shape of the regions depends on amplitude and direction of the magnetic field as well as temperature and time. The regions are delimited by lines of high vortex density. These observations are in agreement with the predictions for the magnetic

fingerprint of chiral superconductivity in a time reversal symmetry breaking superconductor: In case of a spin triplet superconductor vortex sheets of half quantum vortices are predicted to separate domains of superconducting condensate of opposite chirality.
Our observations support the prediction of spin triplet superconductivity in the B-phase of UPt_3.

Uranium-based Ferromagnetic Superconductors

Kenji Ishida, Department of Physics, Graduate School of Science, Kyoto University,

Superconductivity was discovered in 1911 in Leiden and has been intensively studied ever since. This is because fascinating new superconductors continue to be discovered, which often surprise us and sometimes change our understanding. Uranium-based ferromagnetic superconductors are a good example of this. I will explain UCoGe, which Anne discovered, and what its discovery has brought us.

High pressure works in UvA since 1998:

Takashi Naka (Ryuku Univerity, Japan)- Pressure-induced phenomena, magnetic and metal-insulator transitions
Ayako Ohmura (Niigata University, Japan)- Superconducting research combining high-pressure evaluations of transport property and crystal structure

Our collaborations with Anne for experimental studies on strongly correlated systems under high pressure started in 1998. Combined with noble cryogenic and high field facilities developed in UvA, we have realized that a clamped pressure cell is a suitable gadget for applying pressure to tiny specimens, such as uranium-, rare earth- and transition metal-based compounds which have been examined in UvA. While, obviously, most acknowledged and pronounced investigations under high pressure have been conducted for the unconventional superconductors, such as UCoGe (ferromagnetic superconductor), carrier-doped Bi_2Se_3, and $PdTe_2$ (topological superconductors), we also need to address the development of piston-cylinder type high-pressure cell used to use in UvA. In recent collaboration on $PdTe_2$ and related materials since 2018, we have also employed structural information obtained by structural analysis with a diamond anvil cell to interpret the pressure effect on superconductivity. In this talk, we will introduce the history of high-pressure work with Anne, including some research examples.