Electronics – Transport & Structure

1. Electrical transport

Drude Model - Conductivity

Wiedermann – Franz's Law

2. Electronic structure

Bloch's Theorem

Band structure

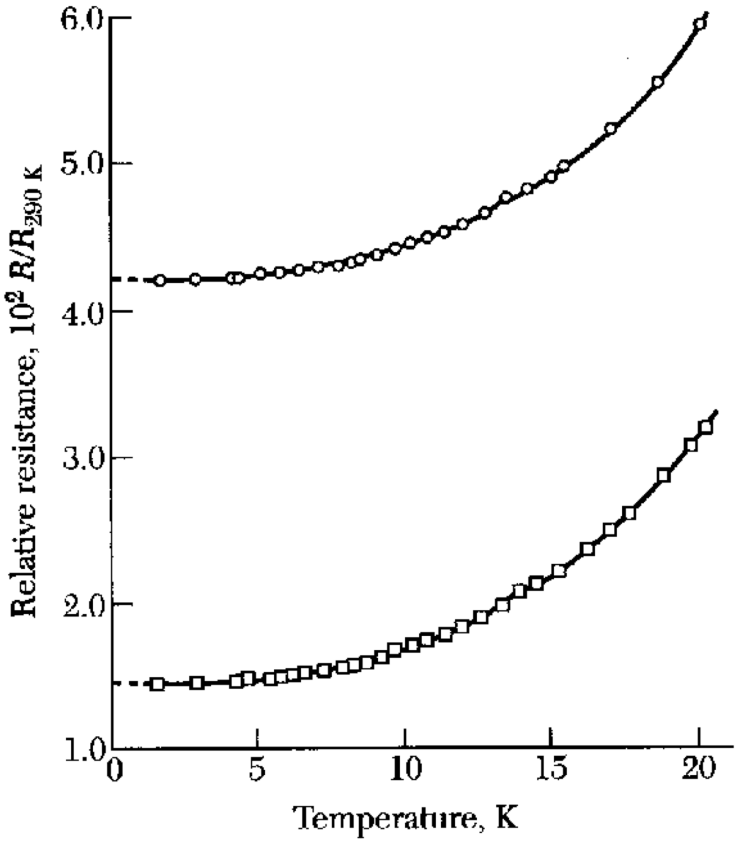
3. How to measure band structure

Photoemission

Angle resolved photoemission

IMPORTANT: 11th of May – LECTURE AND EXERCISE IN 36J33

Residual Resistivity - $\rho(T = 0)$



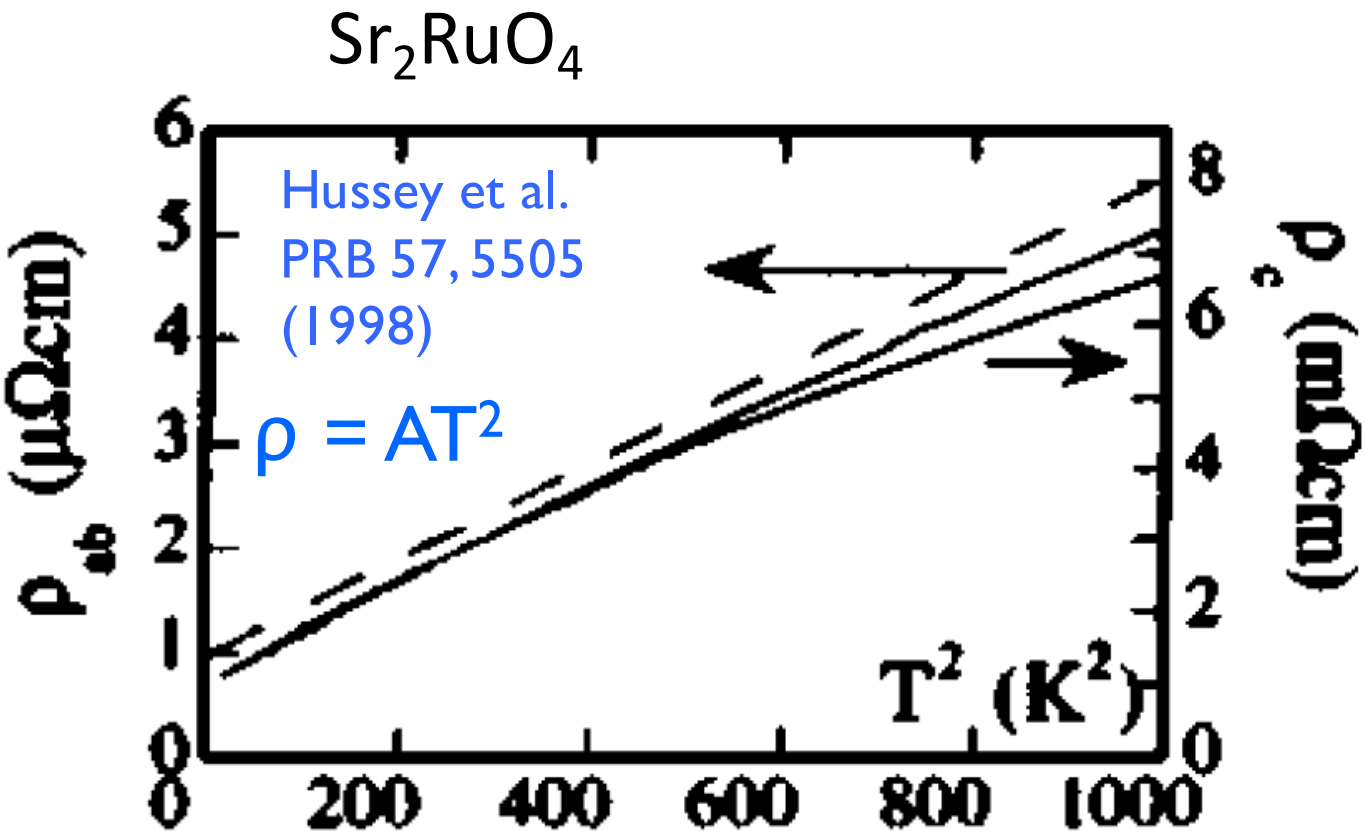
Definition: Residual Resistivity Ratio

RRR = $\frac{\rho(300\ K)}{\rho(0\ K)}$

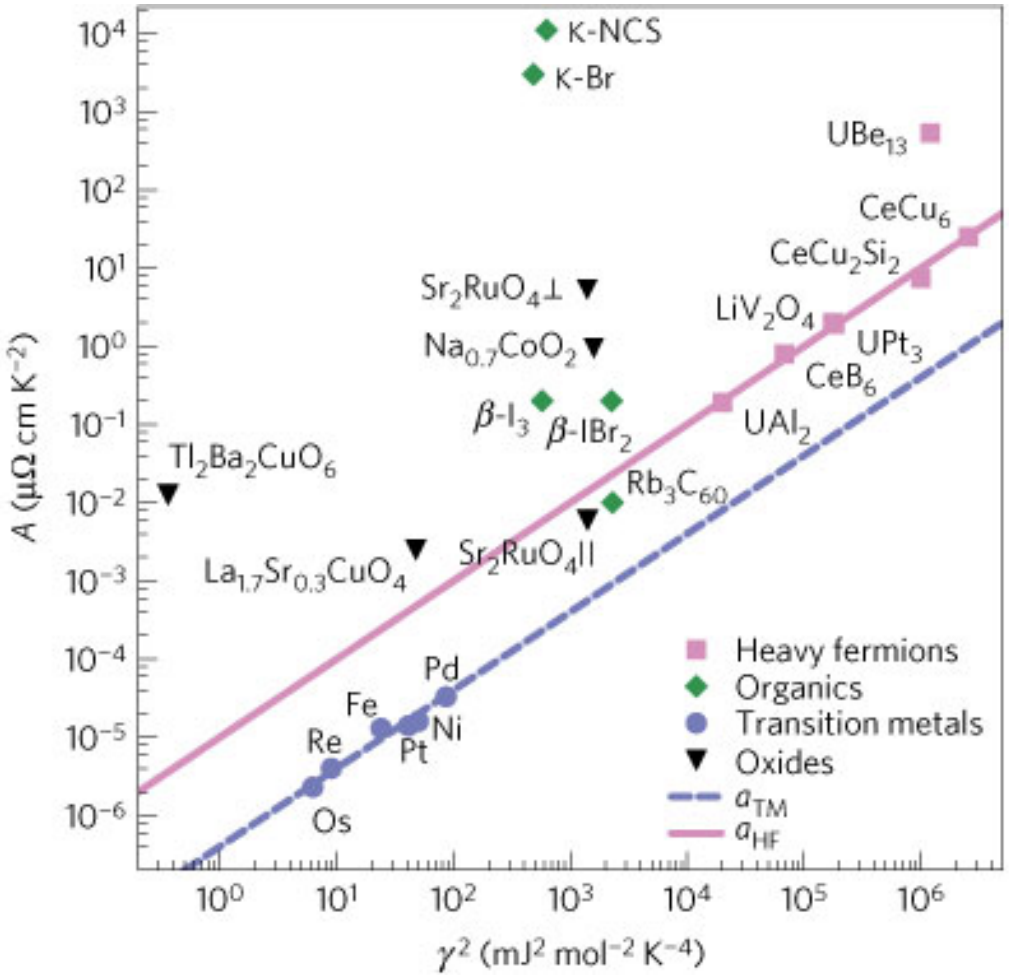
RRR is a measure of purity

Figure 12 Resistance of potassium below 20 K, as measured on two specimens by D. MacDonald and K. Mendelssohn. The different intercepts at 0 K are attributed to different concentrations of impurities and static imperfections in the two specimens.

Resistivity: T - dependence



Heavi Fermions



Nature Physics **5**, 422 - 425 (2009)

Figure of Merit - Thermoelectricity

$$zT = \frac{S^2}{\rho\kappa} T.$$

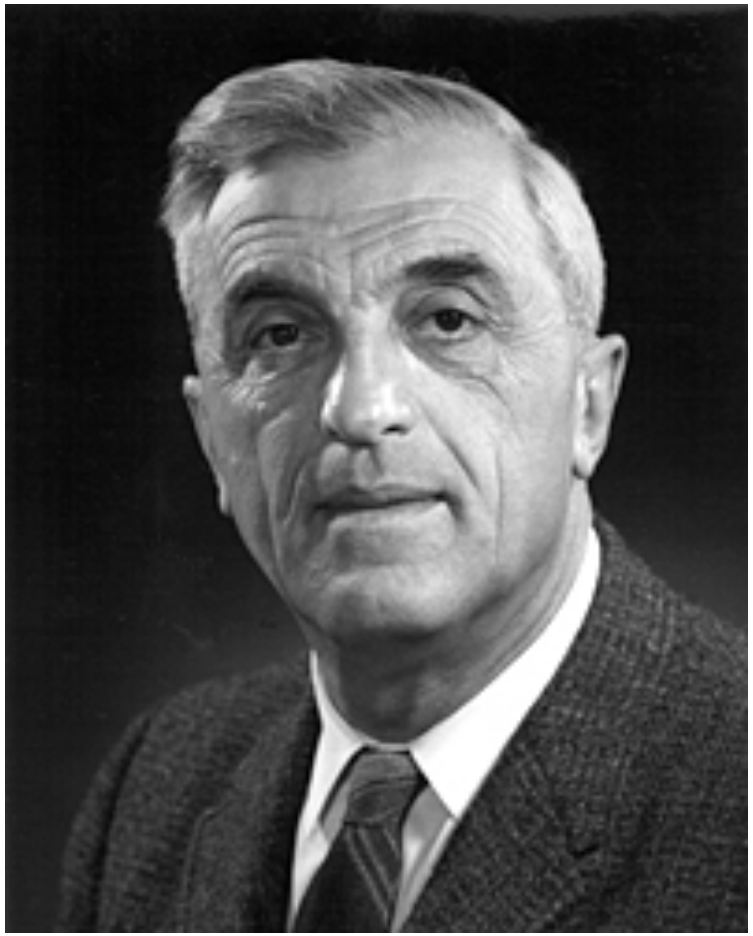
S = Seebeck coefficient

T = Temperature

ρ = Resistivity (ohm)

κ = Thermal conductivity

Bloch's Theorem



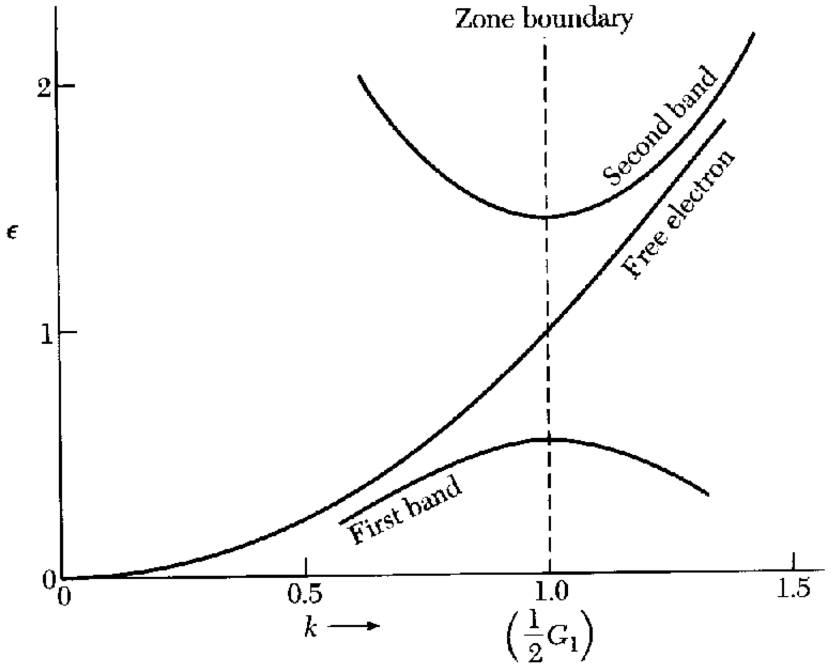
Felix Bloch

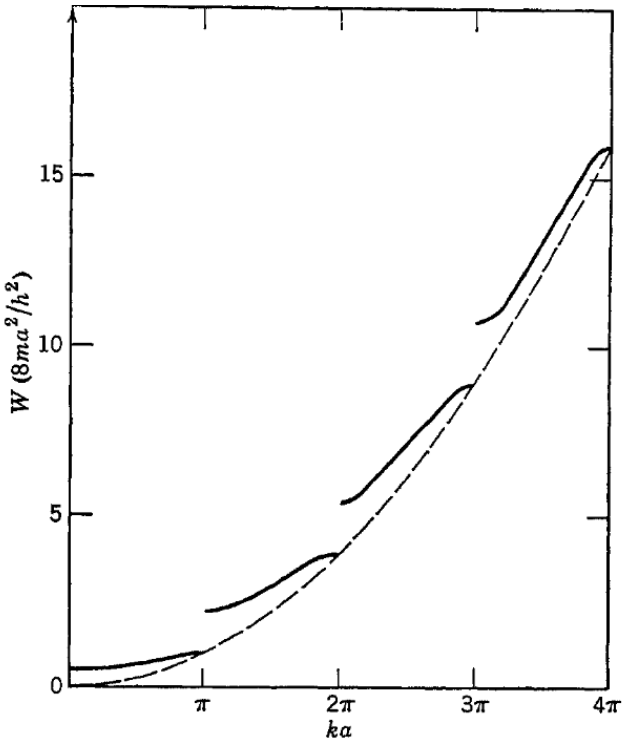
Er erhielt 1952 den Nobelpreis für Physik

'When I started to think about it, I felt that the main problem was to explain how the electrons could sneak by all the ions in a metal….
By straight Fourier analysis I found to my delight that the wave differed from the plane wave of free electrons only by a periodic modulation'

F. BLOCH

Band structure





Reduced zone scheme

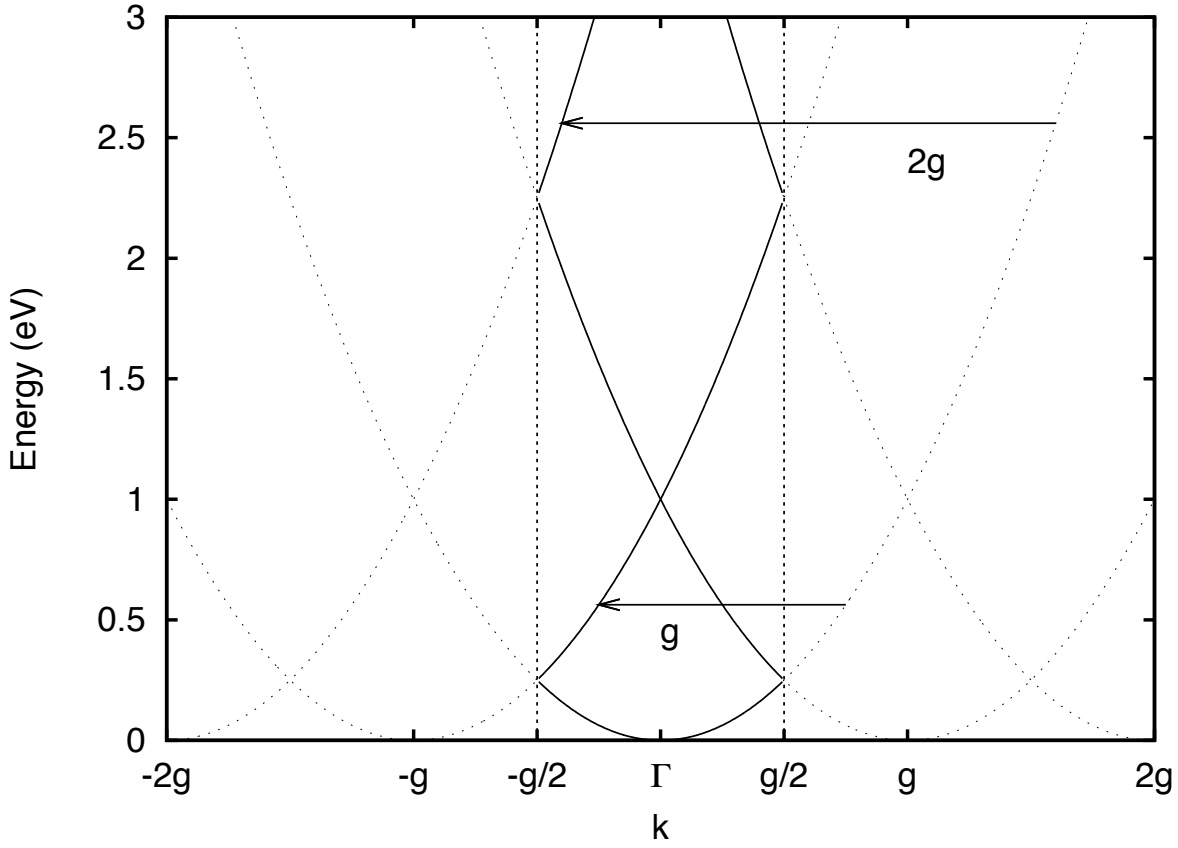
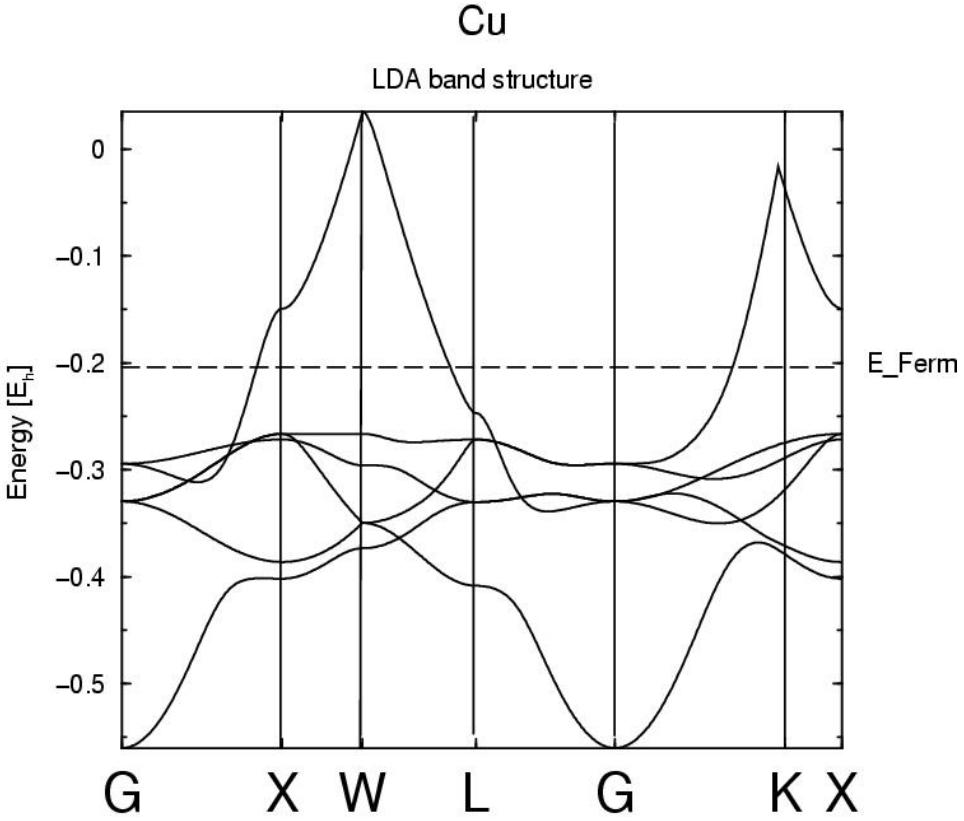
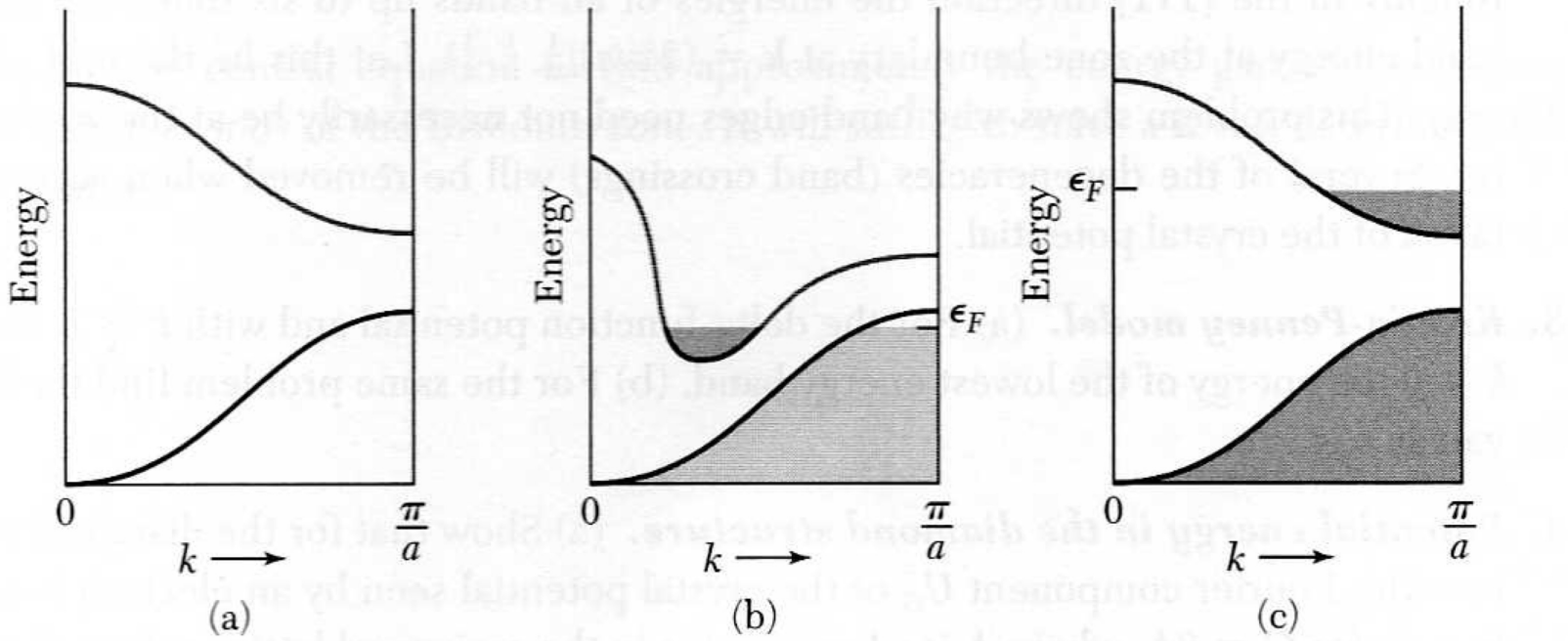


Figure 1: Illustration of the reduced zone scheme. The parts of the E-$\mathbf{k}$ curve outside the first Brillouin zone are folded back into the first Brillouin zone by translating by an integer number of reciprocal lattice vectors. The dotted vertical lines denote the edges of the first Brillouin zone at $\mathbf{g}/2$ and $-\mathbf{g}/2$.

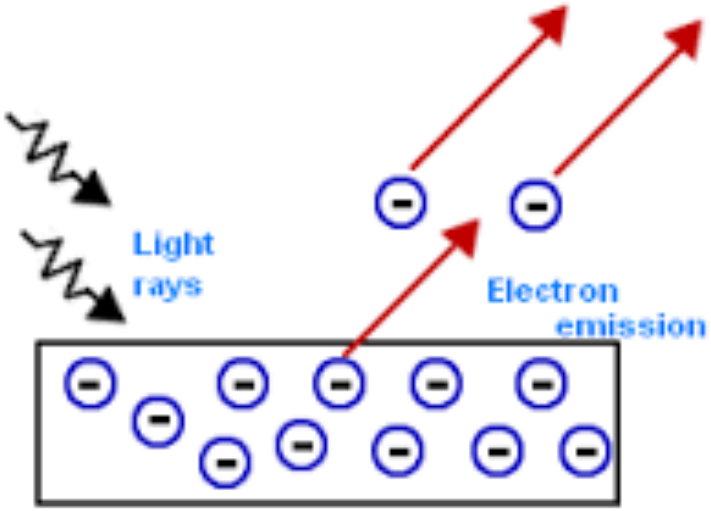
Band structure of Copper

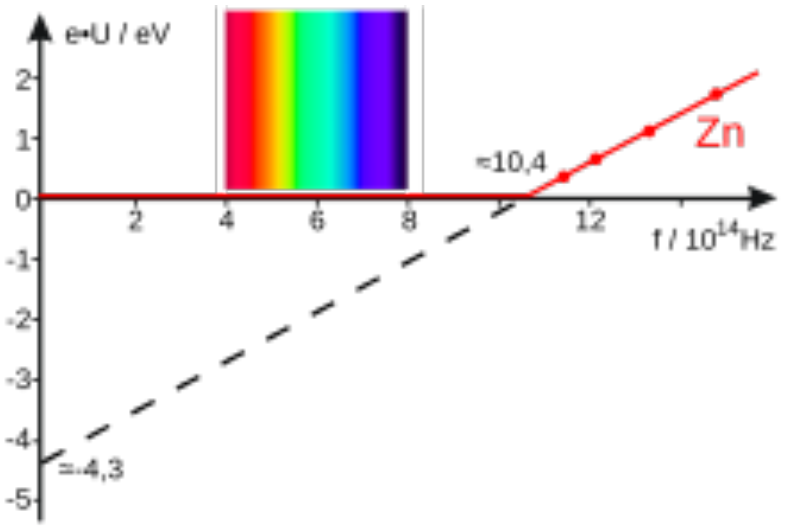


Metals, Band Insulators, Semi metals



Photoelectric effect

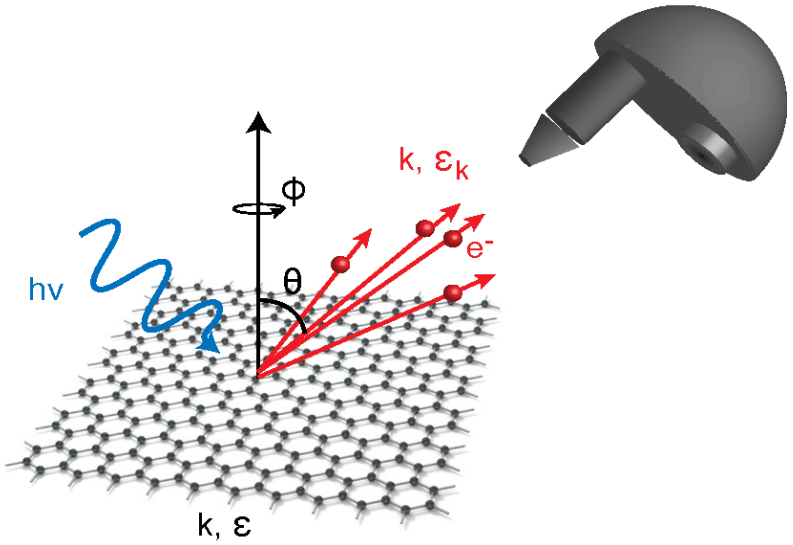


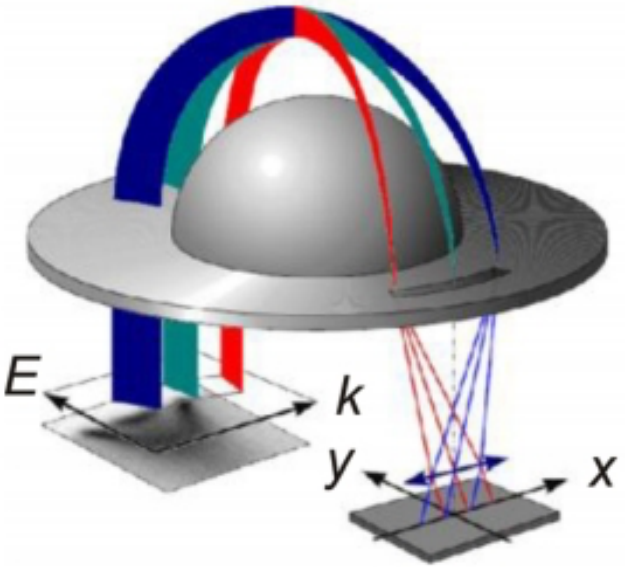


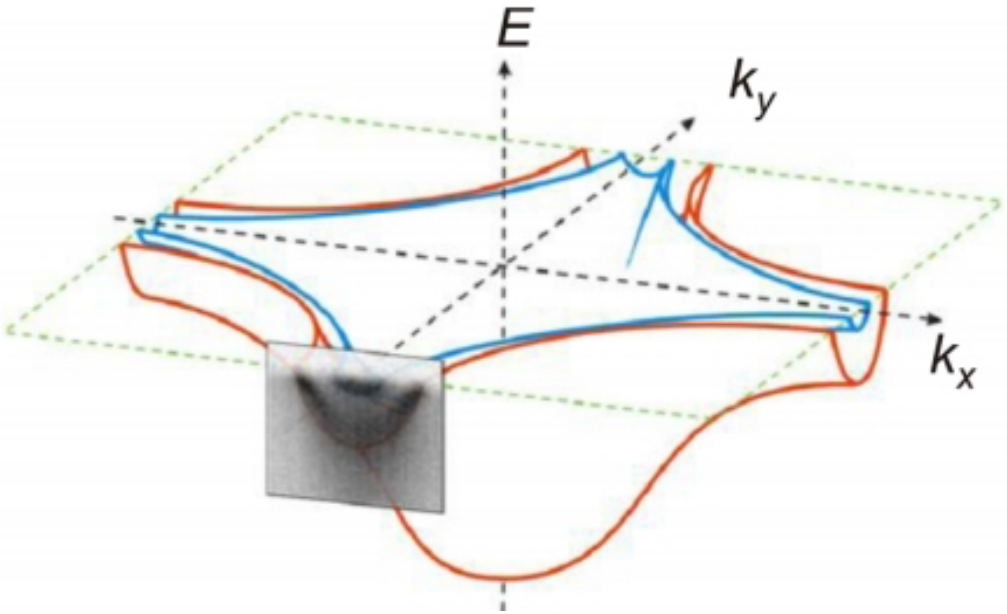
In 1905, Albert Einstein solved this apparent paradox by describing light as composed of discrete quanta, now called photons, rather than continuous waves. Based upon Max Planck's theory of black-body radiation, Einstein theorized that the energy in each quantum of light was equal to the frequency multiplied by a constant, later called Planck's constant. A photon above a threshold frequency has the required energy to eject a single electron, creating the observed effect. This discovery led to the quantum revolution in physics and earned Einstein the Nobel Prize in Physics in 1921.

From wikipedia

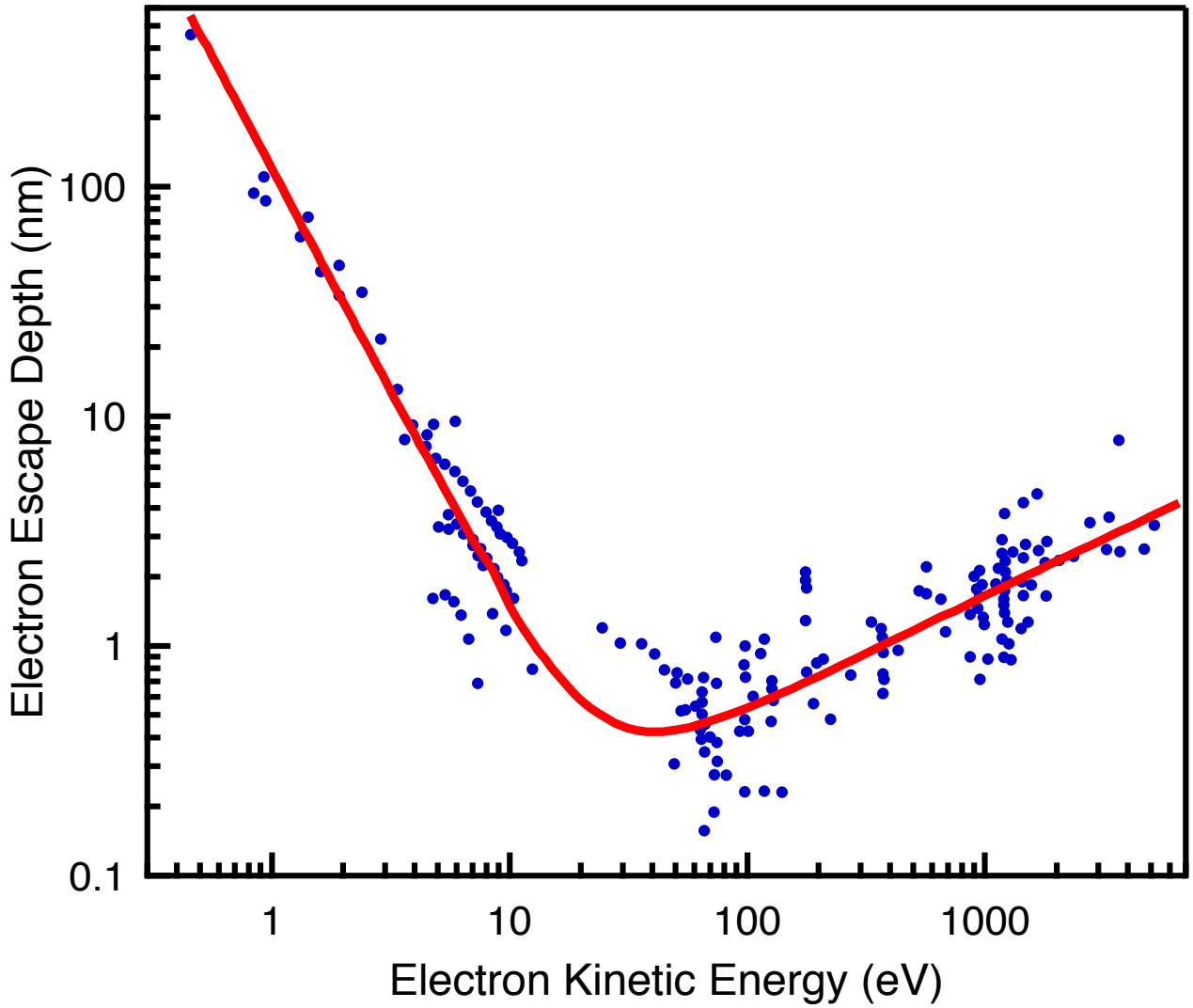
Angle resolved photoemission



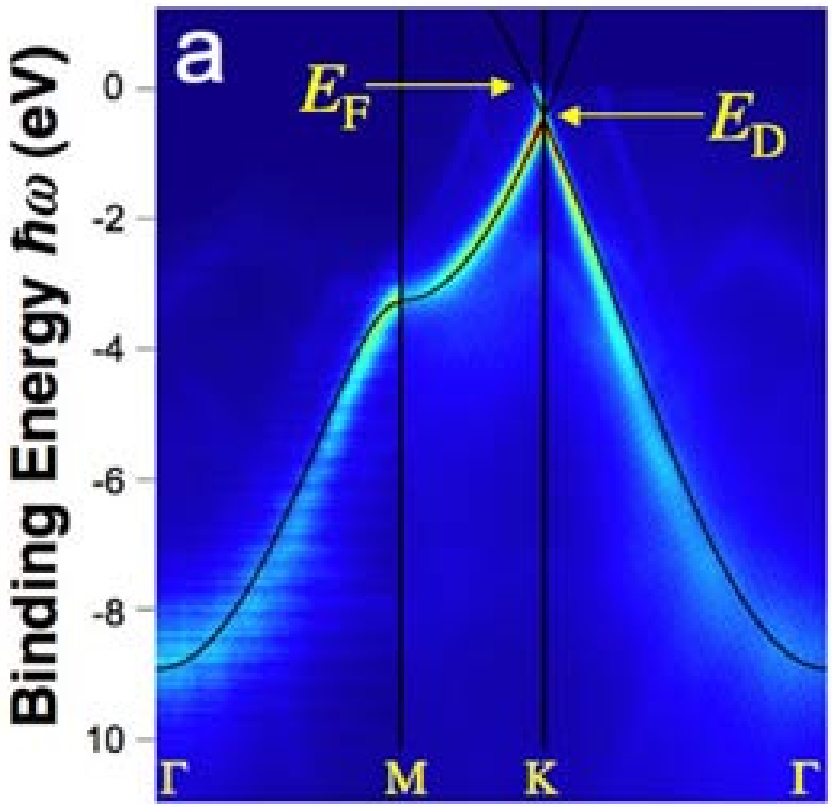




Surface sensitive technique

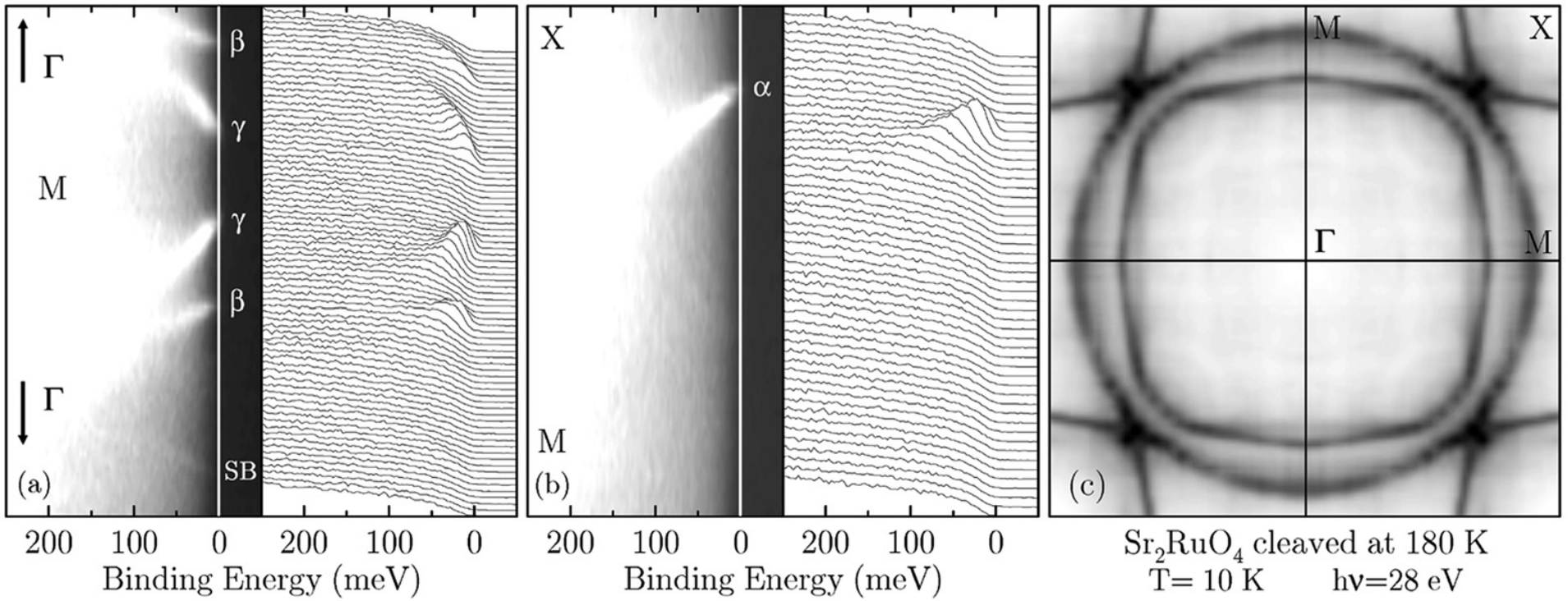


Band structure of graphene

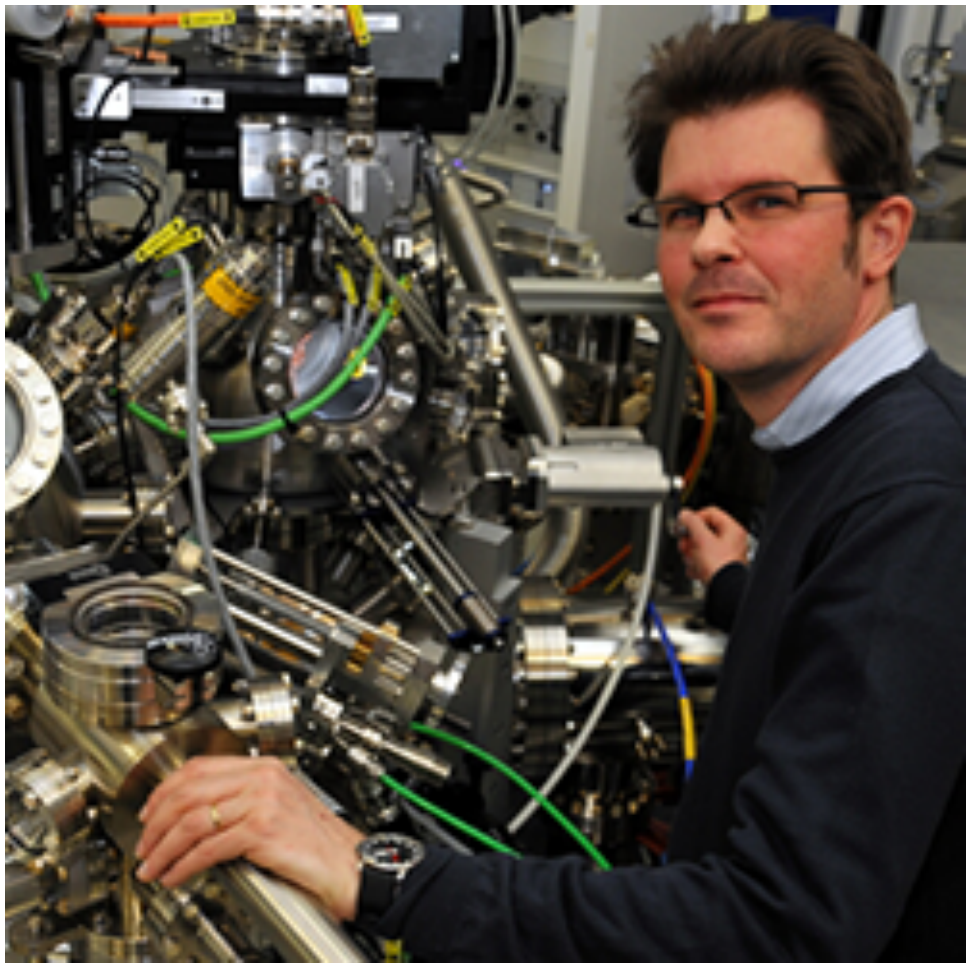


Nature Physics **3**, 36 - 40 (2007)

Band structure of Sr_2RuO_4



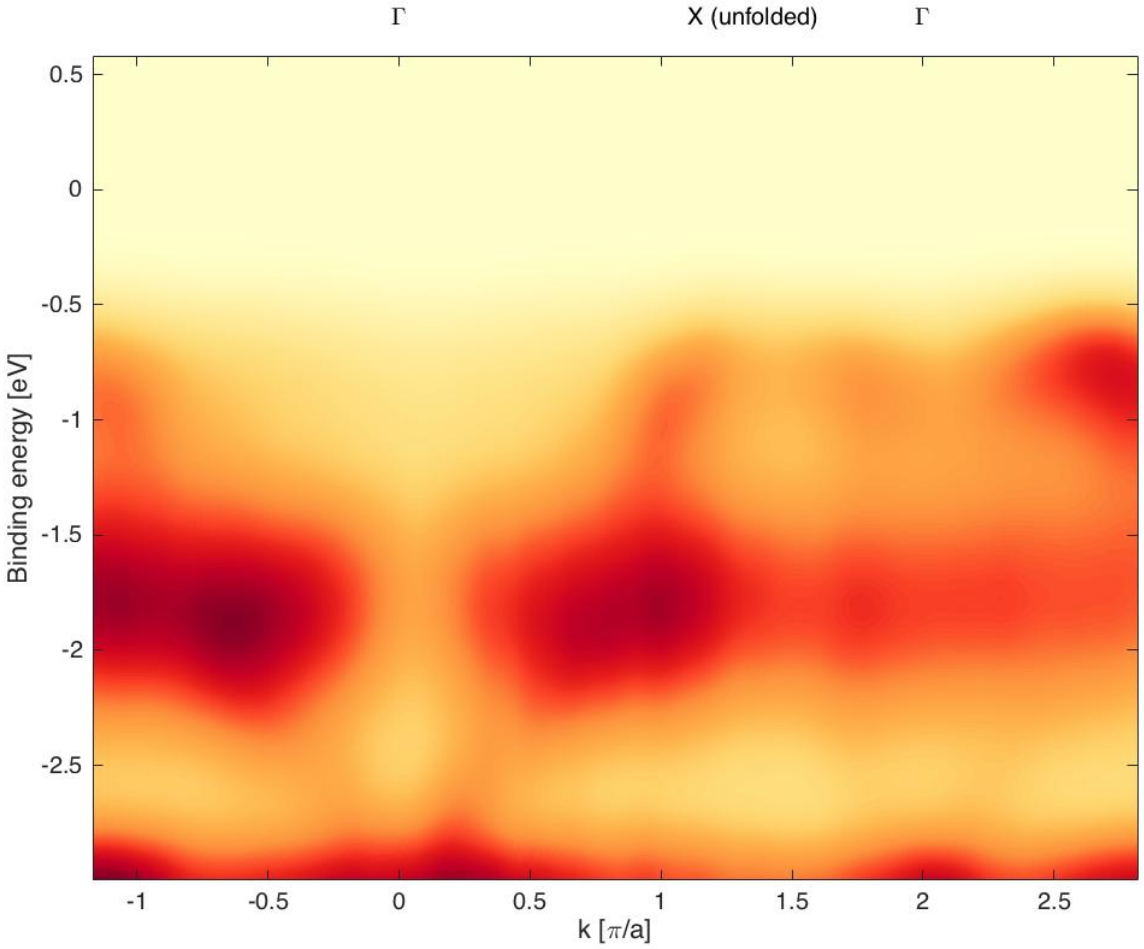
THIS WEEKEND
Bachelor & Master Project (Fabio Cossalter & Denys Sutter)



Since coming online in 2014, the Angle-Resolved Photoemission Spectroscopy (ARPES) beamline, known as I05, has been publishing ground-breaking research in a number of high-impact physics journals. 2015 saw 22 articles published in 13 different journals (including Nature Nanotechnology, Science, and Nature Physics), together scoring an average Impact Factor of 14.241. Here we get a taste of what I05 can do, and with summaries of the big hitters from last year.

http://www.diamond.ac.uk/Home/Corporate-Literature/newsletter/Spring2016/Science/I05.html

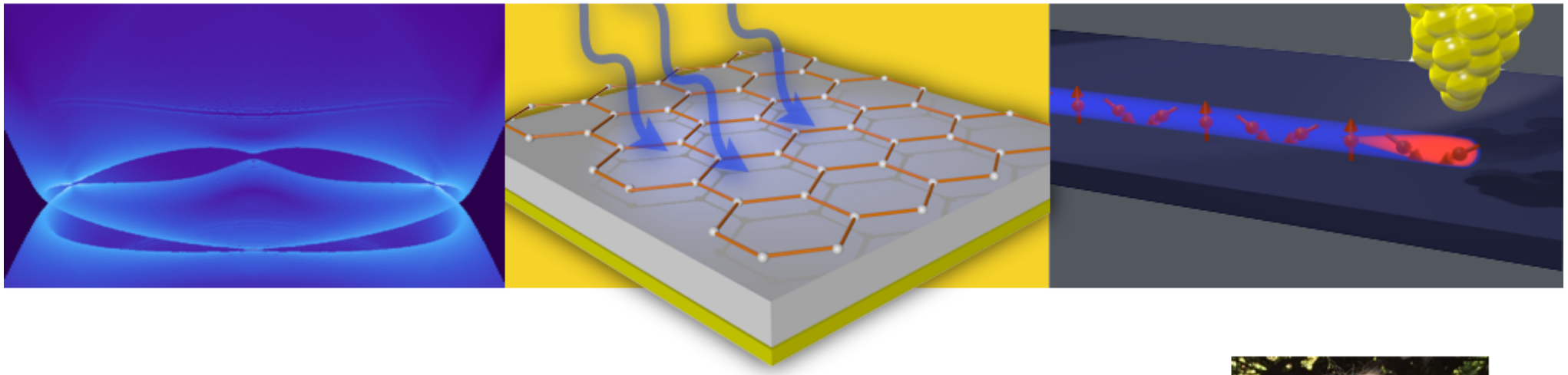
THIS WEEKEND
Bachelor & Master Project (Fabio Cossalter & Denys Sutter)



Band Structure
Insulating (150 K)
Ca_2RuO_4

Bachelor and Master Projects

Theoretical Condensed Matter Physics



Titus Neupert
to arrive June 2016 at UZH

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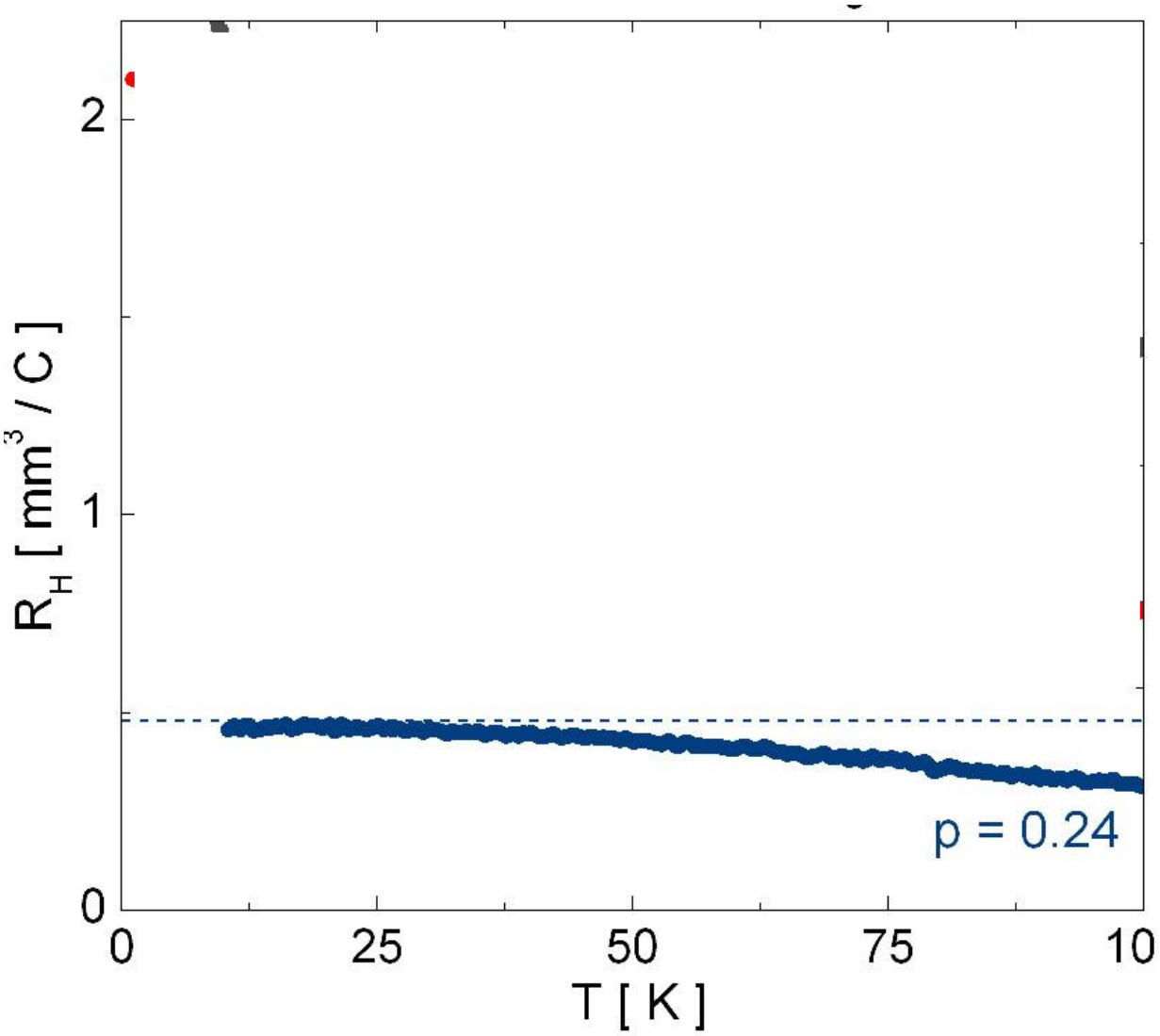
Hall effect: Carrier density



Wiedermann- Franz’s Effect