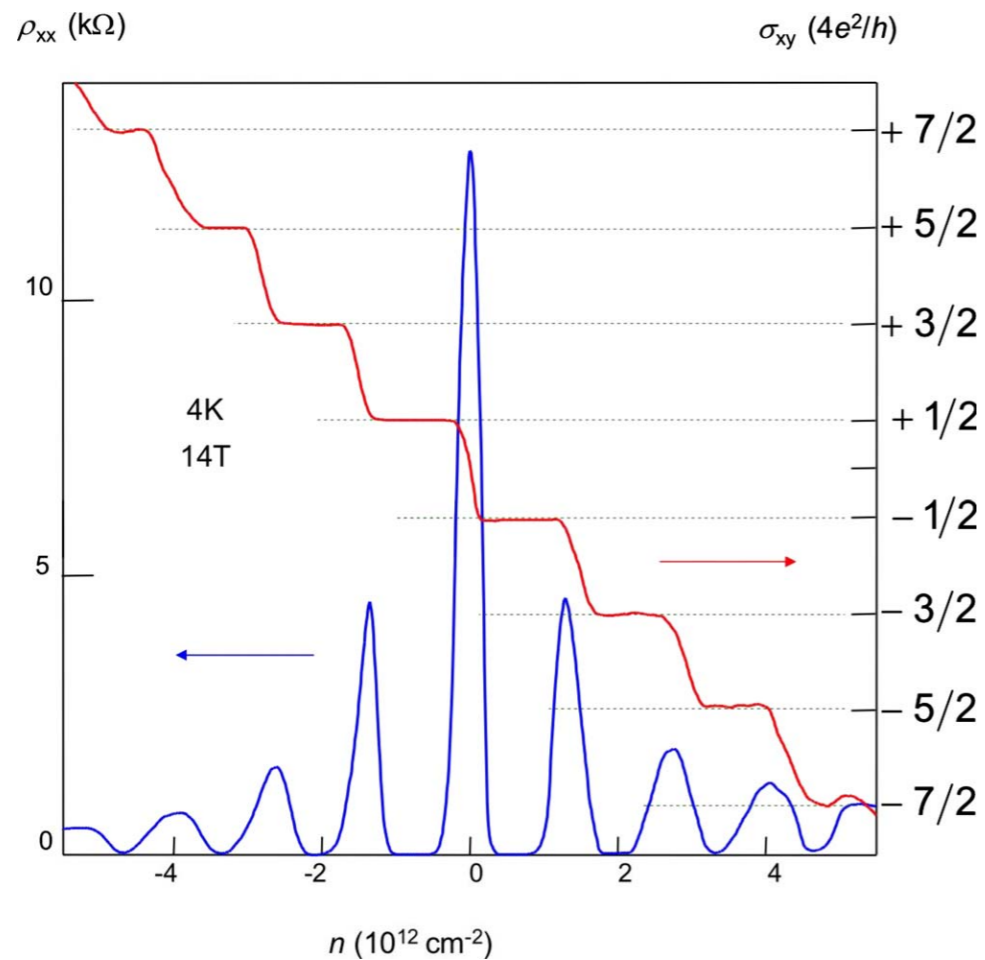


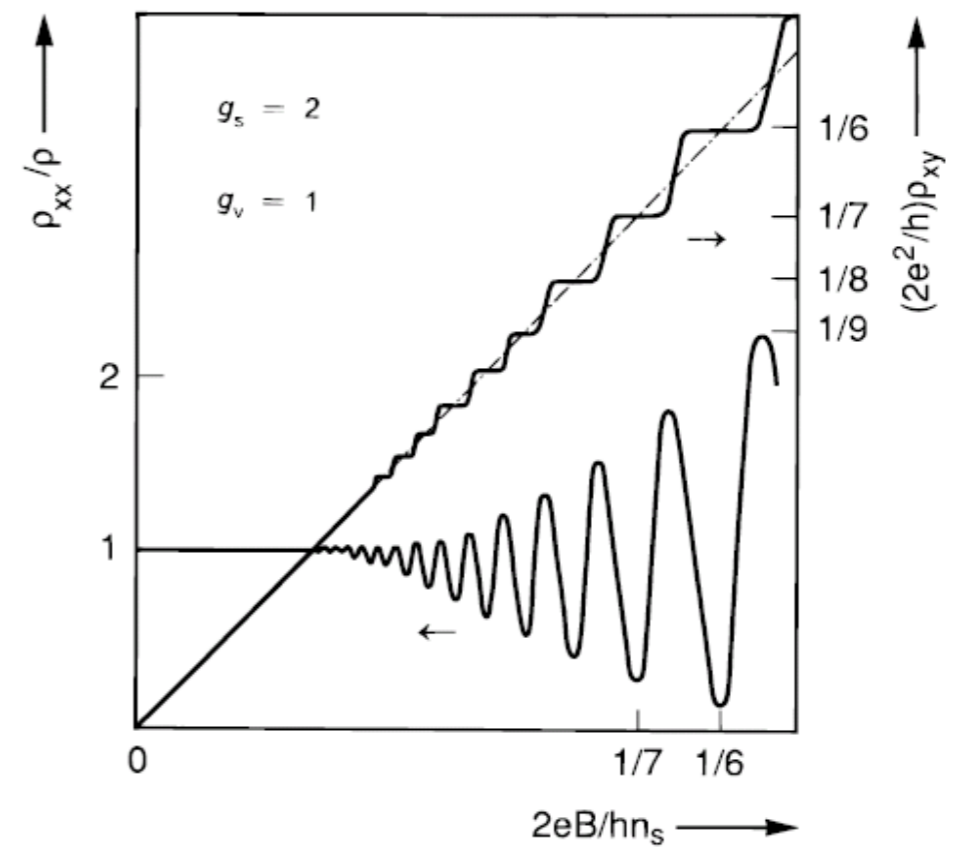
# Berry phase manifestation in Landau level offset

graphene



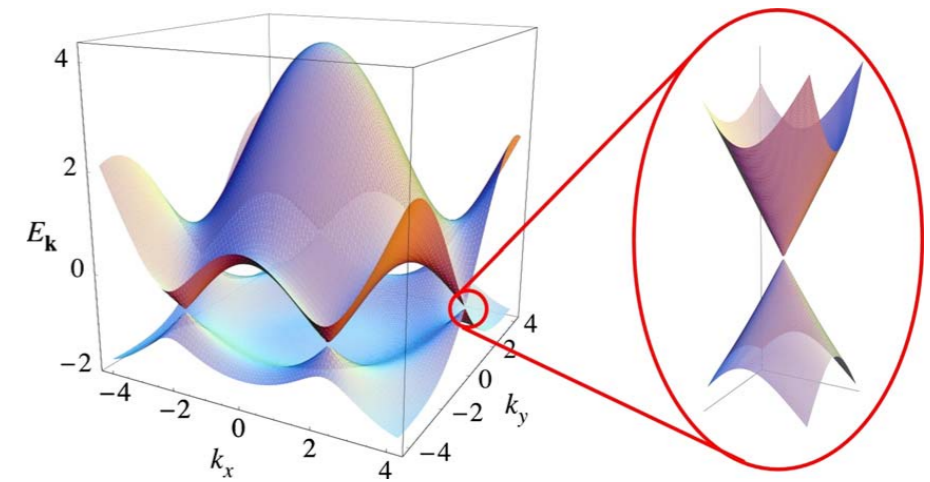
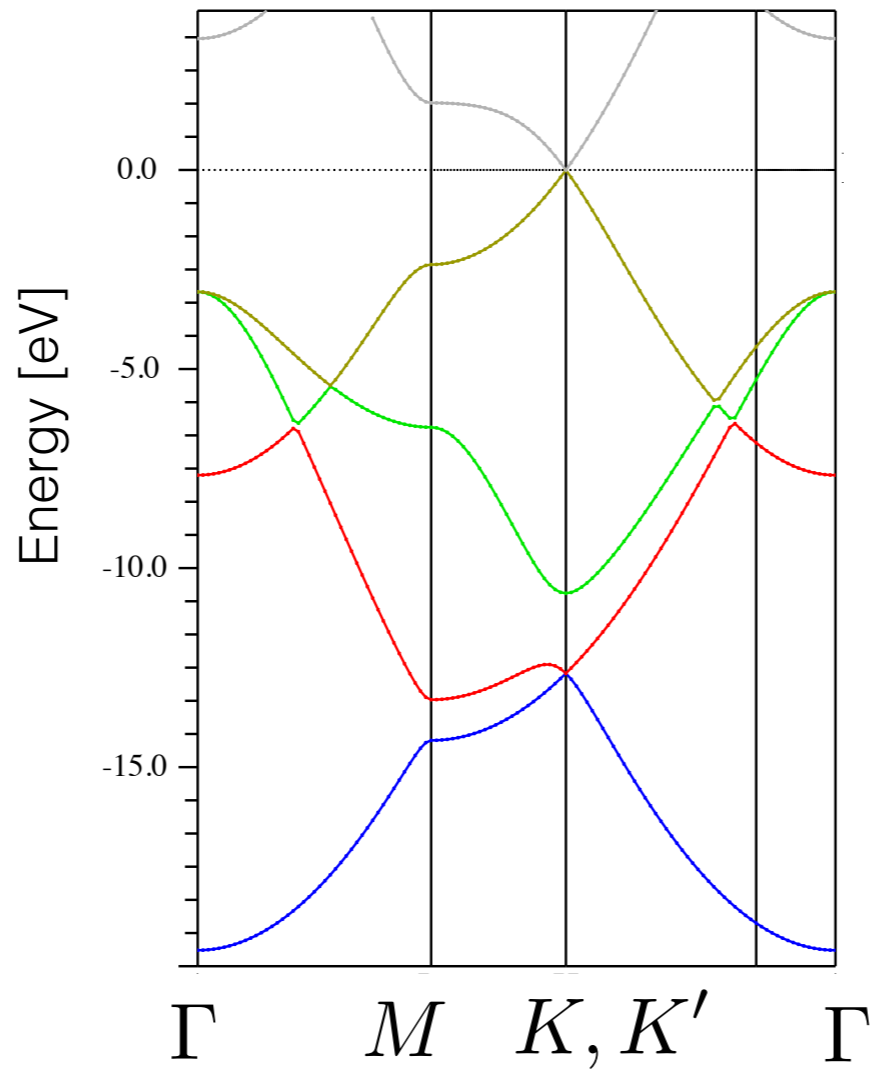
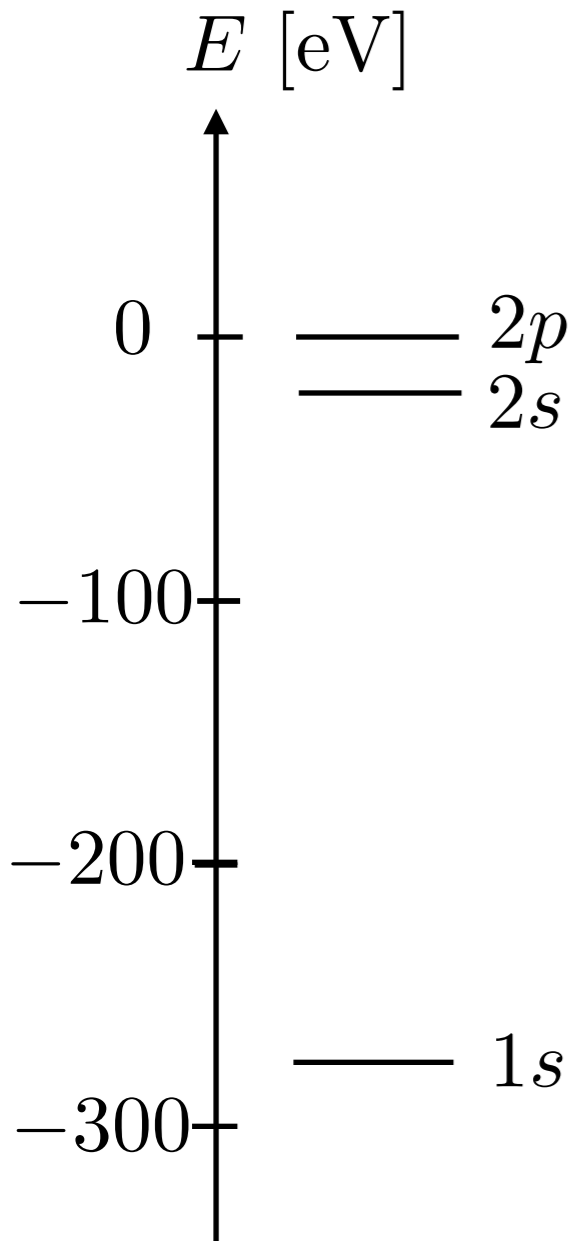
- 'half-integer' IQHE
- Berry phase =  $\pi$

2DEG

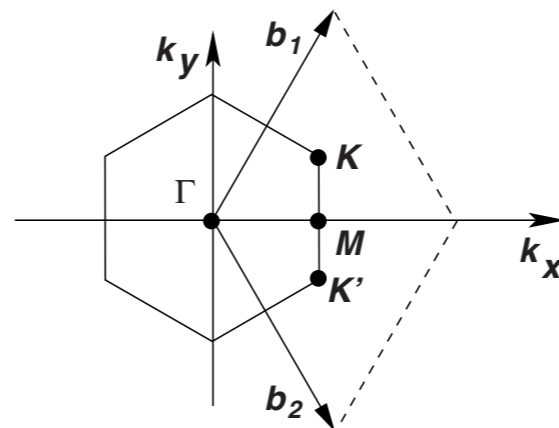
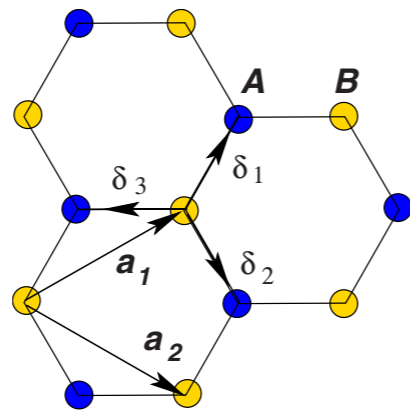
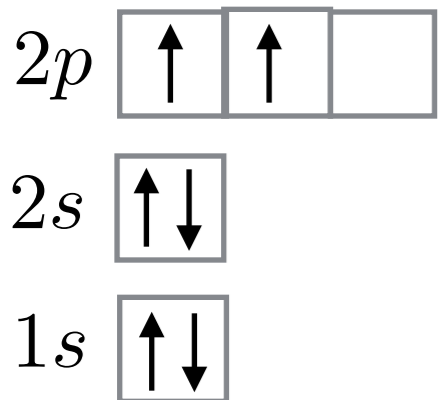


- true IQHE
- Berry phase = 0

# Graphene band structure

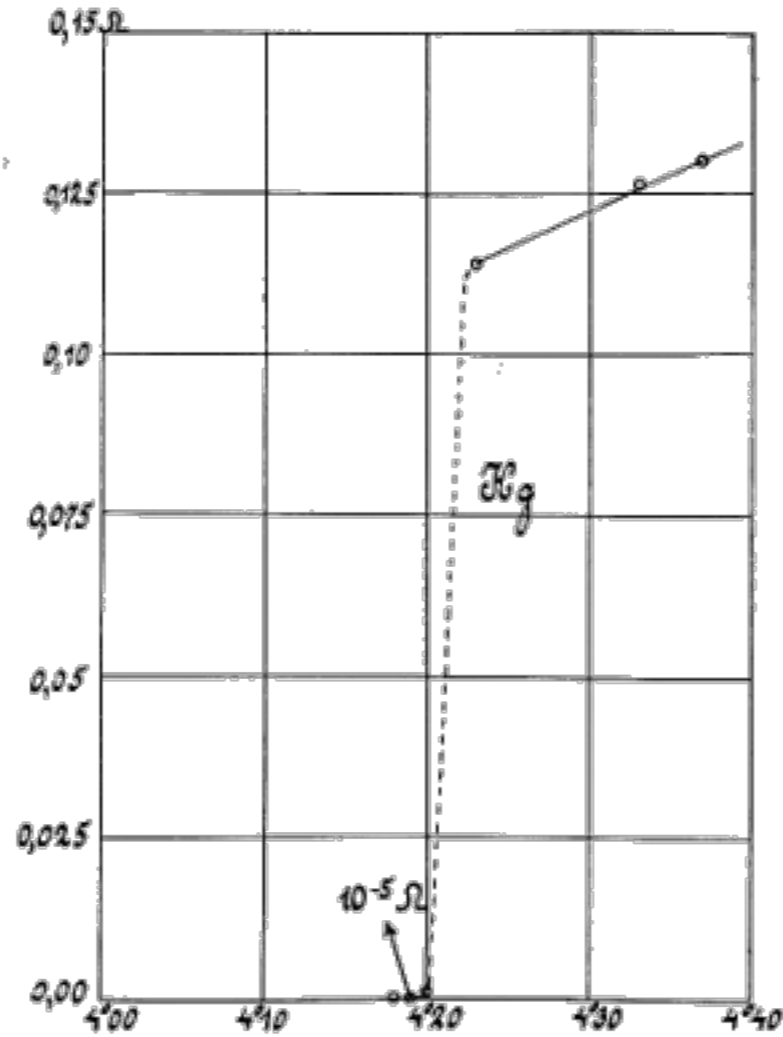
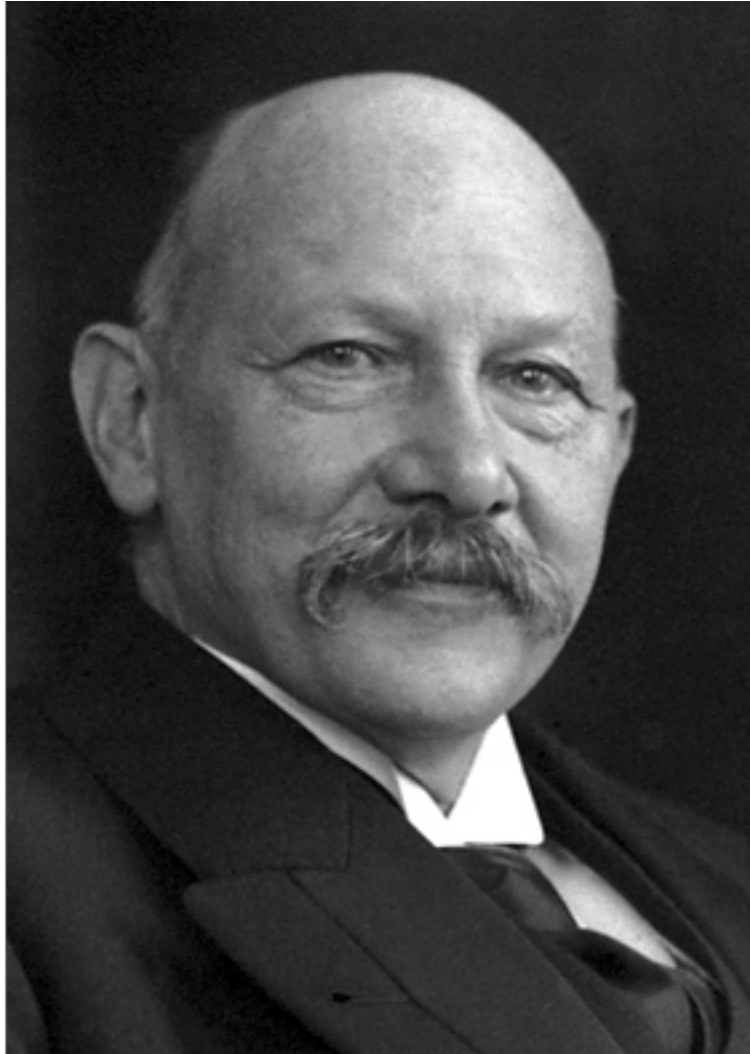


- Dirac cones
- Fermi velocity replaces eff. mass



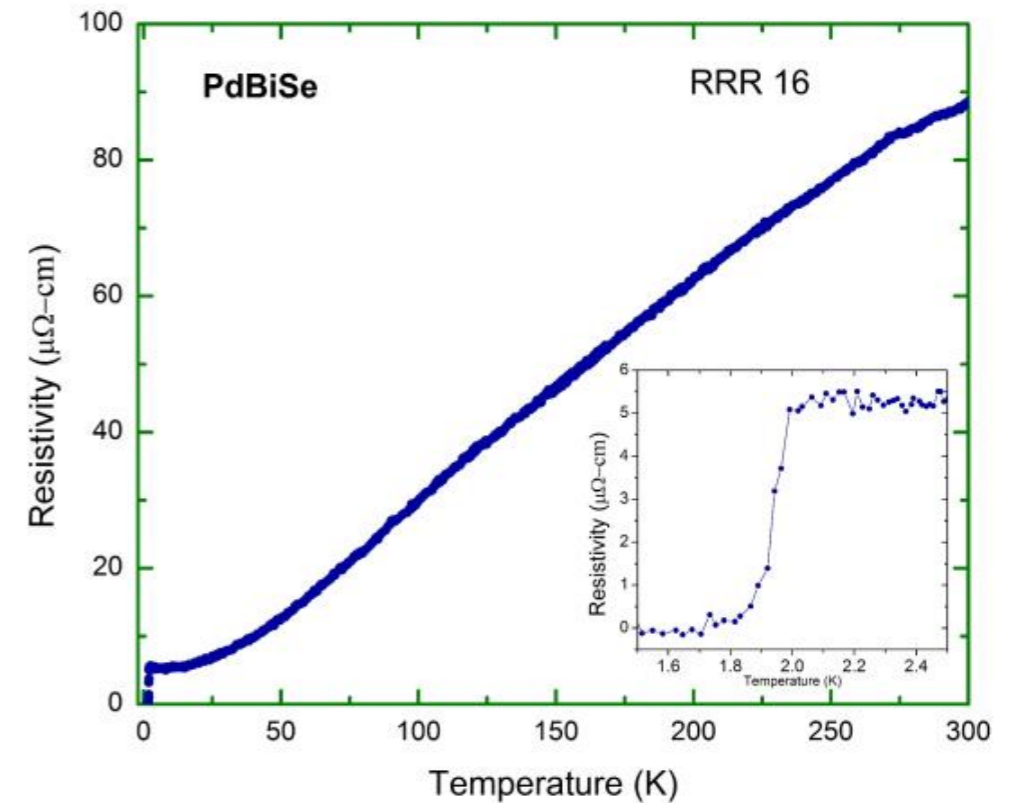
$$\hat{H} = \hbar v_F \vec{k} \cdot \vec{\sigma}$$

# Superconductivity

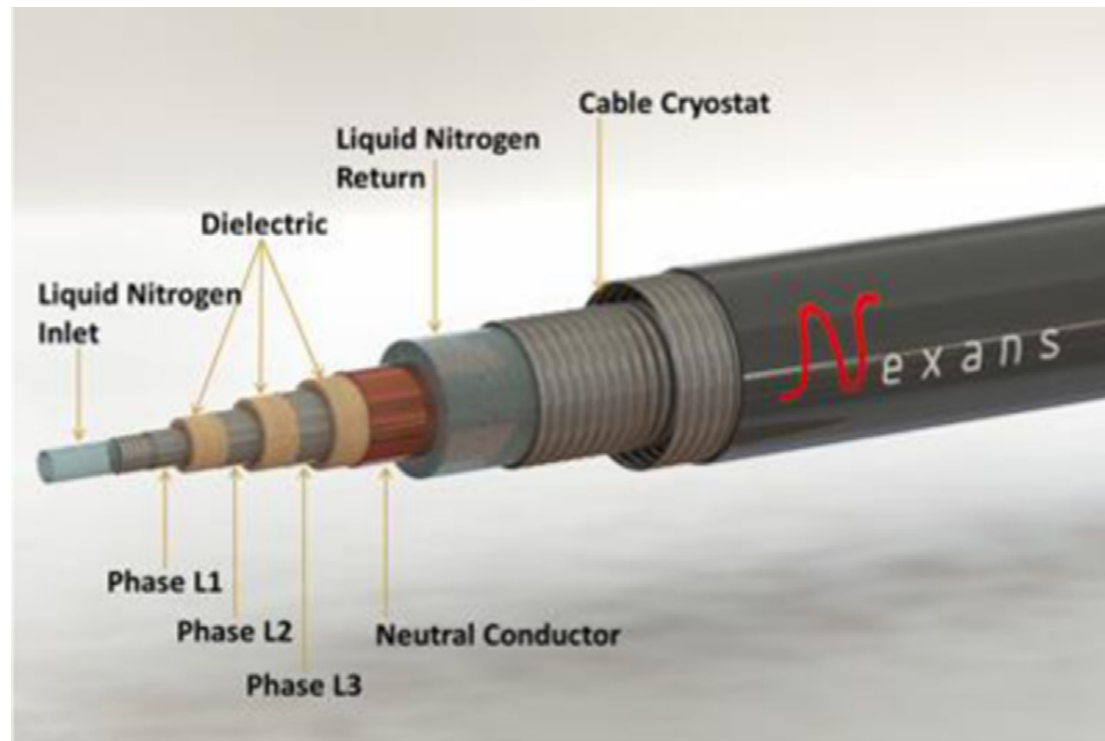


100 years ago...

... 5 years ago



# Superconducting cables in action

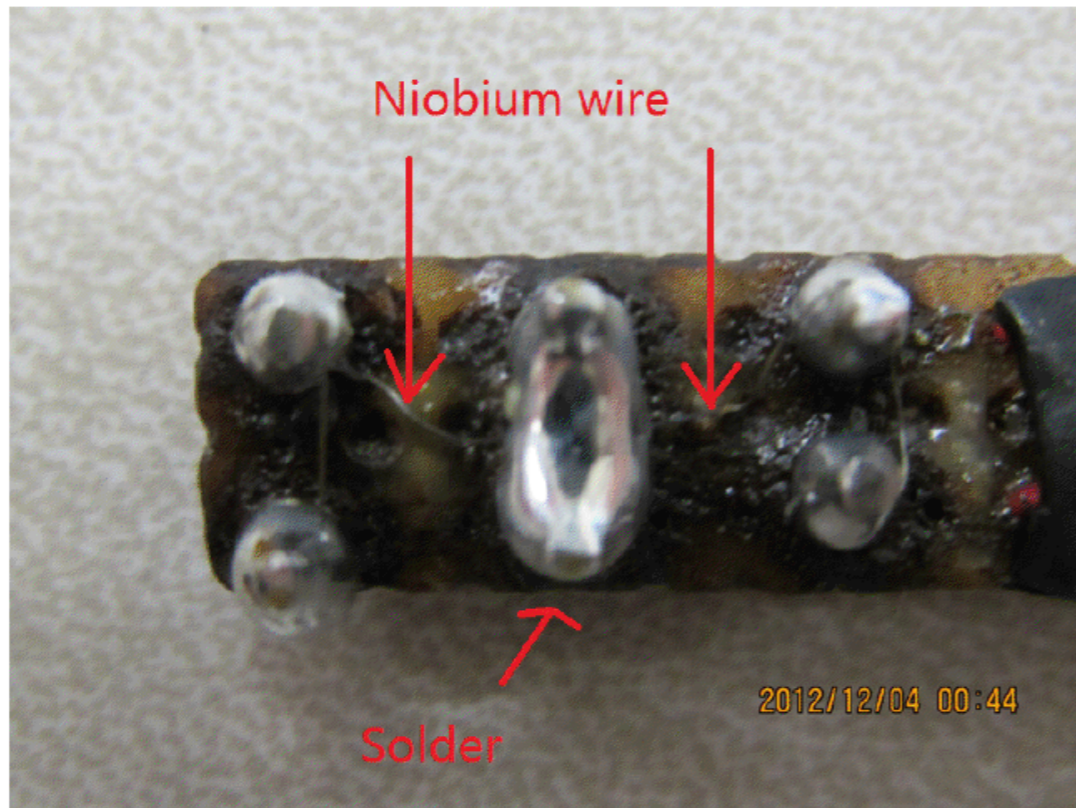


Project	Location	Length [m]	Capacity [MVA]	Schedule	Operator
LIPA	Long Island/USA	600	574 (138 kV AC, 2.4 kA)	In operation since 2008	LIPA
AmpaCity	Essen/Germany	1000	40 (10 kV AC, 2.3 kA)	Start of operation 01/2014	RWE
	Amsterdam/NL	6000	250 (50 kV AC)	Proposed	Alliander
St. Petersburg Project	St. Petersburg/Russia	2500	50 (20 kV DC, 2.5 kA)	Start of operation 2015	FGC UES <sup>a</sup>
Ishikari	Ishikari/Japan	2000	100 ( $\pm 10$ kV DC, 5 kA)	Start of construction spring 2014	City of Ishikari
	Icheon/Korea	100	154 (154 kV AC, 3.75 kA)	Operating since 11/2013	KEPCO <sup>b</sup>
	Jeju Island/Korea	1000	154 (154 kV AC, 3.75kA)	Operation 2015	KEPCO
	Jeju Island/Korea	500	500 (80kV DC)	Operation 2014	KEPCO
HYDRA	Westchester county/USA	170	96 (13.8 kV AC/4 kA)	Start of construction early 2014	ConEdison
	Yokohama/Japan	250	200 (66 kV AC, 5kA)	Operation stopped December 2013, continuation planned with new high-performance refrigerator 2015.	TEPCO <sup>c</sup>
REG <sup>f</sup>	China	360	13 (1.3 kV DC, 10 kA)	Operation since 2011	IEE CAS <sup>d</sup>
Tres Amigas	Chicago/US	5 km	to be specified	Planning since 2014	ComEd <sup>e</sup>
	New Mexico/US		750/5000	Postponed	Tres Amigas LLC

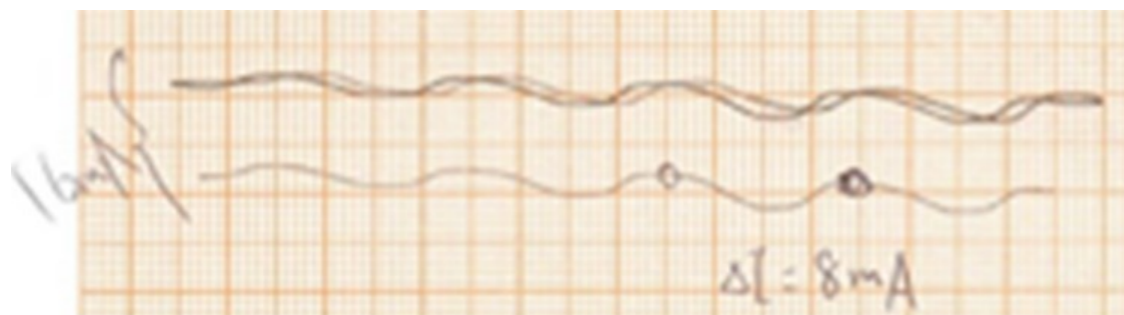


**Fig. 2.** TEPCO/Sumitomo 66 kV AC HTS test station at Asahi substation in Yokohama/Japan: left image shows the cable with a joint, right image shows the 66 kV AC end stations responsible for the transition from standard conductor to superconductor and from room to cryogenic temperature (2014).

# Weak superconductivity



Current larger than  $I_c$ ,  
voltage measured

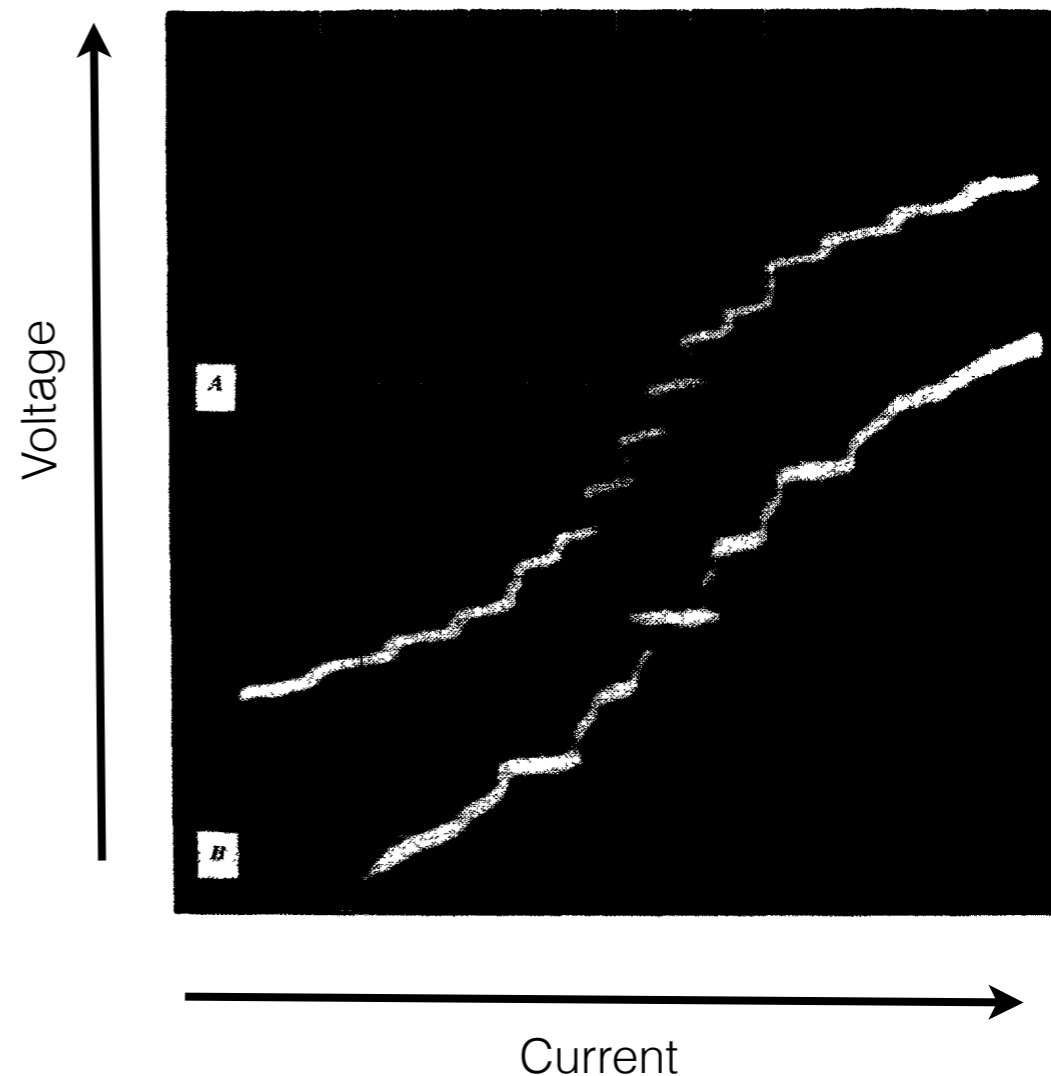


AC current (used to  
generate mag. field)

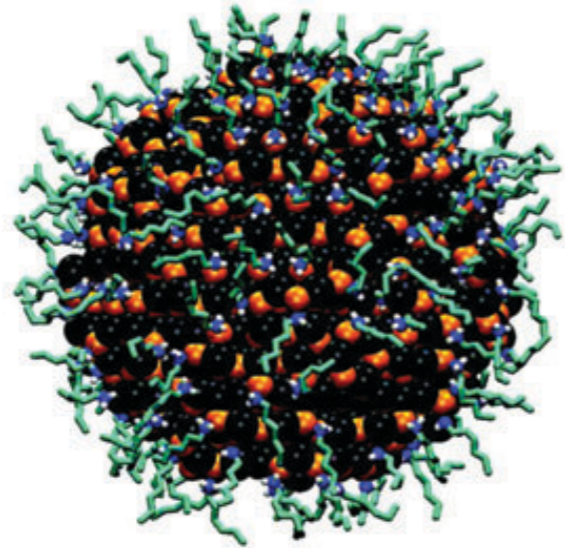
Josephson junction subject...



- homogeneous mag. field
- microwave radiation (Shapiro steps)



# Quantum dots (QDs)



**Fig. 2** Molecular simulation snapshot of a colloidal CdSe NC capped by hexylamine molecules. Colour coding: black, Se; orange, Cd; light blue, C; dark blue, N; white, H; yellow, S; brown, P; red, O. The simulation methodology is described in ref. 3. Courtesy of P. Schapotschnikow (Delft University of Technology, Netherlands).



Colloidal CdSe nanocrystals (NC), diameter 1.7-4.5 nm (left to right) under UV illumination.

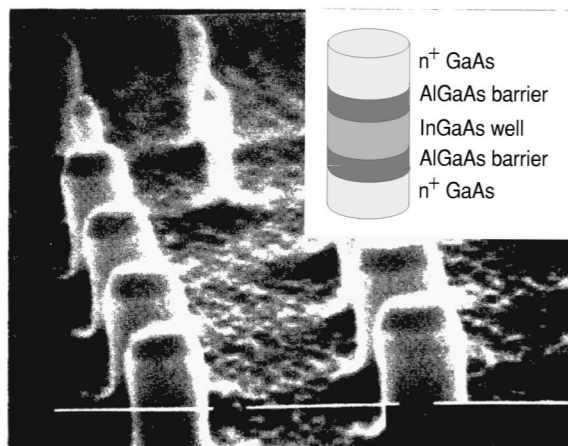
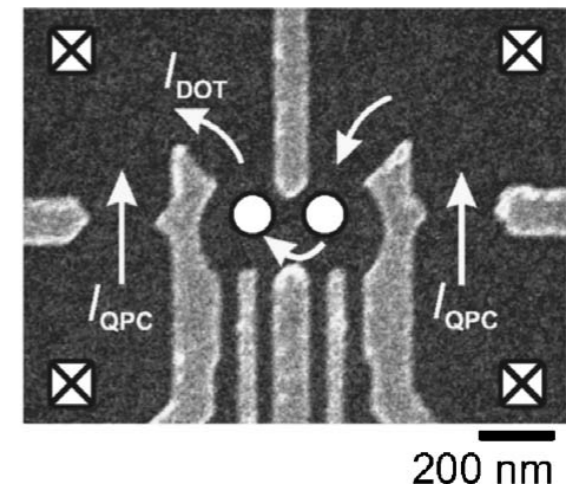
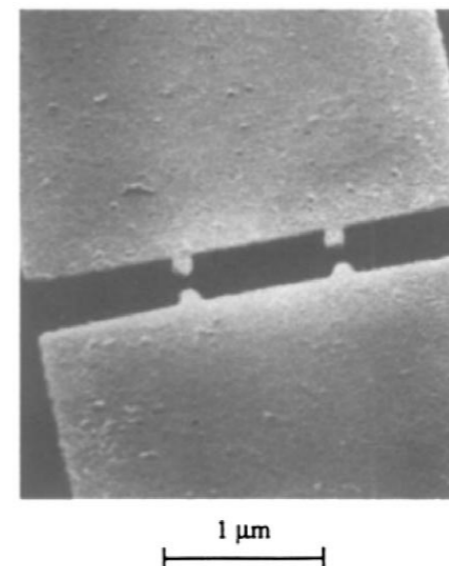
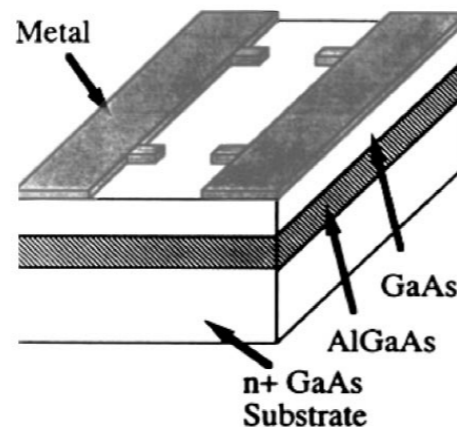
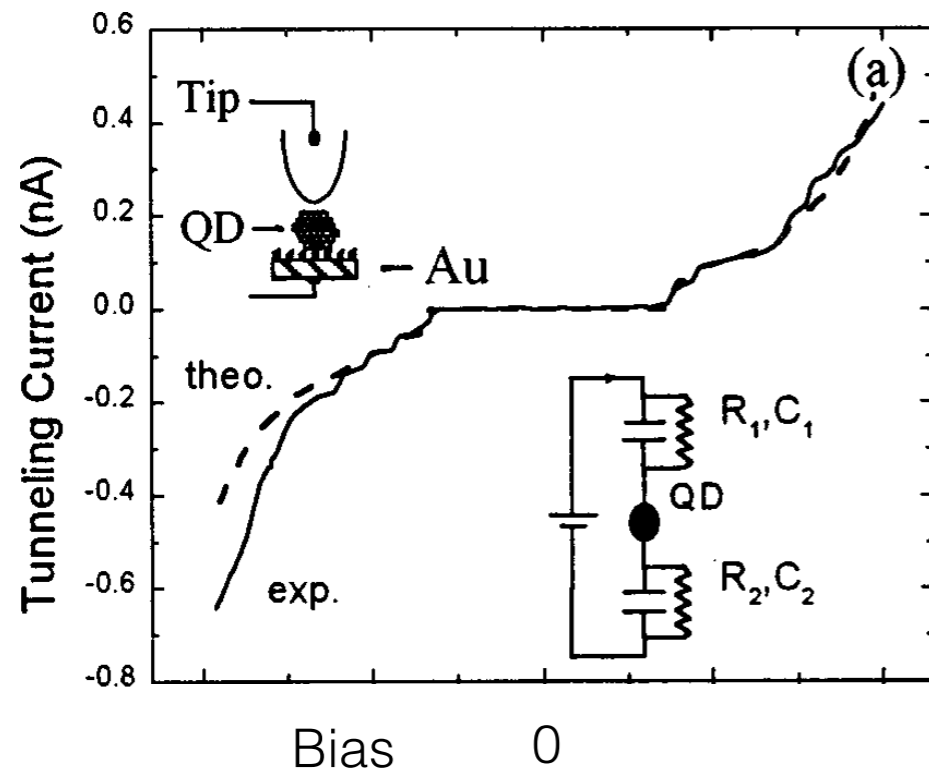


FIG. 4. Scanning electron micrograph showing etched quantum dots. (The white bars have a length of  $0.5 \mu\text{m}$ .) Inset, schematic picture of a single dot structure. After Reed *et al.*, 1988.



# Tunneling current: tip-QD-substrate



- non-linear VA characteristics
- clear steps visible at certain voltages
- InAs QD, diameter 4.4 nm

Differential conductivity - energy level spectroscopy

