20th Conference
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Physicists

HIGHLIGHTS IN PHYSICS OF 2D CRYSTALS THROUGH CRYOMAGNETIC OPTICS

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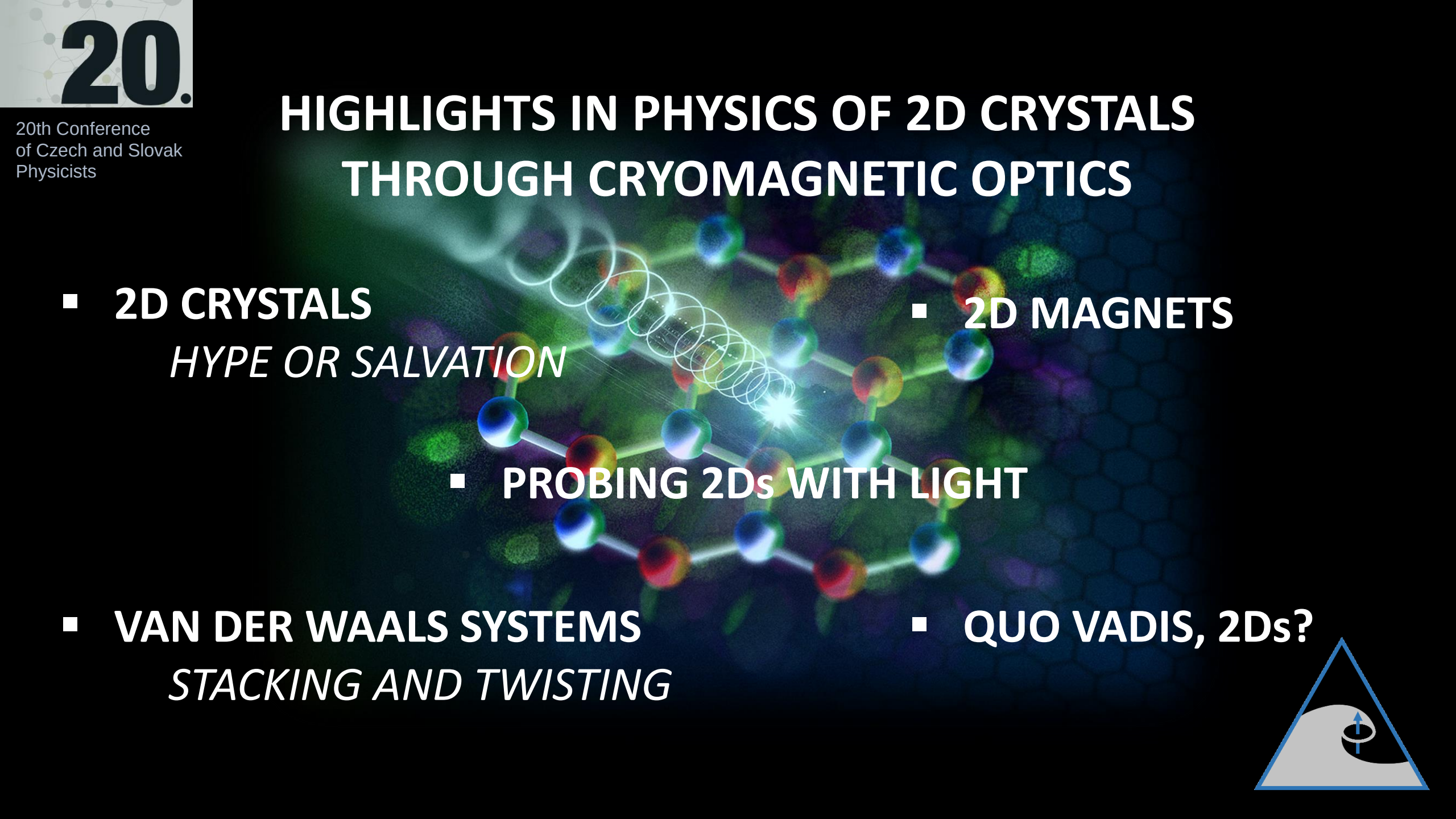
Faculty of Mathematics and Physics
Charles University

20th Conference
of Czech and Slovak
Physicists

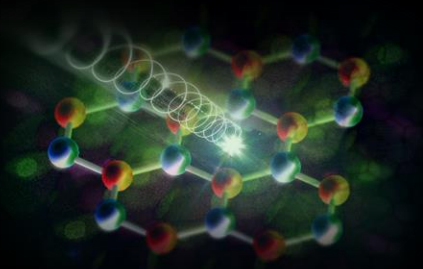
HIGHLIGHTS IN PHYSICS OF 2D CRYSTALS THROUGH CRYOMAGNETIC OPTICS

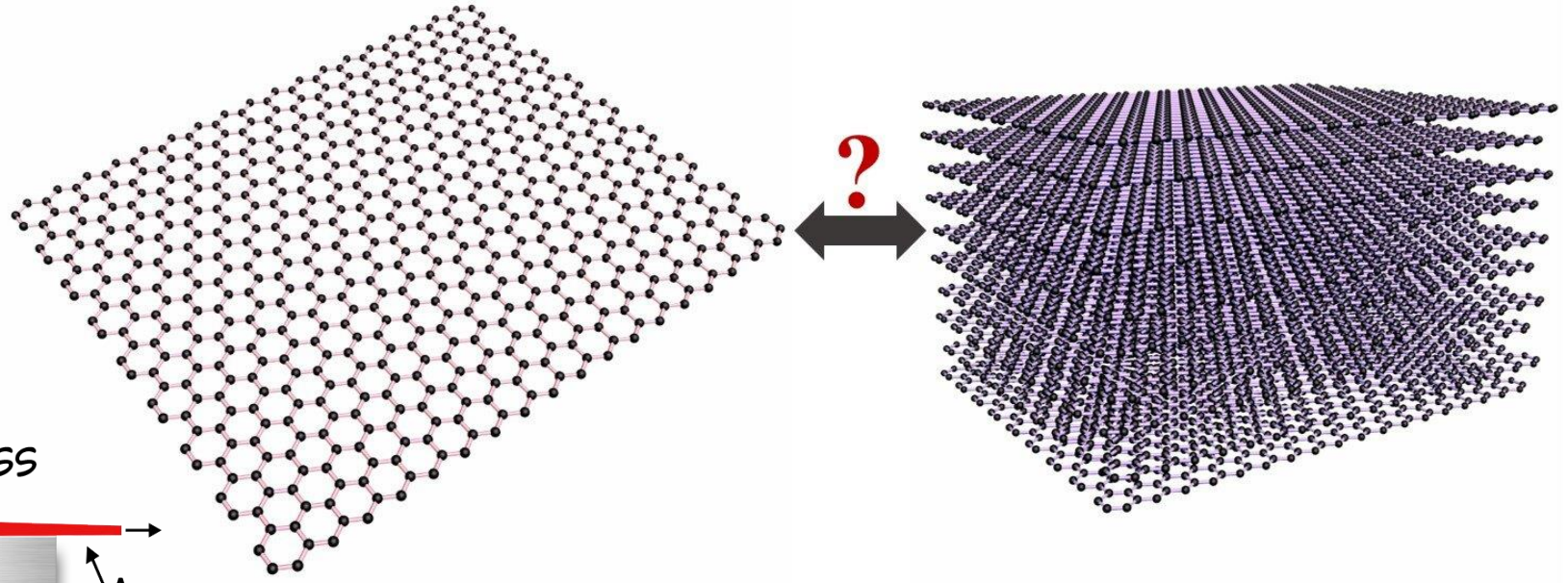


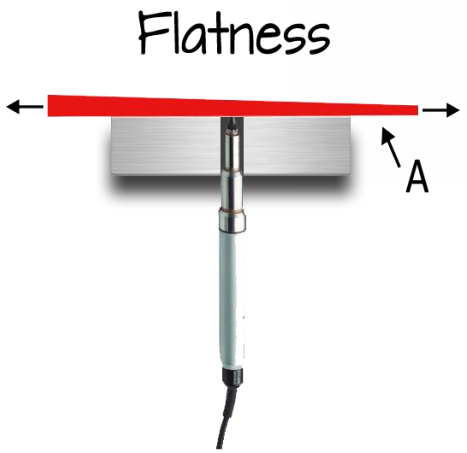
- **2D CRYSTALS**
  HYPE OR SALVATION
- **2D MAGNETS**
- **PROBING 2Ds WITH LIGHT**
- **VAN DER WAALS SYSTEMS**
  STACKING AND TWISTING
- **QUO VADIS, 2Ds?**

2D CRYSTALS

HYPE OR SALVATION







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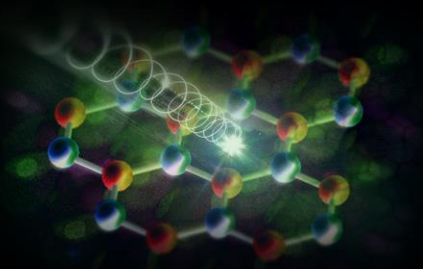
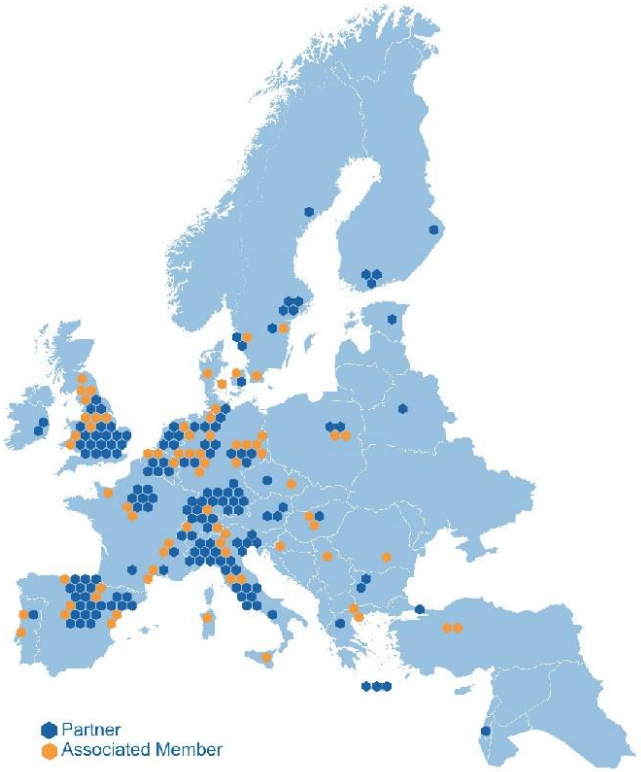
2D CRYSTALS
HYPE OR SALVATION

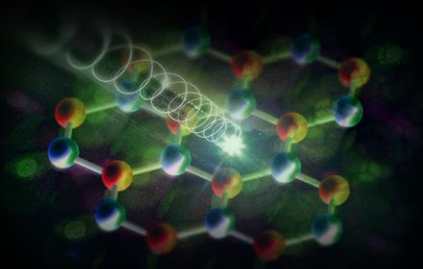


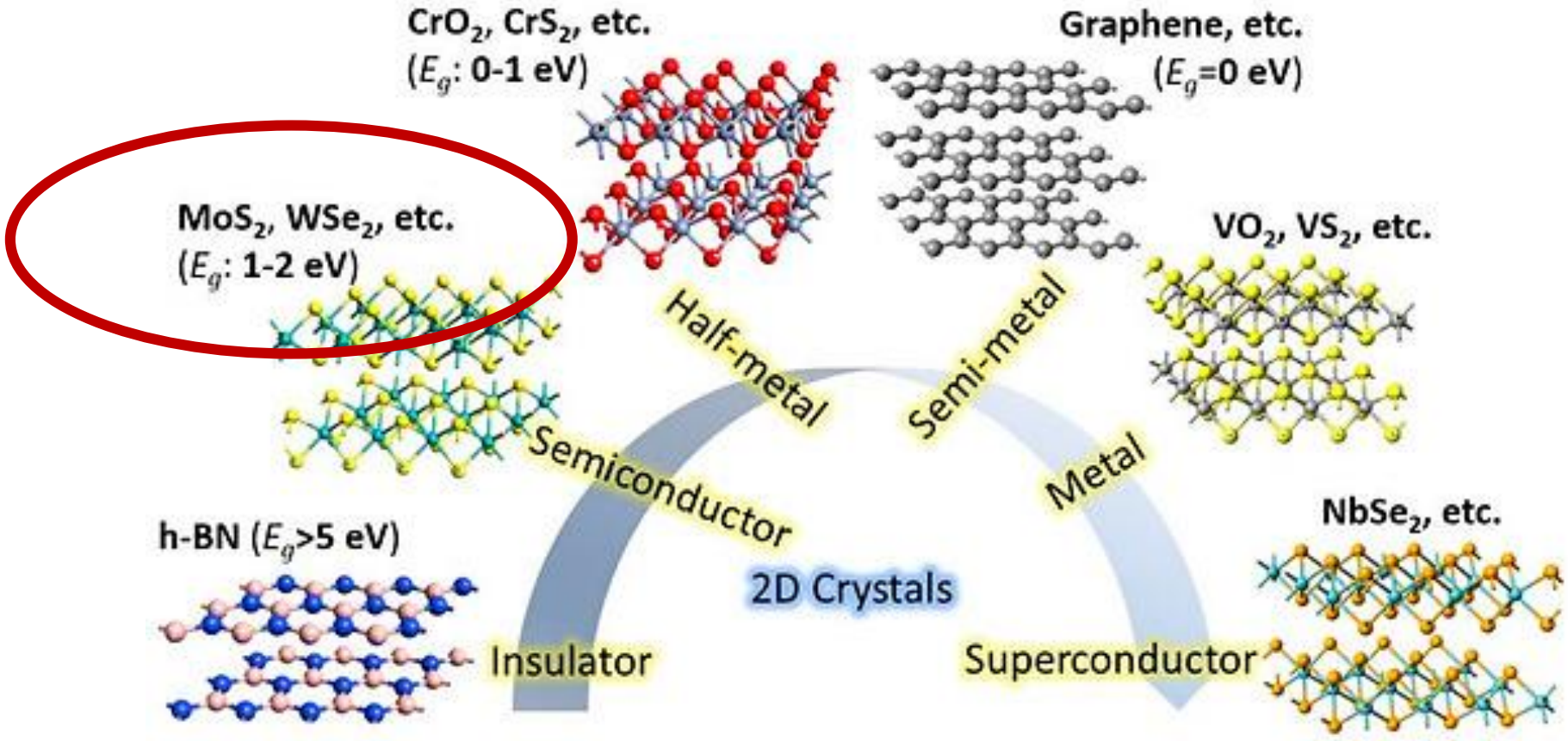
GRAPHENE FLAGSHIP

€1 billion

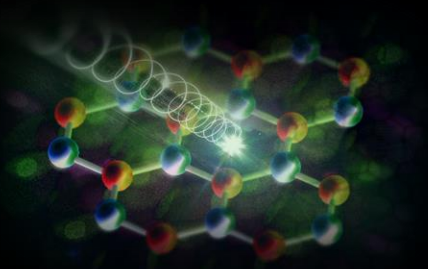


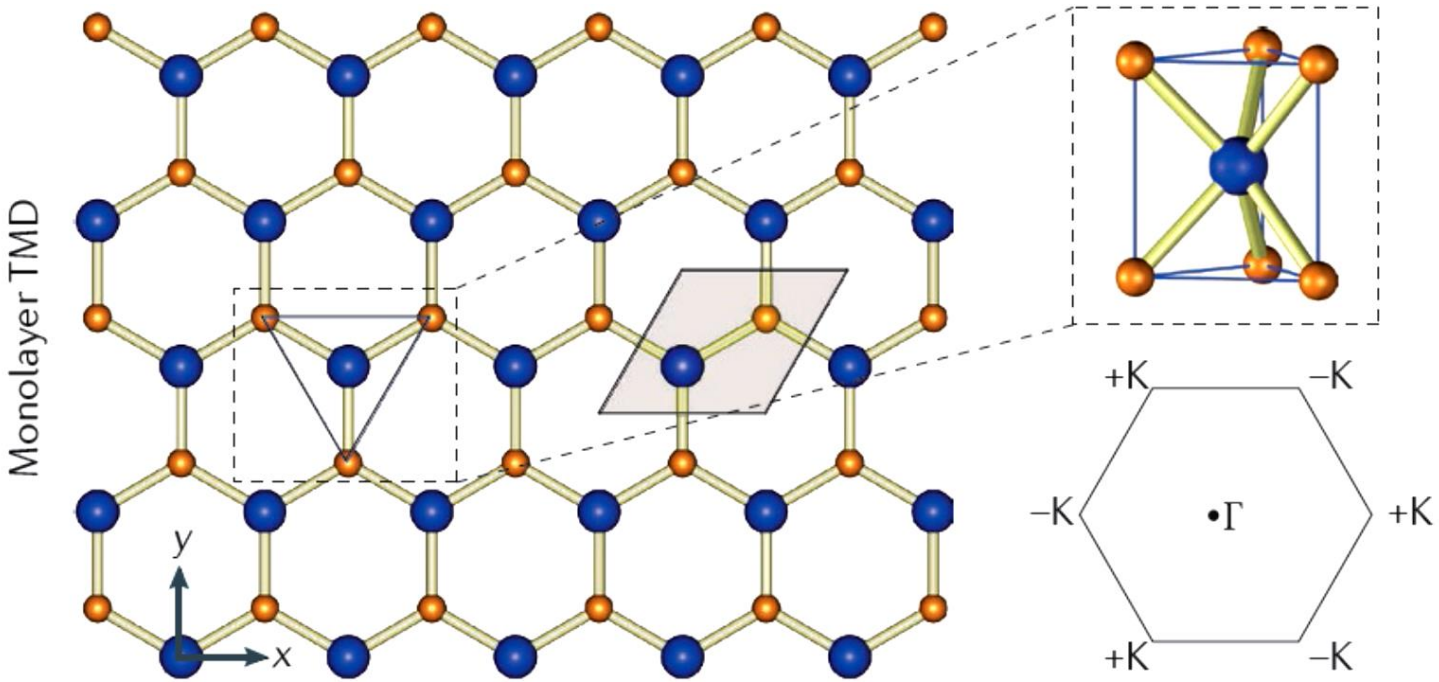
2D CRYSTALS
HYPE OR SALVATION



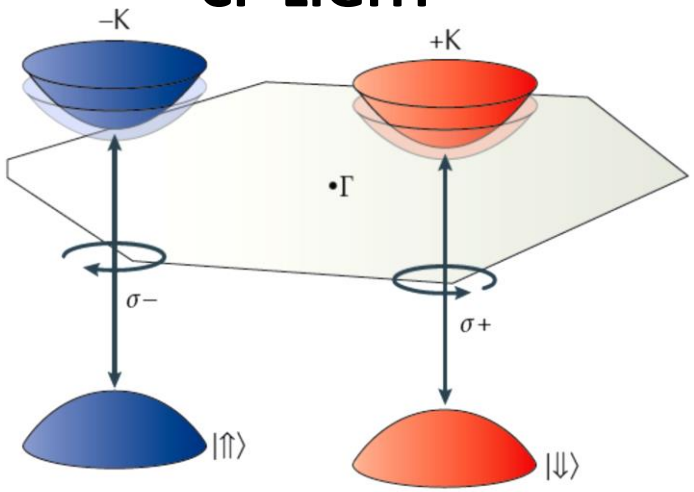


2D CRYSTALS
VALLEYTRONICS

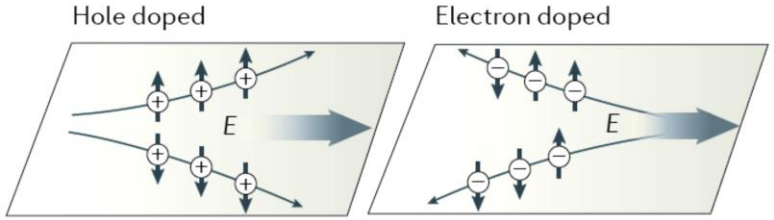




CP LIGHT

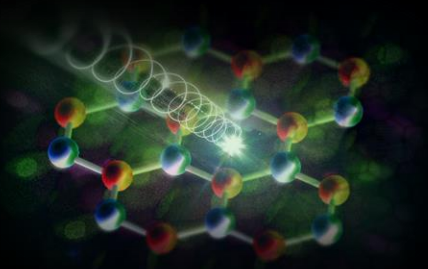


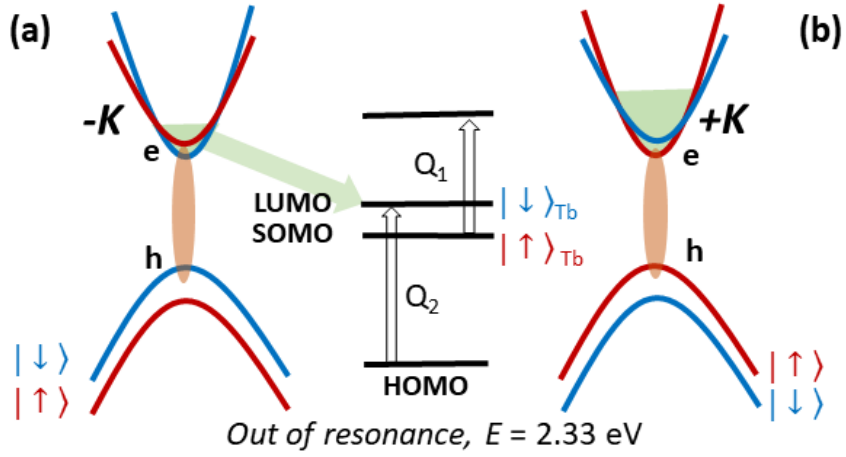
VALLEY HALL EFFECT



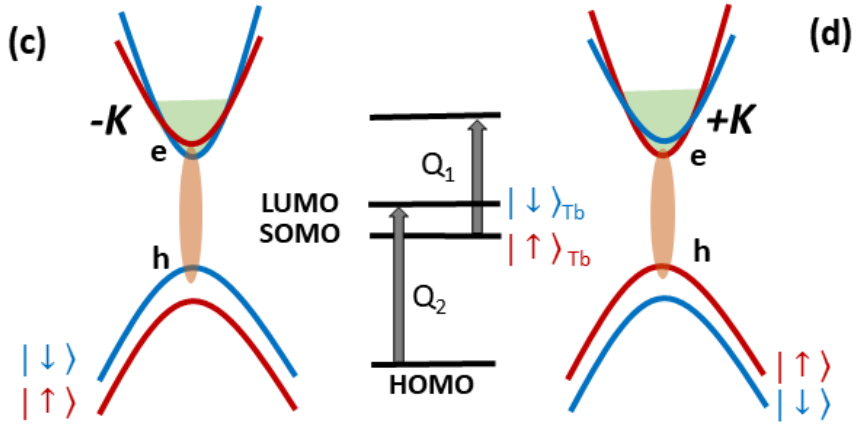
2D CRYSTALS

BOOSTING VALLEY POLARIZATION

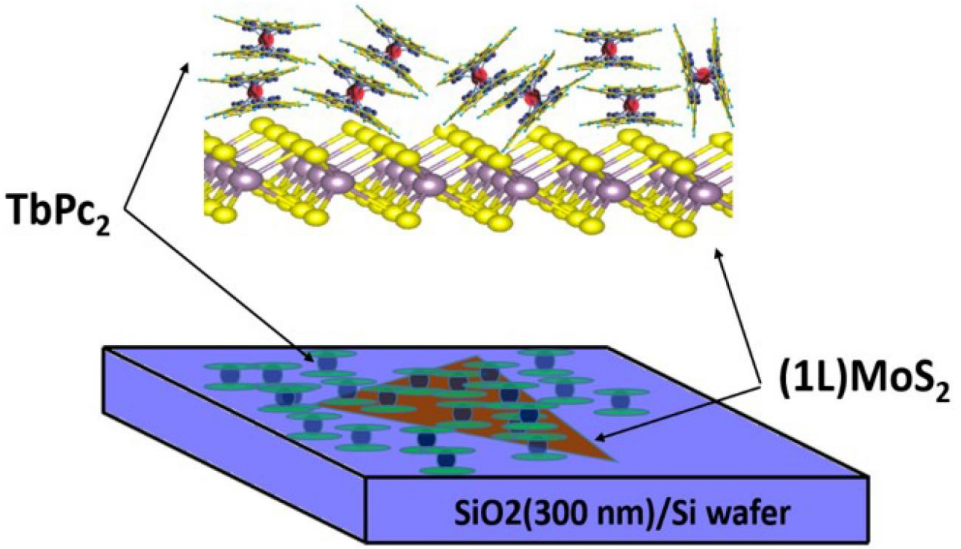




Out of resonance, E = 2.33 eV



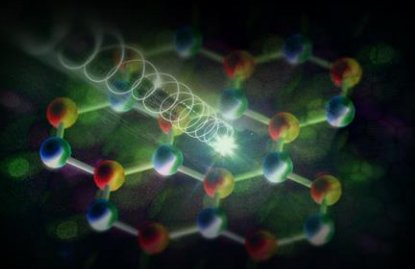
In resonance, E = 1.96 eV

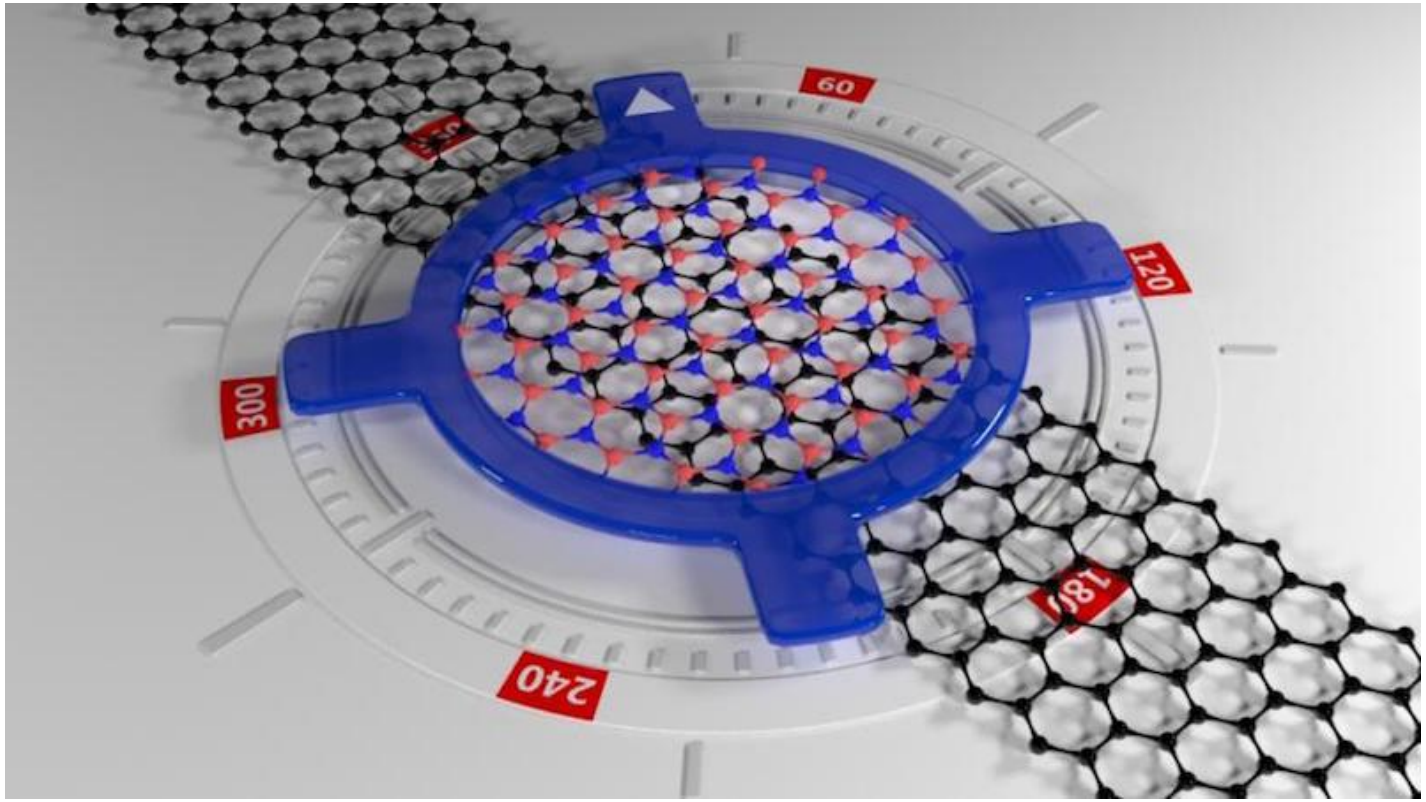


Varade et al, submitted

VAN DER WAALS SYSTEMS

STACKING AND TWISTING

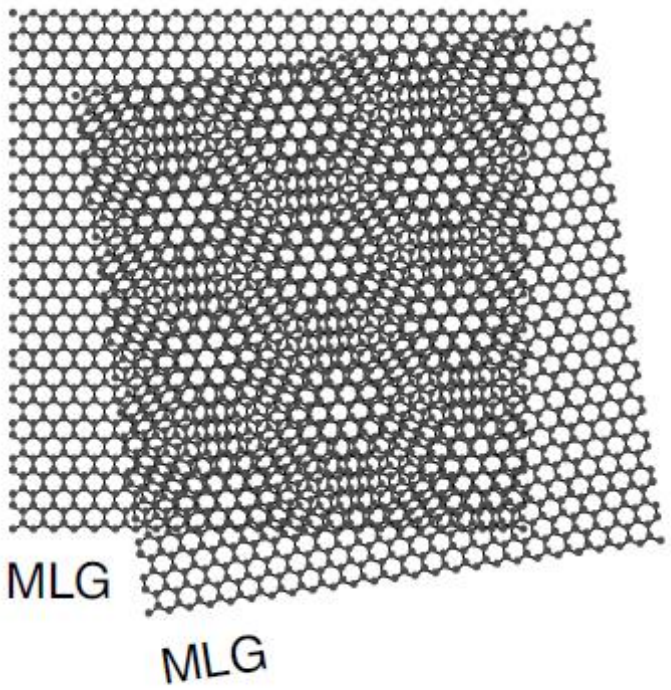


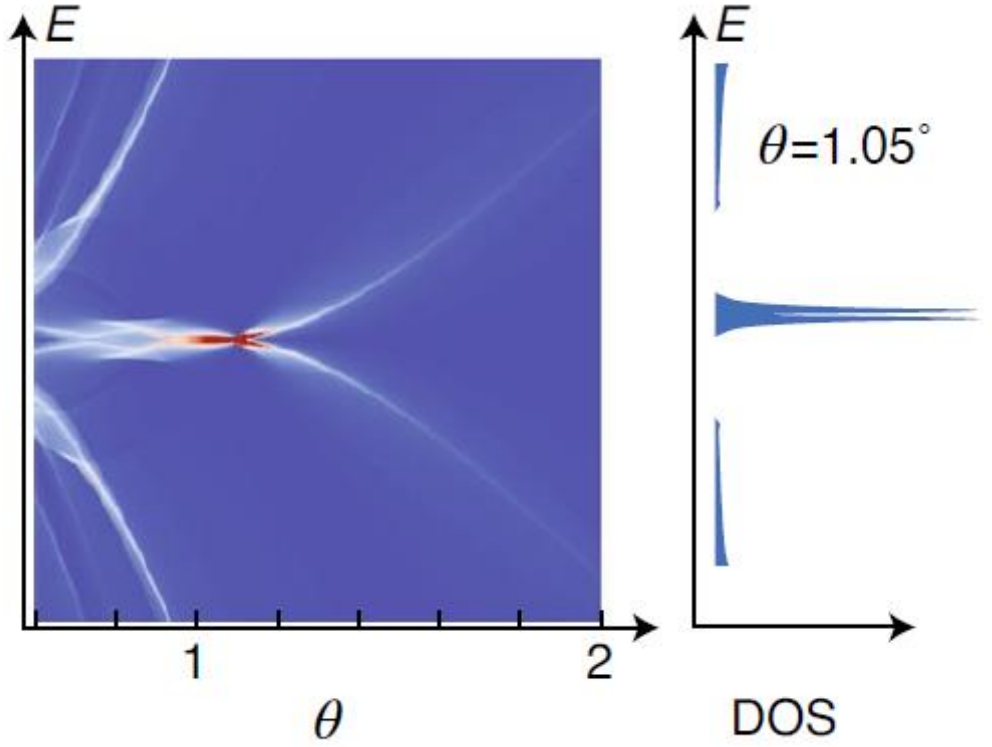


Herrero group, MIT
https://www.nature.com/articles/nature26160

VAN DER WAALS SYSTEMS

Superconductivity and strong correlations in moiré flat bands



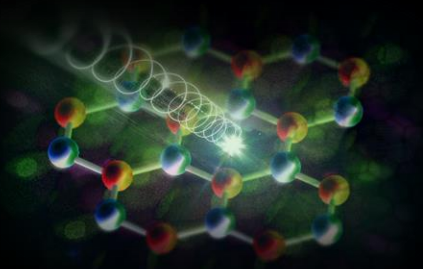


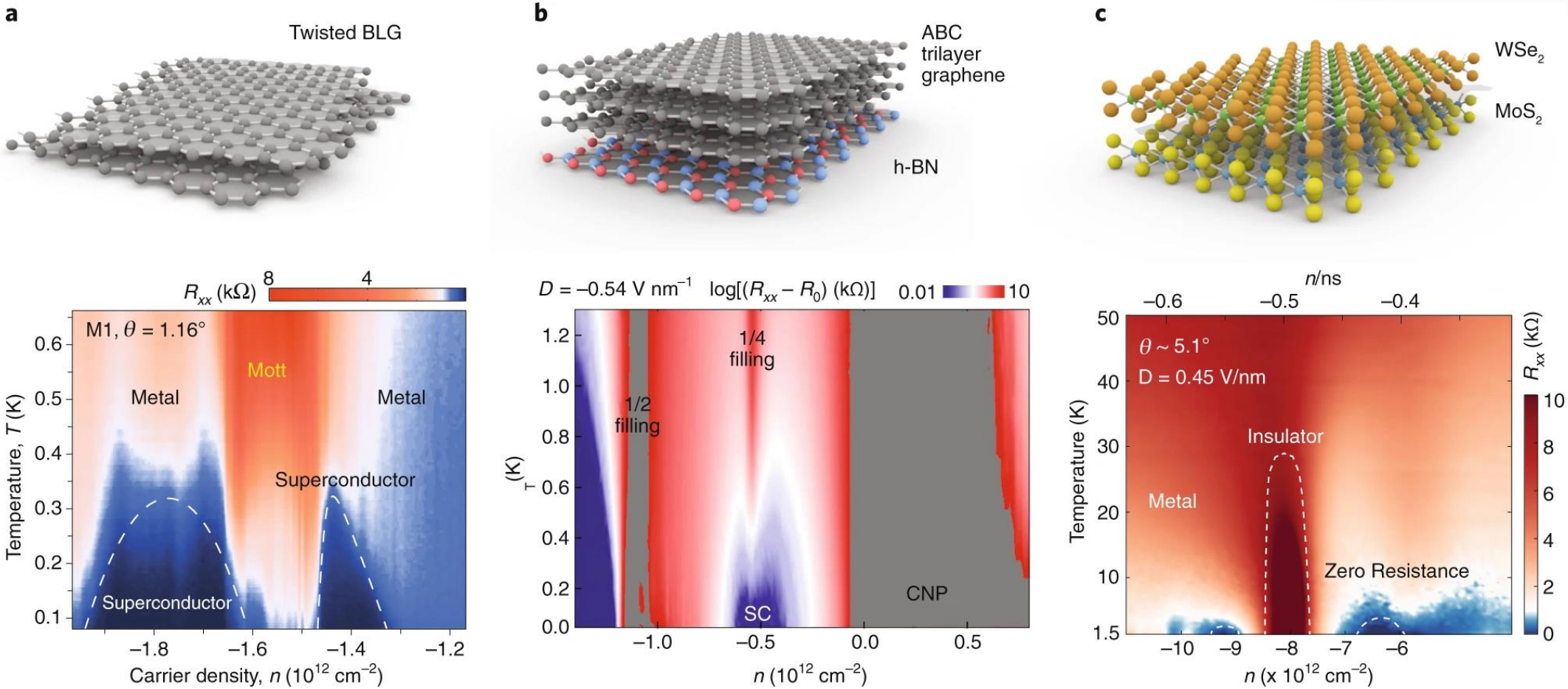
B = 0T

Nature Physics **16**, 725–733(2020)

VAN DER WAALS SYSTEMS

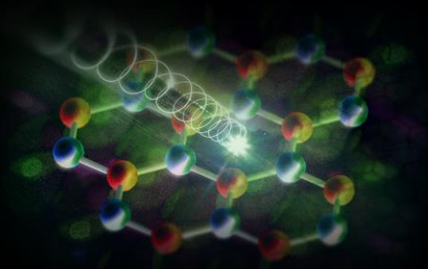
MAGIC ANGLE - TWISTRONICS





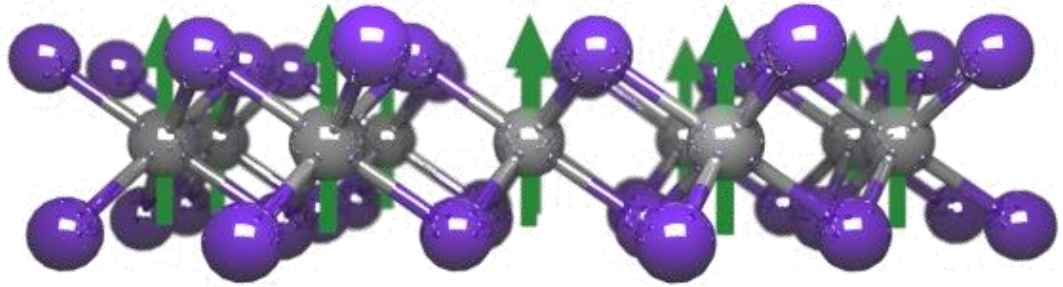
Nature Physics **16**, 725–733(2020)

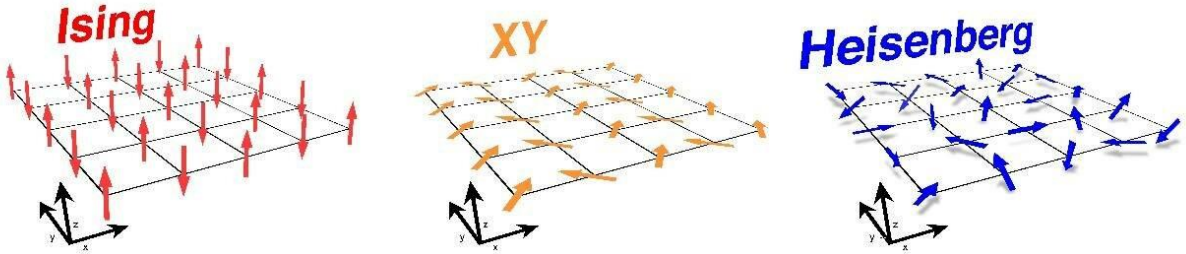
2D MAGNETS



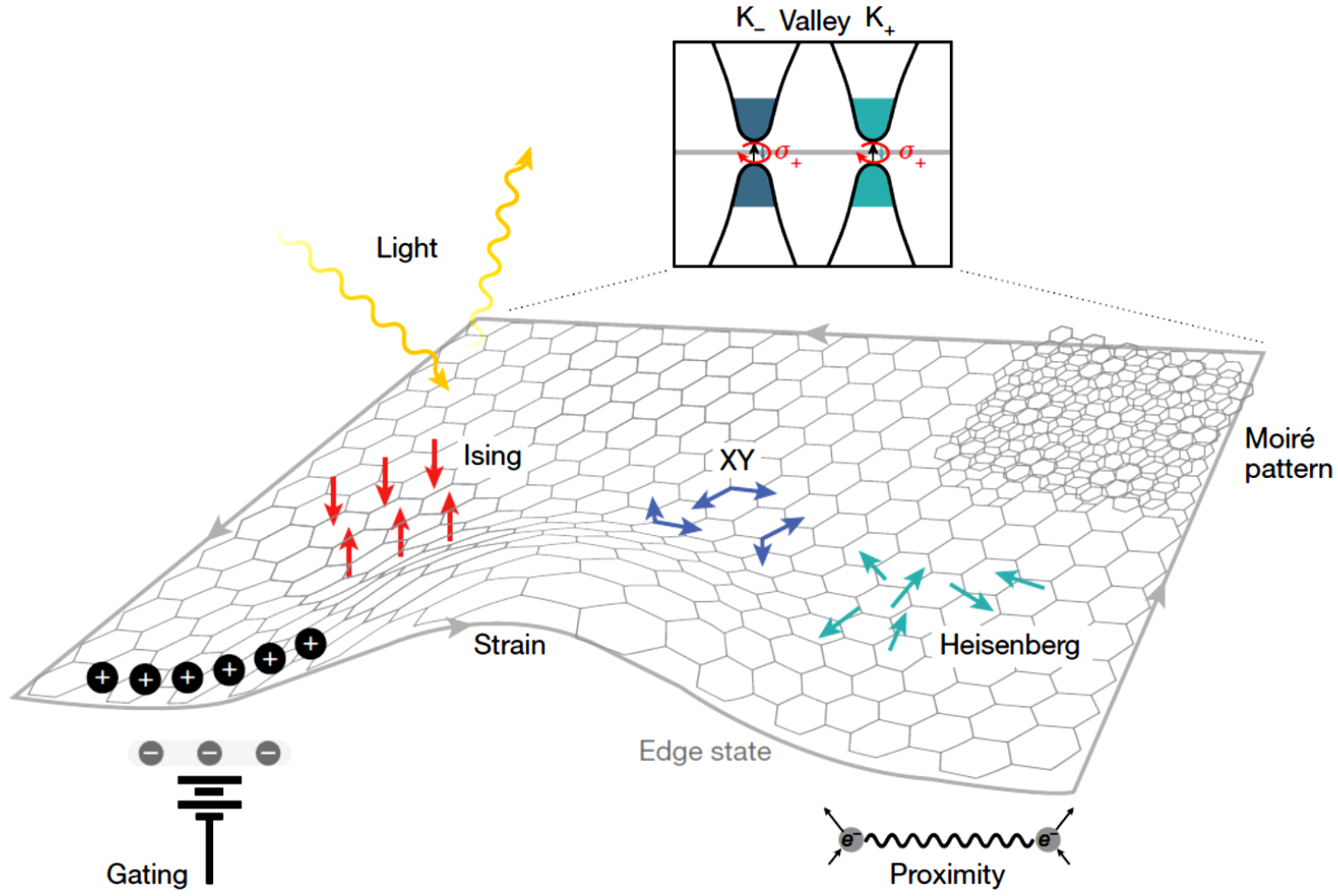
”At any non-zero temperature, a one- or two-dimensional isotropic spin-S Heisenberg model with finite-range exchange interaction can be neither ferro-magnetic nor antiferromagnetic.”

see Mermin & Wagner, Phys. Rev. Lett. 17 (1966) 1133



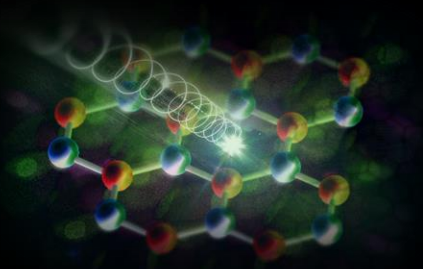


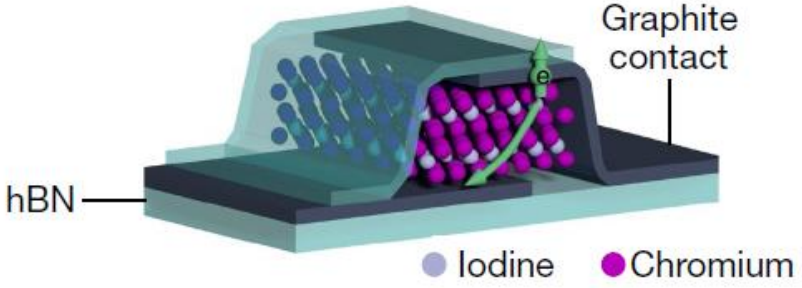
2D MAGNETS

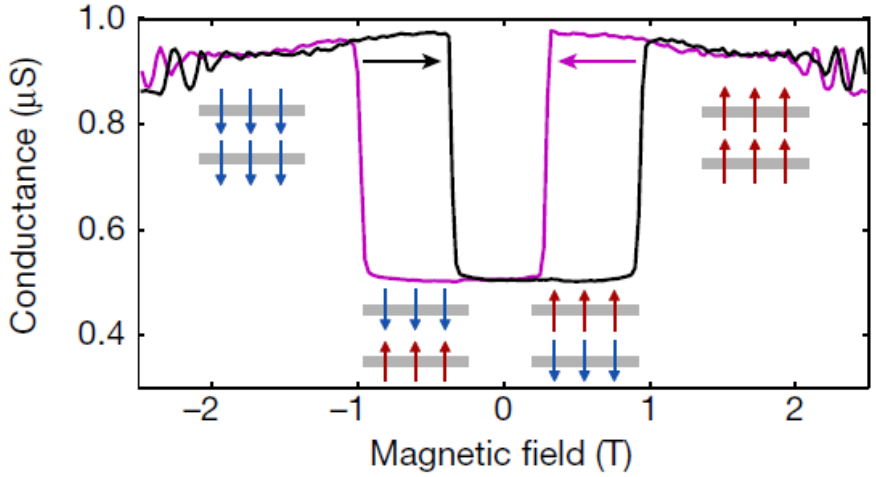


Nature 563 (2018) 47

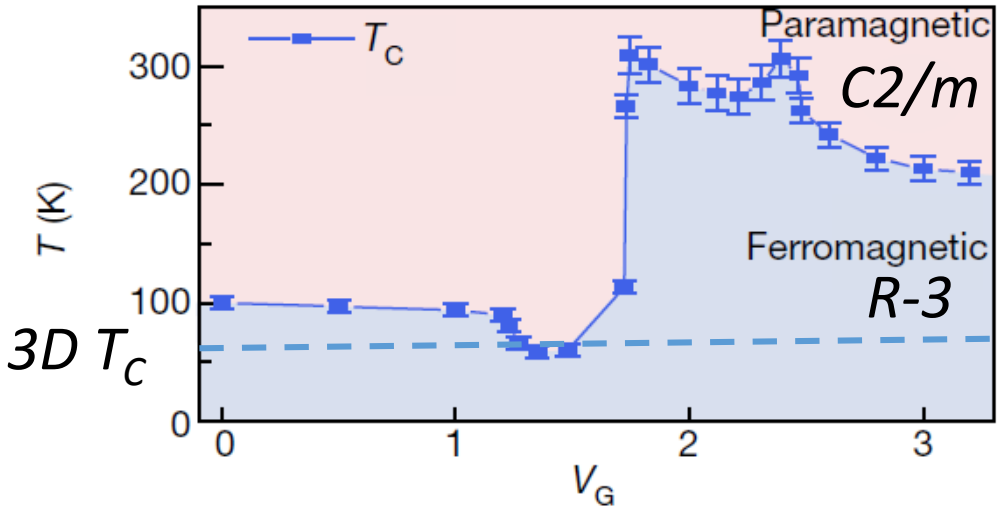
PROBING 2D MAGNETS …







CrI_3



3D T_C

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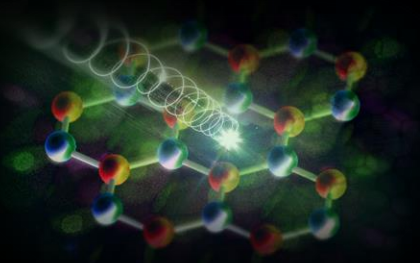
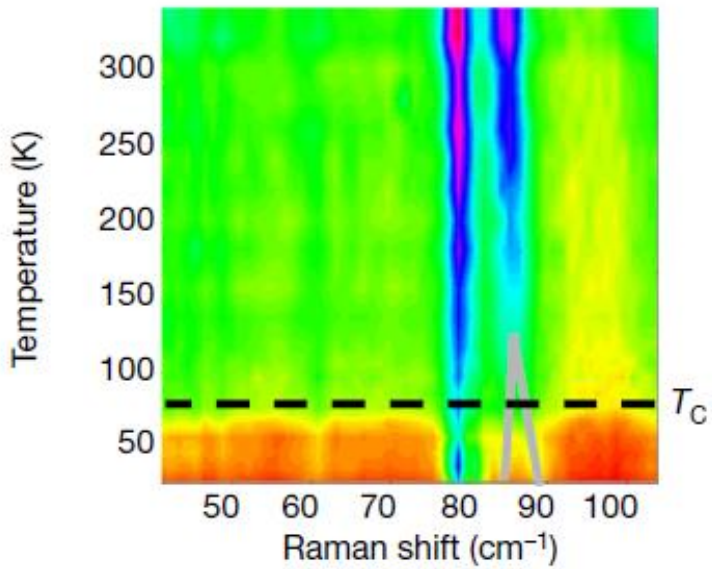
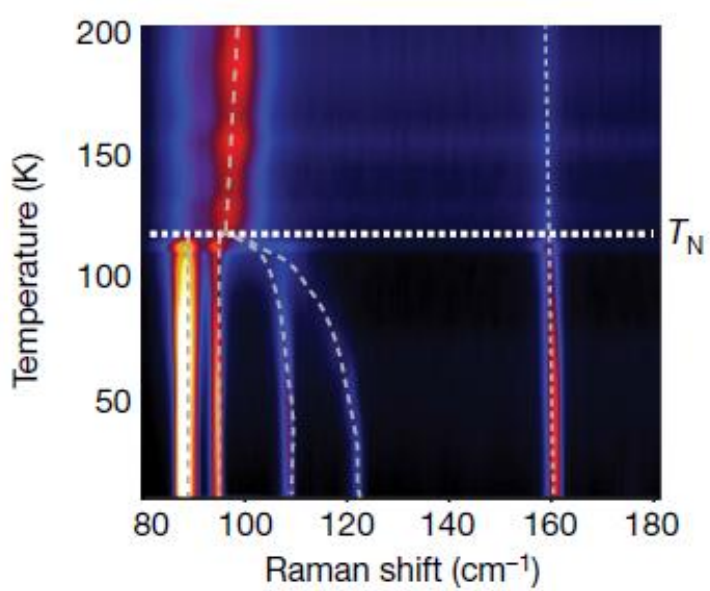
PROBING 2D MAGNETS WITH LIGHT



$Cr_2Ge_2Te_6$



$FePS_3$



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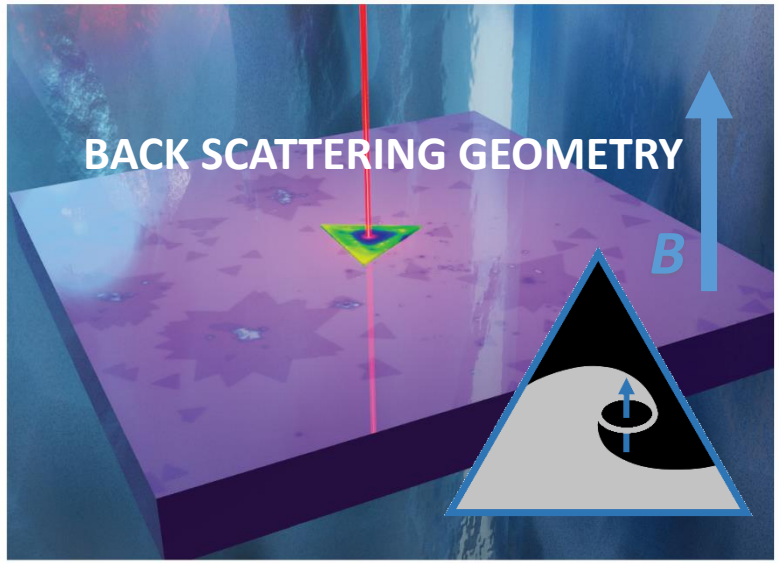
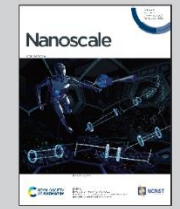


Showcasing research from Charles University & J. Heyrovsky Institute of Physical Chemistry, Prague, Czech Republic.

Towards the evaluation of defects in MoS_2 using cryogenic photoluminescence spectroscopy

We reveal the power of cryogenic photoluminescence (PL) for exploring defects in transition metal dichalcogenides (TMDs) *via* characteristic relaxation mechanisms of the excitons involved. We demonstrate that the transfer process has enormous impact on amount, localization and type of defects within a single flake giving rise to significant variation of electronic and optical properties of the TMD monolayers. Our study thus provides a new insight into the defect-driven phenomena in TMDs, with prospect for research of TMD-based heterostructures and superlattices.

As featured in:



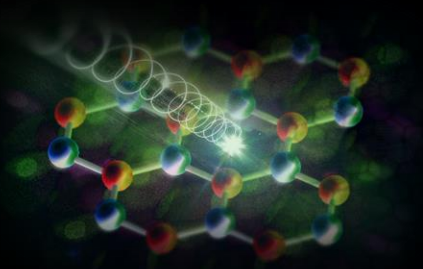
See Martin Kalbac, Jana Vejpravova *et al.*, *Nanoscale*, 2020, **12**, 3019.

ROYAL SOCIETY OF CHEMISTRY

rsc.li/nanoscale

Registered charity number: 207890

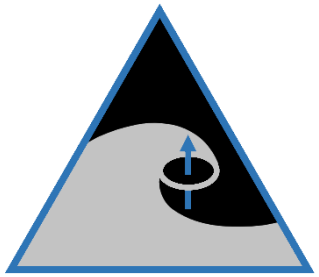
PROBING 2D MAGNETS WITH LIGHT
Helicity resolved Raman scattering



Helicity-resolved Raman scattering

- sensitive to the electronic spin configuration in magnetic materials
- evidence of the time-reversal symmetry breaking
- FM phase transition and hysteresis behavior can be clearly resolved
- quasi-elastic scattering in paramagnetic state
- spin wave gap
- **an effective tool to probe the magnetic structures in 2D magnets**

Nano Lett. 2020, 20, 6024−6031 (VI_3)
Varade et al, submitted ($Cr_2Ge_2Te_6$)



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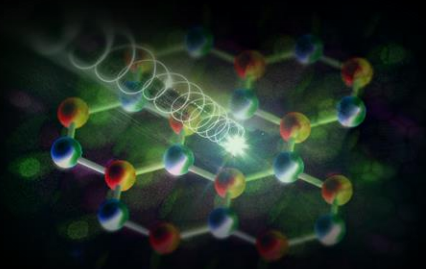
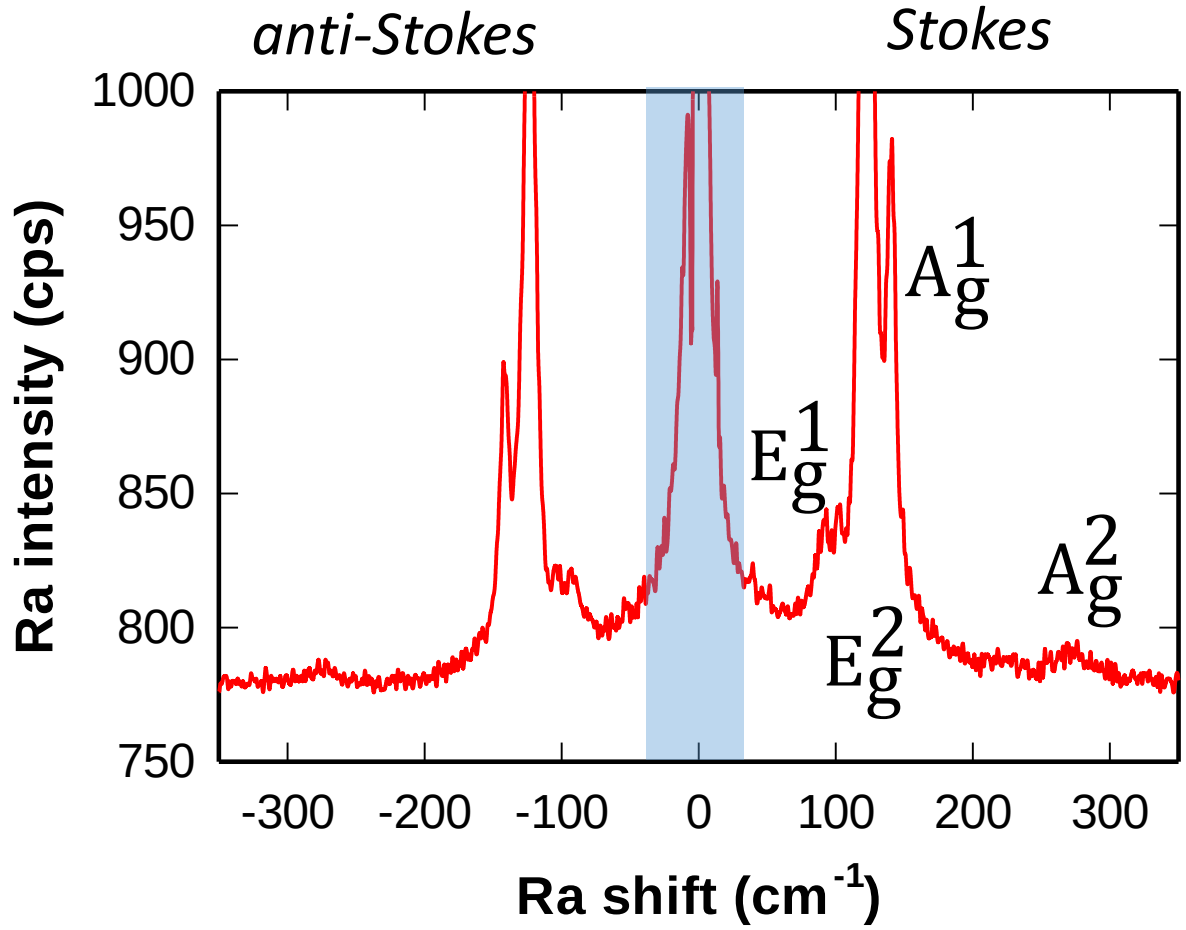
PROBING 2D MAGNETS WITH LIGHT

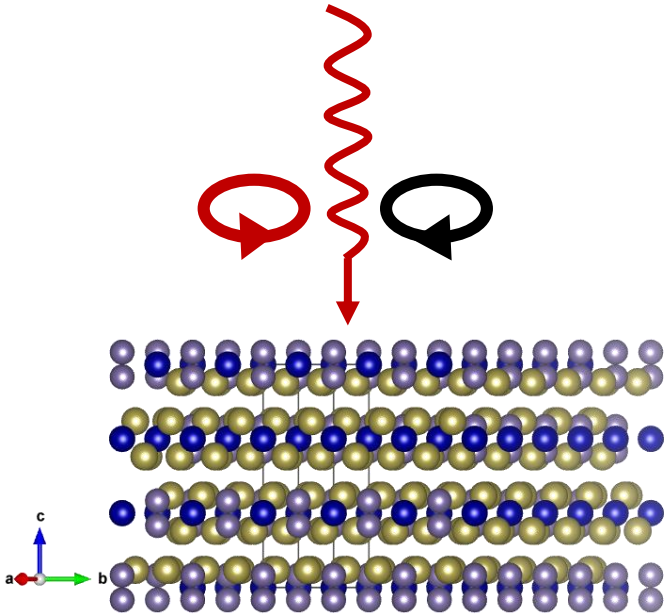


$Cr_2Ge_2Te_6$
T_c = 60 K

no dichroism

T = 300 K
E = 1.96 eV





Varade et al, submitted

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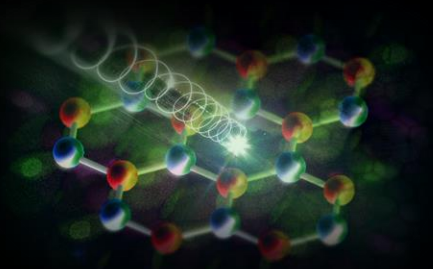
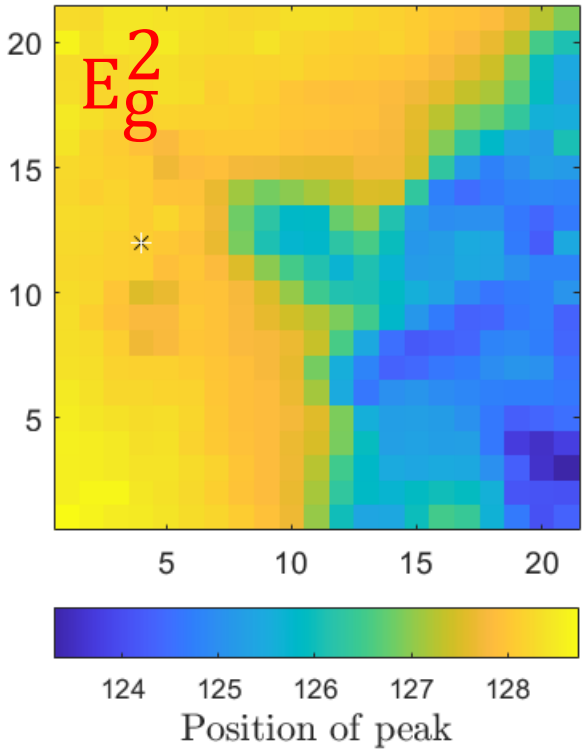
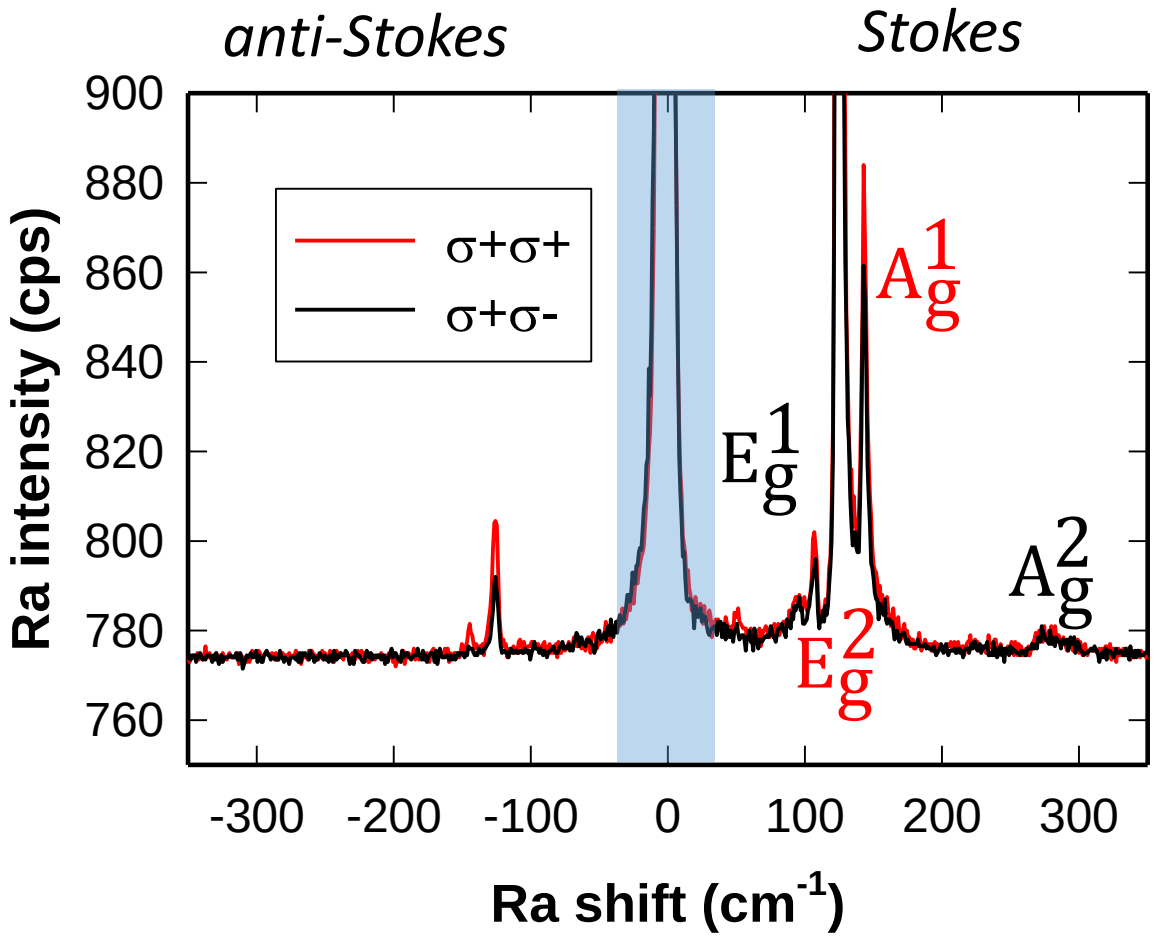


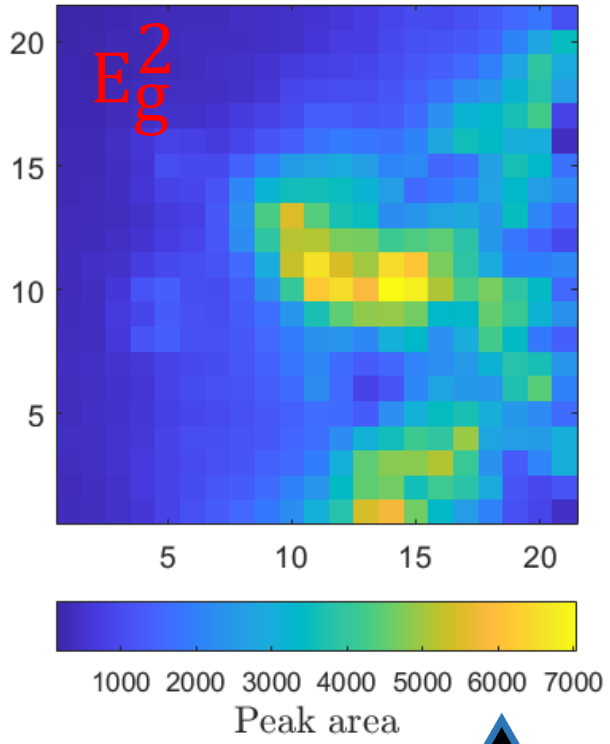


T = 10 K

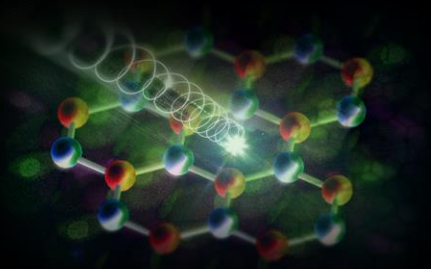
E = 1.96 eV

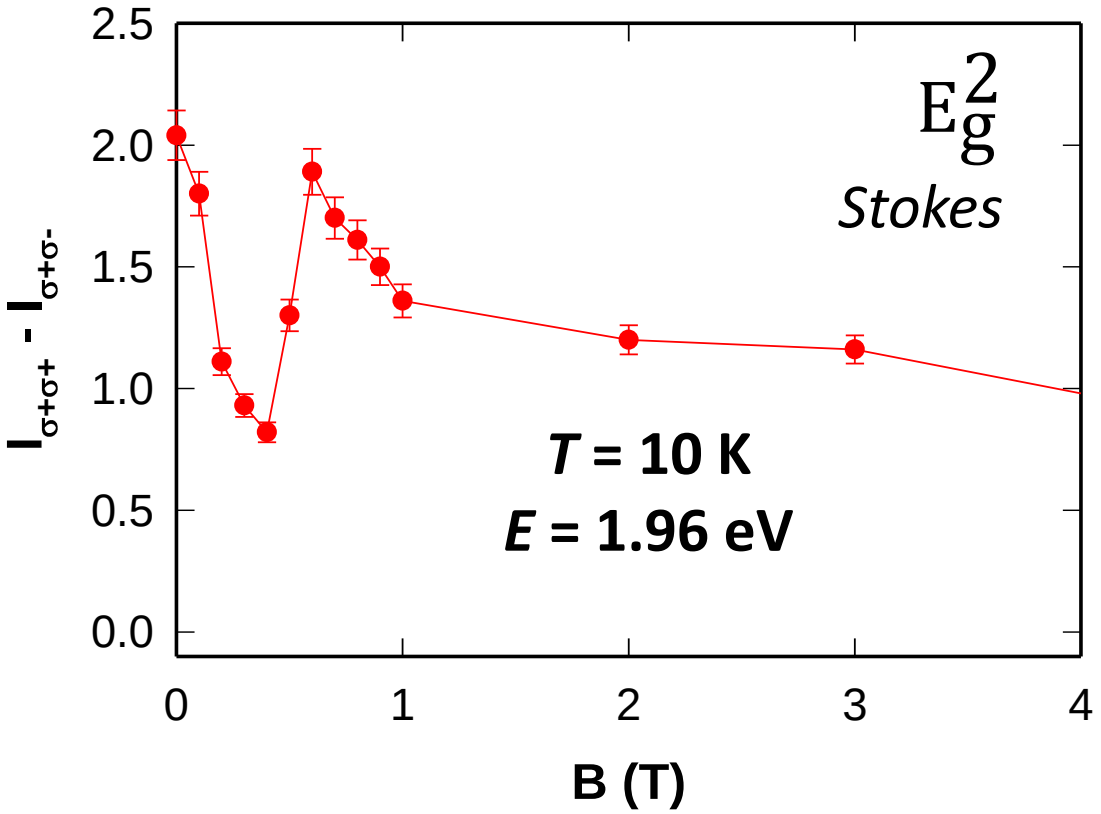


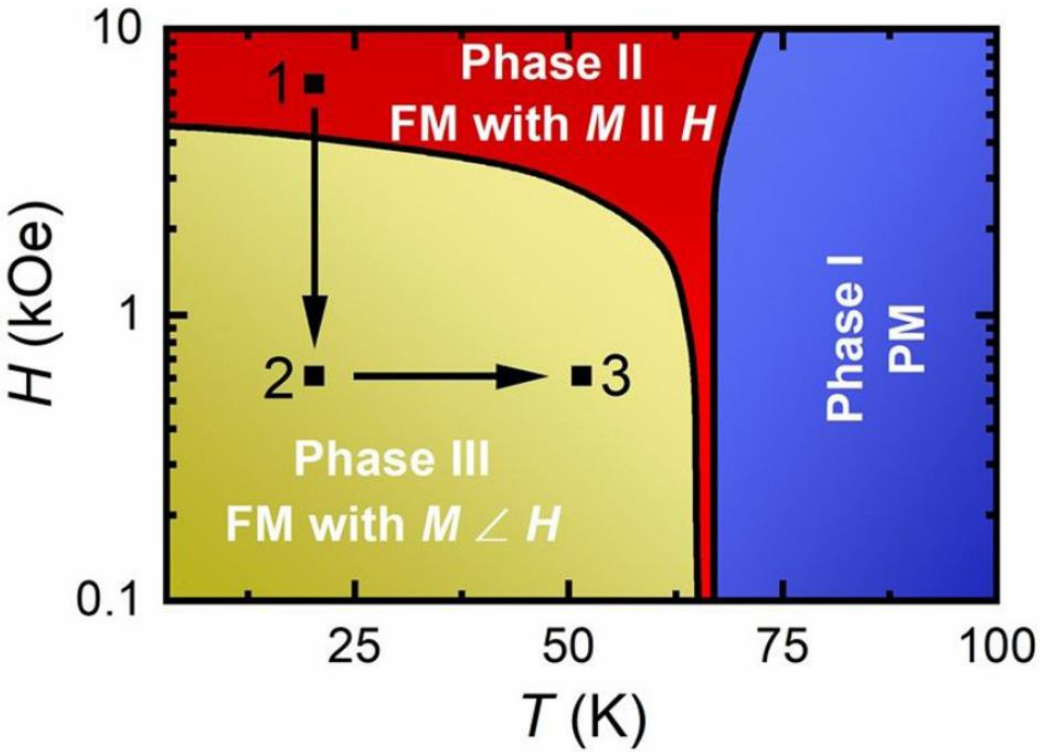
Varade et al, submitted



PROBING 2D MAGNETS WITH LIGHT







PRB 101, 014440 (2020)

Varade et al, submitted

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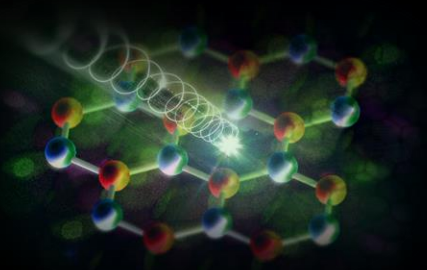
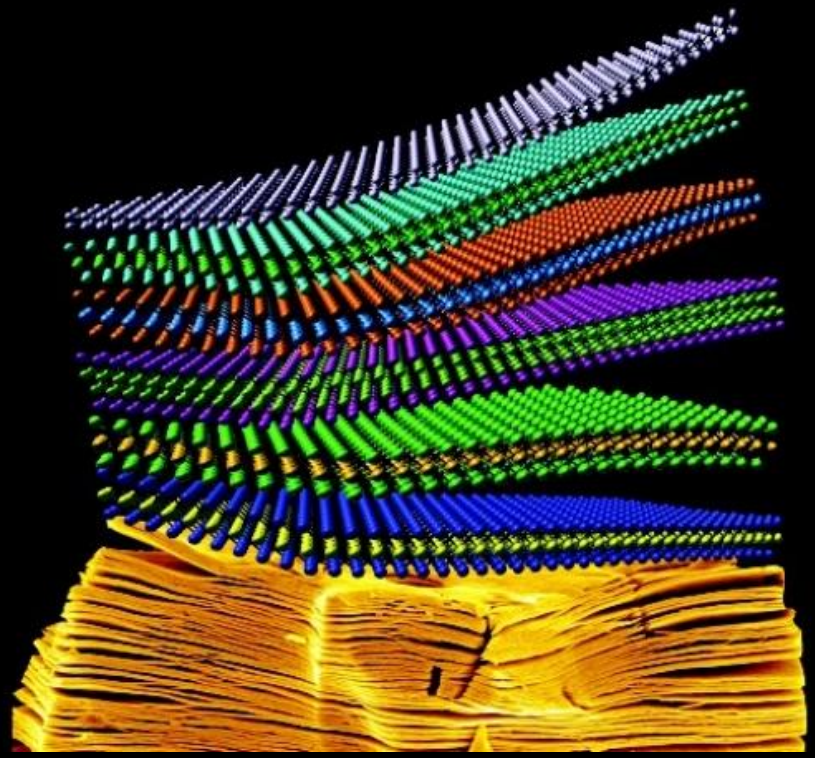
QUO VADIS, 2Ds?



vdW MAGNETS

- NEW MATERIALS
- DEVICES
- EXOTIC STATES
- FUNDAMENTALS



- BOOSTING VALLEY POLARIZATION
- SPIN-LATTICE COUPLING

HIGH QUALITY SAMPLES

CHIRAL OPTICAL PROBES

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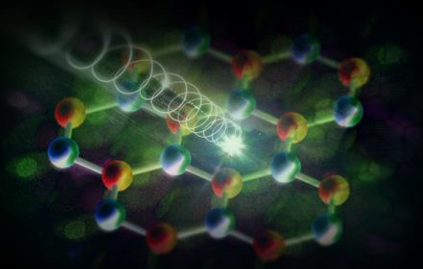
ACKNOWLEDGEMENTS



NANOCARBON GROUP

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V. Valeš
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J. Plšek

J. Heyrovský Institute of Physical Chemistry

V. Varade
S Khanal
M. Žáček

erc

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MŠMT

NSF

MGML
Materials Growth & Measurement Laboratory

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MIT

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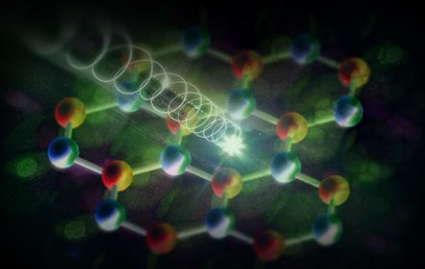
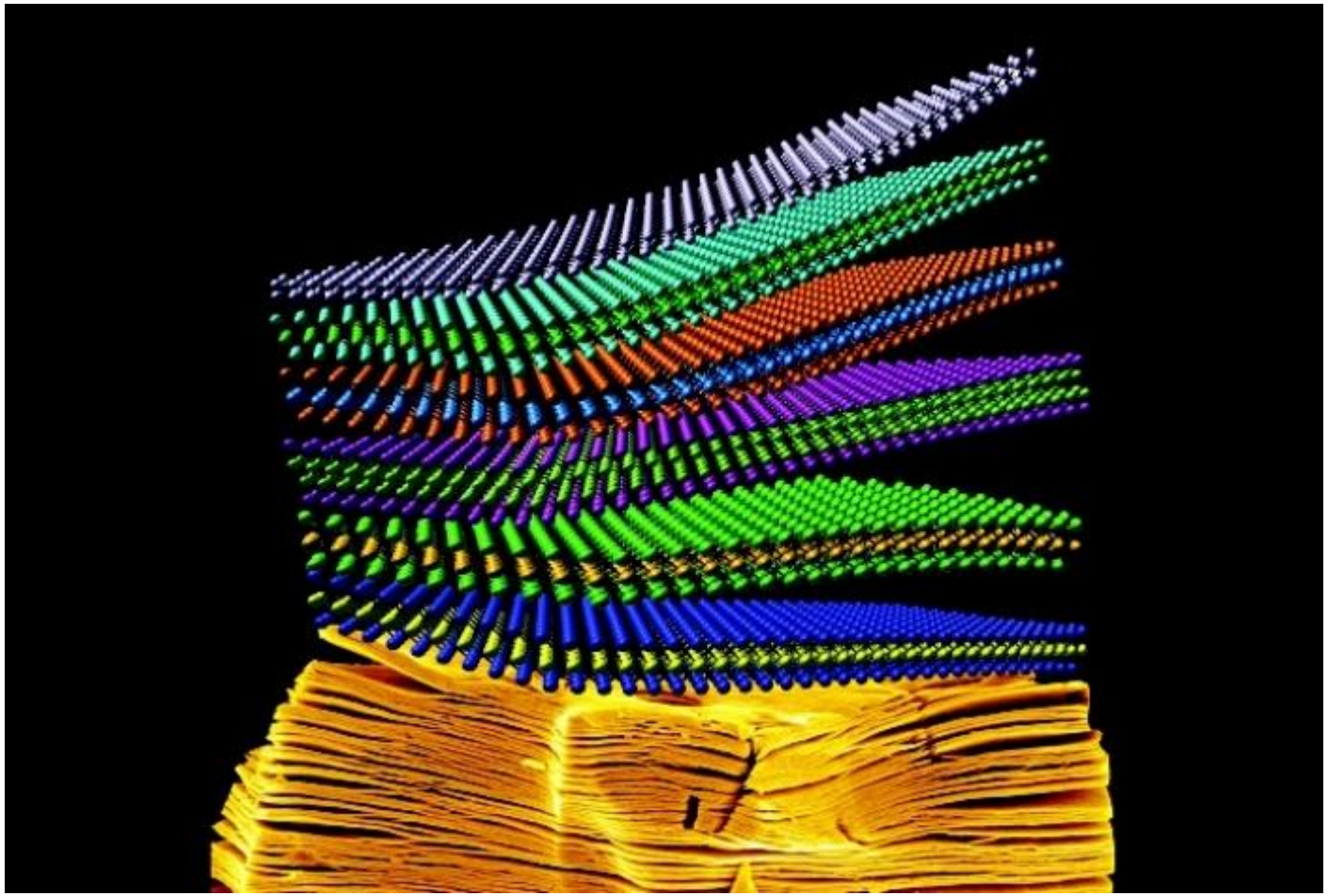
QUO VADIS, 2Ds?





Science moves forward not when we understand something, it's when something totally unexpected happens in experiment...

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of Czech and Slovak
Physicists

HIGHLIGHTS IN PHYSICS OF 2D CRYSTALS THROUGH CRYOMAGNETIC OPTICS

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QUO VADIS, 2Ds?