Polarized phases and chiral superconductivity in multilayer graphene

20th CAPRI SPRING SCHOOL

On Transport In Nanostructures

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EXCELENCIA SEVERO OCHOA

Outline

- Motivation.
- Isospin polarized phases in R4G.
- The KL-RPA framework.
- Chiral SC in quarter-metal R4G.
- Conclusions.

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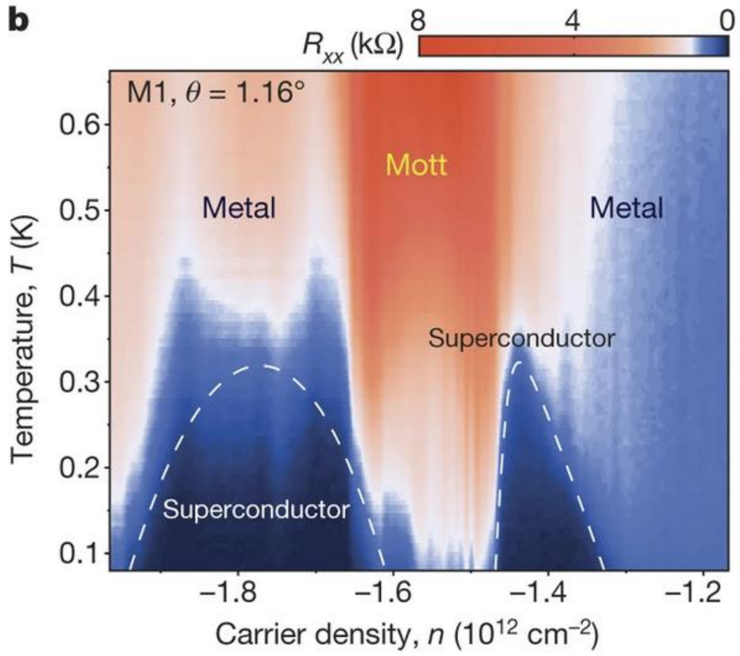
Motivation

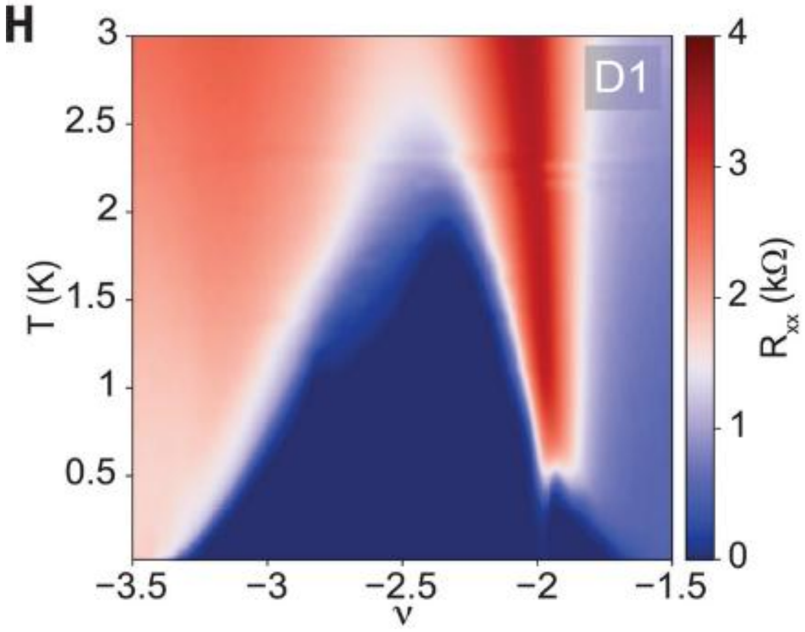
Unconventional SC in TBG



Y. Cao, V. Fatemi, S. Fang, et al., Nature 556, 43 (2018)

- No electric field is required
- $T_c \approx 0.5 - 2$ K
- No clear Pauli limit violation

Promotion of SC in twisted multilayers

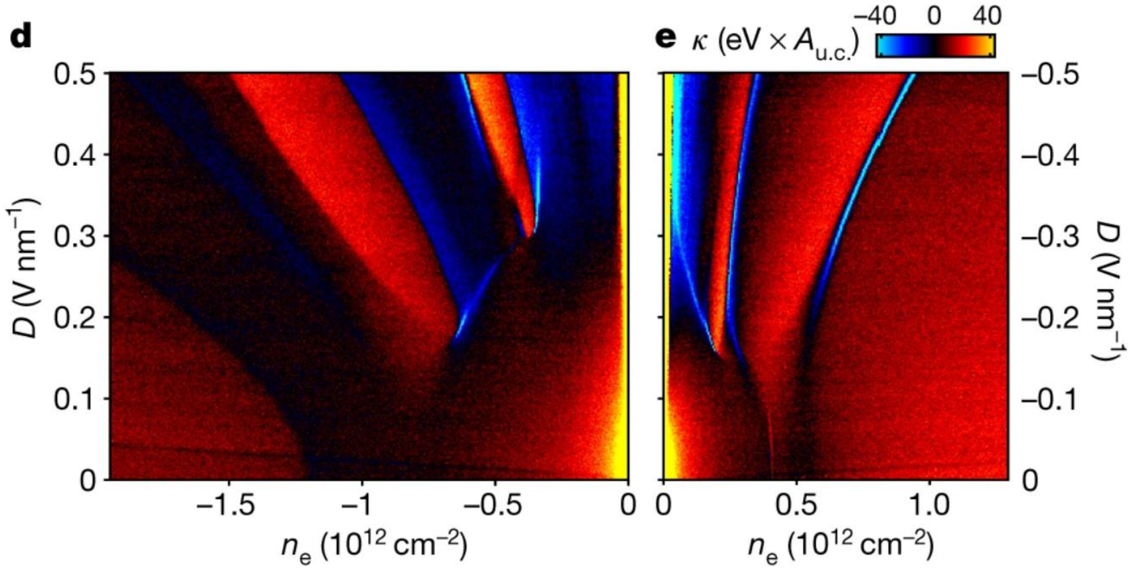


Y. Zhang, R. Polski,, et. al. Science 377, 6614 (2022)

- No electric field is required
- $T_c \approx 1 - 2.5$ K
- Large Pauli limit violation

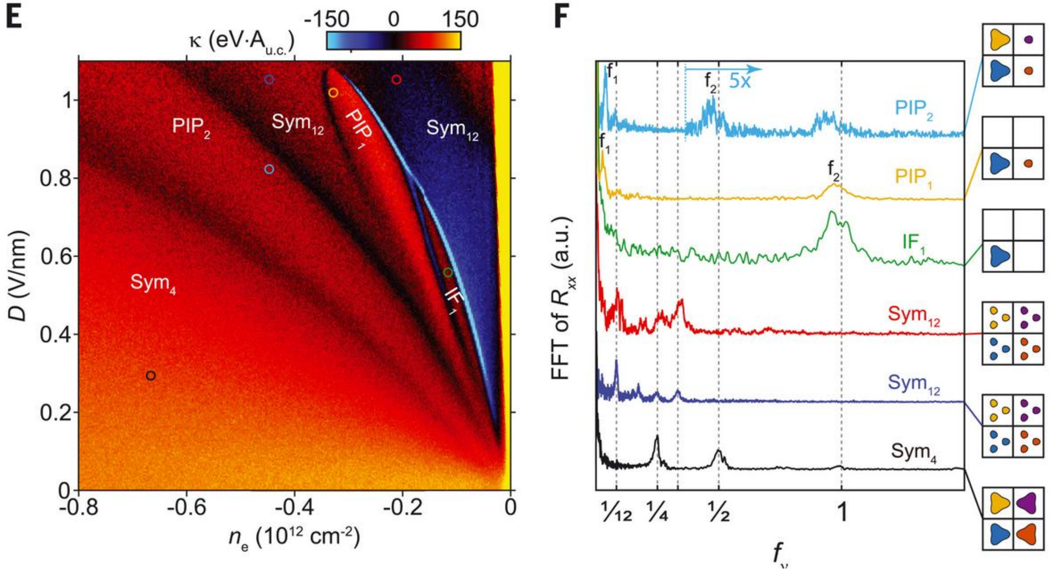
Motivation

Polarized phases in RTG



H. Zhou, T. Xie, et. al. Nature 598, 429–433 (2021)

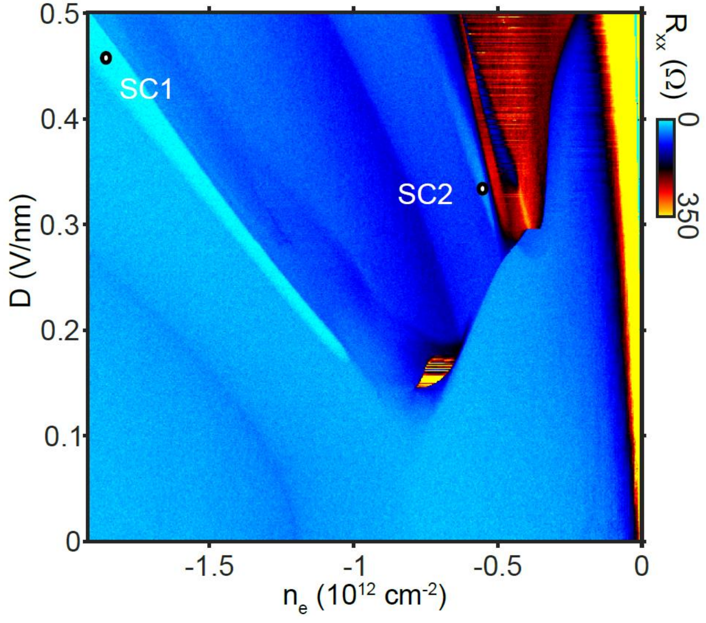
Polarized phases in BBG



H. Zhou, L. Holleis, et. al. Science 375, 6582 (2022)

Motivation

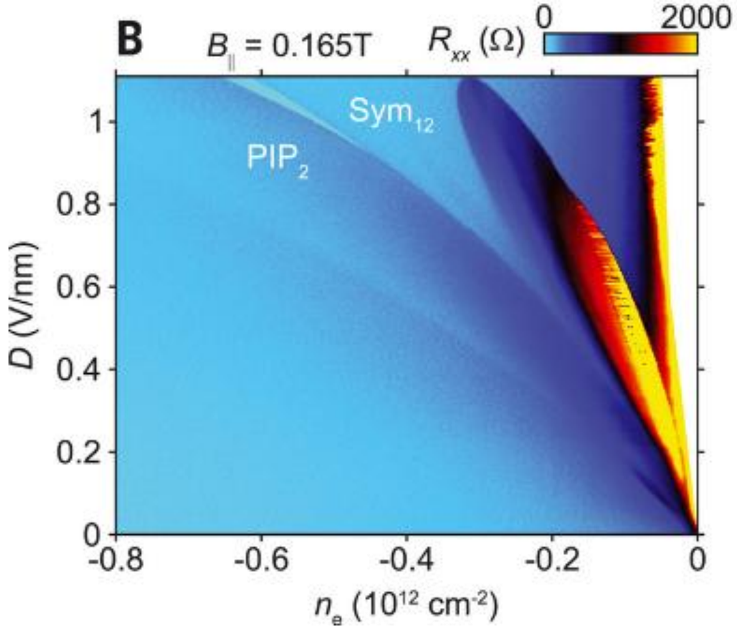
Superconductivity in RTG



H Zhou, T Xie, et. al. Nature 598, 434–438 (2021)

- Need applied electric field
- $T_c \approx$ 106 mK for hole doping near the vHs.
- Robust SC up to $B_{\parallel} \approx$ 0.3 T.

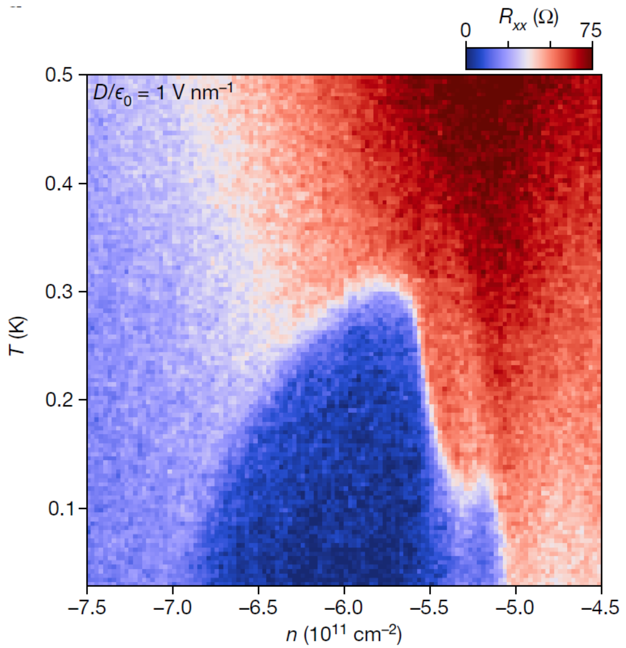
Superconductivity in BBG



H Zhou, L. Holleis, et. al. Science 375, 6582 (2022)

- Need applied electric field.
- Requires $B_{\parallel} \approx$ 150 mT
- $T_c \approx$ 26 mK for hole doping near the vHs.
- Robust SC up to $B_{\parallel} \approx$ 0.8 T.

SOC enhanced SC in BBG+WSe_2

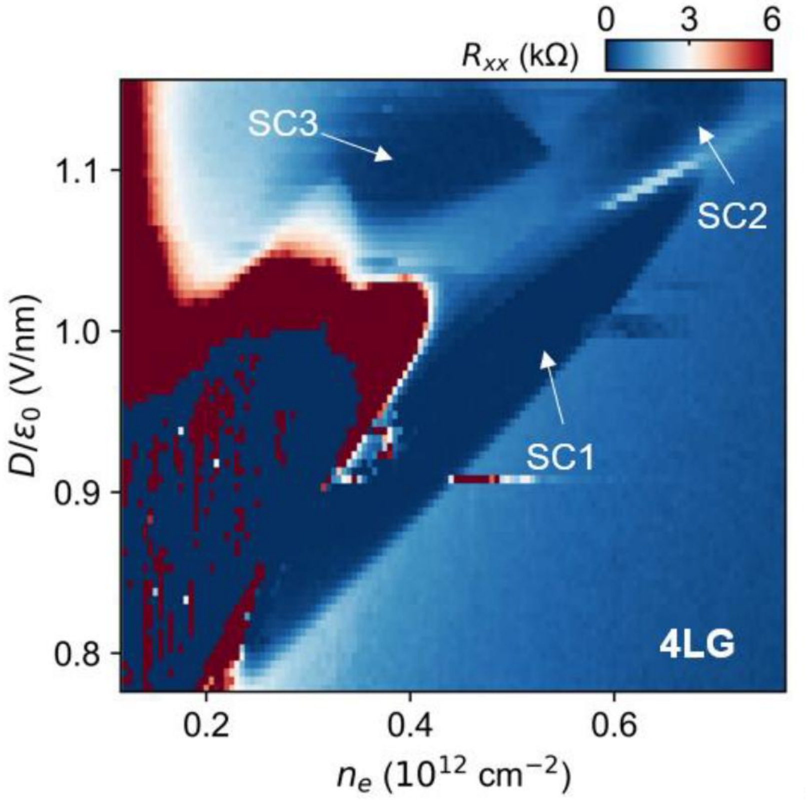


Y. Zhang, R. Polski, et. al. Nature 613, 268–273 (2023)

- Need applied electric field.
- ~~Requires $B_{\parallel} \approx$ 150 mT~~
- $T_c \approx$ 260 mK for hole doping near the vHs.
- Robust SC up to $B_{\parallel} \approx$ 1 T.

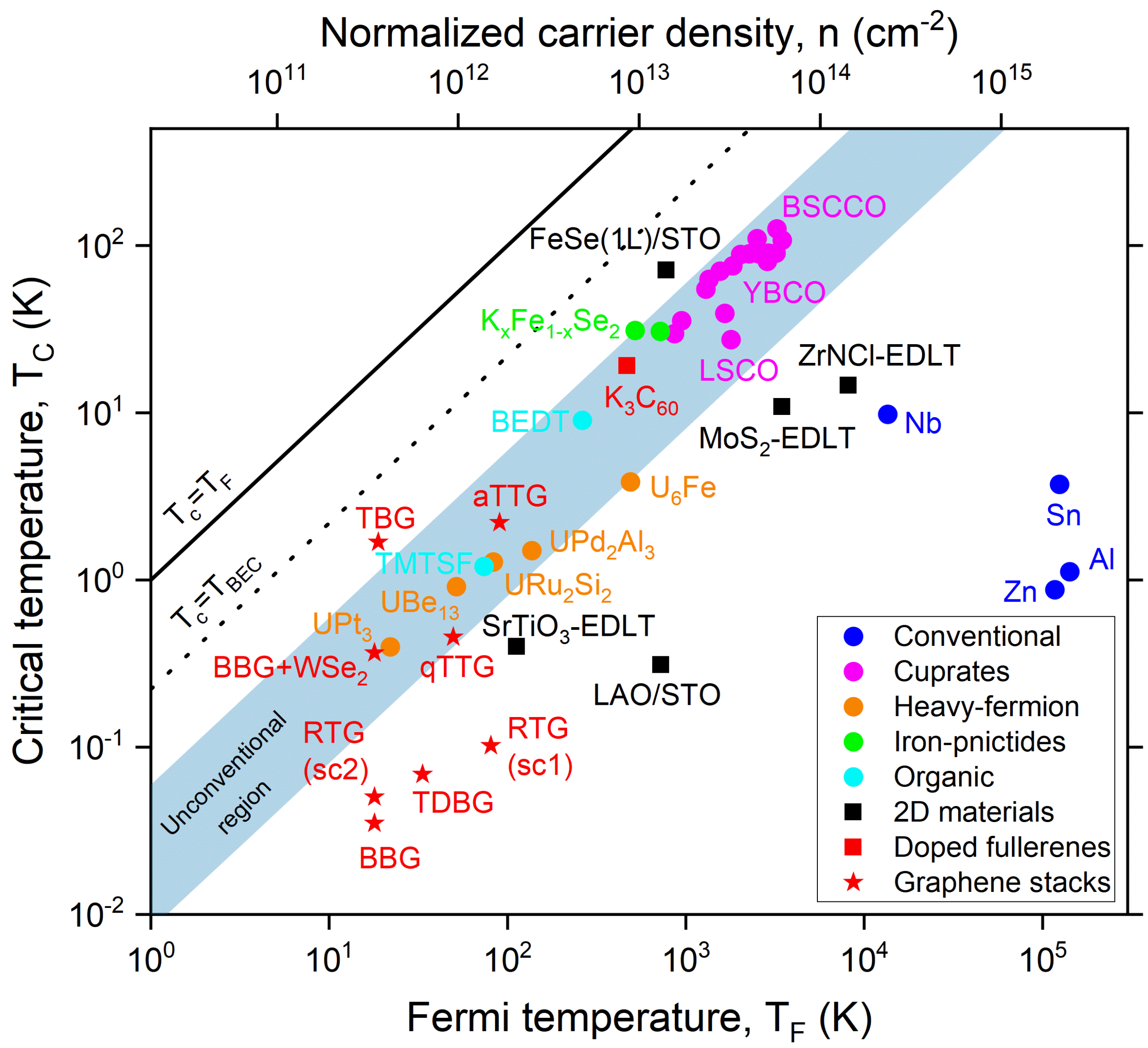
Motivation

Quarter-metal (chiral) SC in rhombohedral tetralayer graphene



T. Han, Z. Lu, Z. Hadjri, *et al*. Signatures of chiral superconductivity in rhombohedral graphene. *Nature* **643**, 654–661 (2025)

Motivation



P. A. Pantaleón, A. Jimeno-Pozo, H. Sainz-Cruz, V. T. Phong, T. Cea, and F. Guinea. *Superconductivity and correlated phases in non-twisted bilayer and trilayer graphene*. **Nature Reviews Physics 5 (5), 304-315 (2023)**

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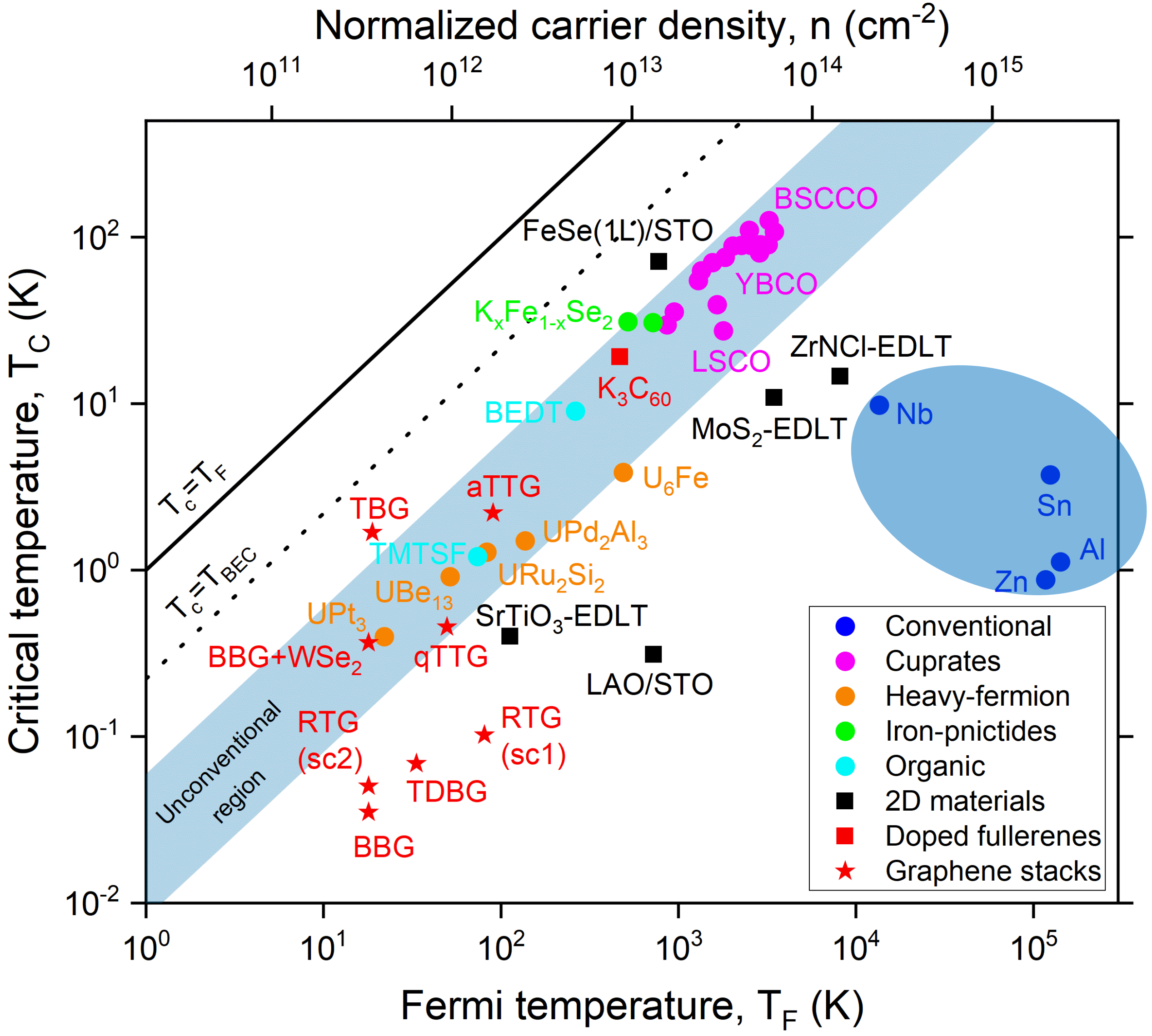

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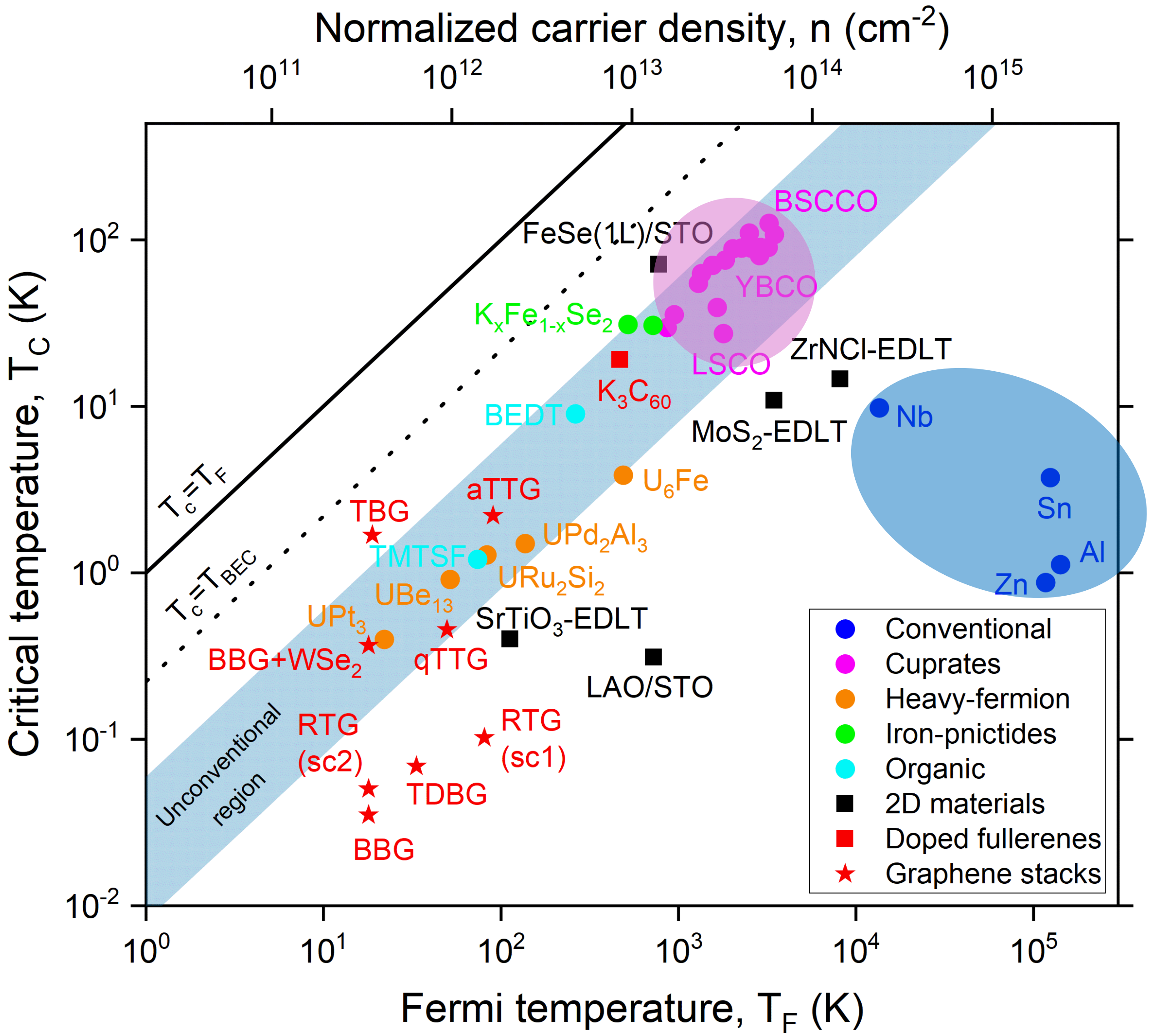

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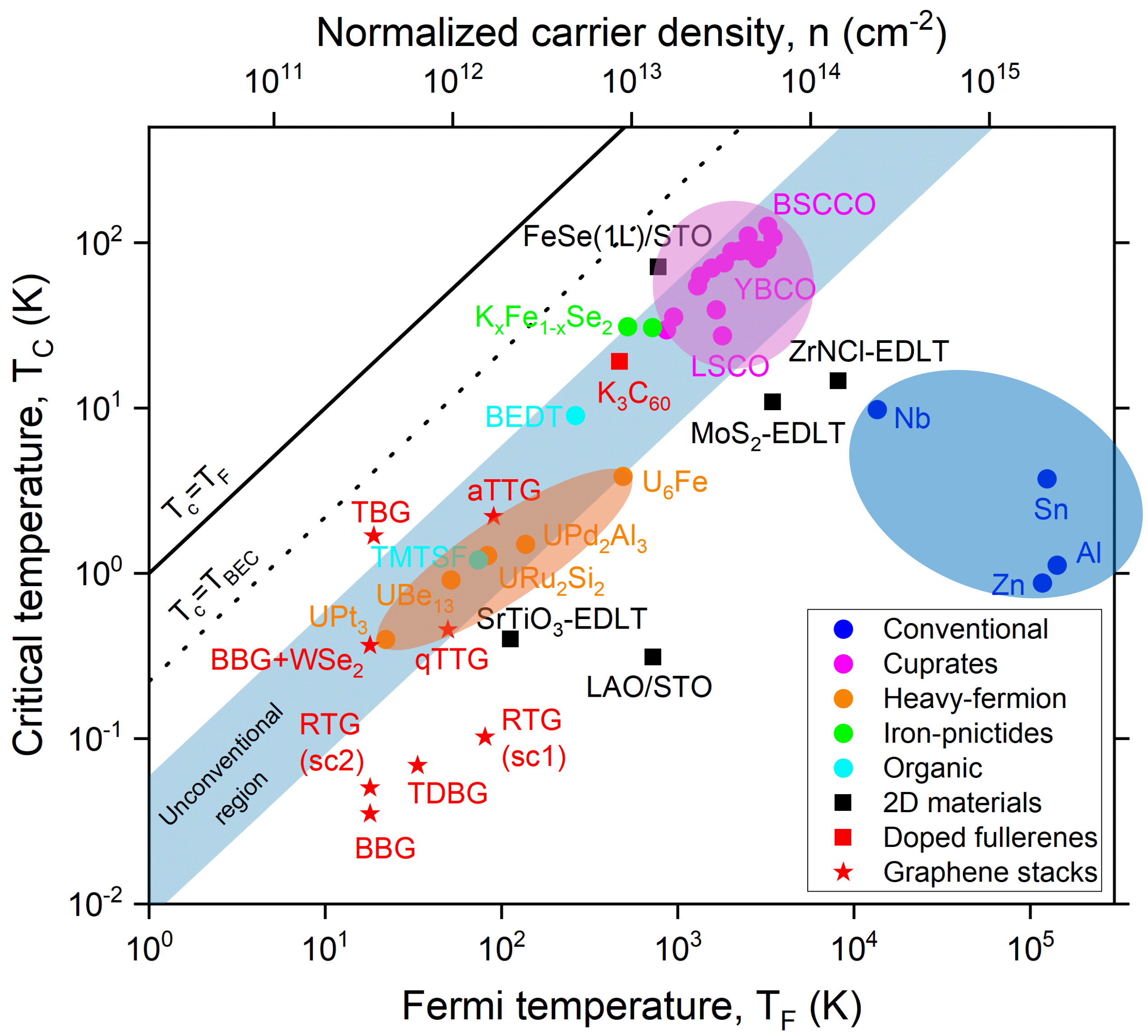

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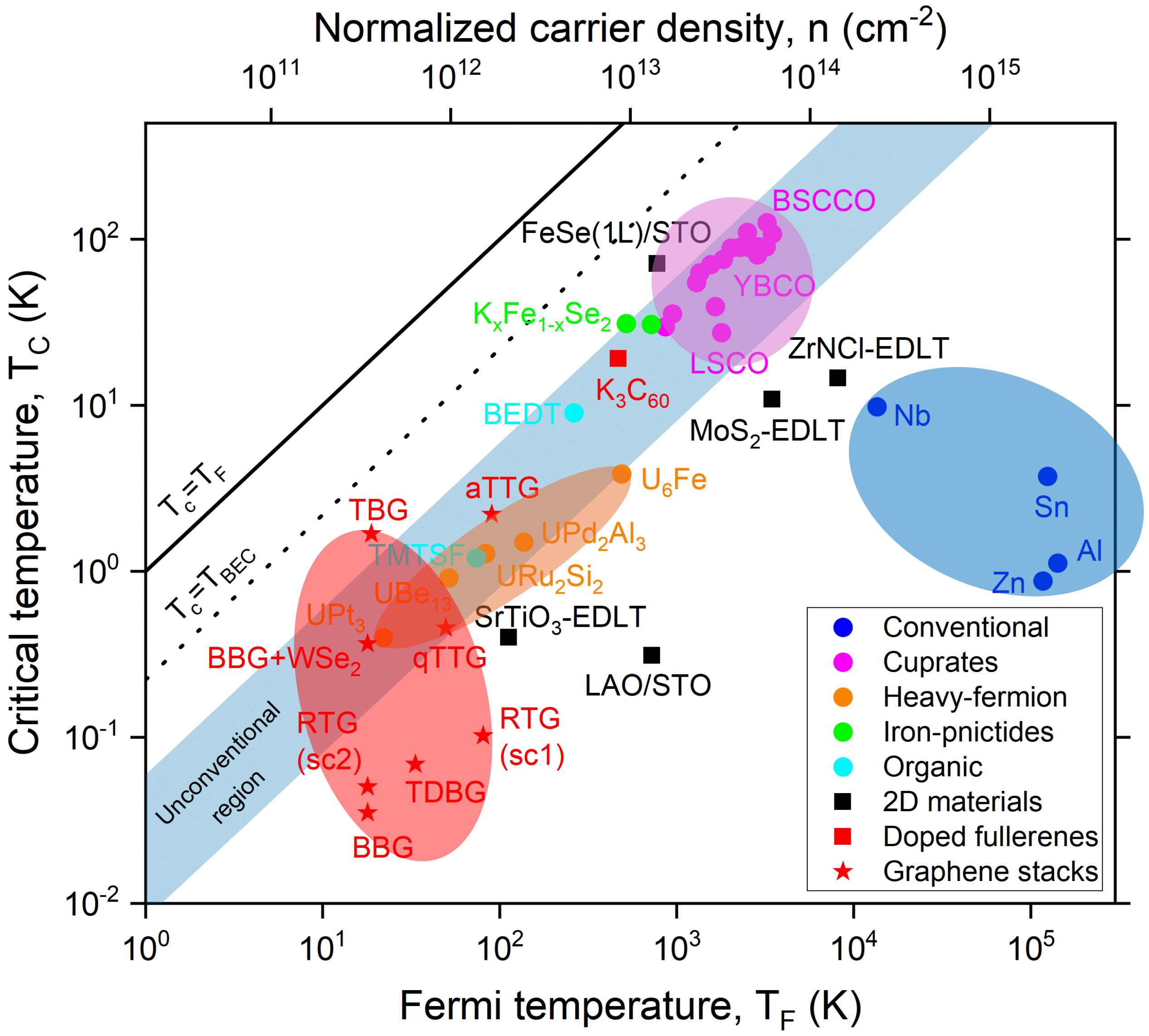

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Motivation

It is clear that polarized phases are driven by electronic interactions…

Could electronic interactions be the reason behind this kind of unconventional superconductivity in these graphene stacks?

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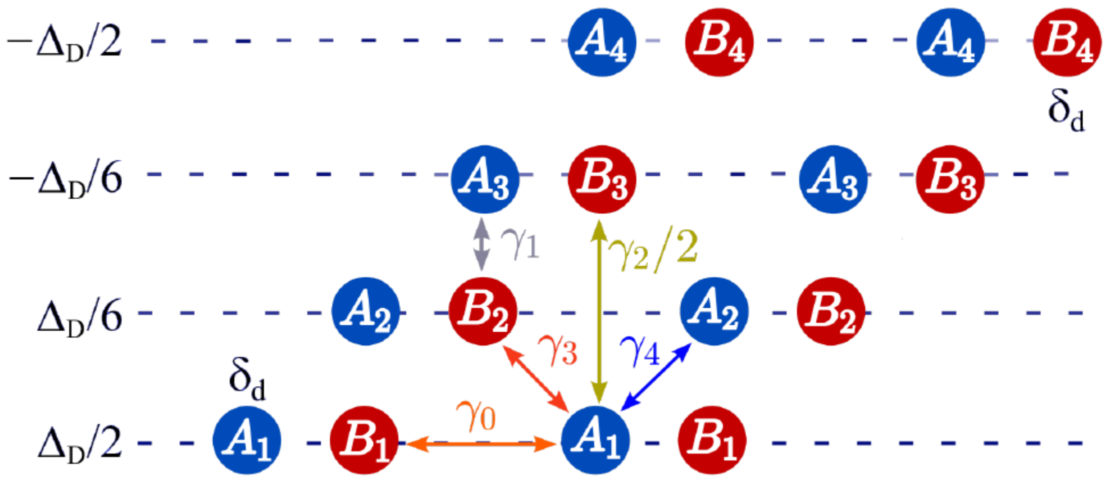
Isospin polarized phases in R4G

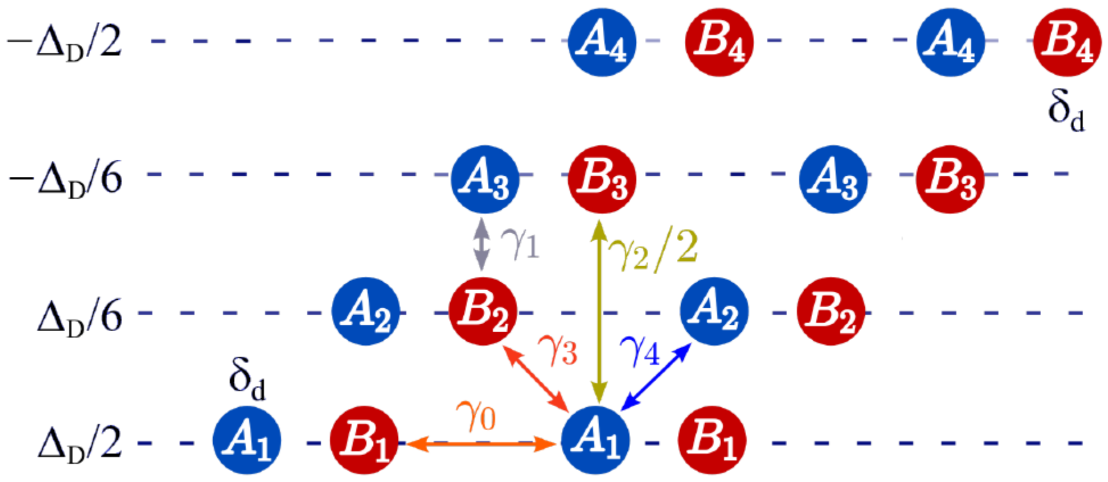
Rhombohedral (ABC)
tetralayer graphene



G. Parra-Martínez, A. Jimeno-Pozo, V. T. Phong, H. Sainz-Cruz, D. Kaplan, P. Emanuel, Y. Oreg, P. A. Pantaleón, J. A. Silva-Guillén, and F. Guinea. *Band Renormalization, Quarter Metals, and Chiral Superconductivity in Rhombohedral Tetralayer Graphene.* **Phys. Rev. Lett. 135, 136503 (2025).**

Isospin polarized phases in R4G

Rhombohedral (ABC) tetralayer graphene



Mean-field approximation

$$\hat{\mathcal{V}}_C \approx \sum_{\mathbf{k},\alpha} \left[\mathcal{V}_0\left(\mathbf{0}\right) \sum_{\mathbf{p},\beta} n_{\beta\beta}(\mathbf{p}) \right] \hat{c}^{\dagger}_{\alpha,\mathbf{k}} \hat{c}_{\alpha,\mathbf{k}}$$

$$- \sum_{\mathbf{k},\alpha,\alpha'} \left[\sum_{\mathbf{p}} \mathcal{V}_0\left(\mathbf{p}-\mathbf{k}\right) n_{\alpha\beta}(\mathbf{p}) \right] \hat{c}^{\dagger}_{\alpha,\mathbf{k}} \hat{c}_{\beta,\mathbf{k}},$$

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Isospin polarized phases in R4G

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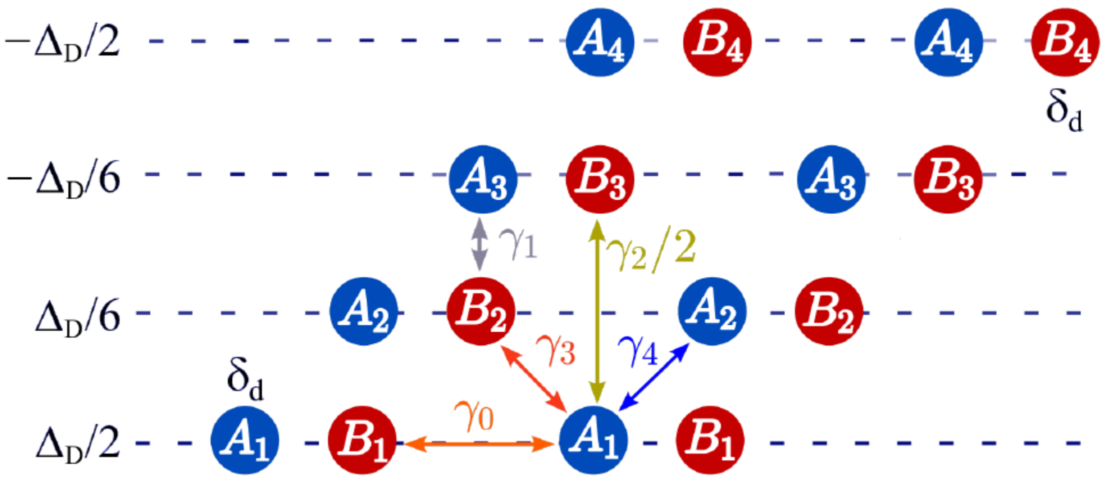

Isospin polarized phases

Isospin polarized states		
Full metal	FM	$(\alpha, \alpha, \alpha, \alpha)$
Half metal	HM	$(\alpha, 0, \alpha, 0)$
Quarter metal	QM	$(\alpha, 0, 0, 0)$

G. Parra-Martínez, A. Jimeno-Pozo, V. T. Phong, H. Sainz-Cruz, D. Kaplan, P. Emanuel, Y. Oreg, P. A. Pantaleón, J. A. Silva-Guillén, and F. Guinea. *Band Renormalization, Quarter Metals, and Chiral Superconductivity in Rhombohedral Tetralayer Graphene.*
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Isospin polarized phases in R4G

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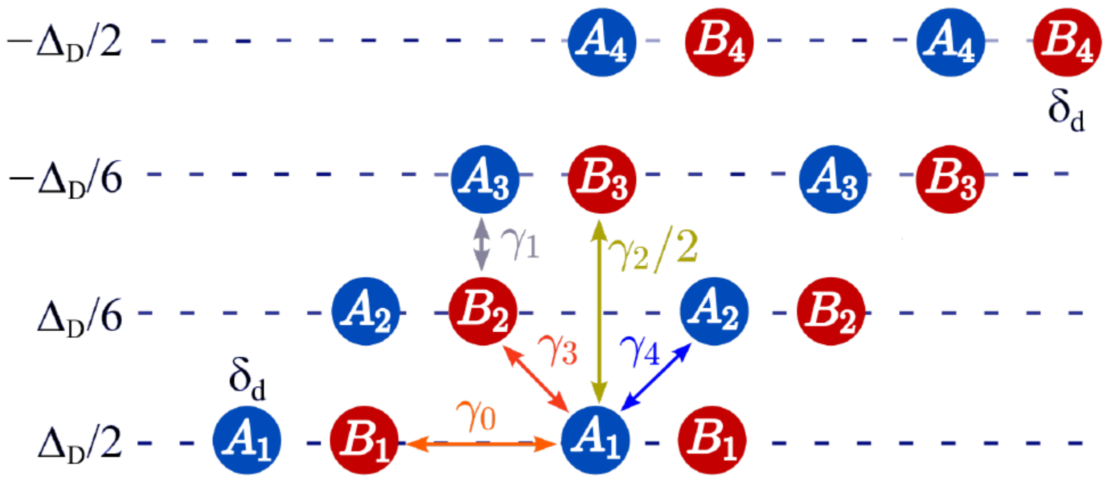
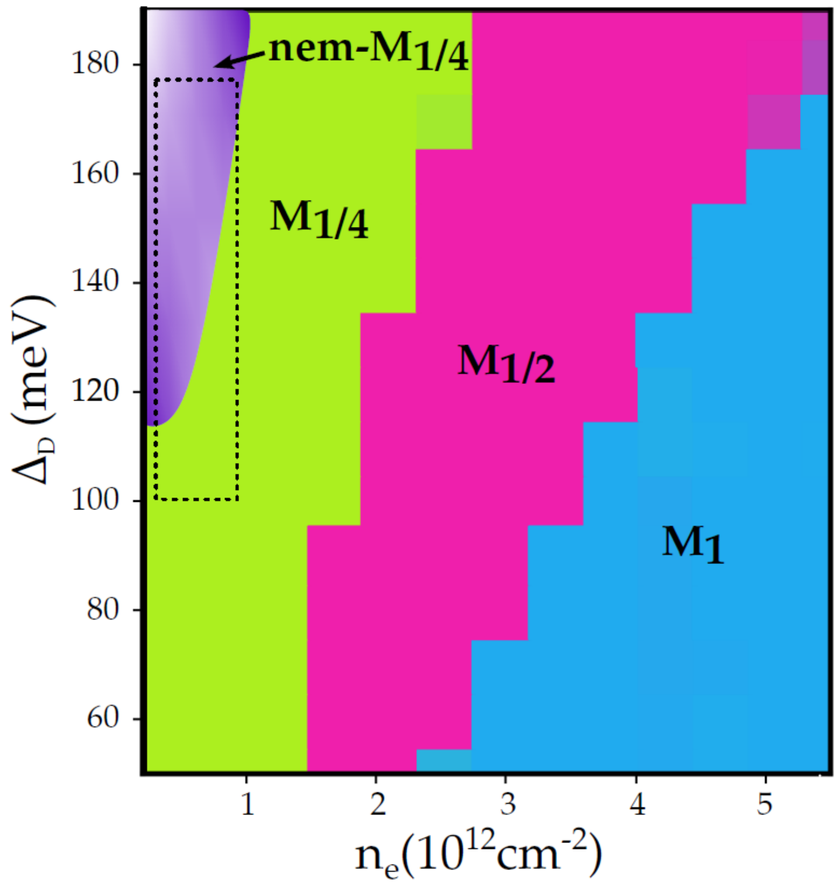


Hartree-Fock phase diagram



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The Kohn-Luttinger-RPA framework

NEW MECHANISM FOR SUPERCONDUCTIVITY*

W. Kohn

University of California, San Diego, La Jolla, California

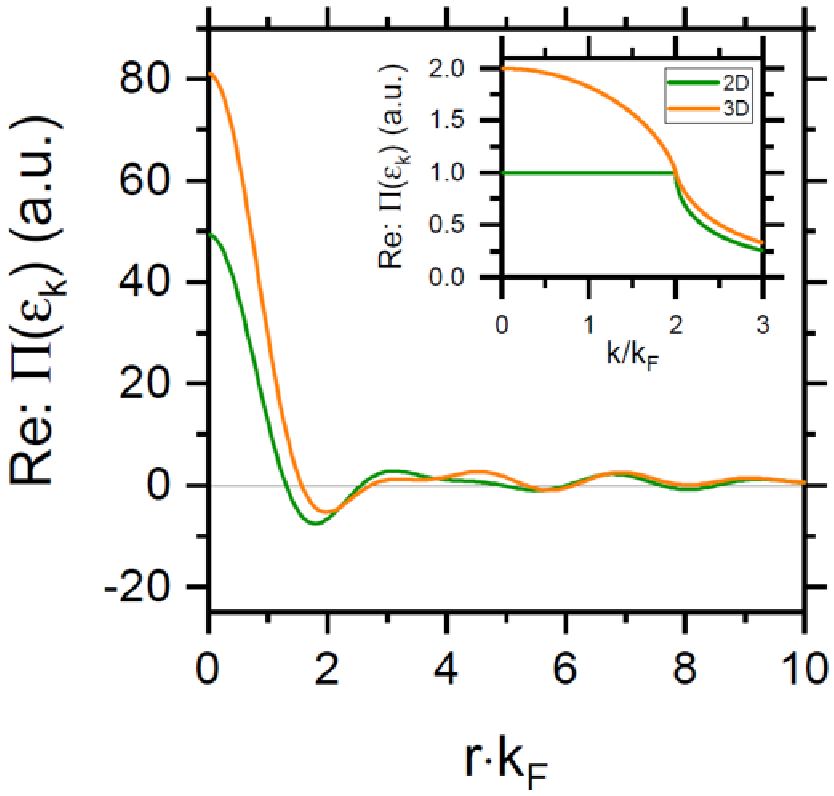
and

J. M. Luttinger

Columbia University, New York, New York
(Received 16 August 1965)

We find that a weakly interacting system of fermions cannot remain normal down to the absolute zero of temperature, no matter what the form of the interaction.

Friedel oscillations



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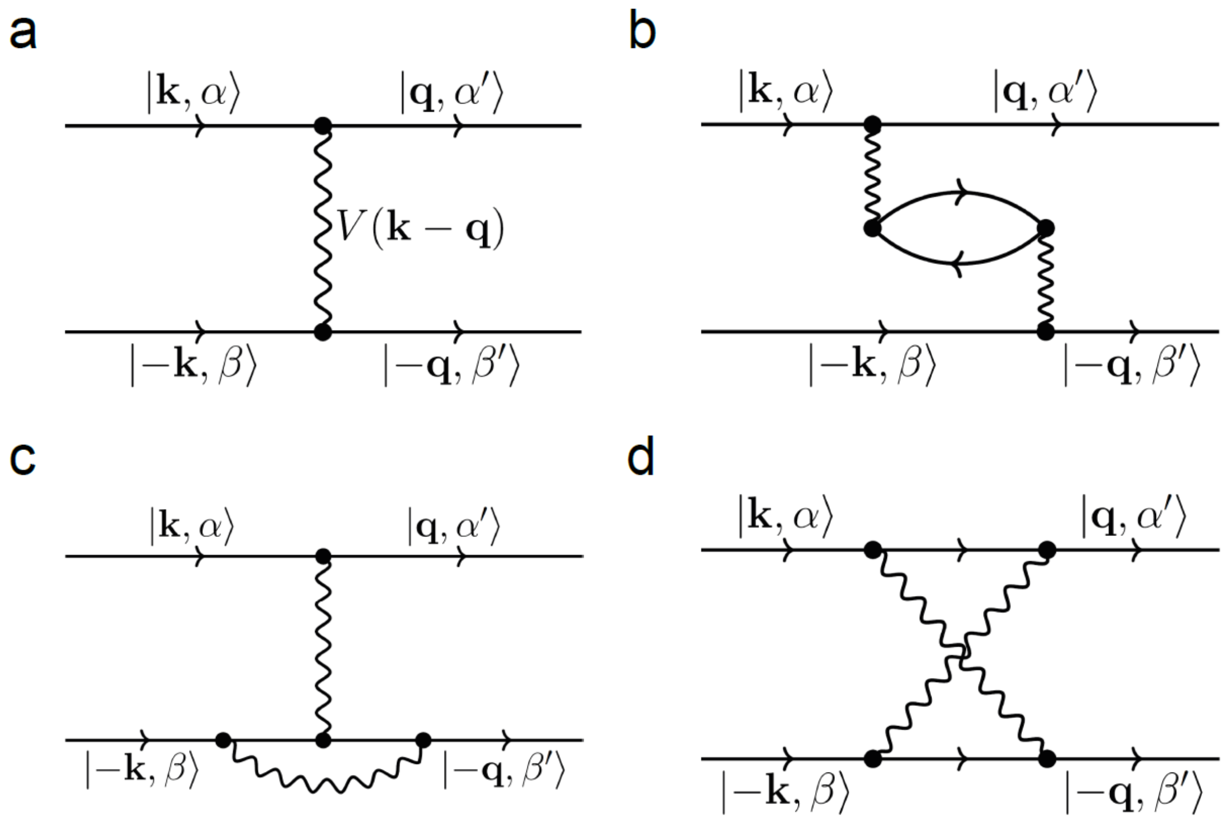
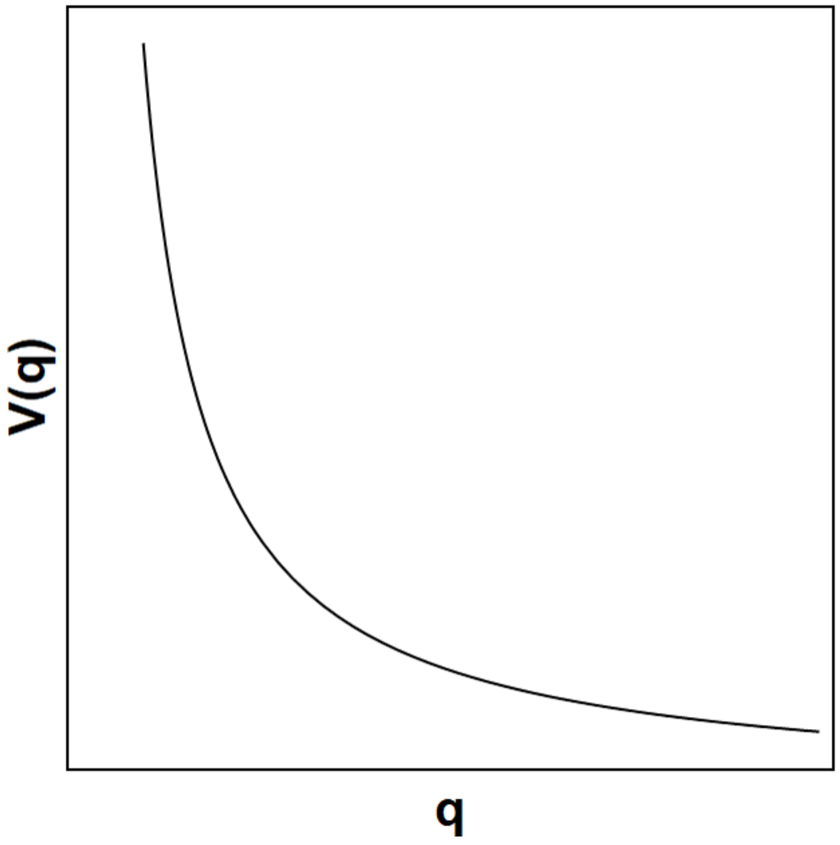
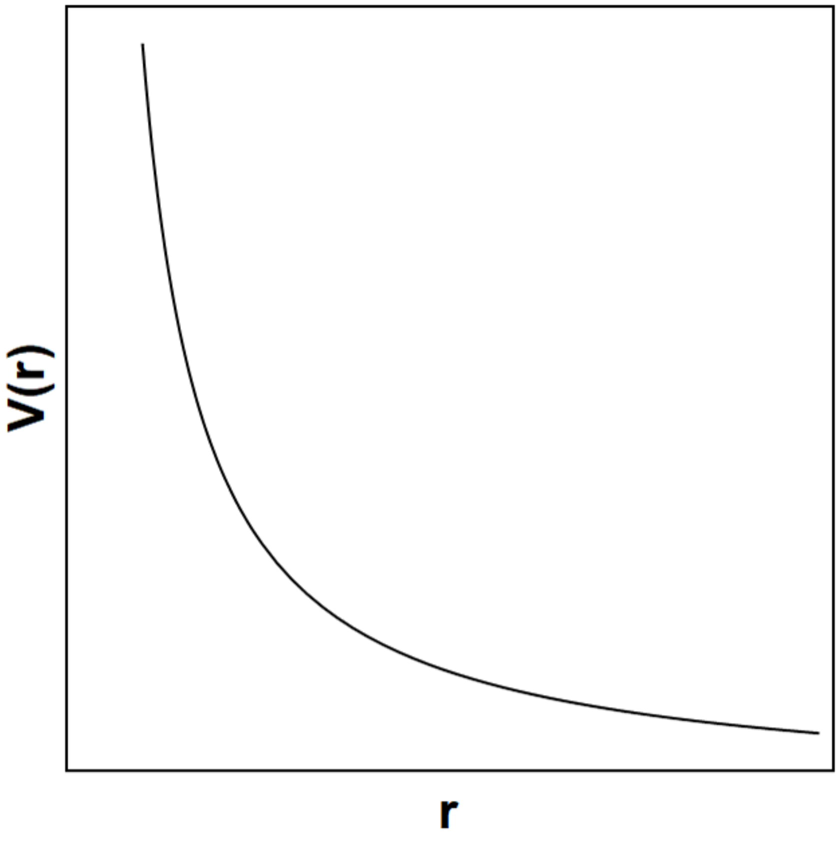
The Kohn-Luttinger (second-order) diagrams



The Kohn-Luttinger-RPA framework

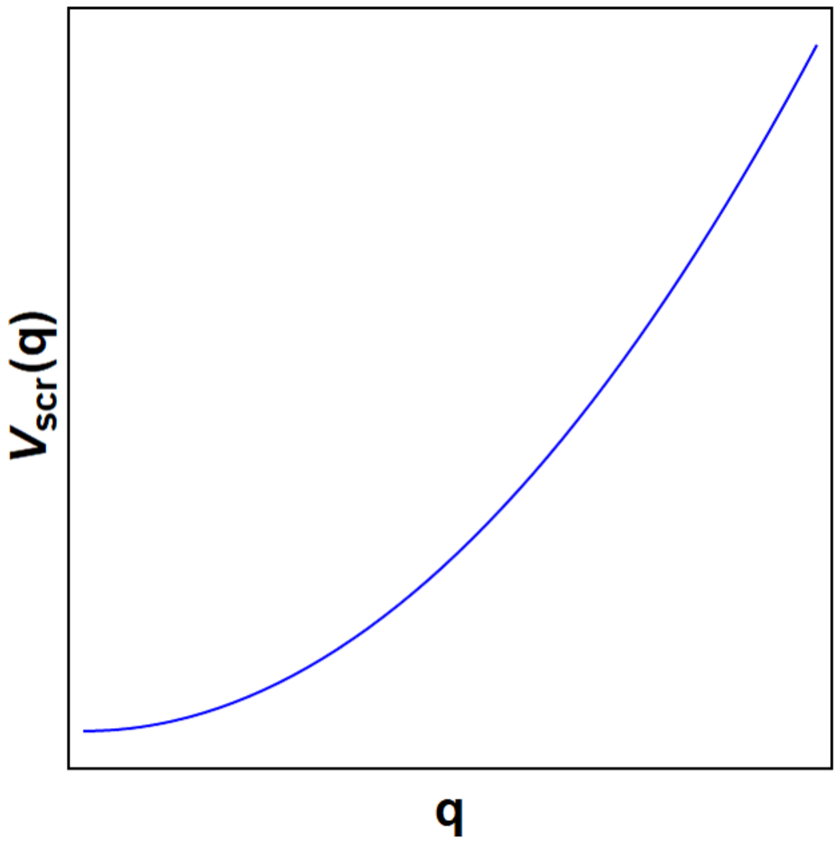
The bare Coulomb potential

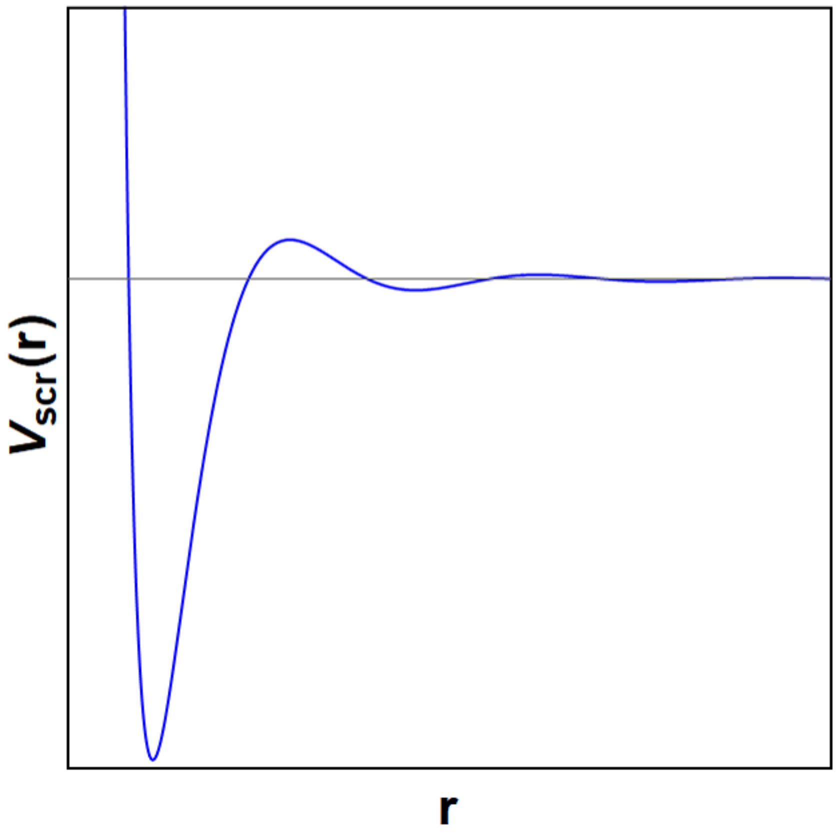




The Kohn-Luttinger-RPA framework

The screened Coulomb potential





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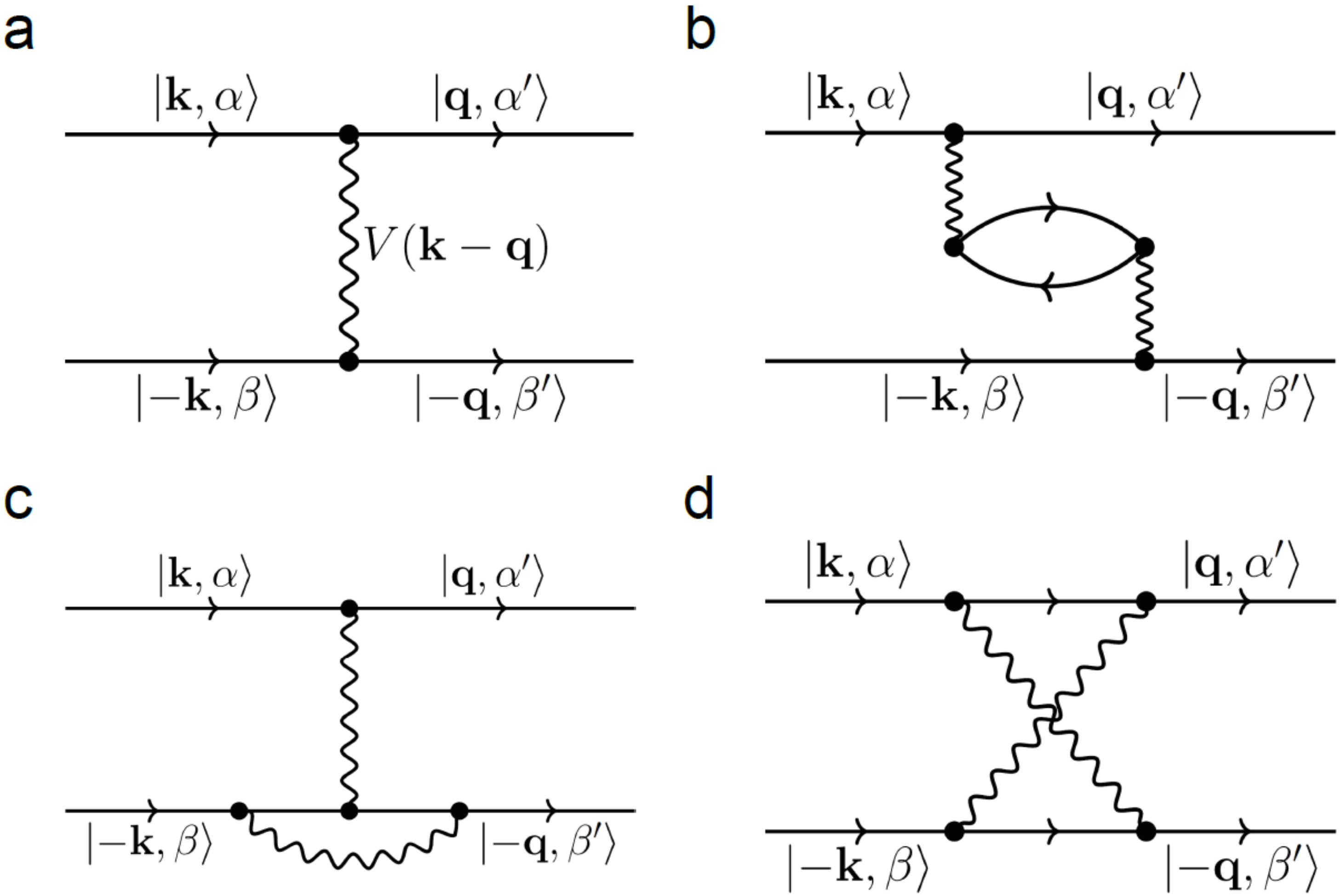

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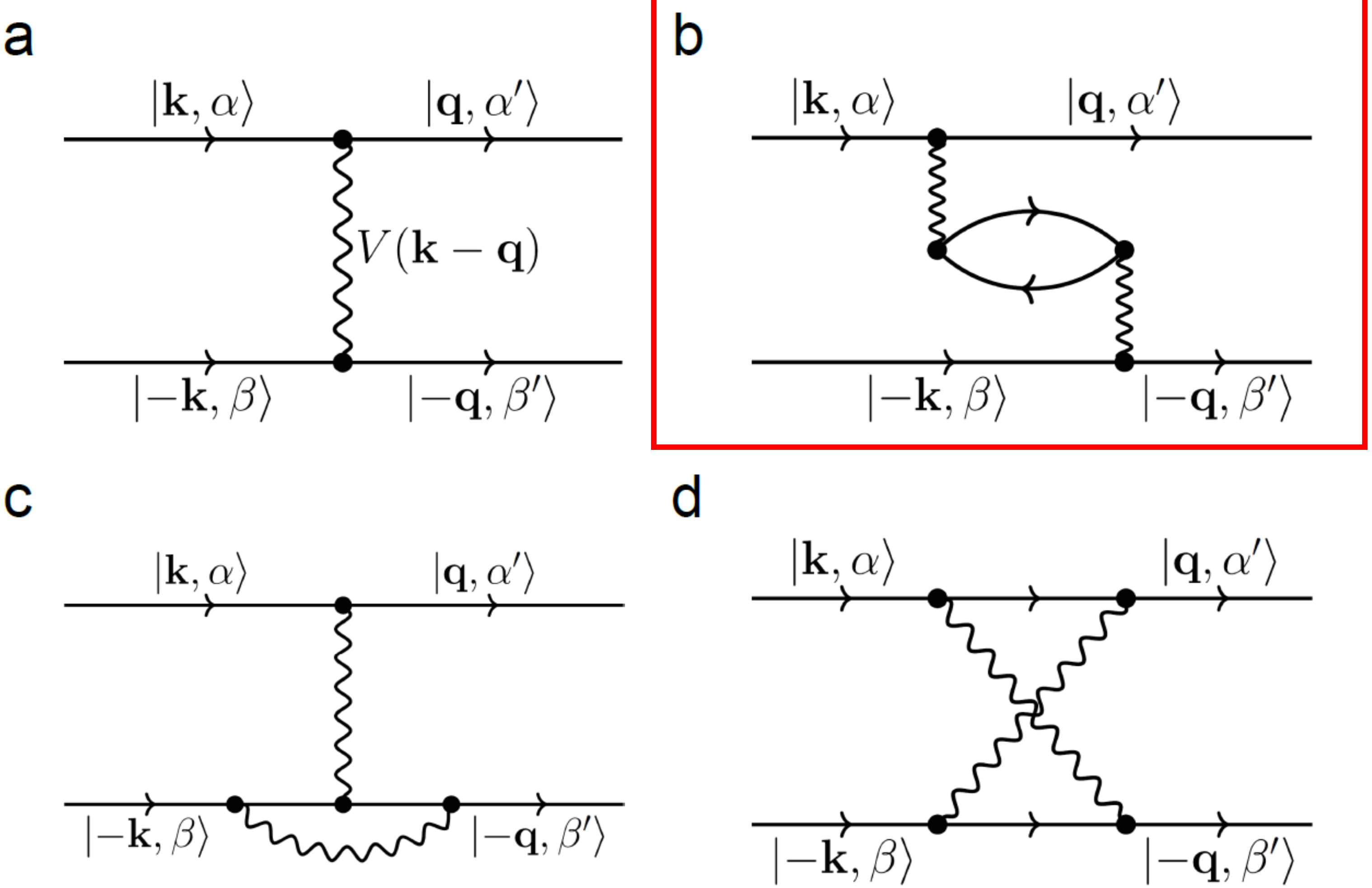
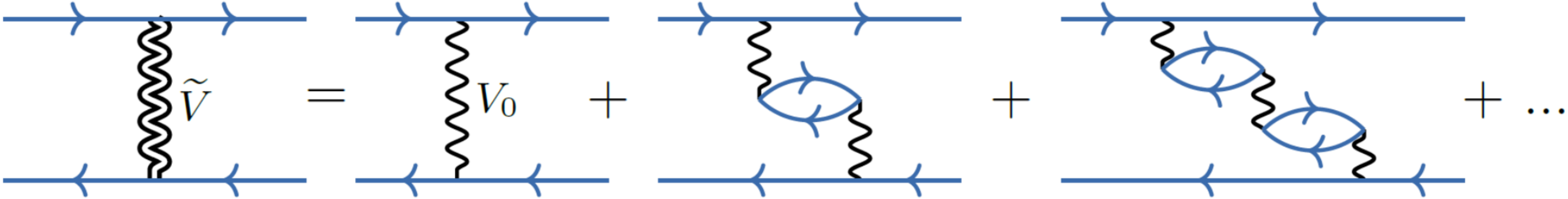
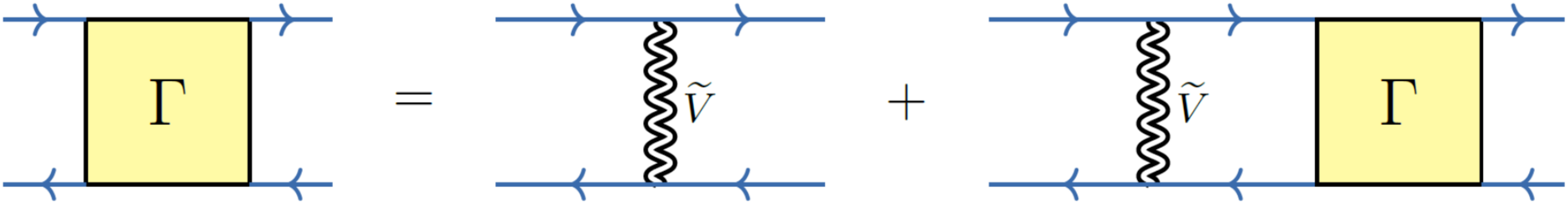


The Kohn-Luttinger-RPA framework

Random phase approximation



Gap equation



The Kohn-Luttinger-RPA framework

1) Electronic band structure and eigenfunctions

$$\epsilon_{n,\mathbf{k}} \quad \psi_{n,\mathbf{k}}$$

2) Electronic susceptibility

$$\Pi_0(\mathbf{q}) = \frac{g_s}{\mathcal{V}} \sum_{m,n} \sum_{\mathbf{k}} \frac{f(\epsilon_{n,\mathbf{k}}) - f(\epsilon_{m,\mathbf{k}+\mathbf{q}})}{\epsilon_{n,\mathbf{k}} - \epsilon_{m,\mathbf{k}+\mathbf{q}}} |\langle \psi_{m,\mathbf{k}+\mathbf{q}} | \psi_{n,\mathbf{k}} \rangle|^2$$

3) Screened interaction at RPA

$$V_{scr}(\mathbf{q}) = \frac{V_C(\mathbf{q})}{1 - V_C(\mathbf{q})\Pi_0(\mathbf{q})}$$

4) Interaction kernel

$$\Gamma_{m,n}(\mathbf{k},\mathbf{q}) = -\frac{V_{scr}(\mathbf{k}-\mathbf{q})}{\mathcal{V}} \sqrt{\frac{f(-\epsilon_{m,\mathbf{k}}) - f(\epsilon_{m,\mathbf{k}})}{2\epsilon_{m,\mathbf{k}}}} \sqrt{\frac{f(-\epsilon_{n,\mathbf{q}}) - f(\epsilon_{n,\mathbf{q}})}{2\epsilon_{n,\mathbf{q}}}} \; |\langle \psi_{m,\mathbf{k}} | \psi_{n,\mathbf{q}} \rangle|^2$$

The Kohn-Luttinger-RPA framework

A. Jimeno-Pozo, H. Sainz-Cruz, T. Cea, P. A. Pantaleón, F. Guinea. *Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene.* **Physical Review B 107 (16), L161106 (2023).**

Z. Li, X. Kuang, A. Jimeno-Pozo, H. Sainz-Cruz, Z. Zhan, S. Yuan, F. Guinea. *Charge fluctuations, phonons, and superconductivity in multilayer graphene.* **Physical Review B 108 (4), 045404 (2023).**

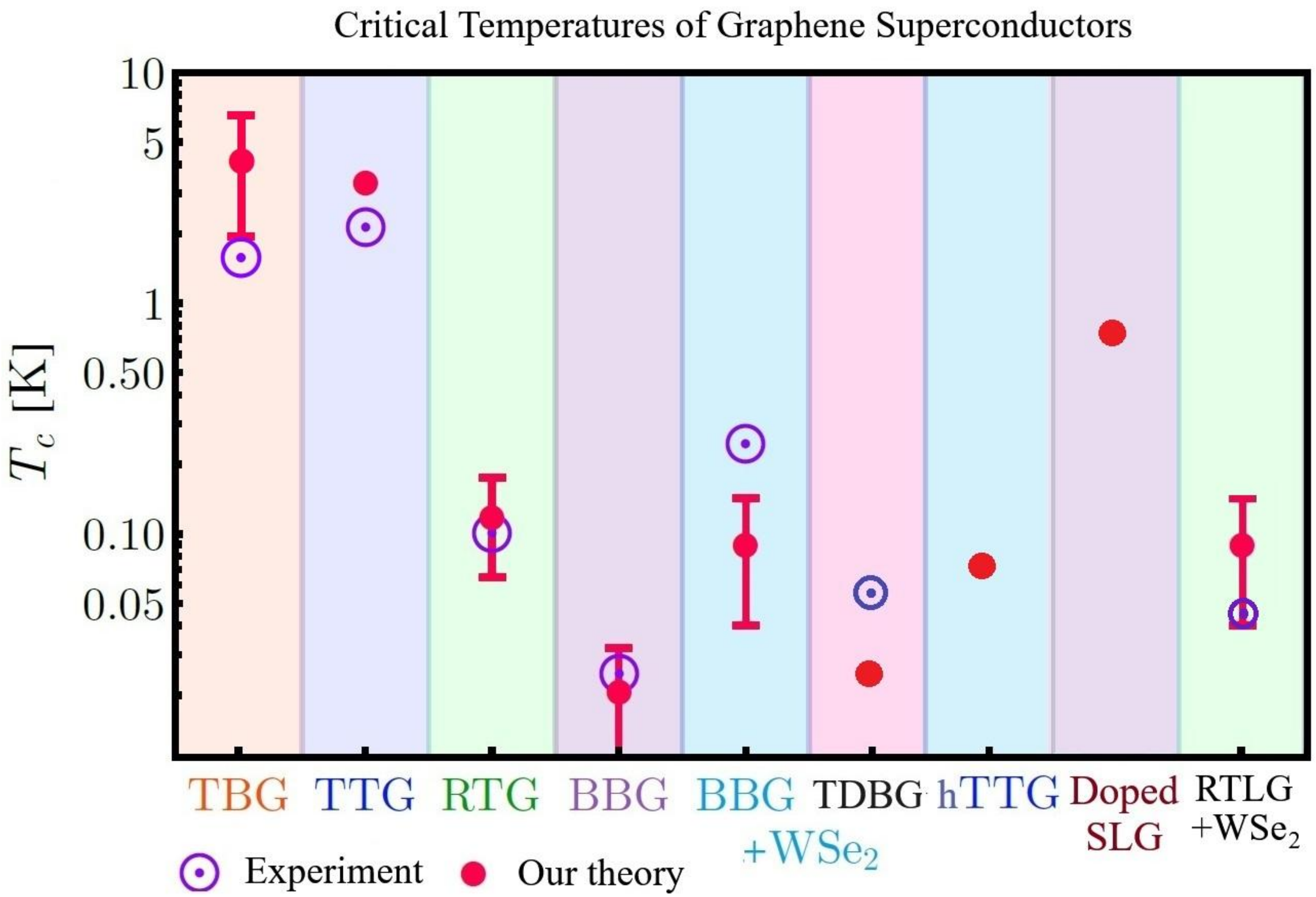
H. Sainz-Cruz, P. A. Pantaleón, V. T. Phong, A. Jimeno-Pozo, F. Guinea. *Junctions and superconducting symmetry in twisted bilayer graphene*. **Physical Review Letters 131 (1), 016003 (2023).**

P. A. Pantaleón, A. Jimeno-Pozo, H. Sainz-Cruz, V. T. Phong, T. Cea, F. Guinea. *Superconductivity and correlated phases in non-twisted bilayer and trilayer graphene.* **Nature Reviews Physics 5 (5), 304-315 (2023).**

M. Long, A. Jimeno-Pozo, H. Sainz-Cruz, P. A. Pantaleón, F. Guinea. *Evolution of superconductivity in twisted graphene multilayers*. **Proceedings of the National Academy of Sciences 121 (32), e2405259121 (2024).**

E. Andrade, A. Jimeno-Pozo, P. A. Pantaleon, F. Guinea, G. G. Naumis. *Electrostatic charge fractionalization and unconventional superconductivity in strained monolayer graphene.* **arXiv:2507.00112**

The Kohn-Luttinger-RPA framework



S. A. Herrera, G. Parra-Martínez, P. Rosenzweig, B. Matta, C. M. Polley, K. Küster, U. Starke, F. Guinea, J. A. Silva-Guillén, G. G. Naumis, and P. A. Pantaleón. *Topological Superconductivity in Heavily Doped Single-Layer Graphene*. **ACS nano 18 (51), 34842-34857 (2024).**

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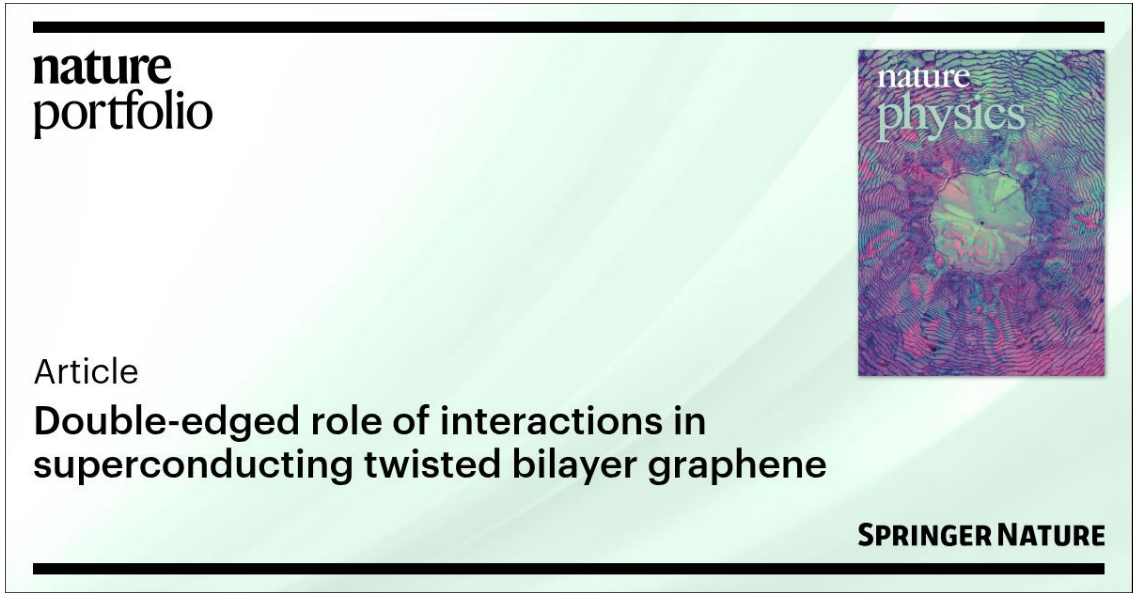
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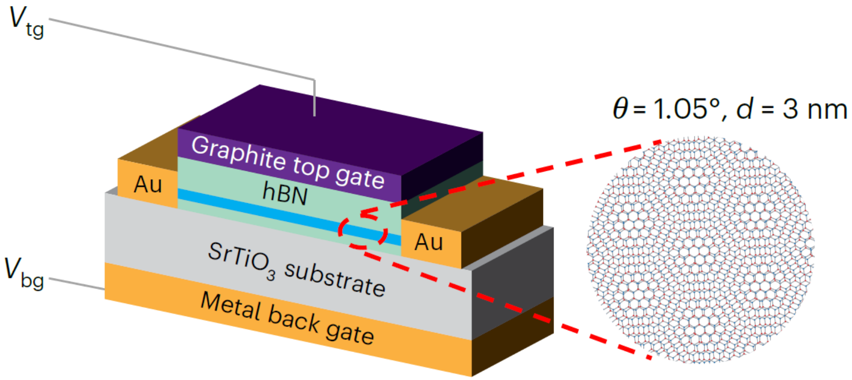
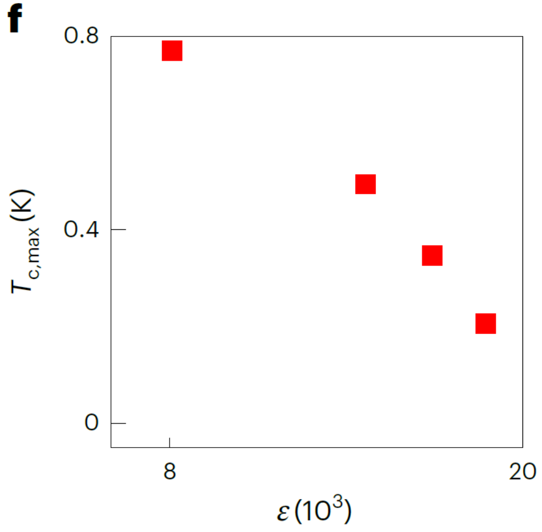
Article

Double-edged role of interactions in superconducting twisted bilayer graphene

SPRINGER NATURE





X. Gao, A. Jimeno-Pozo, P. A. Pantaleón, E. Codecido, D. L. Sharifi, Z. Zhang, Y. Liu, K. Watanabe, T. Taniguchi, M. W. Bockrath, F. Guinea, and C. N. Lau. *Double-edged Role of Interactions in Superconducting Twisted Bilayer Graphene.* **Nature Physics (2026).**

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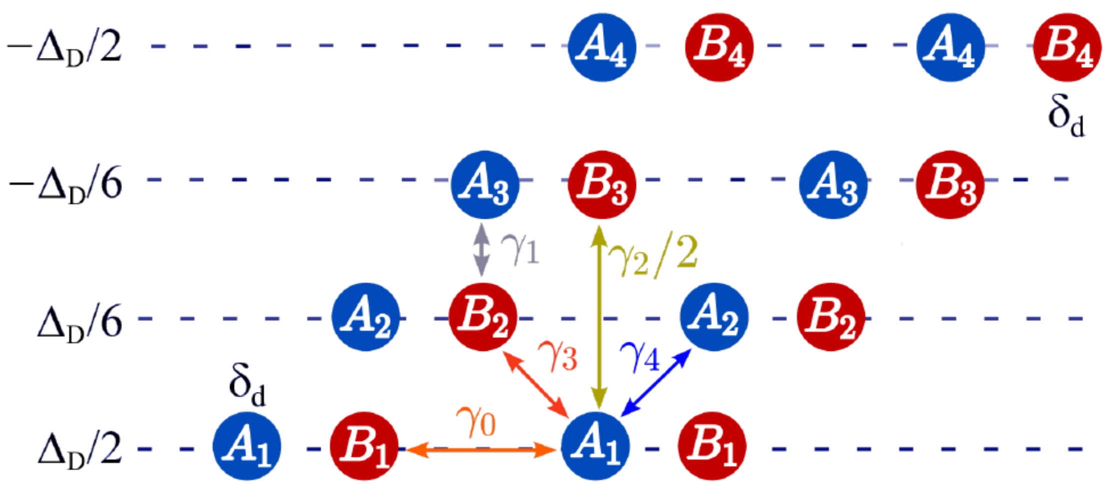
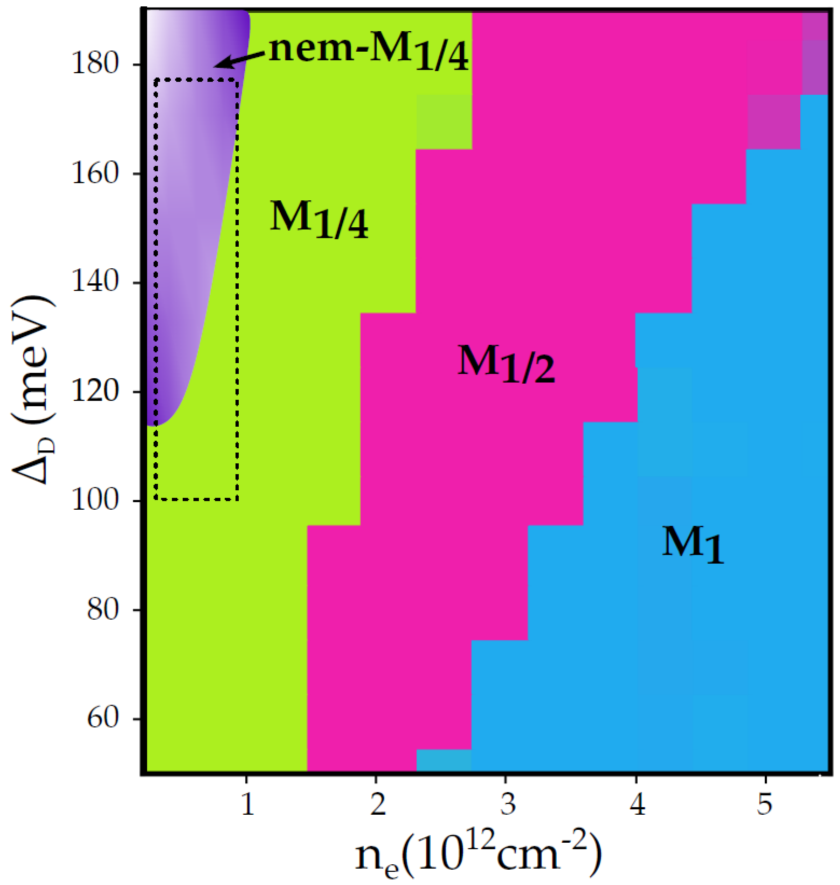


Hartree-Fock phase diagram



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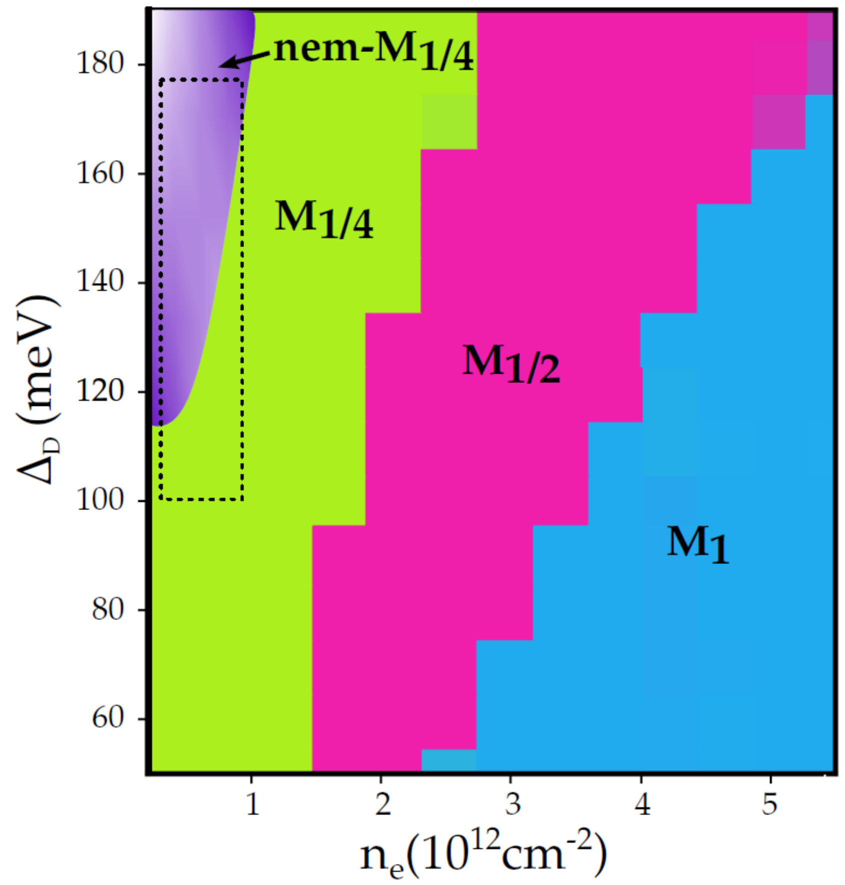
Chiral SC in quarter-metal R4G

Screened Hartree-Fock-RPA procedure for superconductivity

Hartree-Fock phase diagram



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Screened Hartree-Fock-RPA procedure for superconductivity

1. Dual gate Coulomb potential

$$\mathcal{V}_0(q) = \frac{2\pi e^2}{\epsilon|\mathbf{q}|}\tanh(d_g|\mathbf{q}|)$$

2. Non interacting Hamiltonian

$$\hat{\mathcal{H}}_0|\psi_n^0\rangle = \varepsilon_n^0|\psi_n^0\rangle$$

3. T=0 Susceptiblity

$$\Pi_0(\mathbf{q}) = \frac{1}{\Omega}\sum_{\mathbf{k},m,n}\frac{\Theta(\epsilon^0_{n,\mathbf{k}})-\Theta(\epsilon^0_{m,\mathbf{k+q}})}{\epsilon^0_{n,\mathbf{k}}-\epsilon^0_{m,\mathbf{k+q}}}|\langle\psi^0_{m,\mathbf{k+q}}|\psi^0_{n,\mathbf{k}}\rangle|^2$$

4. Non interacting RPA screened potential

$$\mathcal{V}^0_{\mathrm{RPA}}(\mathbf{q}) = \frac{\mathcal{V}_0(\mathbf{q})}{1-\Pi_0(\mathbf{q})\mathcal{V}_0(\mathbf{q})}$$

5. Self consistent HF iterative loop

$$\hat{\tilde{H}}|\tilde{\psi}_n\rangle = \tilde{\varepsilon}_n|\tilde{\psi}_n\rangle$$

6. T dependent Susceptiblity

$$\tilde{\Pi}(\mathbf{q}) = \frac{1}{\Omega}\sum_{\mathbf{k},m,n}\frac{f(\tilde{\epsilon}_{n,\mathbf{k}})-f(\tilde{\epsilon}_{m,\mathbf{k+q}})}{\tilde{\epsilon}_{n,\mathbf{k}}-\tilde{\epsilon}_{m,\mathbf{k+q}}}|\langle\tilde{\psi}_{m,\mathbf{k+q}}|\tilde{\psi}_{n,\mathbf{k}}\rangle|^2$$

7. Interacting RPA screened potential

$$\tilde{\mathcal{V}}(\mathbf{q}) = \frac{\mathcal{V}_0(\mathbf{q})}{1-\tilde{\Pi}(\mathbf{q})\mathcal{V}_0(\mathbf{q})}$$

8. Interacting kernel

$$\Gamma(\tilde{\varepsilon},\tilde{\psi},\tilde{\mathcal{V}}(\mathbf{q}))$$

9. Interacting gap equation

$$\Delta(\mathbf{k}) = \sum_{\mathbf{q}}\Gamma(\mathbf{k},\mathbf{q})\Delta(\mathbf{q})$$

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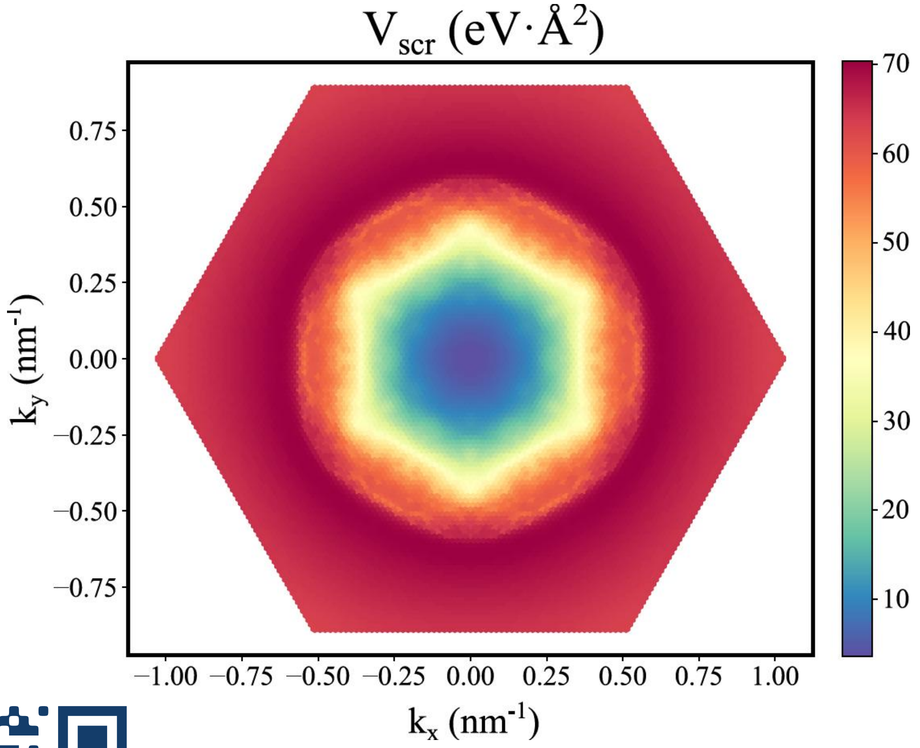
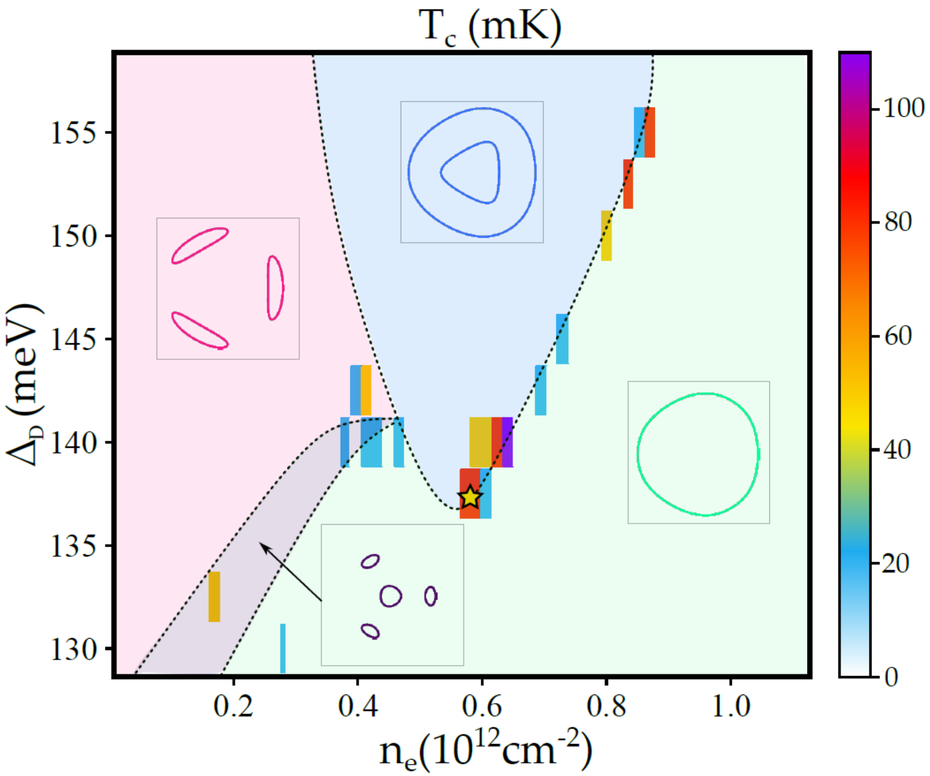
Chiral SC in quarter-metal R4G

Screened Coulomb potential



Critical temperature



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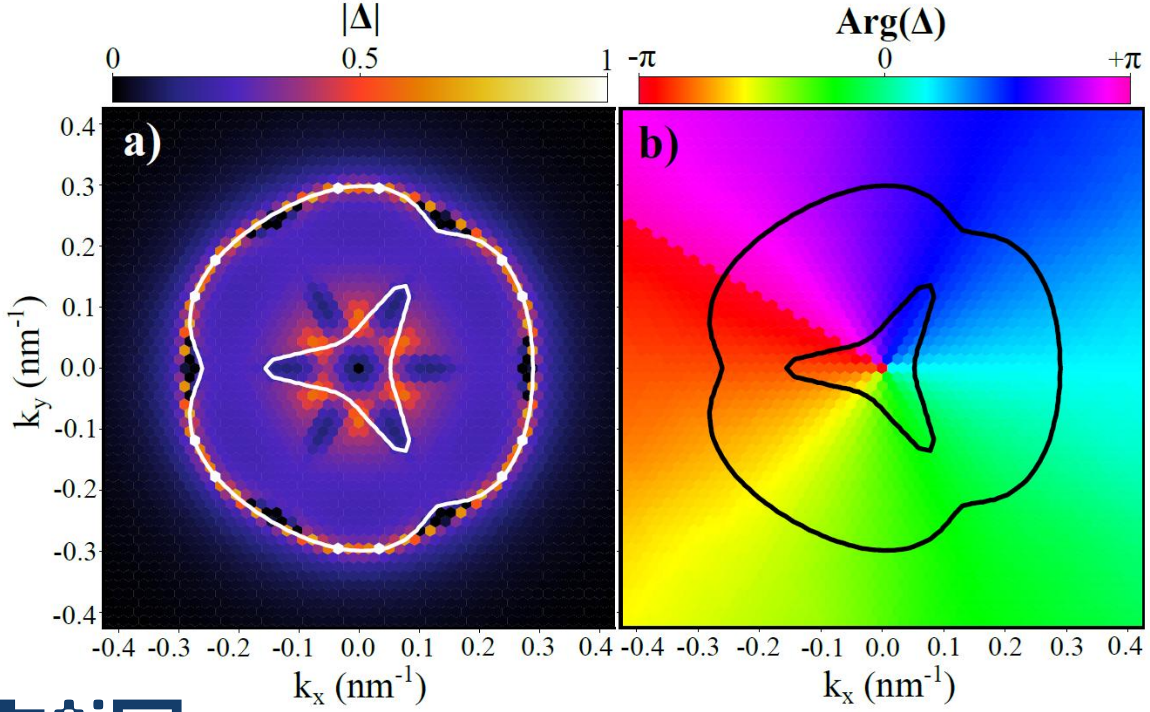
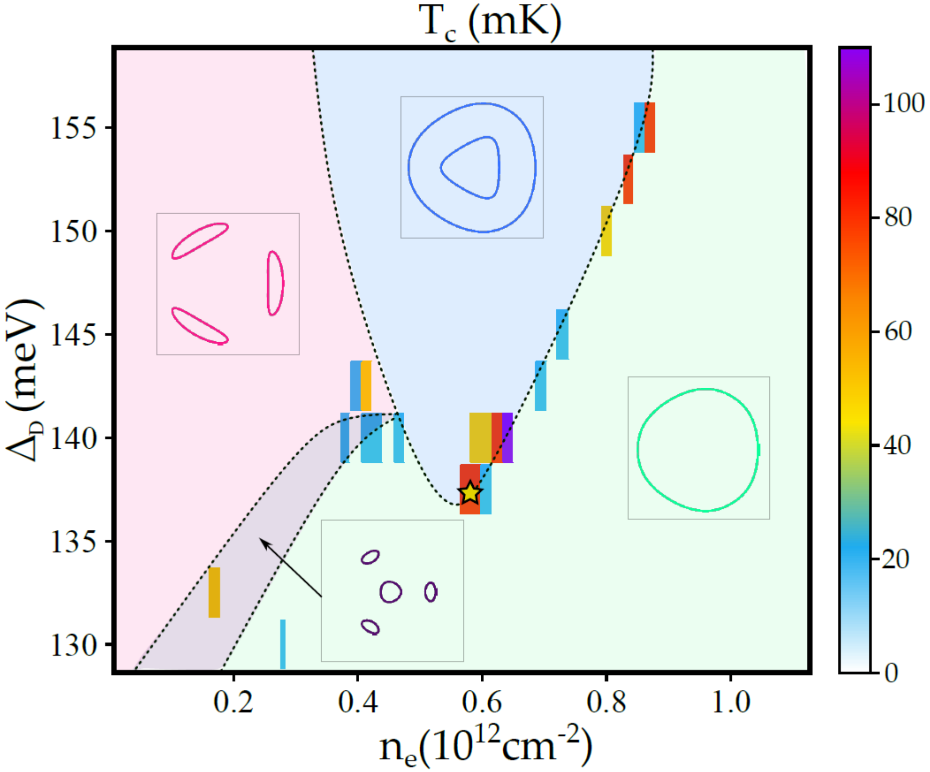
Order parameter



Critical temperature



G. Parra-Martínez, A. Jimeno-Pozo, V. T. Phong, H. Sainz-Cruz, D. Kaplan, P. Emanuel, Y. Oreg, P. A. Pantaleón, J. A. Silva-Guillén, and F. Guinea. *Band Renormalization, Quarter Metals, and Chiral Superconductivity in Rhombohedral Tetralayer Graphene.* **Phys. Rev. Lett. 135, 136503 (2025).**

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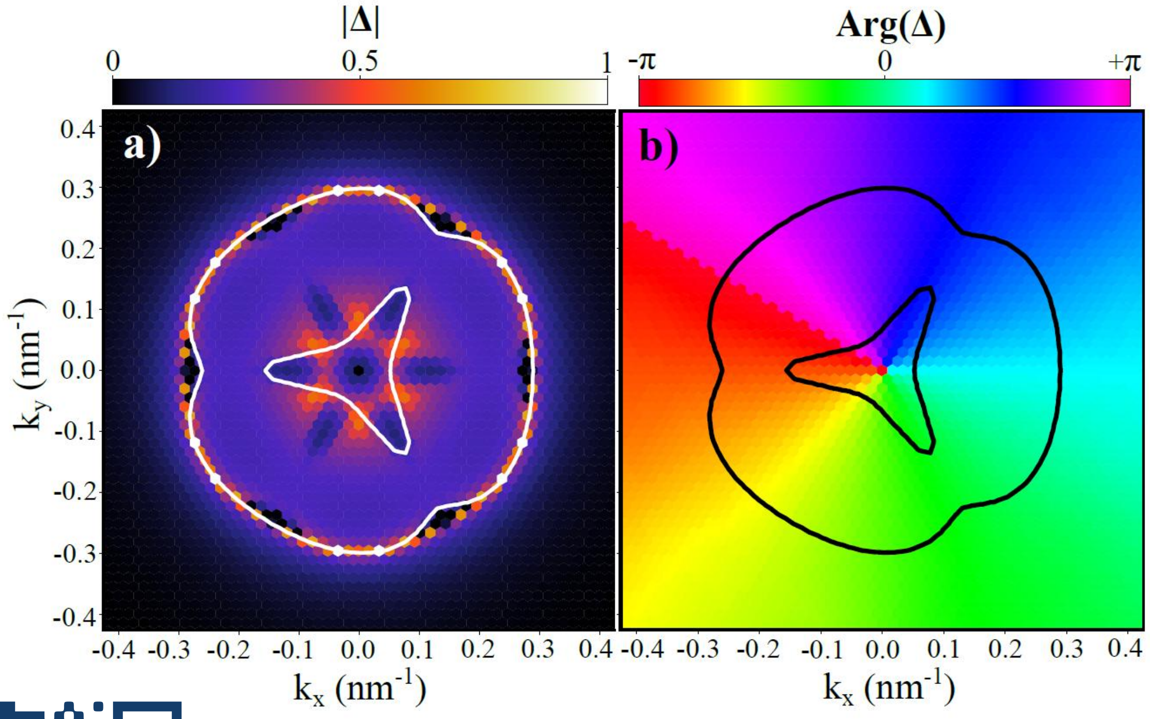
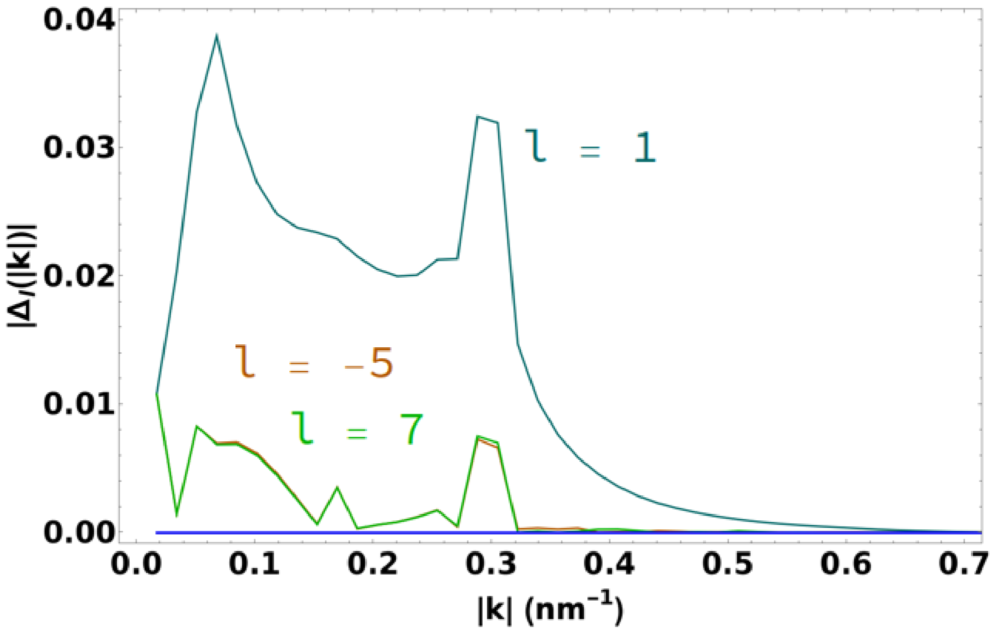


Fourier descomposition of the order parameter

$$\Delta(\mathbf{k}) = \sum_l \Delta_l(|\mathbf{k}|)e^{il\theta_\mathbf{k}},$$



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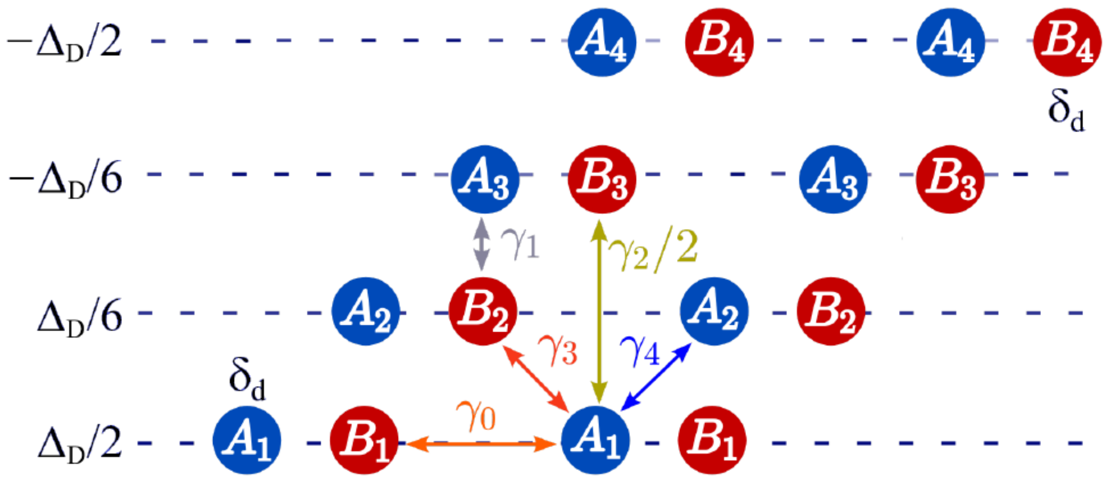
Bonus: partially polarized phases in R(N-layer)G

Rhombohedral (ABC)
tetralayer graphene

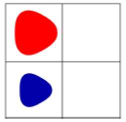
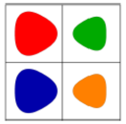
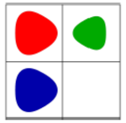
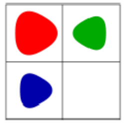
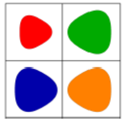
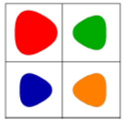


Isospin polarized phases

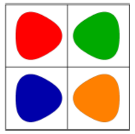
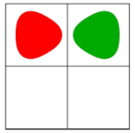
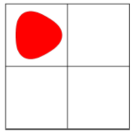
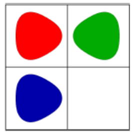
Isospin polarized states			
Full metal	FM	$(\alpha, \alpha, \alpha, \alpha)$	
Half metal	HM	$(\alpha, 0, \alpha, 0)$	
Quarter metal	QM	$(\alpha, 0, 0, 0)$	
Three-quarter metal	TQM	$(\alpha, \alpha, \alpha, 0)$	

Bonus: partially polarized phases in R(N-layer)G

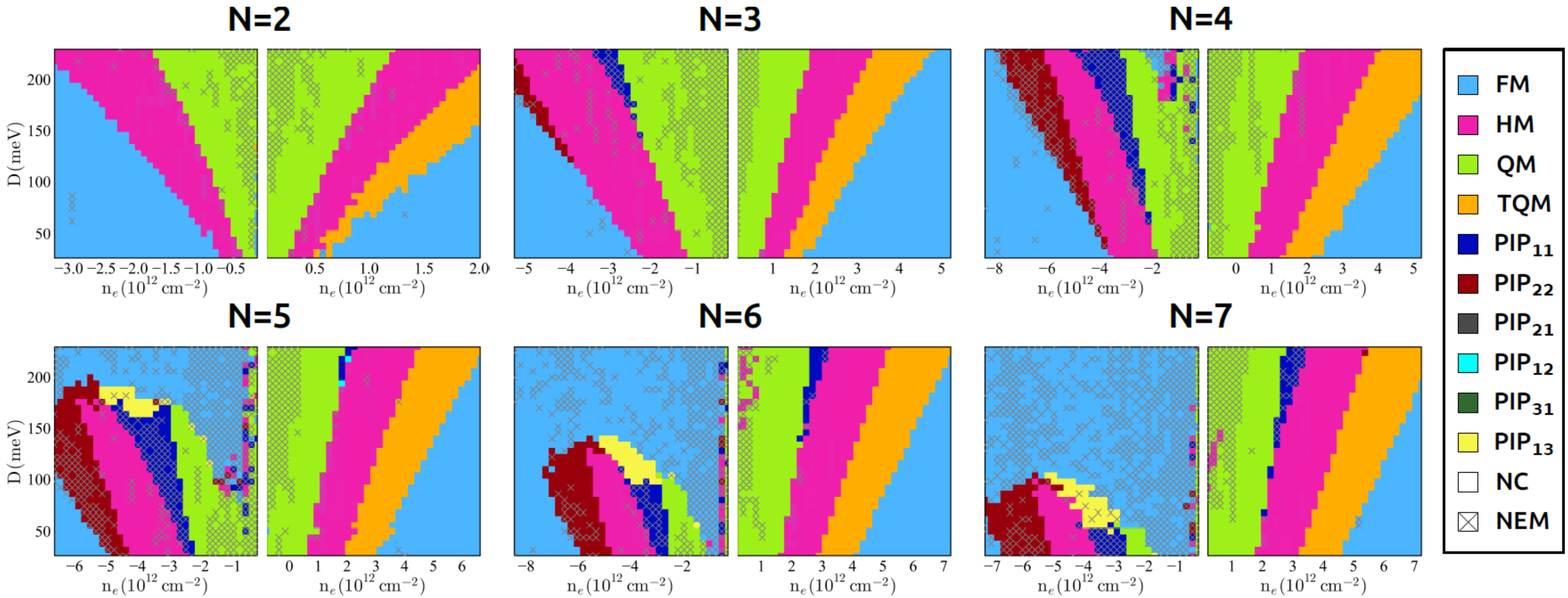
Isospin partially polarized phases

Partially isospin polarized states			
QM to HM	PIP_{11}	$(\alpha, \beta, 0, 0)$	
HM to FM	PIP_{22}	$(\alpha, \alpha, \beta, \beta)$	
HM to TQM	PIP_{21}	$(\alpha, \alpha, \beta, 0)$	
QM to TQM	PIP_{12}	$(\alpha, \beta, \beta, 0)$	
TQM to FM	PIP_{31}	$(\alpha, \alpha, \alpha, \beta)$	
QM to FM	PIP_{13}	$(\alpha, \beta, \beta, \beta)$	

Isospin polarized phases

Isospin polarized states			
Full metal	FM	$(\alpha, \alpha, \alpha, \alpha)$	
Half metal	HM	$(\alpha, 0, \alpha, 0)$	
Quarter metal	QM	$(\alpha, 0, 0, 0)$	
Three-quarter metal	TQM	$(\alpha, \alpha, \alpha, 0)$	

Bonus: partially polarized phases in R(N-layer)G



G. Parra-Martínez, A. Jimeno-Pozo, J. A. Silva-Guillén, and F. Guinea. *Nematic and Partially Polarized Phases in Rhombohedral Graphene with Varying Number of Layers: An Extensive Hartree–Fock Study.* **Adv. Mater. (2025): e14008.**

Outline

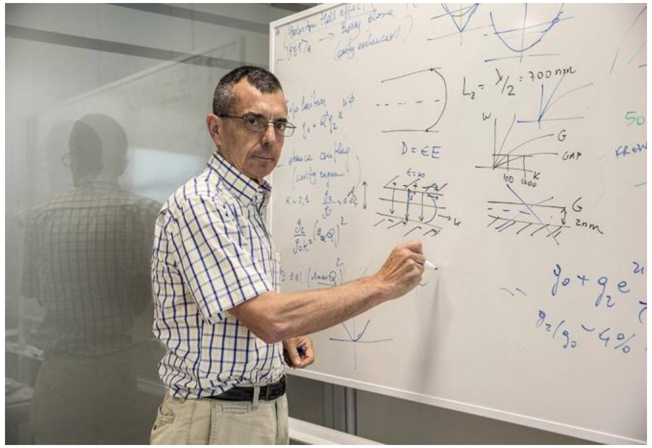
- Motivation.
- Isospin polarized phases in R4G.
- The KL-RPA framework.
- Chiral SC in quarter-metal R4G.
- Conclusions.

Conclusions

- Strong electron correlations enhanced by van Hove singularities give rise to isospin-polarized phases in graphene stacks.
- Superconductivity in graphene stacks may be mediated by an unconventional mechanism.
- By applying a Kohn-Luttinger inspired approach we can solve the linealized gap equation and obtain the critical temperature and symmetry of the order parameter in particular systems of interest.
- Calculations closely resemble the experimental phenomenology across three orders of magnitude in several graphene multilayers (moiré and non-moiré).
- In the case of rhombohedral tetralayer graphene, we take a further step by first analyzing the stability of the quarter-metal phase (parent state of SC phase) and then obtain a superconducting phenomenology in line with the experiments both in terms of the critical temperature and the electronic densities at which the superconducting region appears.

Acknowledgements

IMDEA Nanoscience and DIPC



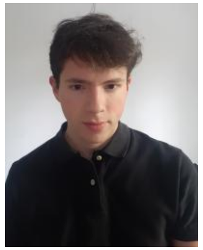
Prof. Francisco Guinea

IMDEA Nanoscience

Dr. Pierre A. Pantaleón

Dr. José Ángel Silva-Guillén

Dr. Héctor Sainz-Cruz



Guillermo Parra-Martínez

National High Magnetic Field Laboratory

Dr. Võ Tiến Phong

Rutgers University

Dr. Daniel Kaplan

Weizmann Institute of Science

Prof. Yuval Oreg

Peleg Emanuel

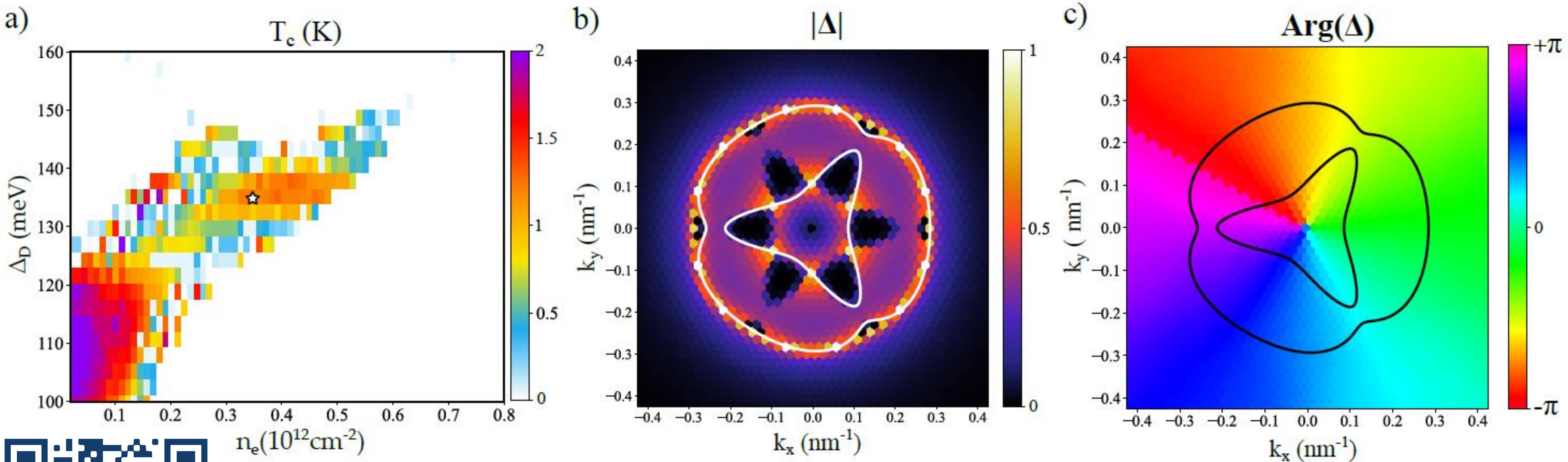
Thank you for your attention!

Questions and comments are welcome

Extra slides

Chiral SC in quarter-metal R4G

Superconductivity in the non-interacting rhombohedral tetralayer



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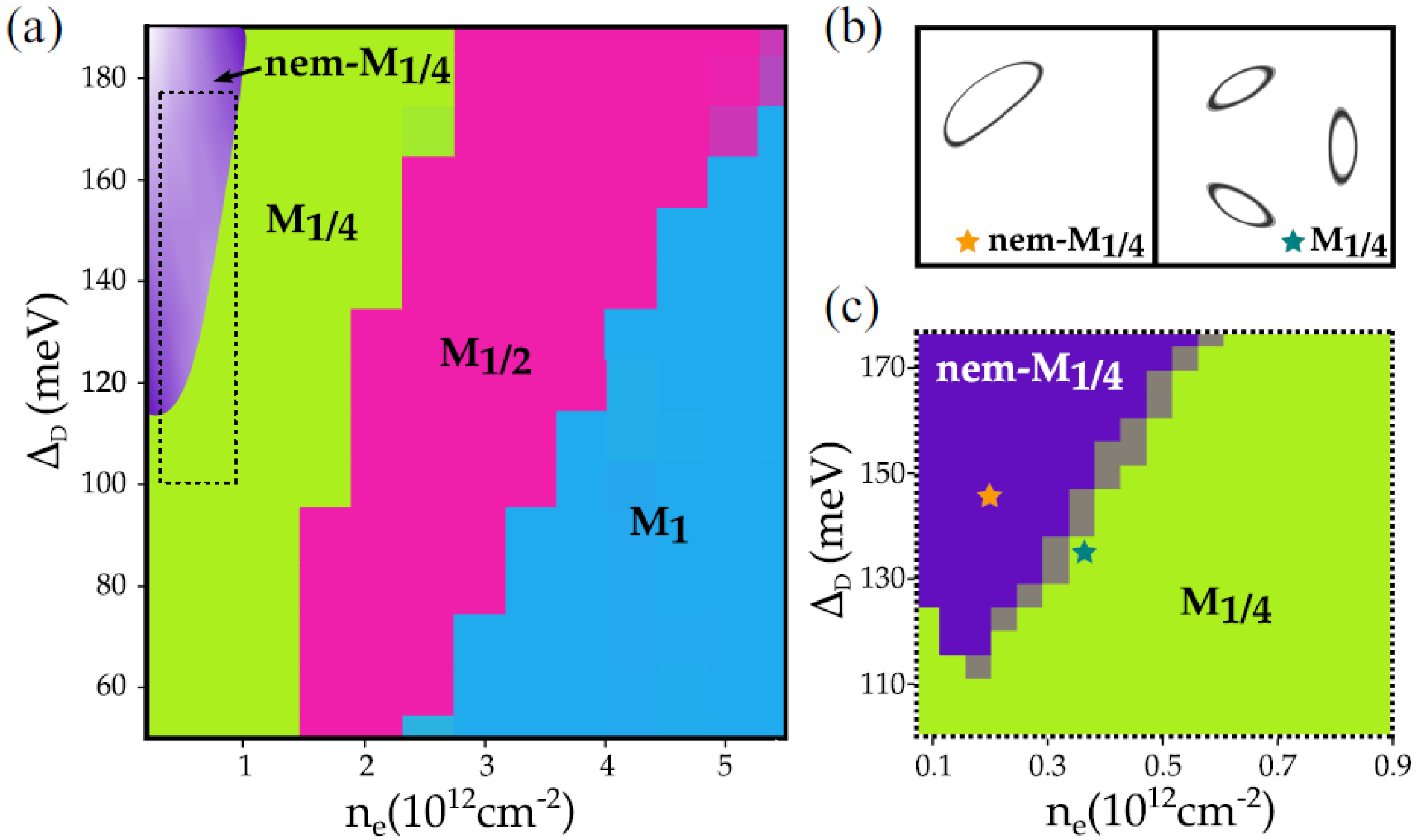
Chiral SC in quarter-metal R4G

Nematicity in rhombohedral tetralayer graphene tetralayer



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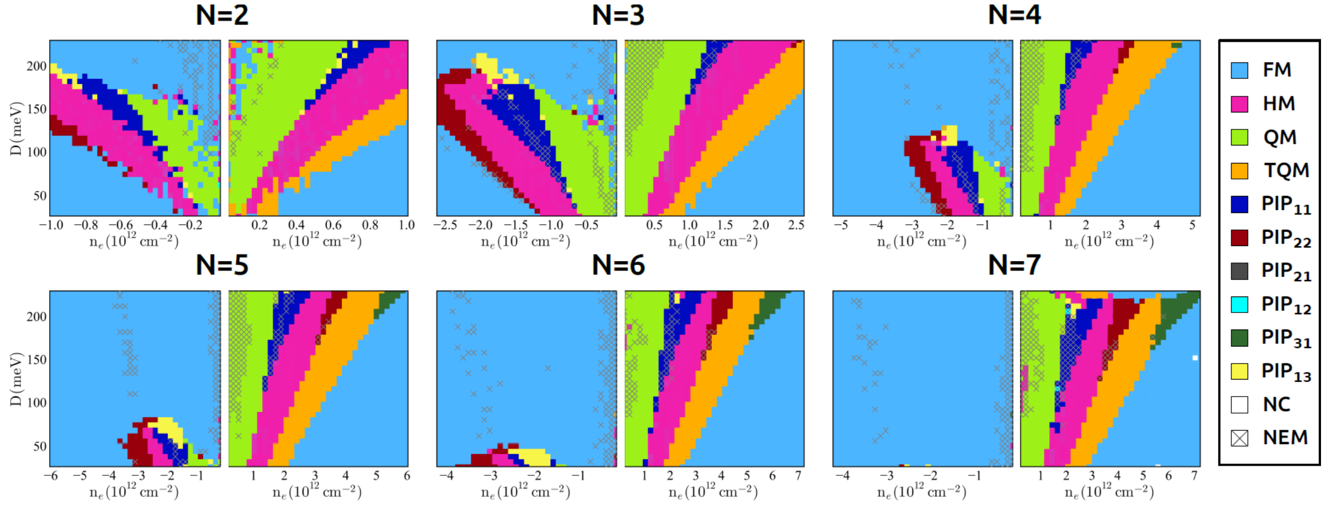
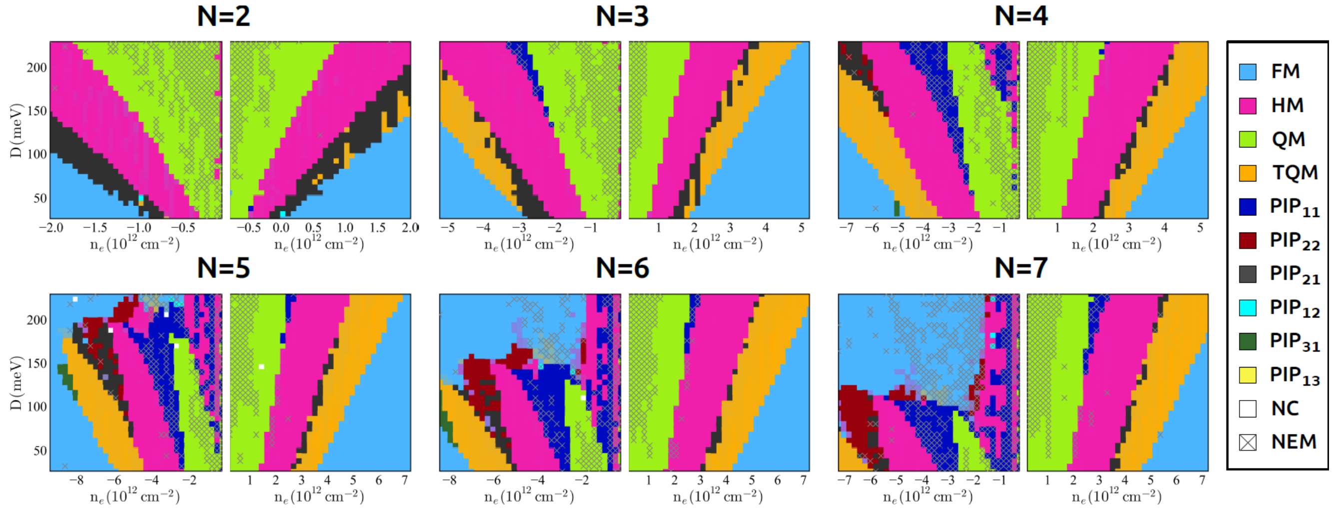
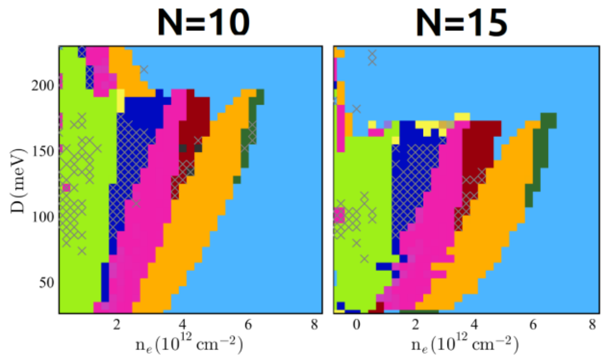
Bonus: partially polarized phases in R(N-layer)G







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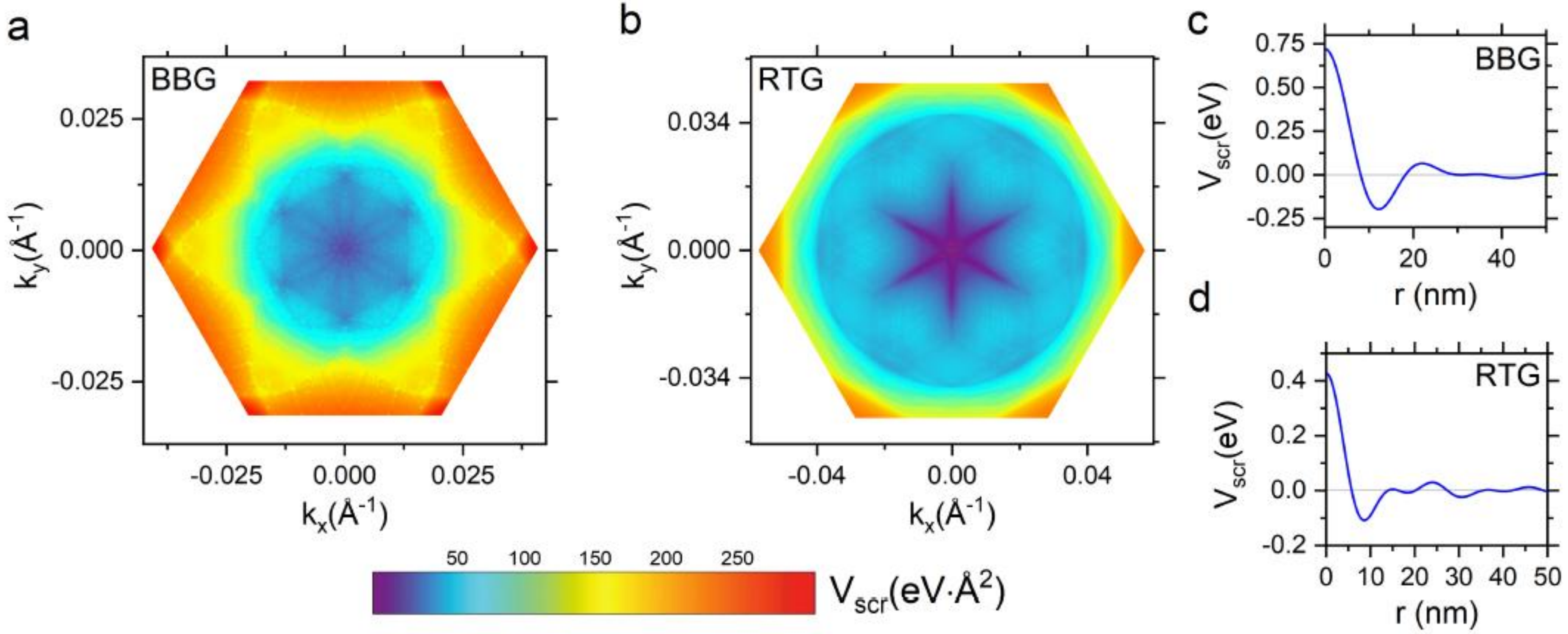
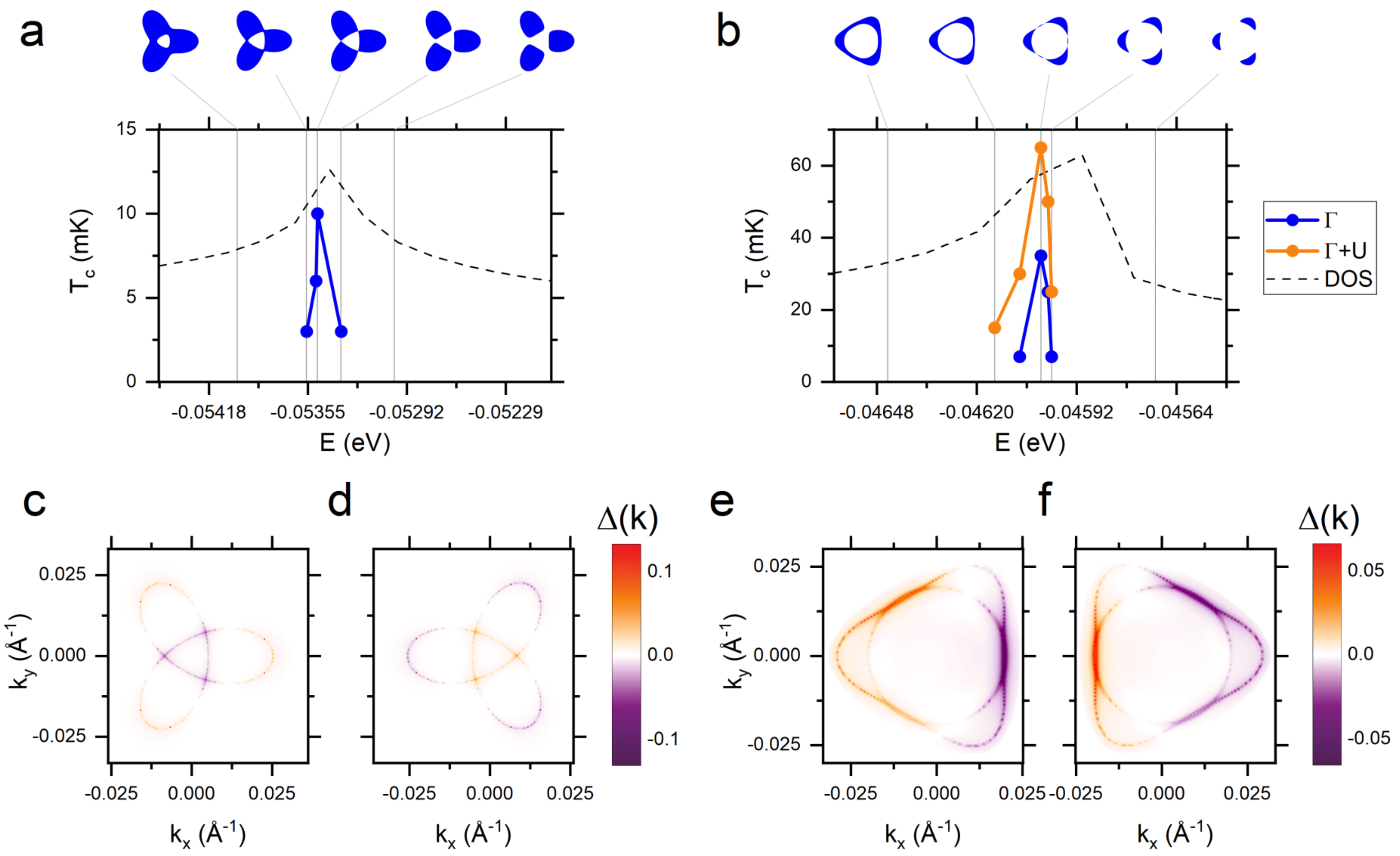
Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene

Screened Coulomb potential



A Jimeno-Pozo, H Sainz-Cruz, T Cea, PA Pantaleón, and F Guinea. **Physical Review B 107 (16), L161106 (2023)**

Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene



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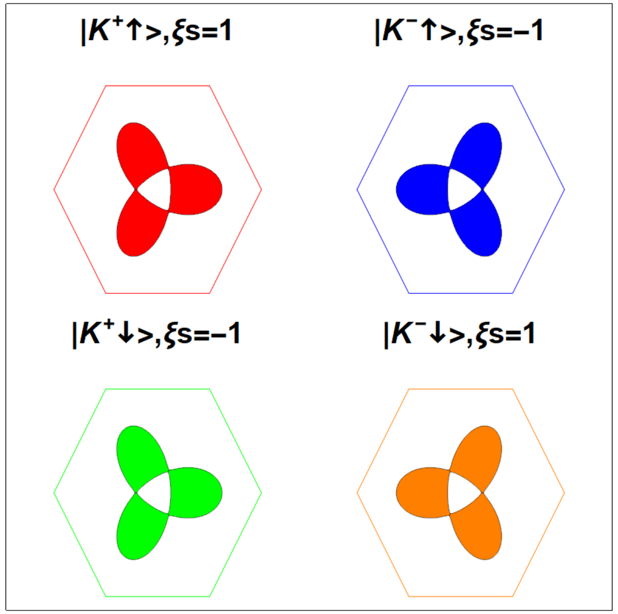
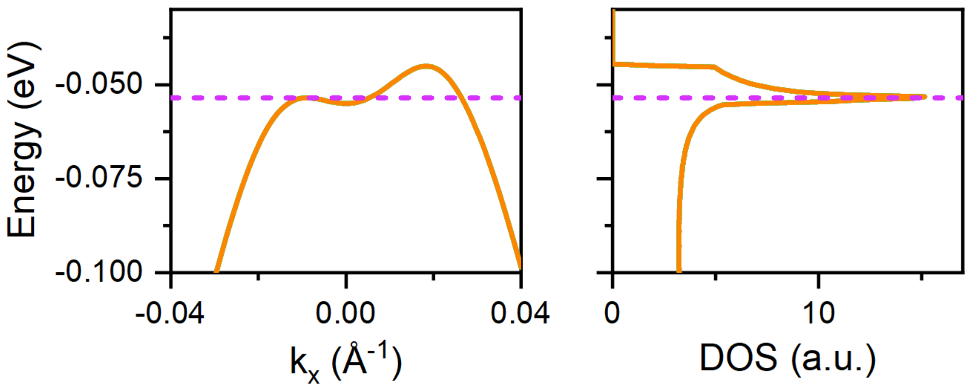
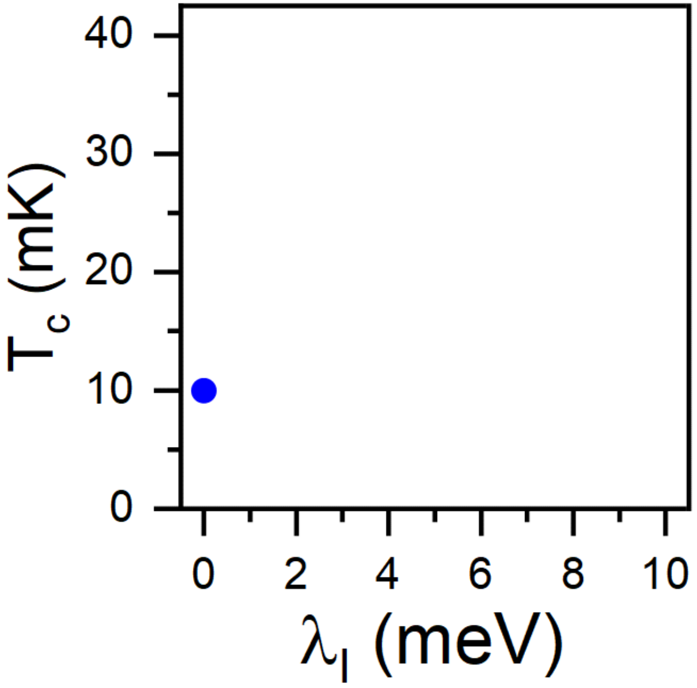


The role of Ising SOC in Bernal bilayer graphene





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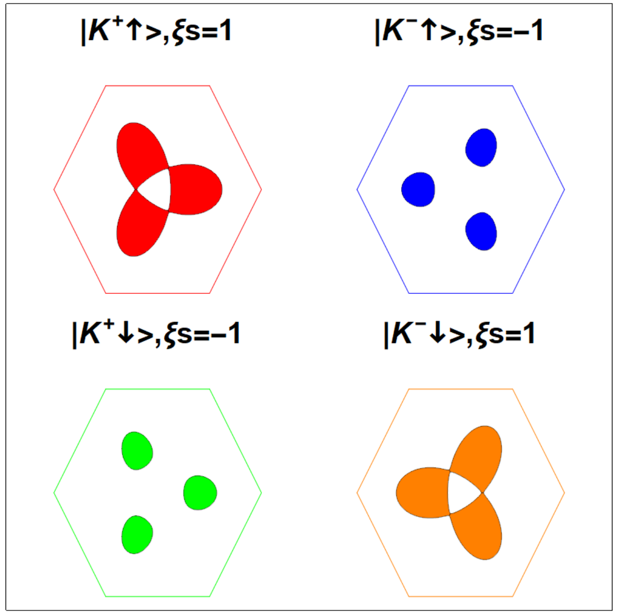

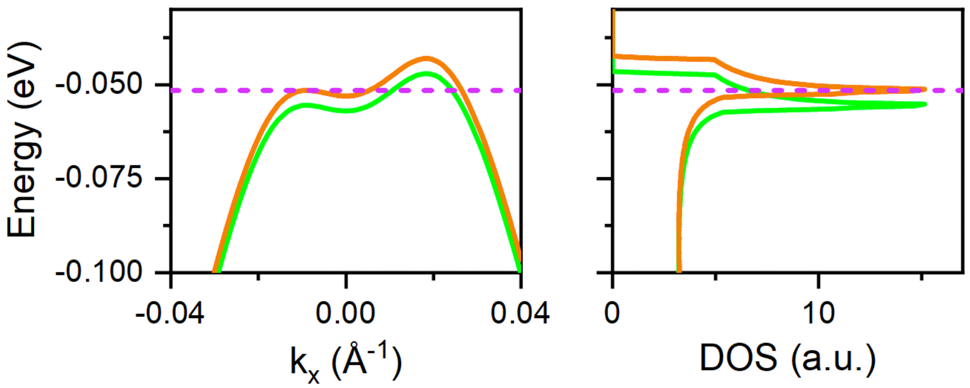

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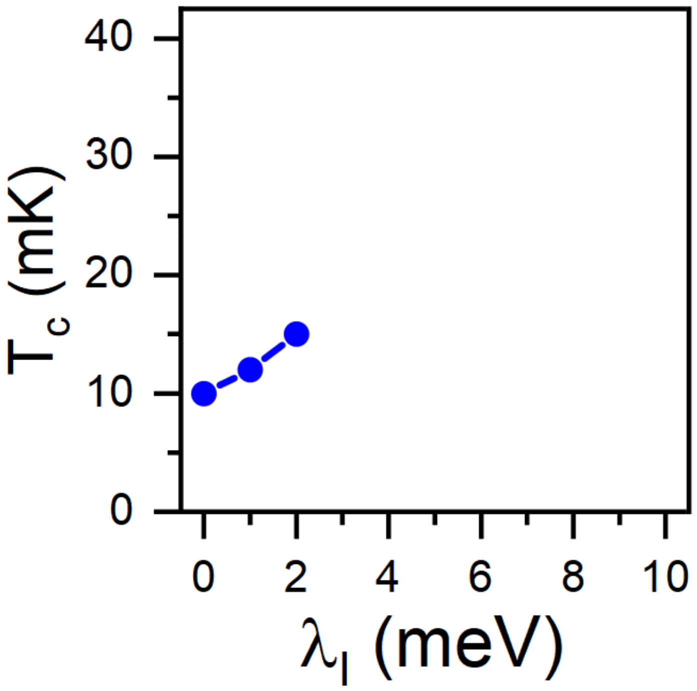

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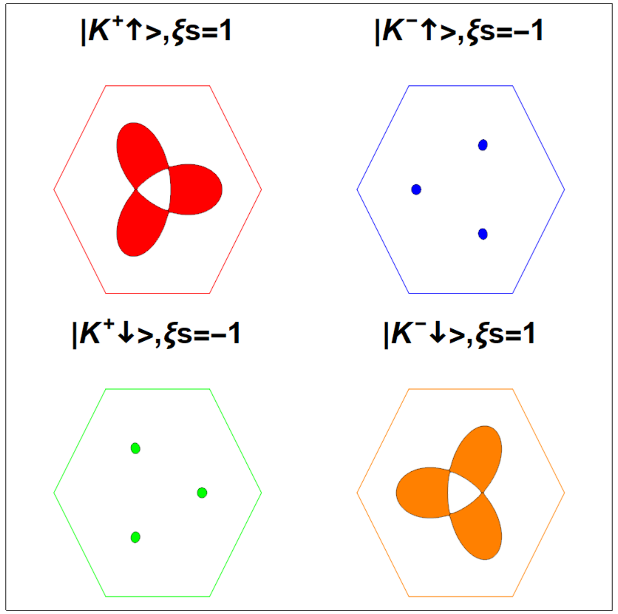

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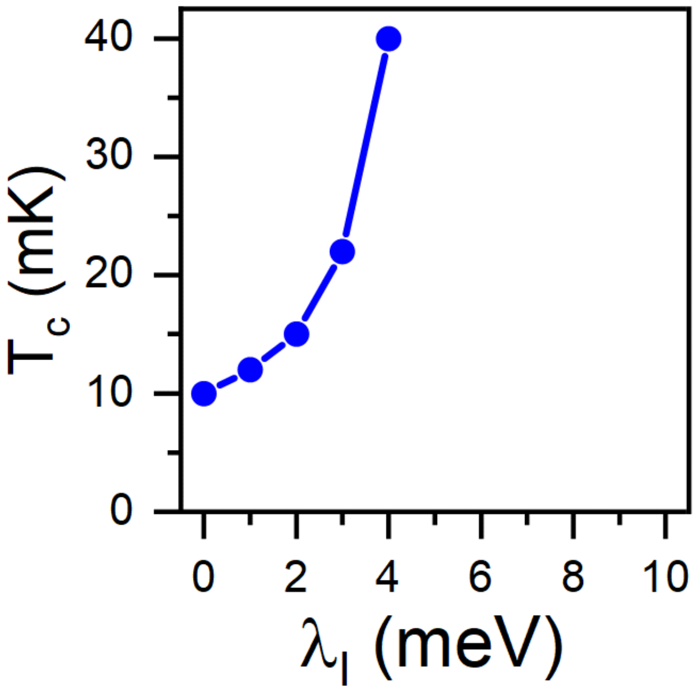

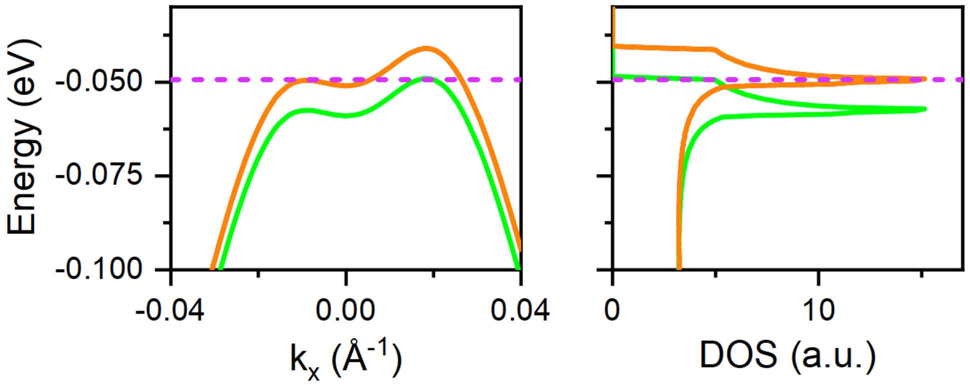

A Jimeno-Pozo, H Sainz-Cruz, T Cea, PA Pantaleón, and F Guinea. **Physical Review B 107 (16), L161106 (2023)**

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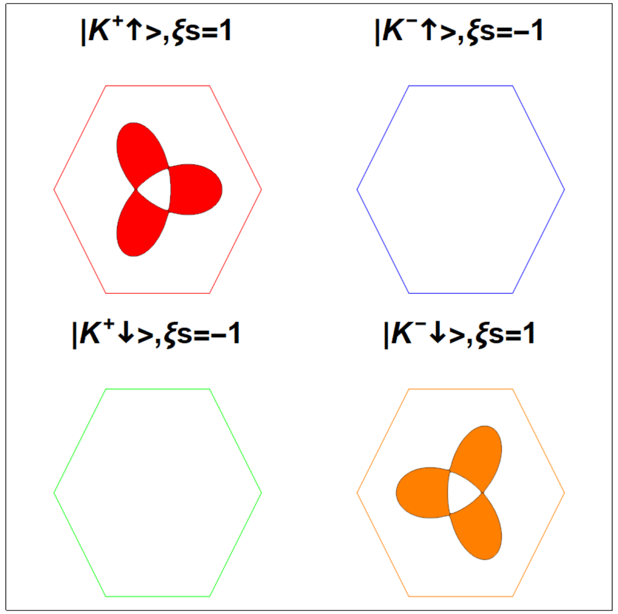

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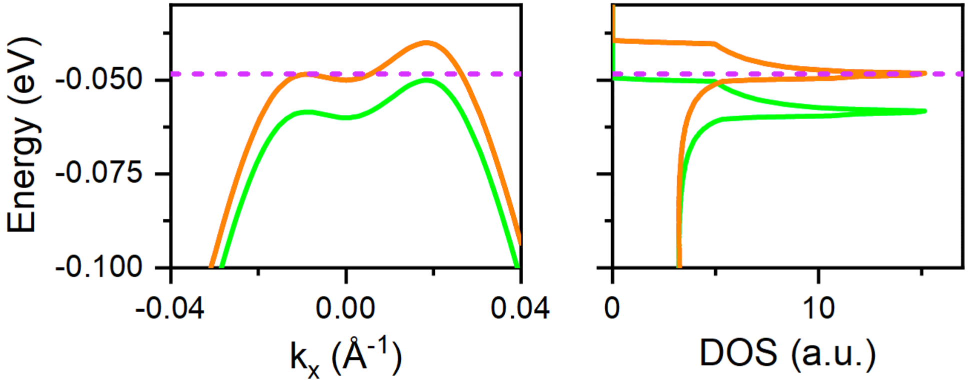
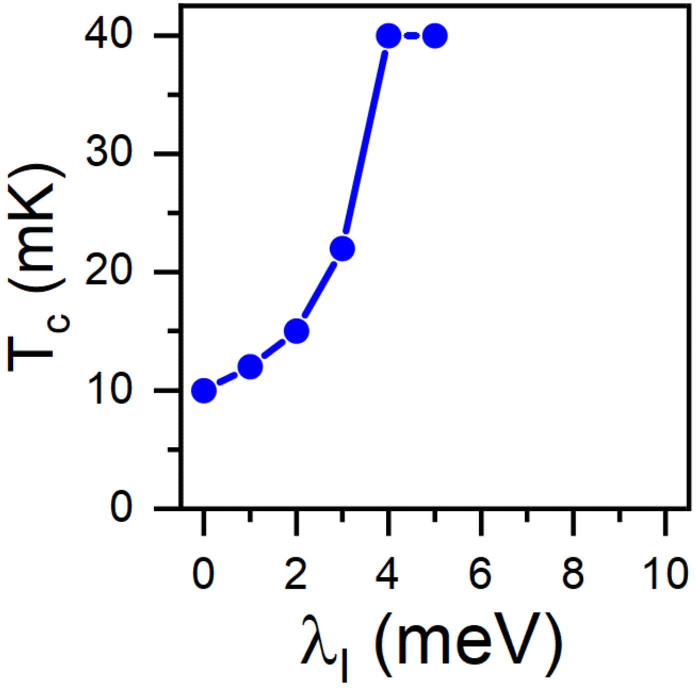
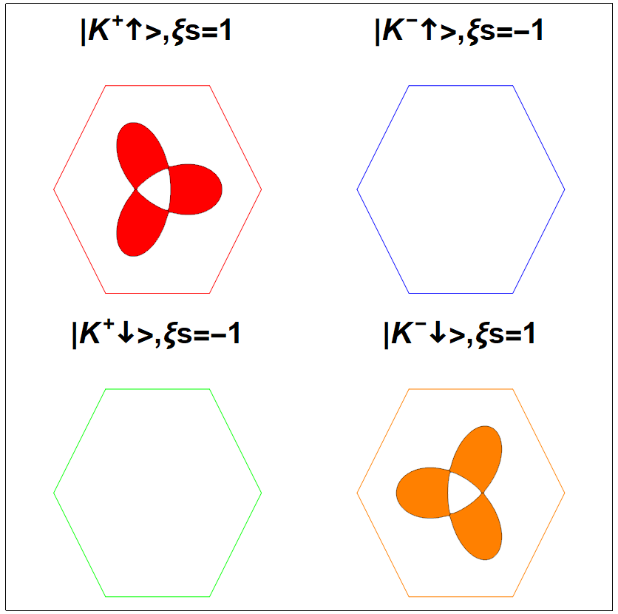
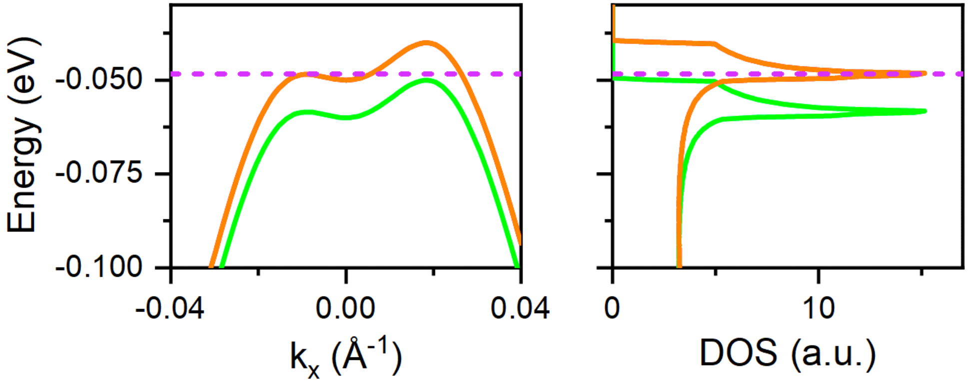




A Jimeno-Pozo, H Sainz-Cruz, T Cea, PA Pantaleón, and F Guinea. **Physical Review B 107 (16), L161106 (2023)**

Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene





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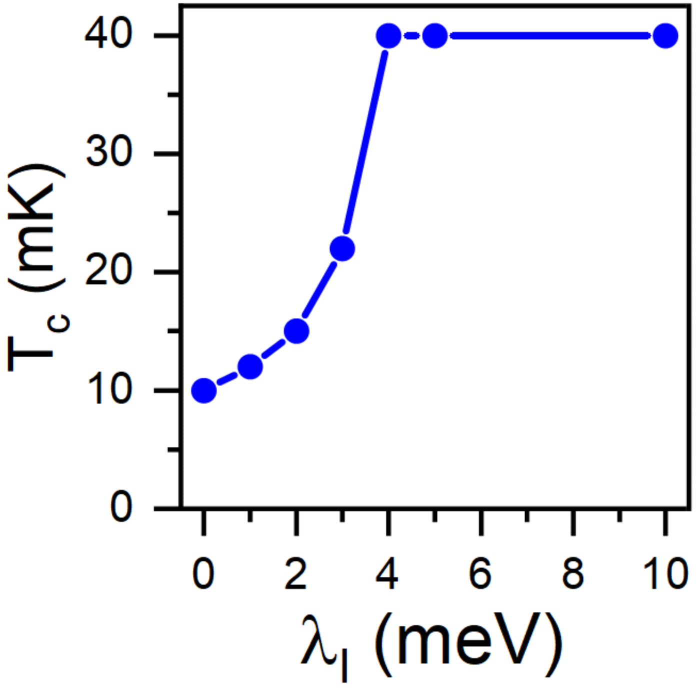
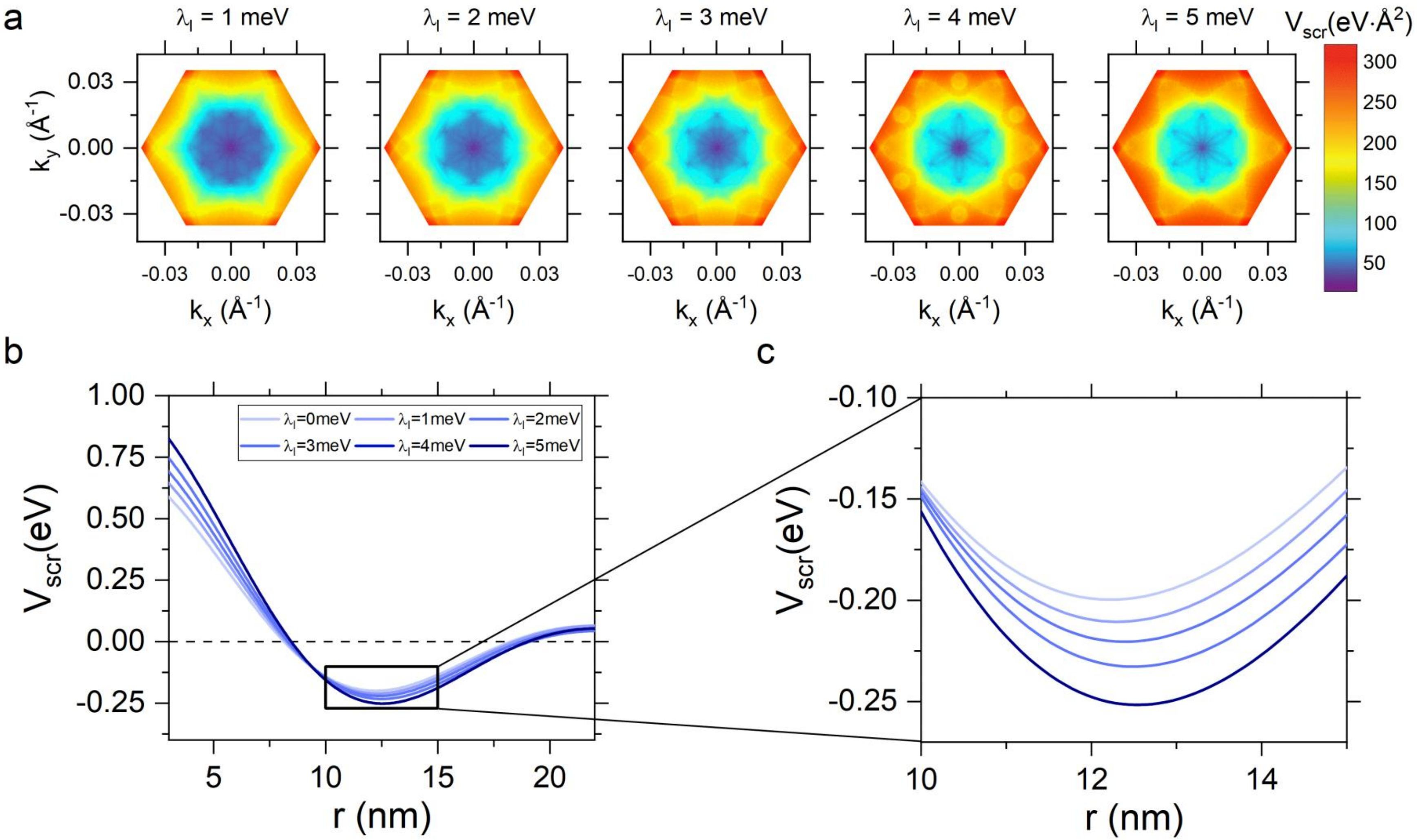


A Jimeno-Pozo, H Sainz-Cruz, T Cea, PA Pantaleón, and F Guinea. **Physical Review B 107 (16), L161106 (2023)**

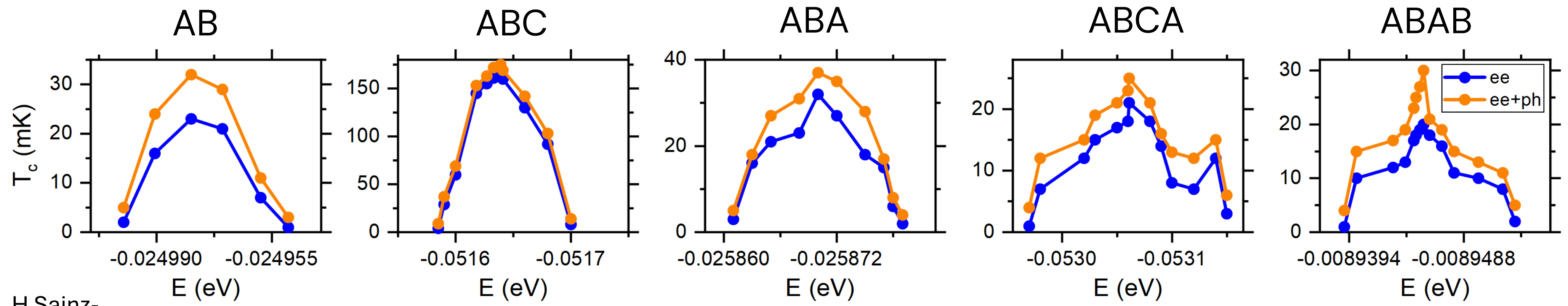
Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene



A Jimeno-Pozo, H Sainz-Cruz, T Cea, PA Pantaleón, and F Guinea. **Physical Review B 107 (16), L161106 (2023)**

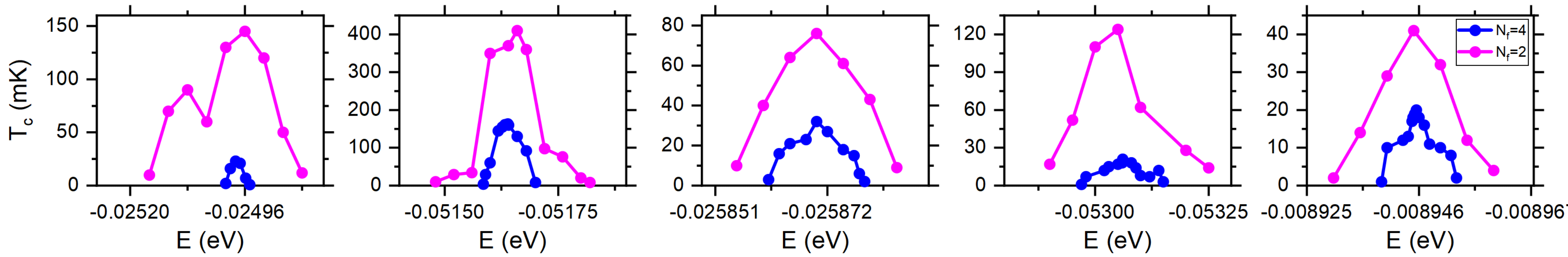
Charge fluctuations, phonons, and superconductivity in multilayer graphene

The effect of electron-phonon interaction



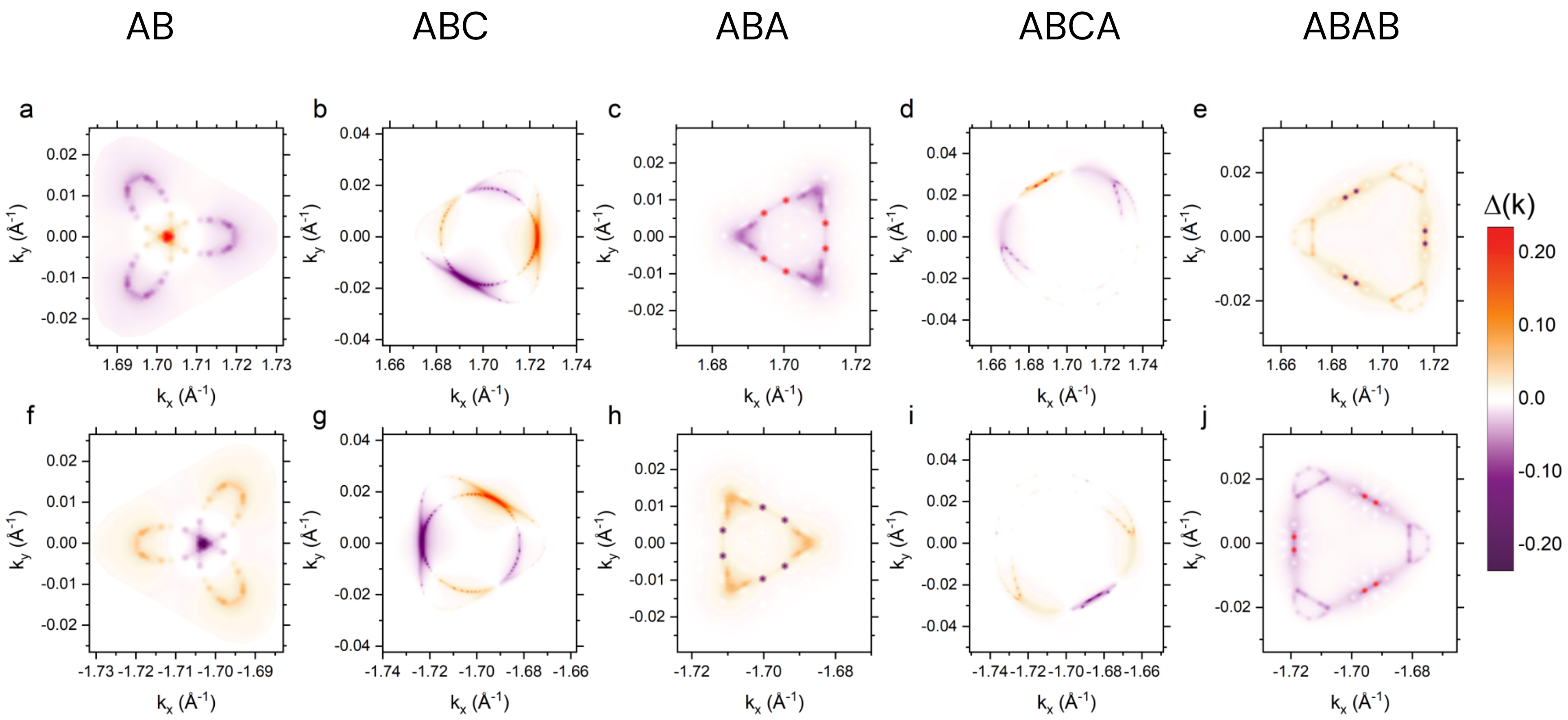
Z Li, X Kuang, A Jimeno-Pozo, H Sainz-Cruz, Z Zhan, S Yuan, and F Guinea.
Physical Review B 108 (4), 045404 (2023)

The effect of flavour degeneracy reduction



Charge fluctuations, phonons, and superconductivity in multilayer graphene

Order parameters in multilayer stacks



Z Li, X Kuang, A Jimeno-Pozo, H Sainz-Cruz, Z Zhan, S Yuan, and F Guinea.

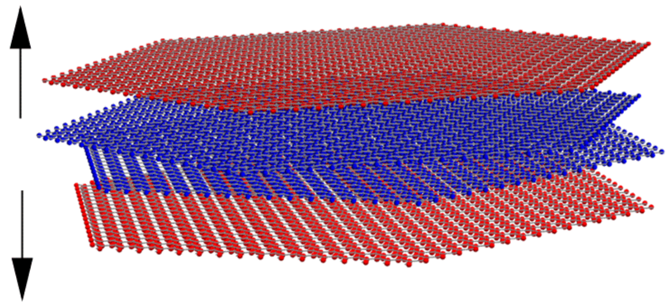
Physical Review B 108 (4), 045404 (2023)

Evolution of superconductivity in twisted graphene multilayers

Parametrized transition between TBG–TDBG band structures

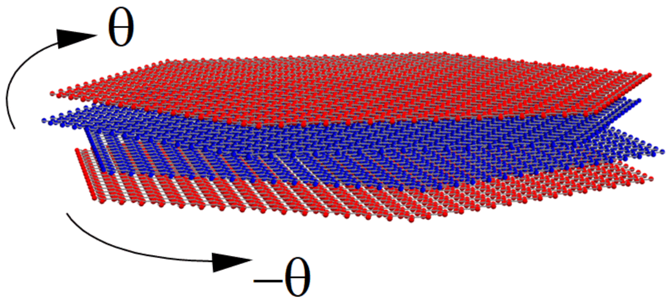
TBG + 2G

κ=0



TDBG

κ=1



$$\mathcal{H}_{TDBG}(\kappa) = \begin{pmatrix} \mathcal{H}_1(\mathbf{k}) & \kappa\mathcal{T}_1(\mathbf{k}) & 0 & 0 \\ \kappa\mathcal{T}_1^\dagger(\mathbf{k}) & \mathcal{H}_1(\mathbf{k}) & \mathcal{T}_\theta(\mathbf{r}) & 0 \\ 0 & \mathcal{T}_\theta^\dagger(\mathbf{r}) & \mathcal{H}_2(\mathbf{k}) & \kappa\mathcal{T}_2(\mathbf{k}) \\ 0 & 0 & \kappa\mathcal{T}_2^\dagger(\mathbf{k}) & \mathcal{H}_2(\mathbf{k}) \end{pmatrix}$$

M Long, A Jimeno-Pozo, H Sainz-Cruz, PA Pantaleón, and F Guinea. **PNAS 121 (32), e2405259121 (2024)**

Evolution of superconductivity in twisted graphene multilayers

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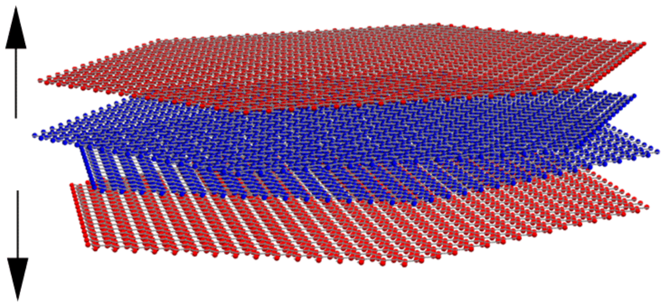
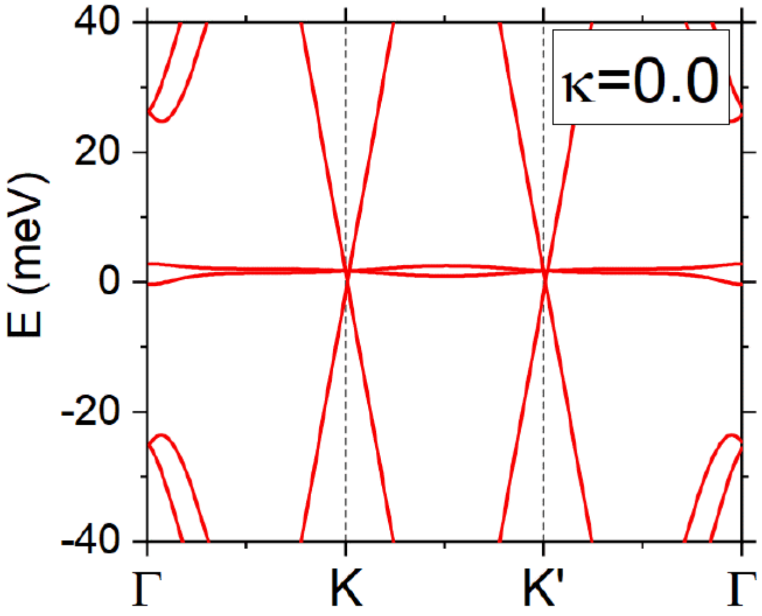
TBG + 2G

κ=0





$$\mathcal{H}_{TDBG}(\kappa) = \begin{pmatrix} \mathcal{H}_1(\mathbf{k}) & \kappa\mathcal{T}_1(\mathbf{k}) & 0 & 0 \\ \kappa\mathcal{T}_1^\dagger(\mathbf{k}) & \mathcal{H}_1(\mathbf{k}) & \mathcal{T}_\theta(\mathbf{r}) & 0 \\ 0 & \mathcal{T}_\theta^\dagger(\mathbf{r}) & \mathcal{H}_2(\mathbf{k}) & \kappa\mathcal{T}_2(\mathbf{k}) \\ 0 & 0 & \kappa\mathcal{T}_2^\dagger(\mathbf{k}) & \mathcal{H}_2(\mathbf{k}) \end{pmatrix}$$

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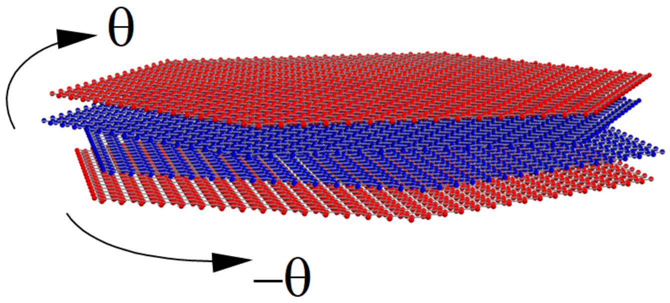
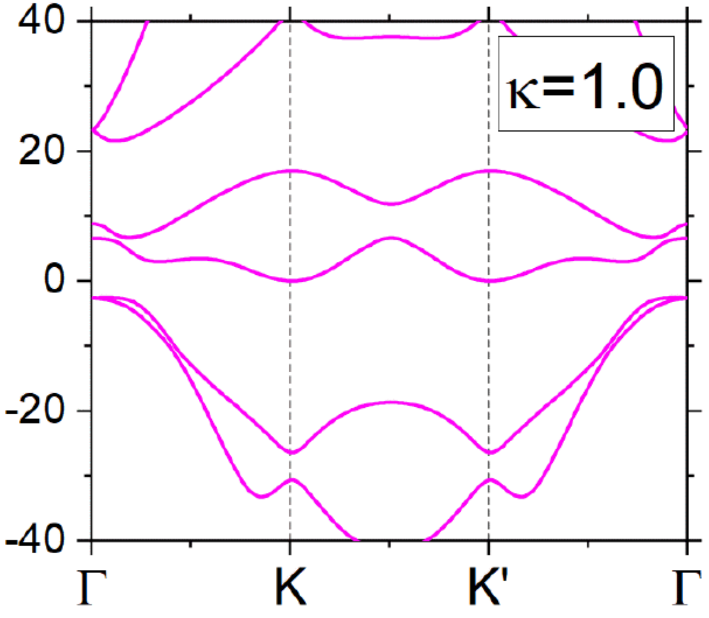
TDBG

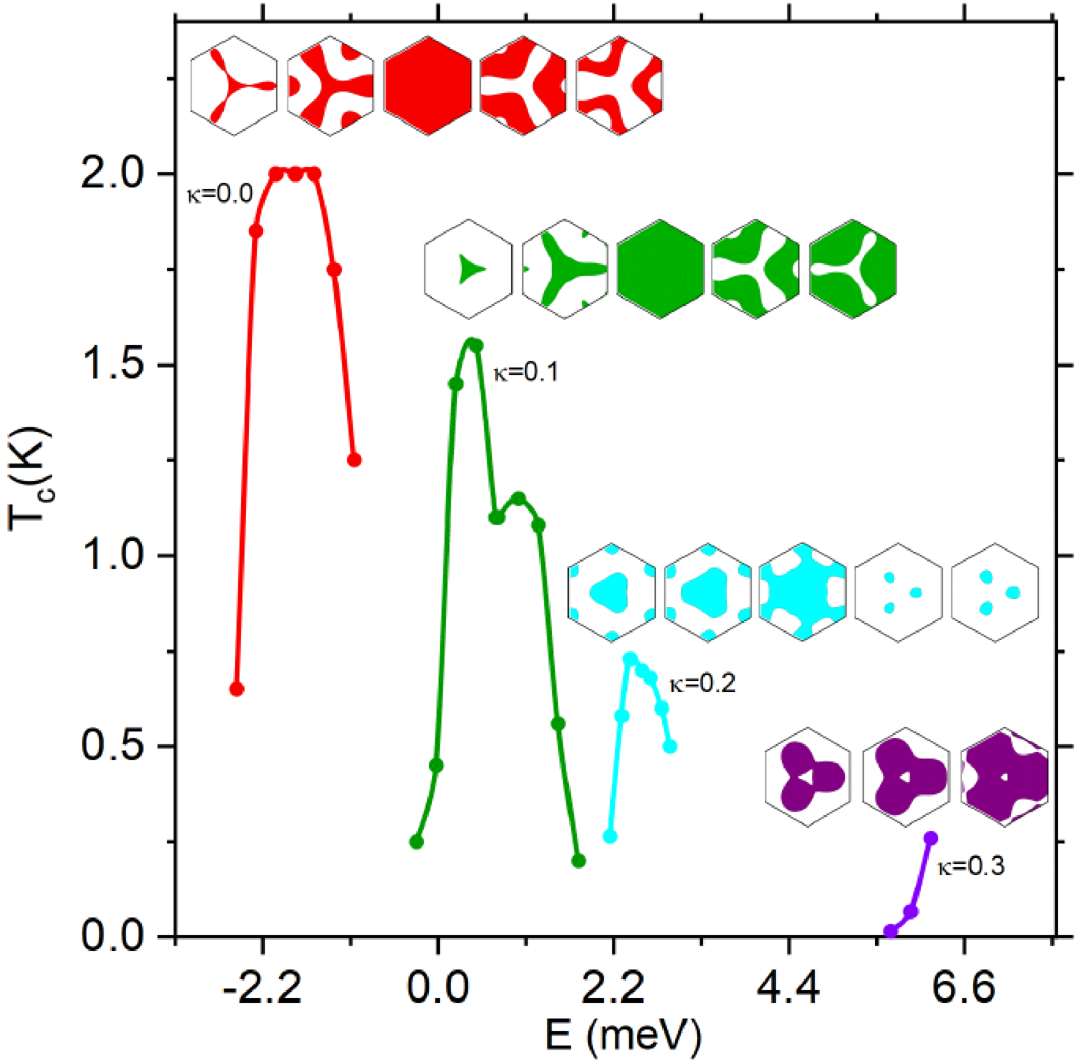
κ=1





Evolution of superconductivity in twisted graphene multilayers

Superconductivity along the parametrized transition



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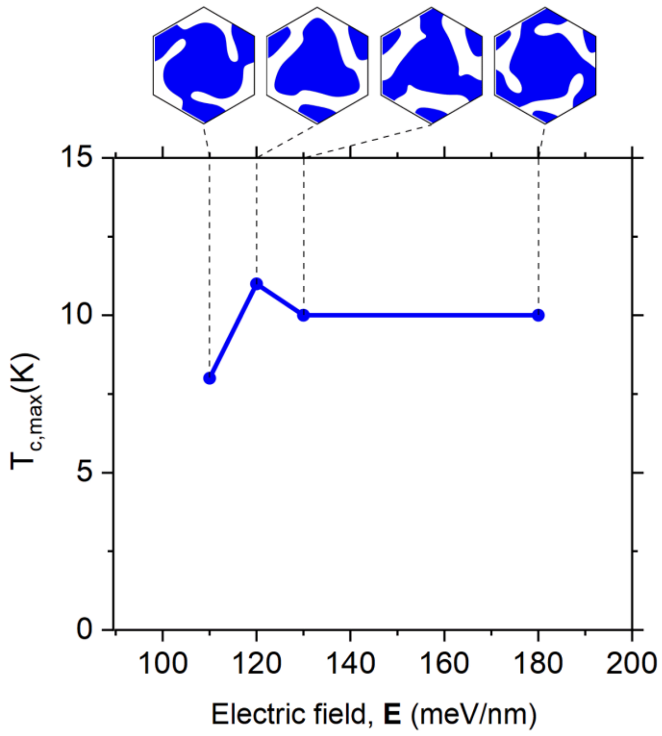
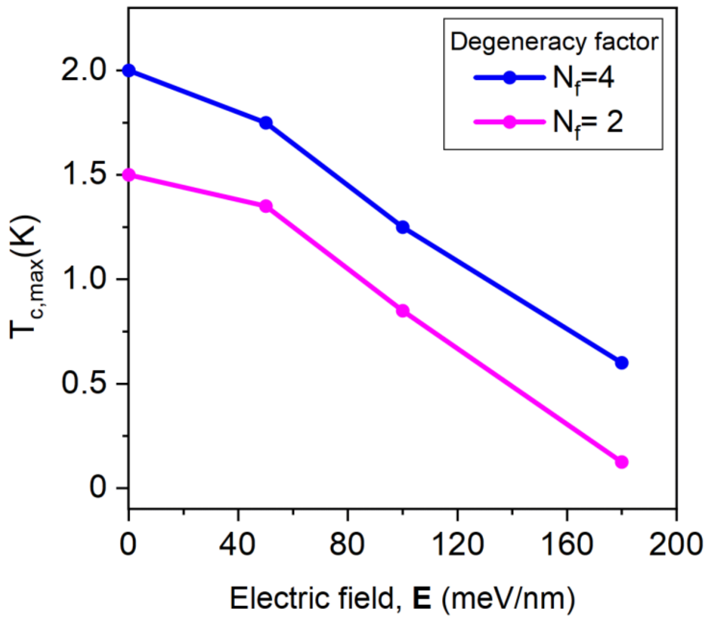
Evolution of superconductivity in twisted graphene multilayers

Superconductivity in the TDBG limit



Superconductivity in the TBG limit as a function of the external electric field



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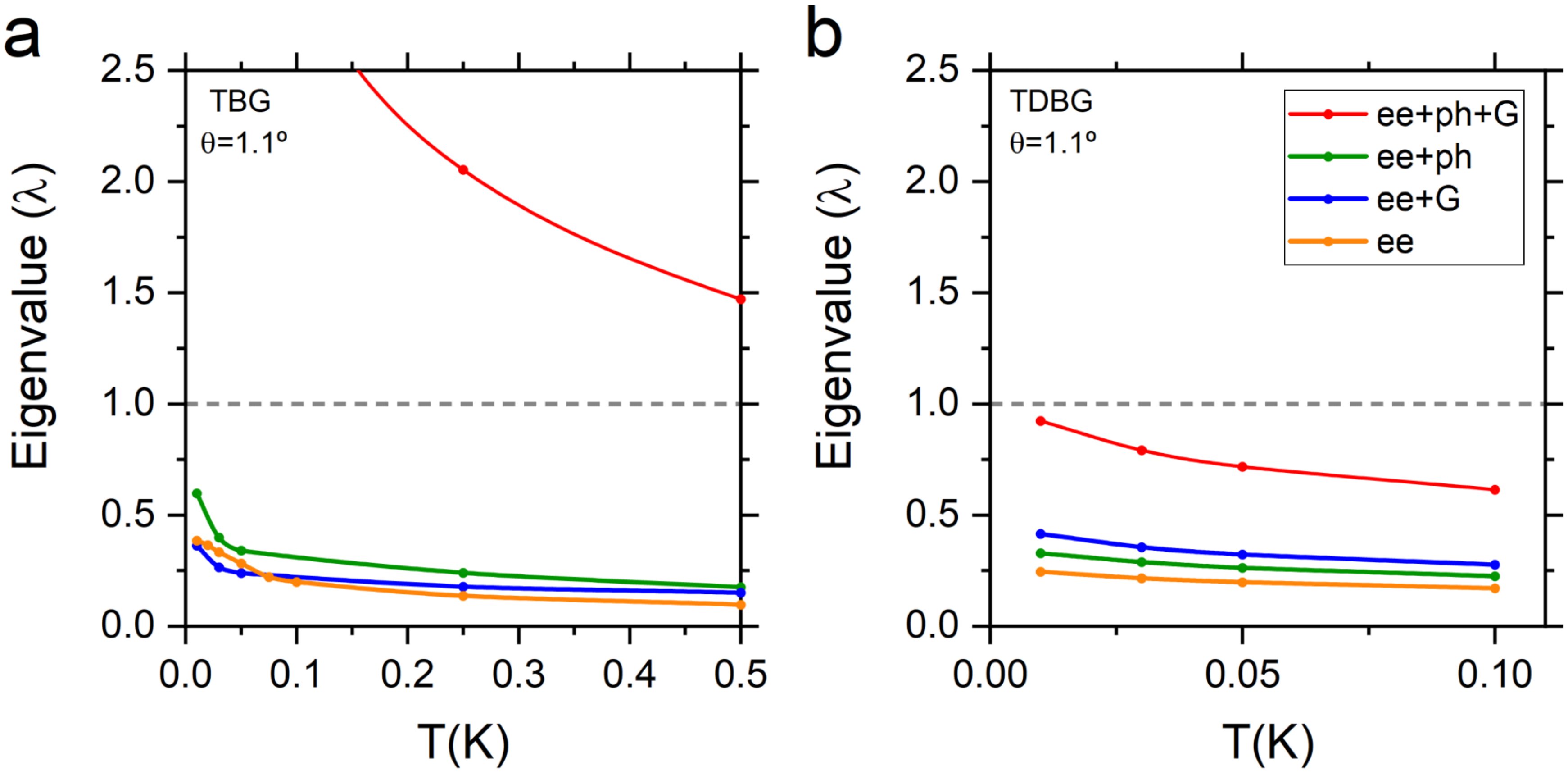
Evolution of superconductivity in twisted graphene multilayers

Contributions to the superconducting instability in twisted stacks



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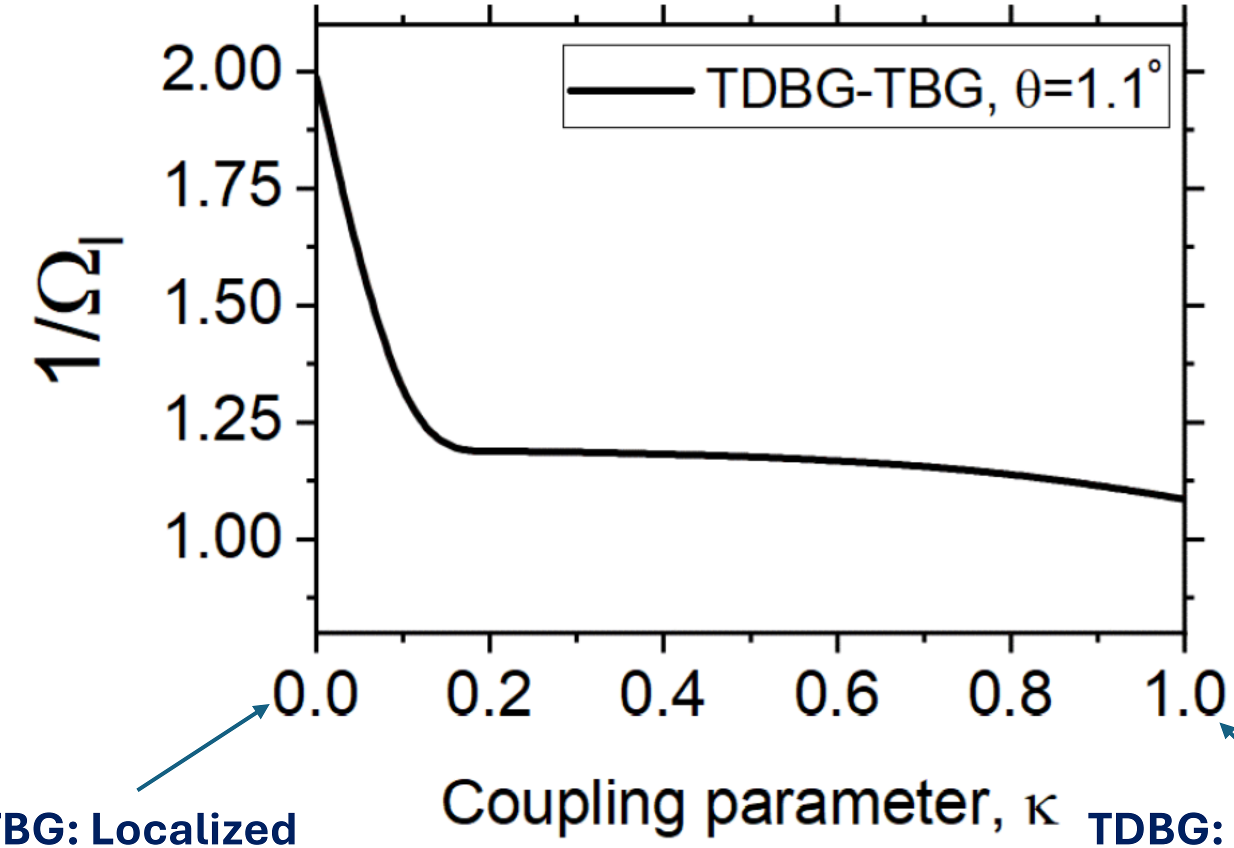
Evolution of superconductivity in twisted graphene multilayers

Quantum metric as a proxy for the superconducting instability in twisted stacks



TBG: Localized wavefunctions (in real space)

TDBG: Delocalized wavefunctions (in real space)

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Marzari-Vanderbilt cumulant

$$\Omega_{\mathrm{I}} = \frac{1}{(2\pi)^2} \int_{BZ} d\mathbf{k} \mathrm{Tr}\left[g(\mathbf{k})\right]$$

The Kohn-Luttinger-RPA framework: Acoustic phonons

Electron-phonon dressing (with longitudinal acoustic phonons)

$$V_{ph}(\mathbf{q}, \omega \to 0) = \frac{D^2}{\lambda + 2\mu}$$

Static limit of electron-phonon interaction

Dressed electron susceptibility

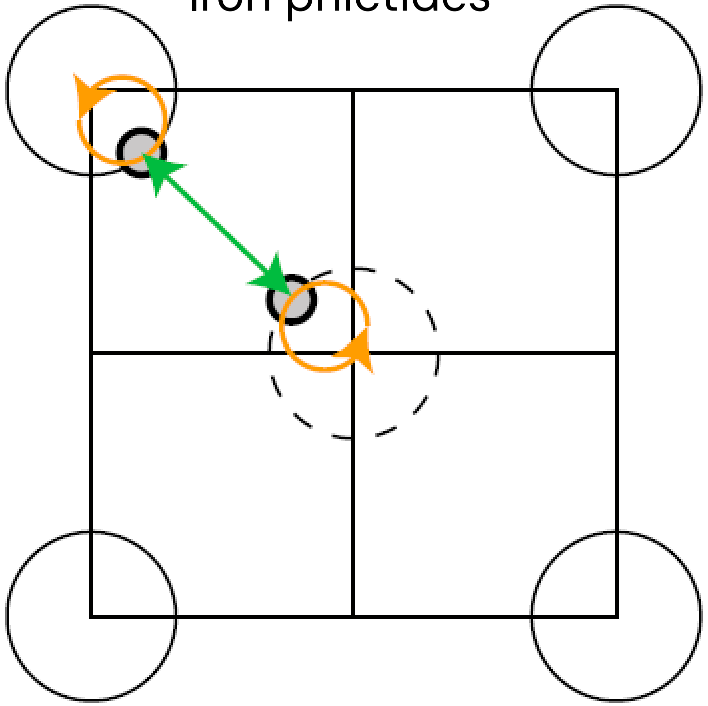
$$\Pi(\mathbf{q}) = \frac{\Pi_0(\mathbf{q})}{1 - V_{ph}(\mathbf{q})\Pi_0(\mathbf{q})}$$

Final screened Coulomb potential

$$V_{scr}(\mathbf{q}) = \frac{V_C(\mathbf{q})}{1 - V_C(\mathbf{q})\Pi(\mathbf{q})}$$

The Kohn-Luttinger mechanism – patches model

Iron pnictides



$$V\left(\mathbf{k}_i - \mathbf{k}_i\right) = g_1$$

$$V\left(\mathbf{k}_1 - \mathbf{k}_2\right) = g_2$$

The 'patches' model

S. Maiti and A. V. Chubukov. Superconductivity from repulsive interaction. AIP Conference Proceedings, 1550, 3–73 (2013).

$$\Gamma_{\mathbf{k},\mathbf{q}} = -V\left(\mathbf{k}-\mathbf{q}\right)\log\left(\beta\Lambda\right)$$

The Kohn-Luttinger mechanism – patches model

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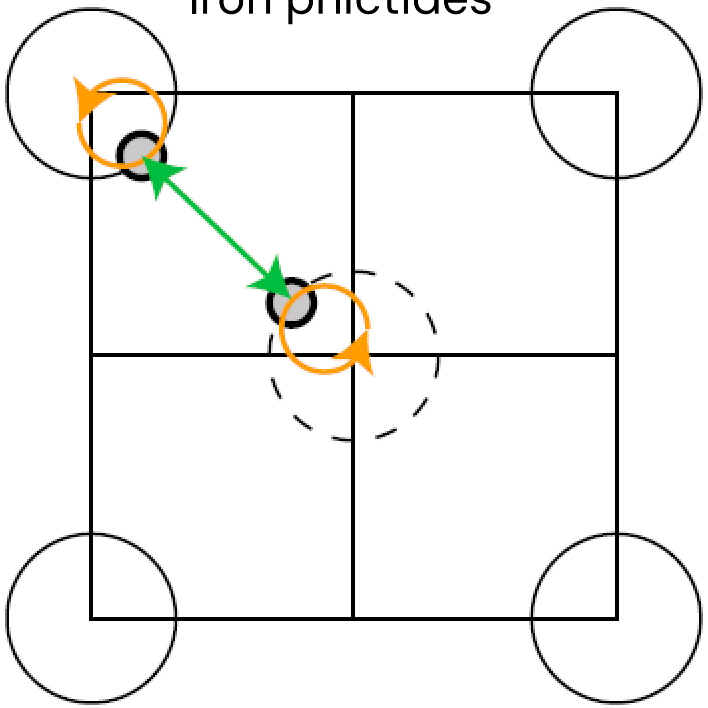

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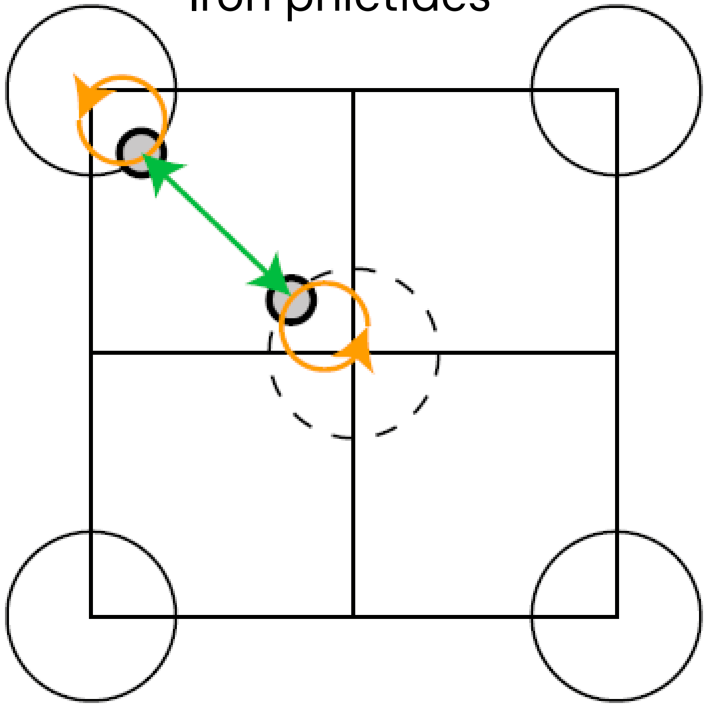
The superconducting kernel

$$\Gamma_{\mathbf{k},\mathbf{q}} = -\begin{pmatrix} g_1 & g_2 \\ g_2 & g_1 \end{pmatrix}$$

The Kohn-Luttinger mechanism – patches model

Iron pnictides



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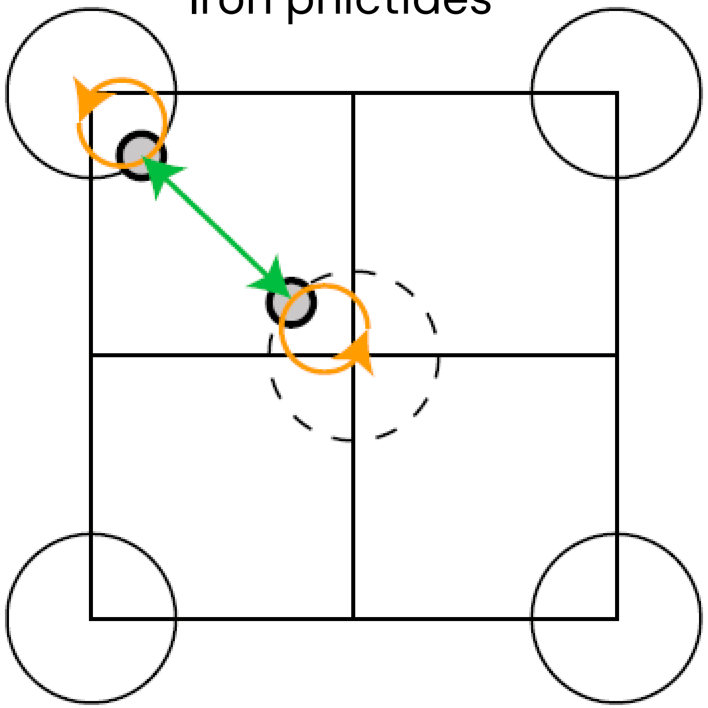
$$\Gamma_{\mathbf{k},\mathbf{q}} = -\begin{pmatrix} g_1+g_2 & 0 \\ 0 & g_1-g_2 \end{pmatrix}$$

The Kohn-Luttinger mechanism – patches model

Iron pnictides



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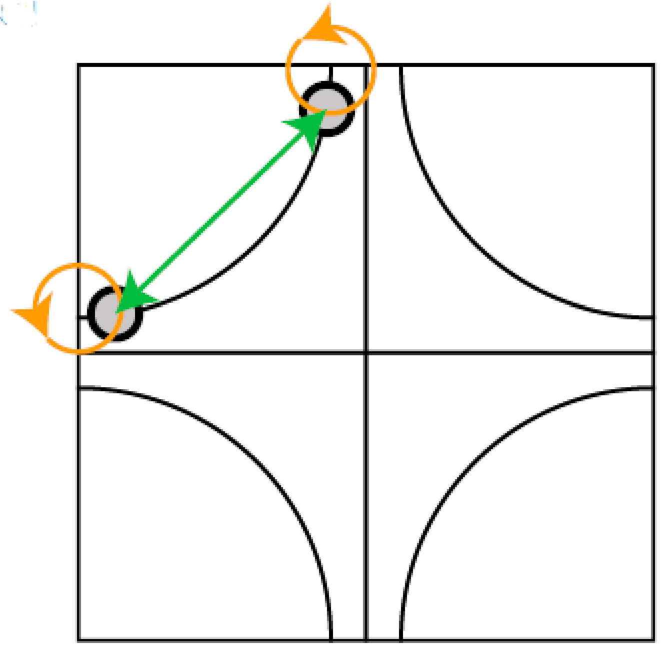
$g_2 > g_1 \longrightarrow$ Attraction!

The Kohn-Luttinger mechanism – patches model

Cuprates



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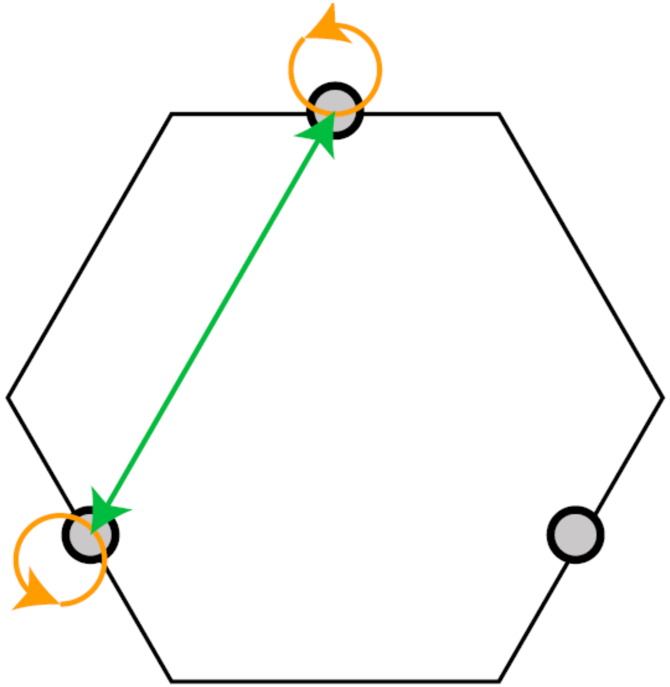
The Kohn-Luttinger mechanism – patches model

Graphene



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The superconducting kernel

$$\Gamma_{\mathbf{k},\mathbf{q}} = \begin{pmatrix} g_1 & g_2 & g_2 \\ g_2 & g_1 & g_2 \\ g_2 & g_2 & g_1 \end{pmatrix} \longrightarrow \begin{aligned} \lambda_a &= \lambda_b = g_1 - g_2 \\ \lambda_c &= g_1 + 2g_2 \end{aligned}$$

$g_2 > g_1 \longrightarrow$ Attraction!