

CURRICULUM VITAE OF TOMMASO CEA

Personal details

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Main research topics

-Twisted graphene bilayer and moiré Physics:

The recent discovery of superconductivity and insulating states at integer filling in small-angle twisted bilayer graphene by the group of Pablo Jarillo-Herrero in 2018 generated a renewed interest in the study of the moiré materials. The exotic phase diagrams observed in many moiré systems make them a paradigmatic platform for studying strongly correlated electronic behaviors, as well as the role of the electron-phonon coupling. Dr. Cea investigated theoretically many aspects of the twisted bilayer graphene, as the role of the Coulomb repulsion, the effects of the heterostrain and/or the substrate, the mechanism at the origin of superconductivity, etc.

-Elastic properties of atomic membranes:

Dr. Cea investigated the theory of the elastic membranes applied to physical systems with atomic thickness, focusing mainly on the cases of hexagonal boron nitride (hBN) and graphene. In particular, for the case of hBN, Dr. Cea studied the role of the strain in the piezoelectric effect, providing the theoretical support for the experimental research lead by the group of KS Novoselov in the University of Manchester (P. Ares et al, *Advanced Materials* 2020). This work has shown that localized regions with large strain in a membrane of hBN can generate a sizable

electric field, making hBN able to convert mechanical into electric energy.

-Collective modes and dynamical features in superconductors:

The loss of the charge conservation in a superconductor comes along with the breaking of the continuum U(1) symmetry, leading to the presence of two collective modes: the Goldstone mode describing the phase fluctuations of the superconducting order parameter, and the massive mode associated to its amplitude fluctuations, also called the Schmid or Higgs mode. During his master and PhD studies, Dr. Cea investigated the dynamics of these two modes and the possibility of tracing experimentally their signatures by means of spectroscopic probes. Dr. Cea showed that these modes are very elusive, as they weakly couple to any external probe. At the same time, Dr. Cea studied the systems and the experimental conditions in which the phase and/or the amplitude mode can become optically active and consequently leave a spectroscopic signature. The analysis led by Dr. Cea in this field refers to peculiar experimental techniques exploiting the light-matter interaction, in particular: the Raman spectroscopy and the third harmonic generation by means of the THz pump-probe excitation protocol.

Keywords

Quantum Field Theory at finite temperature, Many body techniques, Linear response theory, Strongly correlated electrons, Superconductivity, Bloch band theory, 2D Materials, Mean field techniques, Numerical techniques

Education

Dr. Cea graduated **2012** at the Università di Roma La Sapienza, with full marks and honors, under the supervision of Prof. Claudio Castellani, with the master thesis: “Strongly disordered superconductors in proximity of the superconductor-insulator transition”.

Dr. Cea spent the academic year **2012/2013** at the International School for Advanced Studies, SISSA, in Trieste, where he got a three years PhD scholarship.

In **2013** Dr. Cea got a three years PhD scholarship at the Università di Roma La Sapienza, in Rome, where he moved and obtained the PhD with full marks and honors in February, **2017**, under the supervision of Profs. Claudio Castellani and Lara Benfatto, with the PhD thesis: “Unconventional dynamics and spectroscopy in superconductors”. During the doctoral studies Dr. Cea studied theoretically the emergent properties related to the quantum dynamics and spectroscopy in superconducting systems.

In **2017** Dr. Cea was a postdoctoral researcher at the Università di Roma La Sapienza, under the supervision of Prof. Francesco Mauri, with the project: “Studio teorico dei modi di membrana e delle proprietà termodinamiche associate nel grafene”, funded by the European Graphene Flagship.

From September **2017** to June **2020** Dr. Cea was a postdoctoral researcher at the Instituto Madrilenos des Estudios Avanzados IMDEA Nanociencia, in Madrid, Spain, under the supervision of Prof. Francisco Guinea, with the project: “Emerging properties of new materials”, funded by the European Graphene Flagship.

From July **2020** to March 2021 Dr. was a postdoctoral researcher at the Instituto de Ciencia de Materiales de Madrid ICM, CSIS, in Madrid, Spain, under the supervision of Prof. Pilar Lopez Sancho, with the project: “Emerging properties of new materials”, in collaboration with Prof. Francisco Guinea.

At present Dr. Cea is a postdoctoral researcher at the Instituto Madrilenos des Estudios Avanzados IMDEA Nanociencia, in Madrid, Spain.

Bibliometric indices

H index: 14 (Scopus), 16 (Google Scholar)

Citations: 538 (Scopus), 802 (Google Scholar)

Grants and awards

Team projects

- European Graphene Flagship, Core 2, Grant No. 785219. Project: *“Graphene based technologies: development of numerical modeling methods”*
- European Graphene Flagship, Core 3, Grant No. 881603. Project: *“Graphene based technologies: development of numerical modeling methods”*
- NEMAT2D-CM. Project: *“New bi-dimensional materials: characterizations, properties and applications”*

Awards

- *“Junior Presentation Honorable Mention”* at the conference LEES 2021
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Publications

1. T. Cea, *“Superconductivity induced by the intervalley Coulomb scattering in a few layers of graphene”*, Physical Review B, **107** (4), L041111 (2023)
2. P. A. Pantaleon, A. Jimeno-Pozo, H. Sainz-Cruz, T. Cea, V. T. Phong, F. Guinea, *“Superconductivity and correlated phases in bilayer, trilayer graphene and related structures”*, arXiv:2211.02880 (2022), accepted in Nature Reviews Physics
3. L. Benfatto, C. Castellani, T. Cea, *“Comment on: Calculation of an Enhanced A_{1g} Symmetry Mode induced by Higgs Oscillations in the*

Raman Spectrum of High-Temperature Cuprate Superconductors”, Physical Review Letters 129 (19), 199701 (2022)

4. F. Giorgianni, M. Udina, T. Cea, E. Paris, M. Caputo, M. Radovic, L. Boie, J. Sakai, C. W, Schneider, S. L. Johnson, “*Terahertz displacive excitation of a coherent Raman-active phonon in V_2O_3* ”, Communication Physics **5** (1), 103 (2022)
5. V. Crépel, T. Cea, L. Fu, F. Guinea, “*Unconventional superconductivity due to interband polarization*”, Physical Review B, **105** (9), 094506 (2022). **Editor’s Suggestion**
6. M. Udina, J. Fiore, T. Cea, C. Castellani, G. Seibold, L. Benfatto, “*THz non-linear optical response in cuprates: predominance of the BCS response over the Higgs mode*”, Faraday Discuss. (2022)
7. T. Cea, P. A. Pantaleon, V. T. Phong, F. Guinea, “*Superconductivity from Repulsive Interactions in Rhombohedral Trilayer Graphene: a Kohn-Luttinger-Like Mechanism*”, Physical Review B, **105**, 075432 (2022)
8. A. Jimeno-Pozo, H. Sainz-Cruz, T. Cea, P. A. Pantaleon, F. Guinea, “*Superconductivity from electronic interactions and spin-orbit enhancement in bilayer and trilayer graphene*”, arXiv:2210.02915 (2022)
9. T. Cea, P. A. Pantaleon, N. R. Walet, F. Guinea, “*Electrostatic interactions in twisted bilayer graphene*”, Nano Materials Science, 2589-9651 (2021)
10. V. T. Phong, P. A. Pantaleon, T. Cea, F. Guinea, “*Band structure and superconductivity in twisted trilayer graphene*”, Physical Review B, **104** (12), 121116 (2021)
11. H. Sainz-Cruz, T. Cea, P. A. Pantaleon, F. Guinea, “*High transmission in twisted bilayer graphene with angle disorder*”, Physical Review B, **104** (7), 075144 (2021)
12. T. Cea, F. Guinea, “*Coulomb interactions, phonons, and superconductivity in twisted bilayer graphene*”, Proceedings of the

National Academy of Sciences of the United States of America, **118** (32) e2107874118 (2021)

13. P. A. Pantaleon, T. Cea, R. Brown, N. R. Walet, F. Guinea, “*Narrow bands and electrostatic interactions in graphene stacks*”, *2D Materials*, **8** (4), 044006 (2021)
14. L. Chirulli, T. Cea, F. Giazotto, “*Impact of electrostatic fields in layered crystalline BCS superconductors*”, *Physical Review Research*, **3** (2), 023135 (2021)
15. F. Meslpe, A. Missaoui, T. Cea, L. Huder, G. Trambly de Laissaudière, F. Guinea, C. Chapelier, V. T. Renard, “*Heterostrain rules the flat-bands in magic-angle twisted bilayer graphene*”, *Physical Review Letters*, **127** (12), 126405 (2021)
16. T. Cea, P. A. Pantaleon, F. Guinea, “*Band structure of twisted bilayer graphene on hexagonal boron nitride*”, *Phys. Rev. B* **102** (15), 155136 (2020)
17. T. Cea, M. Ruiz-García, L. L. Bonilla, F. Guinea, “*Numerical study of the rippling instability driven by electron-phonon coupling in graphene*”, *Phys. Rev. B* **101** (23), 235428 (2020)
18. T. Cea, F. Guinea, “*Band structure and insulating states driven by the Coulomb interaction in twisted bilayer graphene*”, *Phys. Rev. B* **102** (4), 045107 (2020)
19. P. Ares, T. Cea, M. Holwill, Y. B. Wang, R. Roldán, F. Guinea, D. V. Andreeva, L. Fumagalli, K. S. Novoselov, C. R. Woods, “*Piezoelectricity in monolayer hexagonal boron nitride*”, *Advanced Materials* **32** (1), 1905504 (2020)
20. U. Aseginolaza, T. Cea, R. Bianco, L. Monacelli, M. Calandra, A. Bergara, F. Mauri, I. Errea, “*Quadratic flexural acoustic phonons and in-plane sound propagation in graphene*”, arXiv:2005.12047 (2020)
21. T. Cea, N. R. Walet, F. Guinea, “*Twists and the electronic structure of graphitic materials*”, *Nano Letters* **19** (12), 8683-8689 (2019)

22. T. Cea, N. R. Walet, F. Guinea, “*Electronic bandwidth and pinning of Fermi energy to van Hove singularities in twisted bilayer graphene: a self consistent approach*”, Phys. Rev. B **100** (20), 205113 (2019)
23. F. Giorgianni, U. Puc, M. Jazbinsek, T. Cea, M. J. Koo, J. H. Han, O. P. Kown, C. Vicario, “*Supercontinuum generation in OHQ-N2S organic crystal driven by intense terahertz fields*”, Optics Letters **44** (19), 4881-4884 (2019)
24. M. Udina, T. Cea, L. Benfatto, “*Theory of coherent oscillations detection in THz pump-probe spectroscopy: from phonons to electronic collective modes*”, Phys. Rev. B **100** (16), 165131 (2019)
25. F. Giorgianni, T. Cea, C. Vicario, C. P. Hauri, W. K. Withanage, X. Xi, L. Benfatto, “*Leggett mode controlled by light*”, Nature Physics **15** (4), 341-346 (2019)
26. T. Cea, P. Barone, C. Castellani, L. Benfatto, “*Polarization dependence of the third-harmonic generation in multiband superconductors*”, Phys. Rev. B **97** (9) 094516 (2018)
27. R. Grasset, T. Cea, Y. Gallais, M. Cazayous, A. Sacuto, L. Cario, L. Benfatto, M.A. Méasson, “*Higgs mode radiance and charge-density-wave order in 2H-NbSe₂*”, Phys. Rev. B **97** (9) 094502 (2018)
28. U. Pracht, T. Cea, N. Bachar, G. Deutscher, E. Färber, M. Dressel, M. Scheffler, C. Castellani, A. M. Garcia-Garcia, L. Benfatto, “*Optical signatures of the superconducting Goldstone mode in granular aluminum: experiments and theory*”, Phys. Rev. B. **96** (9) 094514 (2017)
29. T. Cea, L. Benfatto, “*Signature of the Leggett mode in the A_{1g} Raman response: From MgB₂ to iron-based superconductors*”, Phys. Rev. B **94** (6), 064512 (2016)
30. T. Cea, L. Benfatto, C. Castellani, “*Non-linear optical effects and third-harmonic generation in superconductors: Cooper-pairs vs Higgs mode contribution*” Phys. Rev. B **93** (18), 180507(R) (2016)

31. T. Cea, C. Castellani, G. Seibold, L. Benfatto, “*Nonrelativistic dynamics of the amplitude (Higgs) mode in superconductors*” Phys. Rev. Lett. **115** (15), 157002 (2015)
 32. T. Cea, L. Benfatto, “*Nature and Raman signatures of the Higgs amplitude mode in the coexisting superconducting and charge-density-wave state*” Phys. Rev. B **90** (22), 224515 (2014)
 33. T. Cea, D. Bucheli, G. Seibold, L. Benfatto, C. Castellani, “*Optical excitation of phase modes in strongly disordered superconductors*” Phys. Rev. B **89** (17), 174506 (2014)
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Conferences and contributions:

- “Novel Electronic Properties of 2D Materials”, to be held in San Sebastian, Spain on July 11-15th 2022. **Invited talk**
- Theory seminar at Università di Roma La Sapienza (Italy), 14/12/2021. **Invited talk**: “Coulomb interaction, correlations and superconductivity in twisted bilayer graphene”
- Seminar at IMDEA Nanoscience, Madrid (Spain), 16/11/2021. **Invited talk**: “Coulomb interaction, correlations and superconductivity in twisted bilayer graphene”
- “LEES 2020 - Low-energy electrodynamics in solids”, online, 28/06/2021-01/07/2021. **Invited talk**: “Coulomb interaction, phonons, and superconductivity in twisted bilayer graphene”
- “APS March Meeting”, online, 15/03/2021-19/03/2021. Oral presentation: “Plasmons, phonons and superconductivity in twisted bilayer graphene”
- Theory Seminars at the Department of Physics and Astronomy, of the University of Manchester (UK), 01/07/2020. **Invited talk**: “Band structure and insulating states driven by the Coulomb interaction in twisted bilayer graphene”

- “CMD2020GEFES”, Madrid (Spain), 31/08/2020-04/09/2020. Oral presentation: “Band structure and insulating states driven by the Coulomb interaction in twisted bilayer graphene”
- Summer school: “Driving the Road Towards Room Temperature Superconductivity with Electronic Interactions”, Miraflores de La Sierra, Madrid (Spain), 08/09/2019-13/09/2019. Poster+oral presentation: “Twists and the Electronic Structure of Graphitic Materials”
- “Italian National Conference on the Physics of Matter”, Trieste (Italy) 01/10/2017-06/10/2017. Oral presentation: “Thz Pump+Probe spectroscopy in NbN superconductor”
- “Spectroscopies in Novel Superconductors”, Ludwigsburg, Stuttgart (Germany) 19/06/2016-24/06/2016. Poster: “Nature and Raman signatures of the Higgs amplitude mode in the coexisting superconducting and charge-density-wave state”
- “Ugo Fano-Symposium and gold medal ceremony”, Rome (Italy) 17/12/2015-18/12/2015. Oral presentation: "Nature and Raman signatures of the Higgs amplitude mode in the coexisting superconducting and charge-density-wave state”
- “Probing and Understanding Exotic Superconductors and Superfluids”, Trieste (Italy) 27/10/2014-31/10/2014. Oral presentation: "Nature and Raman signatures of the Higgs amplitude mode in the coexisting superconducting and charge-density-wave state”
- “Superconductivity and Functional Oxides”, Rome (Italy) 24/09/2014-26/09/2014. Poster: “Optical excitation of phase modes in strongly disordered superconductors”