SEDUTA DEL COLLEGIO DEI DOCENTI DEL 35° CICLO

28 Ottobre 2022

Il Collegio dei Docenti del 35° ciclo del Dottorato di Ricerca in Scienze Fisiche e Chimiche dell'Università di Palermo, regolarmente convocato in modalità telematica dal Coordinatore Prof. Marco Cannas, si riunisce sulla piattaforma Microsoft Teams alle ore 14,30 del giorno 28.10.2022 con il seguente ordine del giorno:

1) Adempimenti dottorandi per l'esame finale di conseguimento del titolo di dottore di ricerca

2) Varie ed eventuali

Presiede il Coordinatore Prof. Marco Cannas, svolge le funzioni di segretario il Prof. Giacomo Massimo Palma

Sono presenti

M. Cannas, A. Pettignano, B. Pignataro, C. Fazio, F. Reale, F. Messina, F. Ciccarello, F. Ferrante, G.M. Palma, A. Napoli, G. Cusumano, S. Miccichè, R. Passante, , G. Micela, R. Iaria, D. Duca, A. Martorana.

Sono assenti giustificati

G. Lazzara, S. Milioto, D. Valenti, S. Agnello.

Il Presidente, prof. M. Cannas, verificato il numero legale, dichiara aperta la seduta e passa a discutere l'unico punto all'ordine del giorno:

1) Adempimenti dottorandi per l'esame finale di conseguimento del titolo di dottore di ricerca

Il presidente illustra la circolare ricevuta dall'Ufficio Dottorati sugli adempimenti necessari per il conseguimento del titolo di dottore di ricerca per gli allievi del 35° ciclo. In accordo al cronoprogramma. il presente collegio dei docenti dovrà occuparsi dei seguenti punti:

- formulazione della relazione del dottorando sulle attività svolte

- formulazione del parere per il titolo di Doctor Europaeus

- proposta di formazione delle commissioni giudicatrici

- nomina dei valutatori esterni

per gli allievi che terminano il loro dottorato il 31/10/2022 e intendono sostenere l'esame finale in una delle prime due sessioni:

15 novembre - 19 dicembre 2022 (consegna tesi 2 Novembre 2022)

15 febbraio - 15 marzo 2023 (consegna tesi 15 Novembre 2022).

Marco Bertini (I sessione: 15 novembre - 19 dicembre 2022)
Il collegio prende visione della relazione del dottorando (allegato 1 al verbale).

Propone che la commissione giudicatrice sia composta da:
Membri effettivi
1) Giuseppe Lazzara, Università degli Studi di Palermo
2) Francesco Arena, Università di Messina
3) Cristina Giordano, Queen Mary University of London, Gran Bretagna
Membro supplente
Maria Luisa Saladino, Università degli Studi di Palermo

Nomina i valutatori esterni:
1) Carlo Adamo Ecole Nationale Superieure de Chimie de Paris (Francia)
2) Dmitry Murzin, Abo Akademi University (Finlandia)

Dario Alexander Chisholm (II sessione: 15 febbraio - 15 marzo 2023)
Il collegio prende visione della relazione del dottorando (allegato 2 al verbale).

Propone che la commissione giudicatrice sia composta da:
Membri effettivi
1) Angelo Carollo, Università degli Studi di Palermo
2) Andrea Smirne, Università di Milano
3) Chiara Macchiavello, Università di Pavia
Membro supplente
Anna Napoli, Università degli Studi di Palermo

Nomina i valutatori esterni:
1) Sebastian Deffner, University of Maryland, Baltimore County (USA)
2) Steve Campbell, University College Dublin (Irlanda)

Ruggero Biondo (II sessione: 15 febbraio - 15 marzo 2023)
Il collegio prende visione della relazione del dottorando (allegato 3 al verbale).

Propone che la commissione giudicatrice sia composta da:
Membri effettivi
1) Rosario Iaria, Università degli Studi di Palermo
2) Silvia Perri, Università della Calabria
3) Antonino Lanza, Istituto Nazionale di Astrofisica, Osservatorio Astrofisico di Catania
Membro supplente
Andrea Verdini, Università di Firenze

Nomina i valutatori esterni:
1) Luciano Rodriguez, Royal Observatory of Belgium
2) Rui Pinto, Université Paris-Saclay (Francia)

Gianluca Cracchiolo (II sessione: 15 febbraio - 15 marzo 2023)
Il collegio prende visione della relazione del dottorando (allegato 4 al verbale).

Propone che la commissione giudicatrice sia composta da:
Membri effettivi
1) Rosario Iaria, Università degli Studi di Palermo
2) Silvia Perri, Università della Calabria
3) Antonino Lanza, Istituto Nazionale di Astrofisica, Osservatorio Astrofisico di Catania
Membro supplente
Andrea Verdini, Università di Firenze

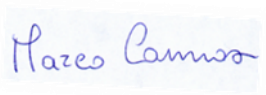
Nomina i valutatori esterni:
1) Ignasi Ribas, Institut de Ciencies de l'Espai, Barcelona (Spagna)
2) Theresa Lueftinger, University of Vienna (Austria)

2) Varie ed eventuali

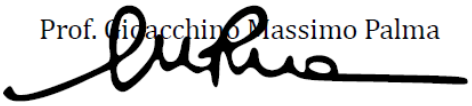
Non ci sono varie ed eventuali.

Il verbale è approvato seduta stante. La seduta si chiude alle ore 15:45.

Il Presidente
Prof. Marco Cannas



Il Segretario
Prof. Gioacchino Massimo Palma



Allegato 1

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXV COURSE

PhD Candidate: Marco Bertini

transcript of records

Tutor: Prof. Dario Duca
Cotutor: Prof. Francesco Ferrante

Courses/school/exam scores
- 12.12.2019 - 13.12.2019 – [16 hours] – Course "La comunicazione in pubblico", Guido Paolo Ridoni e Dan Wiesenfeld
- 18.09.2020 Exam of the course "High Performance Computing", Laurea Magistrale in Informatica. Examining board prof. Fabio Reale, prof. Francesco Ferrante
- 04.02.2021 - 09.02.2021 [10 hours] Course "Programma statistico R", dott. Gianluca Sottile
- 21.06.2021 - 25.06.2021 [10 hours] Course "Thermodynamic techniques for the characterization of nanostructured materials", dott. Giuseppe Cavallaro. Exam held on 13.07.2021, examining board: dott. Giuseppe Cavallaro, prof. Giuseppe Lazzara
- 28.06.2021 - 02.07.2021 [30 hours] - CECAM School "First-principles simulations of materials with SIESTA". Exam held on 20.12.2021, examining board: prof. Dario Duca, dott. Fabrizio Lo Celso
- 05.07.2021 - 09.07.2021 [10 hours] Course "Organic/Inorganic nanocomposites: properties and applications", dott. Giuseppe Cavallaro. Exam held on 13.07.2021, examining board: dott. Giuseppe Cavallaro, prof. Giuseppe Lazzara
- 19.07.2021 - 23.07.2021 [32 hours] Scuola di Calcolo Scientifico con Matlab 2021 – Corso Base
- 26.07.2021 - 30.07.2021 [32 hours] Scuola di Calcolo Scientifico con Matlab 2021 – Corso Avanzato
- 14.03.2022 - 16.03.2022 [24 hours] Cineca Course "Debugging and Optimization of Scientific Applications". Exam held on 23.03.2022, examining board: prof. Francesco Ferrante, prof. Dario Duca
- 11.09.2022 - 24.09.2022 [80 hours] "European Summerschool in Quantum Chemistry". Exam held on 11.10.2022, examining board: prof. Francesco Ferrante, prof. Dario Duca

Conferences/workshop attended
- 5.12.2021 – 16.12.2021 Workshop Cineca HPCQC 2021, (High Performance Computing - Quantum Computing)

Talks

Posters

Papers published

- F. Ferrante, A. Prestianni, M. Bertini, D. Duca, "H2 Transformations on Graphene Supported Palladium Cluster: DFT-MD Simulations and NEB Calculations", Catalysts vol. 10, pp. 1306-1-10, 2020. Articolo pubblicato nella special issue "Computational Chemistry and Catalysis: Prediction and Design". (DOI: 10.3390/catal10111306)

- M. Bertini, F. Ferrante, D. Duca, "Empathes: A General Code for Nudged Elastic Band Transition States Search", Computer Physics Communications vol. 271, pp. 108224-1–10, 2022. (DOI: 10.1016/j.cpc.2021.108224)

- F. Ferrante, M. Bertini, C. Ferlito, L. Lisuzzo, Giuseppe Lazzara, Dario Duca, "A Computational and Experimental Investigation of Halloysite Silicic Surface Modifications After Alkaline Treatment" submitted.

Thesis title: Computational Studies of Materials for Energy Technology: CO_2 Methanation, and Halloysite Carbon-Coating

Abstract
The models and theories of quantum chemistry are applied in order to study two kinds of materials of interest in the field of energy technology, to understand their behavior and to verify their suitability for possible application. In particular, the effect of single Ru/Fe atom deposition on the CO_2 methanation reaction occurring on the Ni(111) surface, and the effect on the band gap produced by carbon atom deposition and carbon cluster accretion on the silicic surface of halloysite, have been investigated by means of the periodic and molecular flavours of density functional theory.
In order to accomplish the investigations above two entirely new computer codes were written and are actually maintained: Emphates, implementing a general interface for transition states identification through climbing-image nudged elastic band calculations, and Pathgen, which by using graph theory finds all possible paths between reactant and product for microkinetic analysys.

The PhD Board Dean

Prof. Marco Cannas

Allegato 2

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXV COURSE

PhD Candidate: Dario Alexander Chisholm

transcript of records

Tutor: Prof. G. Massimo Palma

Courses/school/exam scores

- Corso di Reti complesse (Complex networks), Prof. Salvatore Miccichè and Prof. Rosario Nunzio Mantegna (course held at Università di Palermo in 2019-2020);

Exam: seminar "Exploring the limits of modularity". Score: A

- Lake Como School of Advanced Studies on Thermodynamics of quantum systems and processes, March 22, 2021- March 26, 20212).

Exam: seminar "Non-Abelian quantum transport and thermosqueezing effects". Score: A

- Corso di Physics and information, Prof. G. Massimo Palma (course held at Università di Palermo in 2022).

Exam: seminar "Zeno effect in the Ghirardi-Rimini-Weber collapse model". Score: A

Conferences/workshop attended

• Conference: KOBIT, Quantum Optics and Information Meeting 6, 3-4 Feb 2022 (online event).
• Conference: IQIS 2022, 12-16 Sep 2022, Palermo, Italy.
• Study and research activity at the University of Turku (1 Oct - 31 Dec 2021) under the supervision of Prof. Sabrina Maniscalco.
• Study and research activity at the Queen's University Belfast (1 May - 28 Jul 2019) under the supervision of Prof. Mauro Paternostro.

Talks, posters

- Conference: KOBIT, Quantum Optics and Information Meeting 6, pre-recorded talk: "Nonlocal information encoding and the emergence of quantum Darwinism", 3-4 Feb 2022 (online event).
- Conference: IQIS 2022, poster contribution: "Nonlocality breaks the relations between measures of quantum objectivity", 12-16 Sep 2022, Palermo, Italy.

Papers published

1. Dario A. Chisholm, Luca Innocenti, and G. Massimo Palma. "The importance of using the averaged mutual information in quantum objectivity", Submitted, 2022.
2. Gabriele Lo Monaco, Luca Innocenti, Dario Cilluffo, Dario A. Chisholm, Salvatore Lorenzo, and G. Massimo Palma. "Quantum scrambling via accessible tripartite information", Submitted, 2022
3. Dario A. Chisholm, Luca Innocenti, and G. Massimo Palma. "Nonlocality breaks the relations between measures of quantum objectivity", Submitted, 2022.

4. Dario A. Chisholm, Guillermo García-Pérez, Matteo A.C. Rossi, Sabrina Maniscalco, and G. Massimo Palma. "Witnessing objectivity on a quantum computer", Quantum Science and Technology, 2022.
5. Dario A. Chisholm, Guillermo García-Pérez, Matteo A.C. Rossi, G. Massimo Palma, and Sabrina Maniscalco. "Stochastic collision model approach to transport phenomena in quantum networks", New Journal of Physics, 2021.
6. Guillermo García-Pérez, Dario A. Chisholm, Matteo A.C. Rossi, G. Massimo Palma, and Sabrina Maniscalco. "Decoherence without entanglement and quantum darwinism", Physical Review Research, 2020.

Thesis title: Objective features in quantum states.

Abstract

One of the key features of quantum mechanics is that any superposition of quantum states is in itself a legit quantum state. This has far reaching consequences, and is behind the stark difference in behaviour between quantum and classical systems. In particular, quantum systems are not -unlike classical ones- intrinsically objective, that is, different observers are not always able to agree on the properties of the system. Understanding the conditions for objectivity in quantum states is therefore key to address the wider issue of the quantum-to-classical transition. Here, we discuss several aspects of quantum objectivity, and in particular subtleties that arise to the definitions of objectivity whenever non-ideal scenarios are taken into account. We first explore the emergence of objectivity in novel open system dynamics. We then discuss the relations between different methods to quantify objectivity, prove their non-equivalence and the implications that this entails. We also discuss the meaning of the pointer basis in the case of noncommutative dynamics. Finally, we provide proof-of-principle evidence on the reproducibility of non-trivial objective states on quantum computers.

The PhD Board Dean

Prof. Marco Cannas

Allegato 3

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXV COURSE

PhD Candidate: Ruggero Biondo

transcript of records

Tutor: Prof. Fabio Reale
Cotutor: Dr. Alessandro Bemporad

Courses/school/exam scores

- Course "Atmosfere Stellari", hold by Fabio Reale within the master degree course in Physical Sciences at the University of Palermo (2020), Exam sat on September 2020, Score: A;
- School "16th Advanced School on Parallel Computing", held by CINECA-HPC from February 24 to February 28, 2020;
- School "Dynamical Systems and Machine Learning approaches to Sun-Earth Relations", held by L'Aquila International School of Space Science from February 1 to February 5, 2021;
- Cycle of seminars "PLUTO Symposium 2021" held by the PLUTO team from June 28 to June 29, 2021, exam sat on November 4, 2021, Score: A;
- Course "Project management in the Scientific-Spatial context", hold by Giusi Micela, within the PhD course in Physical Sciences at the University of Palermo (2022), exam sat on July 26 2022, Score: A.

Conferences/workshop attended

- Conference "First meeting of the Space Weather Italian Community (SWICO)", held at ASI, Tor Vergata (Roma) from February 11 to 14, 2020, as attendant (in person);
- Conference "106th National Congress of the Italian Society of Physics (SIF)", held at Milano from September 14 to 18, 2020, as contributed speaker (remote);
- Conference "Second meeting of SWICO", held at ASI, Tor Vergata (Roma) from February 9 to February 11, 2022, as contributed speaker (in person);
- Conference "Parker Two", held at Baltimora (USA) from 21/06/2022 to 24/06/2022, with a presentation poster (remote);
- Workshop "8th Solar Orbiter Workshop", held at Belfast (UK) from 11/09/2022 to 16/09/2022, as contributed speaker (in person).

Talks

- "Data-driven numerical reconstruction of the interplanetary Parker spiral", INAF-Osservatorio Astronomico di Palermo, November 6, 2019 (in person);
- "RIMAP: a data-driven numerical model for the interplanetary Parker spiral", 106th SIF National Congress, September 14, 2020 (remote);
- "RIMAP: a data-driven numerical model for the interplanetary Parker spiral", Modeling And Data Analysis Working Group (MADAWG) of Solar Orbiter meeting, October 26, 2021 (remote);
- "Coronal Mass Ejections and their 1 AU signatures", Chemistry and Physics Department at University of Palermo, May 20, 2021 (remote);

- "Tracing ICME plasma with a MHD simulation", INAF-Osservatorio Astronomico di Palermo, September 29, 2021 (remote);
- "Tracing ICME plasma with a MHD simulation from 0.1 to 1 AU", second SWICO meeting, Rome, February 11, 2022 (in person);
- "Connecting Solar Orbiter remote-sensing observations and Parker Solar Probe in-situ measurements with a numerical MHD reconstruction of the Parker Spiral", 8th Solar Orbiter Workshop, Belfast, United Kingdom, September 15, 2022 (in person).

Posters:

- "Connecting Solar Orbiter remote-sensing observations and Parker Solar Probe in-situ measurements with a numerical MHD reconstruction of the Parker Spiral", Parker Two Conference, June 21-24, 2022, Baltimora, USA (remote).

Papers published

- Biondo R., Bemporad A., Mignone A., and Reale F., "*Reconstruction of the Parker spiral with the Reverse In situ data and MHD APproach – RIMAP*", J. Space Weather Space Clim., 11, 7 (2021), doi: 10.1051/swsc/2020072
- Biondo R., Pagano P., Reale F., and Bemporad A., "*Tracing the ICME plasma with a MHD simulation*", Astronomy & Astrophysics, 654 L3 (2021), doi:10.1051/0004-6361/202141892
- Telloni D. et al., "*Linking Small-scale Solar Wind Properties with Large-scale Coronal Source Regions through Joint Parker Solar Probe-Metis/Solar Orbiter Observations*", The Astrophysical Journal, vol. 935, no. 2 (2022) doi:10.3847/1538-4357/ac8103
- Telloni D. et al., "*Observation of a Magnetic Switchback in the Solar Corona*", *The Astrophysical Journal Letters, vol.* 936, L25 (2022) doi:10.3847/2041-8213/ac8104
- Biondo R., Bemporad A., Pagano P., Telloni D., Reale F., Romoli M., Andretta V., Antonucci E., Da Deppo V., De Leo Y., Fineschi S., Heinzel P., Moses D., Naletto G., Nicolini G., Spadaro D., Stangalini M., Teriaca L., Landini F., Sasso C., Susino R., Jerse G., Uslenghi M., Pancrazzi M., "*Connecting Solar Orbiter remote-sensing observations and Parker Solar Probe in-situ measurements with a numerical MHD reconstruction of the Parker spira*l", Astronomy & Astrophysics, A&A, Forthcoming article, Received: 18 July 2022 / Accepted: 16 September 2022, DOI: https://doi.org/10.1051/0004-6361/202244535

Thesis title:

Data-driven MHD simulation of the Parker spiral and interplanetary propagation of solar transients

Abstract

Accurate reconstructions of the plasma and magnetic field parameters in the ambient interplanetary medium is fundamental to reproduce the interplanetary propagation of solar disturbances such as solar energetic particles (SEPs), stream and corotating interaction regions (SIRs and CIRs), and coronal mass ejections (CMEs), both for understanding the physics of these phenomena and for applications in space weather forecasting. The small-scale features of the ambient solar wind, in fact, affect the evolution, arrival times, and geo-effectiveness of the solar transients.
The Reverse In situ and MHD Approach (RIMAP) is a hybrid analytical-numerical method to reconstruct the heliosphere on the ecliptic plane from in situ measurements acquired by spacecraft with heliocentric orbits. RIMAP uses the in situ measurements as boundary conditions for a MHD simulation based on the PLUTO code, combining ballistic and MHD approaches in order to preserve

the small-scale variability of the solar wind flow lines and thus offering a structured, realistic background medium for modelling the propagation of solar eruptions.
In this dissertation, after an introduction about the main topics and models of heliospheric physics (chapter 1), we present the detailed description of the novelties of the RIMAP model, and its application to the measurements acquired by spacecraft at 0.99 AU in correspondence of solar minima configurations (chapter 2).
Then, in chapter 3, one of these reconstructions is used as a background medium to propagate an interplanetary CME. The perturbation is modelled as a spheroidal, homogeneous plasma cloud without internal magnetic flux rope. We use an artificial, passive tracer to quantify the mixing at 1 AU between ambient solar wind material and the one with coronal eruption origins, in order to evaluate the fraction of plasma measured in situ that can be traced back to its sources on the Sun.
In chapter 4, the RIMAP reconstruction is carried out using measurements acquired by NASA's Parker Solar Probe (PSP) during its seventh solar encounter, in January 2021, between 20 and 40 solar radii. This was the time of the first quadrature between PSP and ESA-NASA's Solar Orbiter (SolO), which at the time was orbiting the Sun around 0.5 AU and providing remote sensing observations of the solar corona via the Metis coronagraph. The RIMAP reconstruction connects density and wind speed estimates inferred from the coronal features observed by Metis/SolO between 3 and 6 solar radii to the measurements acquired by PSP at 21.5 solar radii along the corresponding plasma streamline. Thus, the magnetic connection between the inner corona and the super Alfvénic wind is reconstructed with an high degree of accuracy with a detailed data-driven MHD simulation.
Finally, in chapter 5, we describe the possible future developments of the RIMAP technique such as the extension to a two-fluids treatment, the testing of different models of magnetized coronal mass ejections, the simulation of solar wind switchbacks, and the extension to full three-dimensional boundaries, using coronagraph observations to infer the input parameters.

The PhD Board Dean

Prof. Marco Cannas

Allegato 4

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXV COURSE

PhD Candidate: Gianluca Cracchiolo

transcript of records

Tutor: Giuseppina Micela

Courses/school/exam scores:

- "Project Management in the Scientific-Spatial Context", prof. G. Micela, course held at Università di Palermo in a hybrid form, 17/12/2021 - 31/01/2022;
    - Exam: "Managing an observation campaign proposal involving both space-based telescopes (JWST) and ground-based telescopes (TNG)". Score: A.

- "Severo Ochoa Advanced School: Planets, exoplanets and their systems in a broad and multidisciplinary context", held online, 18/01/2021 - 1/02/2021;
    - Exam: "The observed mass-radius relation of small exoplanets". Score: A.

- "Corso di python e astropy 2020" course held online by Prof. Luca Fini and Dr. Fabio Rossi (INAF), 09/11/2020 - 04/12/2020;
    - Exam: "Python programming for simulations and data analysis". Score: A

Conferences/workshop attended:

- "Course on exoplanets", by Giovanna Tinetti, 18/01/2022 - 22/02/2022, online;
- "Course Project Management in the Scientific-Spatial Context", by G. Micela, 17/12/2021 - 31/01/2022, online;
- "ARES school second edition", 02/10/2021 - 10/10/2021, Biarritz, Francia;
- "Ariel Consortium Meeting - Virtual", 16/06/2021 - 18/06/2021, online;
- "Ariel Italian Meeting - Virtual", 17/05/2021- 21/05/2021, online;
- "Exoplanet atmosphere characterization: from HST and Spitzer to JWST", 09/03/2021 - 12/03/2021, online;
- "The Effect of Stellar Contamination on Space-based Transmission Spectroscopy", 08/03/2021 - 09/03/2021, online;
- "Ariel Consortium Meeting - Virtual", 10/02/2021 - 12/02/2021, online;
- "Dynamical Systems and Machine Learning Approaches to Sun-Earth Relations", 01/02/2021 - 05/02/2021, online;
- "Severo Ochoa Advanced School: Planets, exoplanets and their systems in a broad and multidisciplinary context", 18/01/2021 - 01/02/2021, online;
- "Corso di python e astropy", 09/11/2020 - 04/12/2020, online;
- "Ariel Hybrid Science Consortium Workshop", 23/11/2021 - 24/11/2021, online;
- "Ariel Virtual Consortium Meeting", 12/10/2020 - 14/10/2020, online;
- "AtomDB Workshop and Advanced Spectroscopy School", 03/08/2020 - 05/08/2020, online;
- "XVI GAPS GENERAL MEETING", 04/05/2020 - 06/05/2020, online;
- "Ariel Conference", 14/01/202 - 16/01/2020, ESTEC, Netherlands;

Talks:

- 17-21 May 2021: "Correcting the effect of stellar spots on ARIEL transmission spectra II. The limb darkening effect", Ariel Italian Meeting - Virtual , online;
- 10-12 Feb. 2021 "Correcting the effect of stellar spots on ARIEL transmission spectra II. The limb darkening effect", Ariel Consortium Meeting - Virtual, online;
- 12-14 Oct. 2020: "Extracting planetary spectra from Ariel data in presence of stellar magnetic activity", Ariel Virtual Consortium Meeting, online;
- 4-6 May 2020: "Correcting the impact of stellar spots on ARIEL transmission spectra", XVI GAPS GENERAL MEETING, online.

Posters:

- 09 - 12 Mar. 2021, contributed poster: "Observing planet-starspot crossings with the James Webb Space Telescope", Exoplanet atmosphere characterization: from HST and Spitzer to JWST, online meeting;
- 14 - 16 Jan. 2020, poster: "Derivation of the exo-planetary spectrum in the presence of stellar activity", Ariel conference, ESTEC, Netherlands.

Papers published:

- G. Bruno, N. K. Lewis, J. A. Valenti, I. Pagano, T. J. Wilson, E. Schlawin, J. Lothringer, A. F. Lanza J. Fraine, G. Scandariato, G. Micela, **G. Cracchiolo**, "Hiding in plain sight: observing planet-starspot crossings with the James Webb Space Telescope", Feb. 2022, vol. 509, pp. 5030-5045;

- G. Morello, N. Casasayas-Barris, J. Orell-Miquel, E. Pallé, **G. Cracchiolo**, G. Micela,"The strange case of Na I in the atmosphere of HD 209458 b. Reconciling low- and high-resolution spectroscopic observations", Jan. 2022, vol. 657, pp. A97;

- **G. Cracchiolo**, G. Micela, and G. Peres, "Correcting the effect of stellar spots on ARIEL transmission spectra - II. The limb-darkening effect", Nov. 2021, MNRAS, vol. 507.4, pp. 6118-6131;

- **G. Cracchiolo**, G. Micela, and G. Peres, "Correcting the effect of stellar spots on ARIEL transmission spectra", Feb. 2021, MNRAS, vol. 501.2, pp. 1733-1747.

Thesis title:
Mitigation of the impact of stellar activity on observations of transiting planets

Abstract:

This thesis focuses on the quantification of the impact of stellar activity on observations of transiting planets and on the identification of a methodology to correct these effects. In particular, the role of starspots, both un-occulted and occulted is considered.
The presence of spots on the visible stellar disk may distort the primary transit light curve in a wavelength-dependent way, mimicking the presence of an atmosphere. To take into account this bias, the thesis presents an innovative method to estimate the spots properties and their distribution from the out-of-transit observations and, on this basis, correct the planetary transit light curves, avoiding possible degeneracy between the presence of the planetary atmosphere and of the spots. The method is developed for low-resolution transit spectroscopy and is tested on realistic simulations of future observations of planetary transits with Ariel, a space mission dedicated to the observation of about 1000 transiting exoplanets whose launch is expected in 2029. Then, the method is applied to real observations of HST of a transiting planet. The first chapter of the thesis presents the state of the art of efforts done so far to mitigate the effect of the spots in planetary observations (chapter 1). Chapter 2 presents a method for correcting the effect of spots not-crossed by the transiting planet, starting from a basic model of the stellar activity, where the spotted star is simulated as a linear combination of stellar spectra at different temperatures and the star has a uniform emission. The method is tested on 3 simulated targets of transiting systems that will be observed by the Ariel mission. In Chapter 3, I introduced another component in the stellar model, making it more realistic. In fact, I simulate again the same targets analyzed in Chapter 2 but including the limb darkening effect to the stellar model. In this chapter, I show the importance of taking into account this effect if a good estimate of the spots' parameters and a good correction of the planet's atmosphere have to be obtained. In Chapter 4 the approach presented in the previous chapters, and tested on simulations, is applied to observations of planetary transits of the planet LHS 1140 b, acquired with the Hubble Space Telescope. The analysis leads to two possible scenarios: in the first one the star is very active and almost the 65% of its surface is covered by spots (against other indicators in the literature suggesting a quiet star); in the second one, the star is quiet but is about 300 K cooler than in the first scenario. In both cases, the observed chromatic modulation derived from the planetary transit light curves is not due to the presence of a planetary atmosphere. In Chapter 5, I analyze the TESS light curves of the active star V1298 Tau, by modeling the star with a model dominated by 4 spots, co-rotating with the stellar surface. Such a study allows not only to derive the distribution of spots on V1298 Tau but also to correct the transit light curves of the 4 planets orbiting around the star for the effect of non-occulted spots. The results show that the spots' effect may produce different transit depths for the 4 planets in the TESS and the K2 band, thus justifying the discrepancy between the planetary radii in the two bands reported in the scientific literature.

The PhD Board Dean

Prof. Marco Cannas