SEDUTA DEL COLLEGIO DEI DOCENTI DEL 36° CICLO

29 Aprile 2024

Il Collegio dei Docenti del 36° 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 29.04.2024 con il seguente ordine del giorno:

1) Adempimenti dottorandi per l'esame finale di conseguimento del titolo di dottore di ricerca (III° sessione)

2) Varie ed eventuali

Presiede il Coordinatore Prof. Marco Cannas, svolge le funzioni di segretario il Prof. Simonpietro Agnello

Sono presenti

M. Cannas, A. Pettignano, F. Ciccarello, F. Ferrante, G.M. Palma, A. Napoli, D. Valenti, S. Agnello, M. Miceli, B. Militello, F. Reale, A. Napoli, R. Passante, G. Marsella

Sono assenti giustificati

C. Fazio, S. Milioto, G. Cusumano, S. Miccichè, G. Buscarino, F. Messina, G. Micela, R. Iaria, T. Di Salvo, G. Lazzara

Sono presenti inoltre A. Petralia e S. Lorenzo in qualità di cotutor

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

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

Il presidente illustra gli adempimenti necessari per il conseguimento del titolo di dottore di ricerca per gli allievi del 36° 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 hanno concluso il loro dottorato nel 2024 e intendono sostenere l'esame finale nella terza sessione (26 giugno – 6 luglio 2024).

Alfredo Biagini

(Tutor: Dott.ssa Giusi Micela; Cotutor: Dott. Antonino Petralia)

Il collegio prende visione della relazione del dottorando (**allegato 1 al verbale**).

Il collegio propone che la commissione giudicatrice per l'esame finale sia composta da:

Membri effettivi

1) **Prof. Marco Miceli**, Università degli Studi di Palermo, marco.miceli@unipa.it

2) **Prof. Luigi Mancini**, Università di Roma "Tor Vergata", lmancini@roma2.infn.it

3) **Dr. Alessandro Sozzetti**, Osservatorio Astrofisico di Torino, alessandro.sozzetti@inaf.it

Membro supplente

Dr. Fabrizio Bocchino, INAF – Osservatorio Astronomico di Palermo

Il collegio nomina i valutatori esterni:

1) **Dr. Riccardo Claudi**, INAF-Osservatorio Astronomico di Padova,
email: riccardo.claudi@inaf.it

2) **Dr. Giuseppe Leto**, INAF Osservatorio Astrofisico di Catania,
email: giuseppe.leto@inaf.it

Roberta Giuffrida

(Tutor: Prof. Marco Miceli)

Il collegio prende visione della relazione del dottorando (**allegato 2 al verbale**).

Il collegio propone che la commissione giudicatrice sia composta da:

Membri effettivi

1) **Prof. Fabio Reale**, Università degli Studi di Palermo, fabio.reale@unipa.it

2) **Prof.ssa Gloria Dubner**, Instituto de Astronomía y Física del Espacio, University of Buenos Aires (Argentina)

3) **Dr. Giovanni Morlino** - INAF Osservatorio Astrofisico di Arcetri

Membro supplente

Prof.ssa Costanza Argiroffi, Università degli Studi di Palermo

Il collegio nomina i valutatori esterni:

1) **Prof. Satoru Katsuda** - Saitama University (Giappone)

email: katsuda@mail.saitama-u.ac.jp

2) **Dr. Fabio Acero** - Université Paris Saclay, Université Paris Cité, CEA, CNRS (Francia)

email: Fabio.Acero@cea.fr

Vincenzo Sapienza

(Tutor: Prof. Marco Miceli)

Il collegio prende visione della relazione del dottorando (**allegato 3 al verbale**).

Il collegio propone che la commissione giudicatrice sia composta da:

Membri effettivi

1) **Prof. Fabio Reale**, Università degli Studi di Palermo, fabio.reale@unipa.it

2) **Prof.ssa Gloria Dubner**, Instituto de Astronomía y Física del Espacio, University of Buenos Aires (Argentina)

3) **Dr. Giovanni Morlino** - INAF Osservatorio Astrofisico di Arcetri

Membro supplente

Prof.ssa Costanza Argiroffi, Università degli Studi di Palermo

Il collegio nomina i valutatori esterni:

1**) Dr.ssa Tea Temim** - Princeton University (USA)

email: temim@astro.princeton.edu

2) **Dr.ssa Ping Zhou** - Nanjing University (Cina)

email: pingzhou@nju.edu.cn

Francesca Migliore

(Tutor: Prof. Simonpietro Agnello; Cotutor: Dott. Daniele Vecchio (STMicroelectronics)

Il collegio prende visione della relazione del dottorando (**allegato 4 al verbale**).

Il collegio propone che la commissione giudicatrice sia composta da:

Membri effettivi

1) **Prof. Fabrizio Messina**, Università degli Studi di Palermo, fabrizio.messina@unipa.it

2) **Prof.ssa Giuliana Faggio,** Università degli Studi Mediterranea di Reggio Calabria

3) **Prof. Michele Saba,** Università degli Studi di Cagliari

Membro supplente

Prof. Francesco Quochi, Università degli Studi di Cagliari

Il collegio nomina i valutatori esterni:

1) **Prof. Carlo Maria Carbonaro,** Università degli Studi di Cagliari

email: cm.carbonaro@dsf.unica.it

2) **Dr. Filippo Giannazzo,** CNR-IMM - Catania

email: Filippo.Giannazzo@imm.cnr.it

Claudio Pellitteri

(Tutor: Prof. Massimo G Palma; Cotutor: Prof. Salvatore Lorenzo)

Il collegio prende visione della relazione del dottorando (**allegato 5 al verbale**).

Il collegio propone che la commissione giudicatrice sia composta da:

Membri effettivi

1) **Prof. Francesco Ciccarello**, Università degli Studi di Palermo, francesco.ciccarello@unipa.it

2) **Prof. Francesco Plastina,** Università della Calabria

3) **Prof. Alessandro Ferraro,** Università degli Studi di Milano Statale

Membro supplente

Dr. Umberto De Giovannini, Università degli Studi di Palermo

Il collegio nomina i valutatori esterni:

1) **Prof. André Xuereb,** Department of Physics - Faculty of Science - University of Malta

email: andre.xuereb@um.edu.mt

2) **Prof. Gabriele De Chiara,** School of Mathematics and Physics - Queen's University of Belfast

email: g.dechiara@qub.ac.uk

Giovanni Tripodo

(Tutor: Prof. Giovanni Marsella)

Il collegio prende visione della relazione del dottorando (**allegato 6 al verbale**).

Il collegio propone che la commissione giudicatrice sia composta da:

Membri effettivi

1) **Prof. Davide Valenti**, Università degli Studi di Palermo, davide.valenti@unipa.it

2) **Prof. Fausto Guarino,** Università degli Studi di Napoli Federico II

3) **Dr. Patrick Stassi** Laboratoire de Physique Subatomique et de Cosmologie CNRS-Grenoble

Membro supplente

Dott.ssa Manuela Mallamaci, Università degli Studi di Palermo

Il collegio nomina i valutatori esterni:

1) **Dr. Julian Rautenberg,** Bergische Universität Wuppertal

email: julian.rautenberg@uni-wuppertal.de

2) **Dr. Martina Bohacova**, Faculty of Mathematics and Physics, Charles University in Prague

email: bohacova@fzu.cz

Inoltre, per l'allievo Giovanni Tripodo, il collegio attesta che sono soddisfatti i criteri per conseguire il titolo di Doctor Europaeus, ed esprime un parere positivo

2) Varie ed eventuali

Il Prof. Reale informa che l'attribuzione per scorrimento di graduatoria della borsa cofinanziata da INAF/UNIPA per il corso di dottorato in Scienze Fisiche e Chimiche (ciclo 39°)

a tema vincolato "teoria e modelli fisici del plasma della corona solare e della sua interazione con il campo magnetico, inclusi processi su piccola scala e metodologie analitiche e perturbative"

NON è andata a buon fine. Il Direttore ha dichiarato che si informerà al fine di capire se il cofinanziamento UNIPA sarà disponibile per il ciclo 40°.

Il verbale è approvato seduta stante. La seduta si chiude alle ore 15:30.

Il Presidente
Prof. Marco Cannas

Il Segretario
Prof. Simonpietro Agnello

Allegato 1

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: Alfredo Biagini

Transcript of Records

Tutor: Giuseppina Micela

Cotutor: Antonino Petralia

Courses/school/exam scores:

- 21-25/06/2021 JWST Transiting Exoplanet Community ERS Pre-Launch weekly Data Hackathon, about the new possibilities given by JWST for exoplanet science and related instruments, exam passed *(score A)*
- 28/06/2021- ERS Theory Webinar, about the new possibilities given by JWST for exoplanet science and related instruments
- 18/08/2021 given by JWST for exoplanet science and related instruments, weekly
- 21-23/09/2021 Stellar spectroscopy and Astrophysical parameterisation from Gaia to Large Spectroscopic surveys
- 25-26/09/2021 [ARIEL Consortium List] 1st annual ExoClock meeting course
- 15/12/2021-31/01/2022 Project Management in the scientific-spatial context, exam passed *(score A)*
- 01/2022 weekly "Physics of exoplanets" PHAS0068, course on exoplanetary studies
- 08/09/2022 HST data retrieval course, UCL (remotely)
- 15-22/09/2022 Caracterisations des exoplanetes: des planetes transitionnelles aux jupiters avec les missions spatiales JWST, ARIEL et les observations au sol, exam passed *(score A)*
- 12-16/06/2023 Brave New Worlds II: understanding the planets of other stars, Lake Como School of Advanced Studies

Research and training periods abroad

6-months period working with the "Fondazione Gal Hassin"

Papers published:

- Spot Modeling through Multiband Photometry V1298 Tau Analysis, **Alfredo Biagini**, Antonino Petralia, Claudia Di Maio, Lorenzo Betti, Emanuele Pace and Giuseppina Micela, 2024, submitted to A&A.
- A reanalysis of the LHS 1140 b atmosphere observed with the Hubble Space Telescope, Alfredo **Biagini**, Gianluca Cracchiolo, Antonino Petralia, Jesús Maldonado, Claudia Di Maio, Giuseppina Micela, 2024, MNRAS, in press, March 2024

- "Correcting Exoplanet Transmission Spectra for Stellar Activity with an Optimised Retrieval", A. Thompson, A. **Biagini**, G. Cracchiolo, A. Petralia, Q. Changeat, A. Saba, G. Morello, M. Morvan, G. Micela, G. Tinetti, 2024, ApJ, 960, 107
- Photometric follow-up of the 20 Myr old multi-planet host star V1298 Tau with CHEOPS and ground-based telescopes, Damasso M... A. **Biagini**... et al., 2023, A&A, 680 , 8
- "ExoClock Project III: 450 new exoplanet ephemerides from ground and space observations", A. Kokori... A. **Biagini**... et al., 2022, ApJs, 258, 40

Conferences/workshop attended:

- XIII GAPS Meeting, Napoli ,17-19/11/2021
- 3th Chianti Topics, "Atmospheres", Florence, 20-22/04/2022 *(oral presentation)*
- 2nd Meeting of the Italian community dedicated to Ariel's scientific preparation - online, 25-27/05/2022, *(oral presentation)*
- Ariel Consortium Meeting, Bologna (online attending), 10-12/10/2022
- 3rd Meeting of the Italian community dedicated to Ariel's scientific preparation, Palermo, 16-18/05/2023, *(oral presentation)*
- PLATO Science in Italy Workshop: ready to PLATO data exploitation? Catania (online attending), 25-27/09/2023
- ARIEL Consortium Meeting, Budapest (online attending), 24-27/10/2023
- 5th Chianti Topics, "Atmospheres", Florence, 27/02/2024, *(oral presentation)*

Thesis title: Modeling of stellar activity of stars hosting planets

Abstract:
Stellar activity is one of the main sources of noise in exoplanet observations, especially for planets orbiting around young stars, because they are characterized by a high level of variability that affects both the spectroscopic and photometric observations. To study planet formation in young planetary systems and achieve a level of precision high enough to study exoplanets atmospheres, we need to model the stellar activity, both through spectroscopy and photometry, to correct its effects in the observations. As a prototype of a very active star, I observed and modeled the very young star V1298 Tau, hosting a multi-planetary system, through multiband photometry characterizing its active regions after validating the method on solar data. I also developed a technique to simulate stellar activity effects on transiting planetary spectra. The simulations were used to verify our atmospheric retrieval capability and establish the level of complexity necessary for achieving the corrections needed to correctly interpret low-resolution spectroscopic data.
Finally, I analysed LHS 1140b HST low-resolution transit spectra to test the level of activity of the star and its effect on the retrieval of the atmospheric composition of the planet. In this specific case, I found that the spectrum distortions are not due to star activity but to the non-solar stellar composition of the target. This is a warning for future studies to test if in some cases signals attributed to activity are in fact due to a wrong estimation of stars' composition, and to outline the need to characterize very well the host star.

The PhD Board Dean

Prof. Marco Cannas

Marco Cannas

Allegato 2

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: Roberta Giuffrida

Transcript of Records

Tutor: Marco Miceli

Cotutor:

Courses/school/exam scores:

- Cosmic Ray Physics, S. Gabici (SISSA, 24-27 May 2021) - **Exam**: "Fisica e origine dei raggi cosmici galattici" - 06/07/2021 - **Vote: A**
- Project management in the scientiMic spatial context, Giuseppina Micela (UniPa - 10 ore) - **Exam**: "Cosmic rays on Airlines" - 07/03/2022 - **Vote: A**
- Experimental Techniques in Astroparticle (UNIPA- Prof. Marsella - 16 hours) - **Exam**: "Toward Understanding the Origin of Cosmic-Ray Positrons" - 26/04/2022 - **Vote: A**
- Astrophysics laboratory of thermal X-ray plasmas (UNIPA - Dr. Ciro Pinto - 16 hours)
- Scientific communication in Astronomy School 2021 (3-8 October 2021), University Residential Centre of Bertinoro, Bertinoro, IT
- X-ray Spectral Fitting (XSF) 2022 winter school, 7 - 11 February 2022

Research and training periods abroad

- September - December 2022: LABORATOIRE DE PHYSIQUE DES DEUX INFINIS BORDEAUX. Supervisor: Marianne Lemoine-Goumard - "Gamma-ray emission from the source Puppis A with Fermi - LAT data analysis"
- March - May 2023: LABORATOIRE DE PHYSIQUE DES DEUX INFINIS BORDEAUX. Supervisor: Marianne Lemoine-Goumard - "Gamma-ray emission from the source Puppis A with Fermi - LAT data analysis"

Papers published:

- R. Giuffrida, M. Miceli, D. Caprioli et al. "The supernova remnant SN 1006 as a Galactic particle accelerator", Nature communication, vol. 13, 5098, p. 5098, Aug 2022, DOI: 10.1038/s41467-022-32781-4. arXiv: 2208.14491
- R. Giuffrida, M. Miceli, S. Ravikularaman, *et al.*, "Indication of a fast ejecta fragment in the atomic cloud interacting with the southwestern limb of SN 1006", A&A, DOI: 10.1051/0004-6361/202348257

Papers submitted:

- CTA collaboration, including R. Giuffrida, "Dark Matter Line Searches with the Cherenkov Telescope Array", submitted for publication in JCAP

- R. Giuffrida, M. Miceli, et al. "Measuring the initial mass of 44Ti in SN1987A through the 44Sc emission line", submitted for publication in Apj

Conference proceedings:

- R. Giuffrida, M. Lemoine-Goumard, M. Miceli et al. "Evidence for proton acceleration and escape from the Puppis A SNR using Fermi-LAT observations" vol. ICRC2023, 2023, p.647, DOI: 10.22323/1.444.0647

Conferences/workshop attended:

- Talks:
  1. 28th Cracow Epiphany Conference on Recent Advances in Astroparticle Physics - Contributed: "Cosmic-rays acceleration in SN 1006", 14/01/2022.
  2. European Astronomical Society Annual Meeting - Contributed: The supernova supernova remnant SN1006 as a Galactic particle accelerator - 28/06/2022
  3. Hot topics in high energy astrophysics: pevatrons and their environments - Contributed: The supernova remnant SN 1006 as a Galactic particle accelerator - 29/11/2022
  4. Fermi collaboration meeting, Paris - Contributed: "Evidence for proton acceleration and escape from the Puppis A SNR using Fermi-LAT observations: preliminary results" - March 2023.
  5. X-ray Universe, Athens, Contributed: "Detection of a fast ejecta fragment in the atomic cloud interacting with the southwestern limb of SN 1006" - 13/06/2023
  6. ICRC 2023, Nagoya, Contributed: "Evidence for proton acceleration and escape from the Puppis A SNR using Fermi-LAT observations" - 29/07/2023
  7. TeVPA 2023, Naples, Contributed: "Gamma-ray emission from Puppis A with Fermi-LAT telescope evidence for proton acceleration" - 12/09/2023
  8. Anisotropies in Core Collapse Supernovae Explosions 2, Palermo, Contributed: " Gamma-ray emission from Puppis A with Fermi-LAT telescope: evidence for proton acceleration" - 26/10/2023
  9. Fermi collaboration meeting, Madrid, "Gamma-ray emission from Puppis A with Fermi-LAT telescope: evidence for proton acceleration", April 2024

- Posters:
  - CTAO-symposium, Bologna, ""Gamma-ray emission from Puppis A with Fermi-LAT telescope: evidence for proton acceleration" - April 2024

Thesis title: High energy emission from Supernova Remnants

Abstract:

This thesis is devoted to the analysis and interpretation of X-ray and γ-ray observations of supernova remnants (SNRs) I here discuss two open issues of high energy astrophysics: i) super- nova remnants (SNRs) as galactic cosmic rays accelerators and ii) the origin and evolution of asymmetries in supernova (SN) explosions. Super-nova remnants are the best candidate to be galactic particle accelerators up to relativistic energies (~ 3 PeV).

The kinetic energy released after each explosion (~ 10^{51} erg), considering the rate of supernova explosions in the Milky Way (~ 2 per century), is the only capable to sustain the observed power of cosmic-rays in our Galaxy

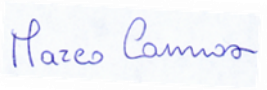
(10^{41} erg s^{-1}). In this framework, SNRs can be the main factory of galactic cosmic rays if they allot approximately 10% of their kinetic energy to accelerate particles. The main process which can explain particle acceleration is the *Diffusive shock acceleration* (DSA), where particles gain energy by crossing the shock front back and forth. X-ray and γ-ray emission from SNRs are crucial to investigate the interaction between the shock wave generated by the supernova explosion and the interstellar medium (ISM). In particular, the acceleration processes and the collisionless heating associated with the shock waves cause nonthermal and thermal X-ray emission in the shocked medium, both the ISM and in the ejecta (fragments expelled after the stellar explosion). Therefore, through the image and spectral analysis of X-ray data, crucial information on the physical and chemical parameters of the post-shock plasma and on the acceleration properties can be obtained. As for the γ-ray emission, it is enhanced in the interaction regions between SNRs and the dense ambient medium, where protons accelerated at the shock front diffuse in the interstellar clouds. The ultrarelativistic hadrons impact on ambient protons generating π^0 mesons which decay into γ–rays ("hadronic" γ–ray emission). On the other hand, ultrarelativistic electrons accelerated by fast shocks propagating in a tenuous environment can up-scatter ambient photons (via Inverse Compton) to the γ–ray band (producing bright "leptonic" emission). In order to study cosmic-rays acceleration in supernova remnants, both X-ray and γ-ray emissions then play a crucial role. I studied two SNRs as galactic particle accelerators: SN 1006 and Puppis A, to address two specific open issues. In particular, through the X-ray image and spectral analysis of SN 1006, I was able to reveal the *shock modification*, i. e., the alteration of the shock properties caused by efficient particle acceleration. In this scenario, the shock compression ratio is expected to deviate from the characteristic value of 4 obtained for adiabatic shocks. I analyzed regions between the shock front and the contact discontinuity, where the X-ray emission stems only from the shocked ISM, which is usually hard to isolate. The combination between the high angular resolution of the *Chandra X-ray observatory* and the high effective area of *XMM-Newton* allowed me to get a deep in- sight on the X-ray emission of the shocked ISM, and in particular on its emission measure and then on the density. By analyzing different regions at the rim of the shell, I found an azimuthal modulation of the compression ratio, which ranges from the value obtained for adiabatic shock ($\chi = 4$), where the magnetic field is perpendicular to the shock velocity (quasi-perpendicular configuration) and there is only thermal X-ray emission, up to $\chi \sim 7$ in regions where the magnetic field is parallel to the shock velocity (quasi- parallel configuration) and the X-ray emission is dominated by synchrotron radiation. I found a very good agreement between these results and the predictions of state-of-the-art hybrid (kinetic ions and fluid electrons) simulations including the formation of a shock postcursor (where non-linear magnetic fluctuations and cosmic rays drift away from the shock front, moving downstream), thus concluding that SN 1006 is an efficient hadron accelerator. My results also provide an observational support for the quasi-parallel acceleration mechanism. On the other hand, the γ-ray emission can provide direct evidence of particle acceleration, both in the leptonic and hadronic scenario. In this thesis, I present my analysis of the γ-ray emission from the Puppis A SNR. A striking difference bet- ween Puppis A (which is a core-collapse SNR) and SN 1006 (a Type Ia SNR) is provided by the ambient environment, which shapes the morphology of their multiwavelength emission and affects their dynamic age. In particular, because of the evolution in a fairly uniform and very tenous environment, SN 1006 results dynamically young even at an age of more than 1 kyr. On the other hand, Puppis A (at 3.7 kyr) is a middle-aged SNRs, and it evolves in a very complex ambient medium. In particular, it interacts with a molecular cloud in its eastern side and with an atomic cloud in its western side. The complex ambient medium forges the highly asymmetric morphology of the source in both X-rays and γ-rays, with the eastern side being much brighter than the western side. In my thesis I took advantage of the good statistics of 14 years of observation with the Fermi-LAT telescope to study the asymmetric morphology and spectral shape of the source. In particular, I revealed the presence of two different cosmic-rays populations accelerated at the shock front via two different mechanisms, namely i) re-accelera- tion of pre-existing cosmic ray seeds at the slow radiative shock interacting with the dense molecular cloud in the eastern part of the remnant and ii) canonical DSA from the fast shock in the western side. Moreover, I delved into the physical origin of two γ-ray excesses located well outside of the remnant. My quantitative analysis shows that their γ–ray emission can be natu- rally associated with cosmic rays escaped from Puppis A and diffusing into dense molecular clumps observed in the radio band. This results provide important information on the energy density of cosmic rays diffusing around SNRs. The second open issue I tackled in my thesis concerns the anisotropies in supernova explosions, which I studied through the analysis of two different sources: SN 1006 and SN 1987A. In particular, I detected an extended, nonthermal X-ray emitting knot (with a clear infrared counterpart) located about 2 pc beyond the shock front in the southwestern limb of SN 1006 (where the remnant in interac-

ting with an atomic cloud). Fast ejecta fragments in SNRs interacting with interstellar clouds produce infrared emission and nonthermal X-ray emission, characterized by a hard continuum and emission lines. By a combined analysis of *XMM-Newton*, *NuSTAR* and *Chandra* data, together with *Spitzer* observations, I found that the observed emission can be nicely associated with an Fe-rich fast moving clump of ejecta, which is moving within the cloud. I estimated density, mass and chemical composition of the clump. My results indicate that this fragment, originating from the inner part of the ejecta, moves faster than the outer ejecta (and of the shock front itself). This suggests an asymmetry in the SN explosion, which is noticeable considering the Type Ia origin of SN 1006. Strong anisotropies in the ejecta are tipycally observed in core-collapse SNRs. In this framework, SN 1987A provides a privileged laboratory being the youngest SNR for which we have spatially resolved observations and nearly uninterrupted monitoring across a spectrum spanning from radio to optical and X-rays. A clear

signature of an asymmetric SN explosion is the presence of Doppler-shifted emission lines. In SN 1987A it has already been found a net redshift in the ^{44}Ti emission lines. Heavy elements are synthesized in the inner layers of core-collapse supernvoae and can "keep memory" of the physical mechanisms governing the explosion. In particular, the yield of ^{44}Ti is strongly dependent on temperature and densitiy conditions, thus providing a powerful diagnostic tool for the explosion physics. However, the estimation of the initial mass of ^{44}Ti in SN 1987A is still debated in the literature. In my thesis I provided a new method to estimate the initial mass of ^{44}Ti, measuring the emission line of its product decay ^{44}Sc. The high angular resolution of the *Chandra* telescope al- lowed me to isolate the X-ray emission of cold ejecta located at the center of the remnant. I detected a significant emission line of ^{44}Sc with a redshifted centroid providing a velocity consistent with that observed for ^{44}Ti, which con- firms the asymmetric explosion. Moreover, the analysis of multi-epoch observations and the comparison with dedicated 3-D MHD simulations allowed me to derive an estimate of the unabsorbed line flux and, as a consequence, of the ^{44}Ti yields. In conclusion, I found that the large ^{44}Ti mass derived from the analysis of *INTEGRAL* data is not consistent with my findings, while the value I obtained is in very good agreement with that measured with the X-ray telescope *NuSTAR*.

The PhD Board Dean

Prof. Marco Cannas



Allegato 3

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: Vincenzo Sapienza

Transcript of Records

Tutor: Prof. Marco Miceli

Cotutor:

Courses/school/exam scores:
Courses:

- Cosmic Ray Physics, S. Gabici (SISSA, course 24-27 May 2021, **6 hrs**), Online
- Project Management in the scientific - Spatial context, G. Micela (Unipa, Dec 2021 - Jan 2022, **10 hrs**).
- Experimental Techniques in Astroparticle Physics, G. Marsella (Unipa, Feb 2022 - Mar 2022, **16 hrs**).
- Astrophysics laboratory of thermal X-ray plasmas, C. Pinto (Unipa, Apr 2023 - May 2023, **20 hrs**)
-

Schools:

- Scientific Communication in Astronomy School, Oct 3-8, 2021 (**40 hrs**), Bertinoro, IT.
- X-ray Spectral Fitting Workshop, Feb 7 - 11, 2022 (**15 hrs**), Online.
- Scuola Italiana di modelli 3D e realtà virtuale e aumentata per l'Astrofisica e l'inclusione nella Scienza, Sep 18 - 22, 2023 (**32 hrs**), Palermo, IT.

Exams:

- Cosmic Ray Physics, S. Gabici (SISSA, course 24-27 May 2021, exam 06 July 2021), Online, grade: A
- Project Management in the scientific - Spatial context, G. Micela, Mar 7, 2022, grade: A
- Experimental Techniques in Astroparticle Physics, G. Marsella, Apr 26, 2022, grade: A

Research and training periods abroad

Research period at The University of Tokyo with a Duration of 5 months (03/2023 - 08/2023) under the supervision of Prof. Aya Bamba.

Papers published:

Refereed:

1. Sapienza et al. (2021): X-ray emitting structures in Vela SNR: ejecta anisotropies and progenitor stellar wind residuals. Astronomy & Astrophysics, V. 649, id. A56.
2. Greco et al. (2022): Additional Evidence for a Pulsar Wind Nebula in the Heart of SN 1987A from Multiepoch X-Ray Data and MHD Modeling. The Astrophysical Journal, V. 931, id. 132
3. Sapienza et al. (2022): A Spatially Resolved Study of Hard X-Ray Emission in Kepler's Supernova Remnant: Indications of Different Regimes of Particle Acceleration. The Astrophysical Journal, V. 935, id. 152
4. Sapienza et al. (2024): Probing Shocked Ejecta in SN 1987A: A Novel Diagnostic Approach Using XRISM-Resolve. The Astrophysical Journal Letters, V. 961, id. 9.

Submitted:

1. Abe et al. (2024): Dark Matter Line Searches with the Cherenkov Telescope Array. Journal of Cosmology and Astroparticle Physics (JCAP).
2. Giuffrida et al. (2024): Measuring the initial mass of ^{44}Ti in SN 1987A through the ^{44}Sc emission line, submitted for publication in the Astrophysical Journal.

Conference Proceedings:

1. Sapienza et al. (2023): Unraveling the Effects of Dense Medium on a Near to Bohm-Limit Acceleration in Kepler's SNR. Proceedings of Science of the 38th International Cosmic Rays Conference (PoS ICRC)

Conferences/workshop attended:

- 9th International Fermi Symposium (12-17 April 2021), Online
- XVIII Cracow EPIPHANY conference on Recent Advances in Astroparticle Physics, Jan 10-14, 2022, Online.
- European Astronomical Society Annual Meeting 2022, Jun 27-Jul 1, 2022, Valencia.
- Supernova Remnant and their Progenitors, Organized by Chandra X-ray Center, Aug 16-18, 2022, Online.
- WORKSHOP 3D Supernova (Remnants): How to connect simulations and observation, Sept 5-8, 2022, Online
- Conferenza Nazionale Oggetti Compatti (CNOC) XII, Sept 27-30, 2022, Cefalù (As LOC Member).
- HONEST workshop 2: PeVatrons and their environment,Nov 29 - Dec 1,2022, Online
- 38th International Cosmic Ray Conference, Jul 26 - Aug 3,2023, Nagoya, JP
- Anisotropies in Core-Collapse Supernova Explosions 2, Oct 23-26, 2023, Palermo, IT (As LOC Member).
- 1st XRISM science performance and data analysis Workshop, Feb 12-14, 2024, Geneva, CH
- CTAO Symposium, Apr 15 - 18, 2024, Bologna, IT

Talks:

1. A Spatially Resolved Study of Hard X-Ray Emission in Kepler's Supernova Remnant: Indications of Different Regimes of Particle Acceleration. (XXVII Cracow EPIPHANY Conference, Jan 14, 2022, Online)
2. A Spatially Resolved Study of Hard X-Ray Emission in Kepler's Supernova Remnant: Indications of Different Regimes of Particle Acceleration. (European Astronomical Society Annual Meeting 2022, Jun 28, 2022, Valencia)
3. A Spatially Resolved Study of Hard X-Ray Emission in Kepler's Supernova Remnant: Indications of Different Regimes of Particle Acceleration. (HONEST workshop 2: PeVatrons and their environment)
4. Probing Shocked Ejecta in SN 1987A: A Novel Diagnostic Approach Using XRISM-Resolve. (Anisotropies in Core-Collapse Supernova Explosions 2)

Invited Seminars:

5. The University of Tokyo - Faculty of Science (11/04/2023) Title: Thermal and non-thermal X-ray emission from SNRs.
6. RIKEN Institute - ABBL-iTHEMS Joint Astro Seminars (19/05/2023) Title: X-ray study on the synchrotron emission in Kepler's SNR
7. The University of Kyoto - Graduate school of Science (06/06/2023) Title: Probing X-ray emission mechanisms in SNRs: thermal and non-thermal perspectives

8. JAXA Institute of Space and Astronautical Science (29/06/2026) Title: Probing X-ray emission mechanisms in SNRs: thermal and non-thermal perspectives

Posters:

1. Unraveling the Effects of Dense Medium on a Near to Bohm-Limit Acceleration in Kepler's SNR. (38th International Cosmic Ray Conference)
2. Unraveling the Effects of Dense Medium on a Near to Bohm-Limit Acceleration in Kepler's SNR: A Multiwavelength Exploration (CTAO Symposium)

Thesis title:

The influence of the explosion anisotropies and of the circumstellar medium on the evolution of Supernova Remnants and on particle acceleration at their shocks

Abstract:

This thesis is dedicated to the analysis of X-ray observations of supernova remnants (SNRs), complemented with the synthesis of X-ray spectra employing 3-Dimensional Magneto-Hydrodynamic (MHD) models.
The primary objective of this work is to acquire a deeper understanding of how the supernova (SN) explosion and the circumstellar medium (CSM) impact both on the evolution of SNRs and on the mechanisms governing particle acceleration.
In particular, I address three key challenges: i) investigating the impact of the environment on electron acceleration through the analysis of the non-thermal radiation in the Kepler's SNR, ii) revealing explosion anisotropies and wind residuals in the Vela SNR through the analysis of X-ray observations, iii) predicting the X-ray emission of the fast expanding ejecta in SN 1987A through the synthesis of the XRISM-Resolve spectrum from a dedicated 3D MHD model.

Synchrotron X-ray emission in young SNRs serves as a diagnostic tool to explore the population of high-energy electrons accelerated at the shock front and to understand the acceleration process.
By conducting a spatially resolved spectral analysis using NuSTAR and XMM-Newton observations of Kepler's SNR, I study the non-thermal emission in hard X-rays, using a synchrotron radiation model in the loss-limited regime.
The analysis reveals two distinct regimes of particle acceleration characterized by different Bohm factors.
In the northern region, where the shock interacts with a dense CSM, I observe more efficient acceleration compared to the southern region, where the shock velocity is higher, and there are no indications of shock interaction with dense CSM.
These results suggest an enhanced efficiency of the acceleration process in regions where the shock-CSM interaction generates an amplified and turbulent magnetic field.
In the proposed scenario, the synchrotron cooling time scale aligns with the acceleration time scale.
Conversely, the low speed of a shock propagating in a dense medium is expected to increase the acceleration time scale, resulting in a lower maximum electron energy (and fainter non-thermal X-ray flux) for a given SNR age.
To explore this scenario, I investigate the temporal evolution of the synchrotron flux, taking advantage of the two deepest Chandra/ACIS X-ray observations of Kepler's SNR, performed in 2006 and 2014.
Analyzing the spectra of different filaments in the northern shell, I measure their proper motion and estimate the ratio between the acceleration time-scale and the synchrotron cooling time.
I identify a region with very low shock velocity and find that the acceleration time-scale is longer than the synchrotron cooling time therein. In this region, I measure a significant decrease in flux from 2006 to 2014, thus obtaining the first evidence of fading synchrotron emission in Kepler's SNR.
Overall, these results contribute to a coherent understanding of the diverse electron acceleration regimes observed in Kepler's SNR and associated with its expansion into a non-uniform CSM.

Core-collapse SNRs have intricate morphologies

arising from inherent asymmetries in the SN explosion and the propagation of explosion shock waves in highly heterogeneous environments.
The Vela SNR, indeed, exhibits multiple ejecta fragments, commonly referred to as shrapnel, extending beyond the forward shock.
Recent investigations have identified elevated silicon (Si) abundance in two specific shrapnel, denoted as A and G, positioned in opposite directions relative to the SNR center.
This observation hints at the potential presence of a Si-rich jet-counterjet structure.
To address this issue I conduct an analysis of an XMM-Newton observation focused on a luminous clump situated behind shrapnel G, which aligns with the trajectory connecting shrapnel A and G, with the aim to scrutinize its physical and chemical properties, determining its association with the supposed jet-like structure.
I identify two distinct structures, each exhibiting different physical characteristics.
The first structure displays a remarkable elongation along the axis connecting shrapnel A and G.
Despite its X-ray spectrum being considerably softer than that of the other two shrapnel, hindering Si abundance determination, its physical and chemical properties are found to be consistent with those of shrapnel A and G. The second structure exhibits a higher temperature and resembles a thin filament.
Thanks to the analysis of archived ROSAT data, I find that this filament is part of an extensive and cohesive structure identified in the western rim of the shell.
This feature is interpreted as a signature of a prior interaction between the remnant and the stellar wind from its progenitor star.
The peculiar Ne/O ratio identified in the wind residual raises the possibility of a Wolf-Rayet progenitor for the Vela SNR.

As for the case of SN 1987A, my research consists in evaluating the efficacy of the newly launched XRISM-Resolve high-resolution spectrometer in discerning distinctive signatures associated with shocked ejecta in SN 1987A.
This celestial object presents a unique opportunity to scrutinize the transformation of a SN into a nascent SNR.
Historically, the dominant source of X-ray emission has been the shocked CSM, with no conclusive identification of shocked ejecta.
However, recent investigations provide compelling indications that the future X-ray emissions from SN 1987A will increasingly originate from the ejecta.
Leveraging a state-of-the-art, self-consistent MHD simulation that intricately depicts the evolutionary stages from SN 1987A to its remnant, I generated a synthetic XRISM-Resolve spectrum for SN 1987A performance verification phase observation anticipated in 2024.
My predictions distinctly highlight the prominent role of shocked ejecta in shaping the emission line profiles.
Doppler broadening, resulting from the bulk motion along the line of sight of the rapidly expanding ejecta, is demonstrated to significantly increase the line widths beyond previously observed values.
The quantitative comparison between my synthetic spectra and the actual XRISM spectra will provide a robust diagnostic for establishing a direct correlation between the broadened line emission and the newly shocked ejecta.
This correlation, in turn, will facilitate the retrieval of essential information regarding the dynamics and chemical composition of the ejecta from the X-ray emission.

The PhD Board Dean

Prof. Marco Cannas

Allegato 4

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: Francesca Migliore

Transcript of Records

Tutor: Professor Simonpietro Agnello

Cotutor: Daniele Vecchio (STMicroelectronics)

Courses/school/exam scores:

- "Clean Concepts" - StMicroelectronics (with final exam)
- "X-rays Photoelectron Spectroscopy", ATeN Center
- "Confocal imaging: from basic to advance", ATeN Center
- "Raman microscopy", ATeN Center
- "SAM: potenzialità della Microscopia Elettronica ed utilizzo del microscopio a scansione FEI-ThermoFisher Versa 3D", ATeN Center
- "Organic/inorganic nanocomposites: properties and application" (with final exam)
- Thermodynamic techniques for the characterization of nanostructed materials (with final exam)
- "Analisi di campioni in soluzione mediante spettroscopia pomu/probe al femtosecondo", ATeN Center
- doctoral school of ICOOPMA-EuroDIM 2022 (2-3 July 2022)

Research and training periods abroad

A period of three months (03/2021-05/2021) has been spent to STMicroelectronics Catania site. Periodic bimonthly meetings have been conducted with STMicroelectronics.

Papers published:

- F. Migliore, A. Alessi, F. Principato, S. Girard, M. Cannas, F. M. Gelardi, A. Lombardo, D. Vecchio, A. Brischetto, S. Agnello; *β*-rays induced displacement damage on epitaxial 4H-SiC revealed by exciton recombination. *Appl. Phys. Lett.* 22 January 2024; 124 (4): 042101.
- F. Migliore, M. Cannas, F. M. Gelardi, D. Vecchio, A. Brischetto, S. Agnello; Defects in epitaxial 4H-SiC revealed by exciton recombination, *J. Phys.: Condens. Matter* 36 185601, 2024.

Papers published (different topics from the Thesis):

- S. E. Panasci, E. Schilirò, F. Migliore, M. Cannas, F. M. Gelardi, F. Roccaforte, F. Giannazzo, S. Agnello; Substrate impact on the thickness dependence of vibrational and optical properties of large area MoS2 produced by gold-assisted exfoliation. *Appl. Phys. Lett.* 119, 093103 (2021).

Conferences/workshop attended:

- Talk: "Comparison of the effects of electrons and X-rays irradiation on epitaxial layers of 4H-SiC", 9th International Conference on Optical, Optoelectronic and Photonic Materials and Applications-14th Europhysical Conference on Defects in Insulating Materials, Ghent. University, Ghent, Belgium, 07/07/2022.

- Talk: "Response of epitaxial layer of 4H-SiC to ß-rays and X-rays irradiation", WOCSDICE - EXMATEC 2023 46th Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe- 17th Expert Evaluation and Control of Compound Semiconductor Materials and Technologies, Palermo, Italy, 23/05/2023.

- Talk: "Effects of beta ray irradiation on 4H-SiC epitaxial layer probed by exciton recombination", SiO2 2023-The 14th international conference on SiO2, advanced dielectrics and related devices, Palermo, Italy, 22/06/2023.

- Talk: "Graphitization effects induced by thermal treatments of 4H-SiC", WOCSDICE - EXMATEC 2023 46th Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe- 17th Expert Evaluation and Control of Compound Semiconductor Materials and Technologies, Palermo, Italy, 23/05/2023.

- Talk: "Vulnerability of epitaxial layers and substrates of 4H-SiC to ionizing radiation and thermal treatments", E-MRS Fall meeting 2023 Warsaw University of Technology-Poland, Warsaw, Poland, 18/09/2023.

- Poster: "Comparison of the effects of electrons and X-rays irradiation on epitaxial layers of 4H-SiC". Poster session presented at the doctoral school 2022 Ghent, Belgium.

Thesis title:
"Influence of ionizing radiations and thermal treatments on 4H-SiC defectivity"

Abstract:
The PhD project is funded by STMicroelectronics, a leader company in the production of semiconductor devices, and is focused on 4H-SiC, a polytype of silicon carbide (a wide bandgap semiconductor) with exceptional properties that make it suitable for the realization of high-power and high-temperature devices and for applications in harsh-environments. Among these properties the most relevant are the indirect bandgap value of 3.27 eV, the high breakdown electric field strength, the thermal conductivity, the chemical inertness, the mechanical strength, the saturation drift velocity and the radiation hardness.
The development of SiC and its utilization as a semiconductor in devices is relatively recent and mainly due to the work of several companies. For these reasons, most of the studies and characterization conducted on SiC have been performed especially using electrical characterization techniques. These ones are known to be invasive or destructive because require fixed metallic contacts. As a consequence, electrical techniques cannot be used "online" in the production to monitor the quality and the properties of the SiC devices during their growth.
In this thesis, substrate and epitaxial layer of 4H-SiC have been experimentally studied with

optical techniques (micro-Raman, steady-state and time resolved photoluminescence, steady-state absorption) to investigate the materials properties. In particular, optical techniques are non-destructive and require minimal or zero sample preparation and for this reason they can be used to check the interested properties, such as the polytype, the doping, the presence of defects, at each step of the growth. Furthermore, optical techniques can allow to get two- or three-dimensional maps of properties of the whole wafer semiconductor.
Wafers produced by different companies were studied together with the epitaxial layer of 4H-SiC grown on them by STMicroelectronics. The used techniques enabled to distinguish among the different productions and to highlight the different defect level by time resolved photoluminescence, allowing to get important information on the quality of the material before the realization of complete device.
Part of the thesis was dedicated to the study and optimization of one of the first steps of the devices growth. This step consists of thermal treatments conducted on the substrates before the growth of the epitaxial layers, an important topic at industrial level because the quality of the substrates influences directly the quality of the epitaxial layer grown on them. In this study criticalities of the process have been evidenced by Raman Spectroscopy and, in particular, the presence of a contaminant layer has been highlighted. This finding enabled the company to reconsider the treatment parameters allowing to improve the production process.
In view of application of devices of SiC in harsh environments the effect of electron and X-ray irradiations on 4H-SiC epitaxial layers has been explored. Literature is rich in studies of different ionizing radiation on several kind of devices made of 4H-SiC (by electrical measurements) but few studies have been carried out on the pristine material. This implies that some effects could be related to the device production processes and not directly to the materials features. The choice to use optical characterization techniques enabled to deepen this aspect directly on the material without the need to include electronic setup. The formation of defects due to electron irradiation has been indirectly shown monitoring the lifetime of the excitonic band by time-resolved photoluminescence spectroscopy. Furthermore, the comparison with the X-rays irradiated samples suggested that the induced defects are related to displacement damage. Finally, thanks to thermal treatments conducted in air up to 900 °C (of the electron irradiated samples) and a comparison with the literature, the defects generated by electron irradiation have been associated with stable carbon vacancies.

The PhD Board Dean

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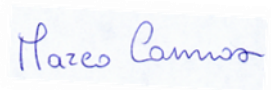

Allegato 5

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: Claudio Pellitteri

transcript of records

Tutors: Prof. Gioacchino Massimo Palma
Prof. Salvatore Lorenzo

Courses/school/exam scores

- G.M.Palma, course "Physics and Information"
  Exam: Quantum Random Walk, Grade A
- F. Ciccarello and A. Carollo, course “Quantum Optics and Topology in Photonic lattices”
  Exam: Topological Phases of Optomechanical Arrays, Grade A
- Lake Como School "Thermodynamics of quantum systems and processes", 22- 26 Marzo 2021
  Exam: Thermodynamics and Quantum Measurement, Grade A
- 2022 Qalypso Summer School on Quantum Computation & Open Quantum Systems

Conferences/workshop attended and talks & posters:
Posters:

- *Cascaded optomechanical systems*, IQIS Trieste, September2022
- Cascaded optomechanical systems at Qalypso Summer School on Quantum Comuptation & Open Quantum Systems, Malta (Gozo) July 2022

Papers

- *Pellitteri, C., Palma, G.M., Lorenzo, S. (2024). Temperature gradient and asymmetric steady state correlations in dissipatively coupled cascaded optomechanical systems. PHYSICA SCRIPTA, 99(1) [10.1088/1402-4896/ad1238].*
- *Amato F., Pellitteri C., Palma G.M., Lorenzo S., Lo Franco R. (2024). Heating and cooling processes via phaseonium-driven dynamics of cascade systems. PHYSICAL REVIEW A, 109(4), 1-11 [10.1103/PhysRevA.109.043705]*
- *Pellitteri C., Palma G. M., Lorenzo S. "Solitary Pulse propagation in optomechanical cascaded array" In preparation*

Thesis title: Correlated dynamics of driven cascaded quantum optical cavities

Abstract

The interaction between a light cavity mode and other quantum systems provides an excellent platform for a multitude of applications in quantum technologies. However, more striking features arise when considering more than one cavity coupled in a unidirectional manner, forming a so-called cascaded configuration.

In this thesis, we first investigate the dynamics of a system composed of a pair of cavity light modes arranged in a cascade configuration, interacting with a thermally excited beam of phaseonium atoms serving as ancillas. We provide exact closed dynamics for the first cavity over arbitrarily long interaction times.
We emphasize the role played by the characteristic coherence phase of phaseonium atoms in determining the steady states of both the cavity fields and the ancillas. Additionally, we demonstrate how the second cavity follows a non-Markovian evolution due to interactions with the "used" ancillary atoms, facilitating information exchange with the first cavity.
By adjusting the parameters of the phaseonium atoms, we can determine the final stable temperature reached by the cavities, thereby enabling both heating and cooling processes.
Subsequently, we focus on the interaction between a light mode and a mechanical harmonic oscillator via radiation pressure, studying the dynamics of a pair of optomechanical systems interacting dissipatively with a waveguide in a unidirectional manner.
Focusing on the regime where the cavity modes can be adiabatically eliminated, we derive an effective coupling between the two mechanical modes and explore the classical and quantum correlations established between the modes in both the transient and stationary regimes.
We highlight the asymmetrical nature of these correlations due to the unidirectional coupling and find that a constant amount of steady correlations can exist at long times. Furthermore, we demonstrate that this unidirectional coupling establishes a temperature gradient between the mirrors, dependent on the frequencies' detuning.
Additionally, we analyze the power spectrum of the output guide field and show how, thanks to the chiral coupling, it is possible to reconstruct the spectra of each single mirror from such spectrum.
Finally, we consider the case of a chain of optomechanical systems, always coupled unidirectionally by means of a waveguide, and find that by adiabatically eliminating the cavity modes, the effective interaction between the mechanical modes exhibits a behavior that extends beyond simple chain-like interactions, forming a network-like structure. This has significant implications for engineering a quantum network. Work in progress: there's also a work still in progress in which we notice that in such cascaded array configuration, looking only at the dynamics of the average values and driving the first cavity with a soliton shaped pulse, it can be seen that there is the propagation of a soliton in the average positions of the mechanical mode.

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The PhD Board Dean

Prof. Marco Cannas

Allegato 6

PHD IN PHYSICAL AND CHEMICAL SCIENCES, XXXVI COURSE

PhD Candidate: TRIPODO GIOVANNI

Transcript of Records

Tutor: Prof. GIOVANNI MARSELLA

Courses/school/exam scores:

- Exam: Experimental techniques in Astroparticle physics - Prof. Giovanni Marsella (16 hours);
- Exam: Project Management in the scientific-spatial context - Prof.ssa Giuseppina Micela;
- Exam: Millisecond Pulsars: Theory and Observations;
- Electronic programmable systems - Prof. Giuseppe Costantino Giaconia (10 hours);
- Fourth Machine Learning - INFN Hackathon: Starting Level;

Research and training periods abroad

6-month period at "Laboratory of Subatomic Physics & Cosmology (LPSC)" - Grenoble (France).

Papers published:

- **Technical and scientific performance of the prototype Schwarzschild-Couder telescope for CTA** , Colin B A et al, Astronomical Optics: Design, Manufacture, and Test of Space and Ground Systems III, 2021;
- **Design and performance of the prototype Schwarzschild-Couder telescope camera,** Colin B A et al, Journal of Astronomical Telescopes, Instruments, and Systems, 2022;
- **Prototype Schwarzschild-Couder Telescope for the medium-sized telescope of Cherenkov Telescope Array Observatory**, Vassiliev V et al, Ground-based and Airborne Telescopes IX, 2022;
- **Assembly and performance of SiPM arrays for the prototype SCT proposed for CTA**, Ambrosi G et al, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2022;
- **Quality control tests on the new front-end electronics for the Schwarzschild–Couder Telescope,** Tripodo G et al, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2023;
- **A SiPM multichannel ASIC for high Resolution Cherenkov Telescopes (SMART) developed for the pSCT camera telescope,** Aramo et al, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2023;
- **High-density near-ultraviolet silicon photomultipliers: Characterization of photosensors for cherenkov light detection**, Ambrosi et al, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2023;

Conferences/workshop attended:

Posters:

- Quality control tests on the new front-end electronics for the Schwarzschild–Couder Telescope, 15th Pisa Meeting on Advanced Detectors, La Biodola (Livorno);

Workshop attended:

- AVENGe - Advances in Very-High Energy Astrophysics with Next-Generation Cherenkov Telescopes, Roma.

Thesis title: Test bench, data acquisition systems and analysis for array of sensors: a transversal approach

Abstract:

During my 3 years Ph.D., which was funded by the "Fondo per lo sviluppo e la coesione - Piano Stralcio (FSC)," I worked transversely on sensor arrays as part of the Cherenkov Telescope Array (CTA) project, in collaboration with the Tecnogreen srls spa company based in Sant'agata di Militello, Sicily, and in addition, I spent a six-month period at the "Laboratory of Subatomic Physics et Cosmology (LPSC)" in Grenoble, France, where I was involved in the project TIARA.
The manuscript is divided into three chapters, one for each of the main aspects. Specifically:

- Chapter 1 : I first introduce CTA, explaining what is and the main features. Then I talk about cosmic rays and gamma rays, describing the used method for the detection from the ground. Finally, I describe the prototype Schwarzschild-Couder Telescope, one of the proposed medium-size telescopes for CTA, whose camera is under the upgrading phase, focusing on the work I have done to test the new electronics and SiPMs.
- Chapter 2 : In this chapter, I talk about hadrontherapy and how prompt gammas help in these applications. Next, I describe the TIARA project in which I was involved, explaining the problems there are in managing such a complex array of detectors. Finally, I propose a data acquisition system and verify its characteristics when used with TIARA detectors. The results and conclusions are described in the final section.
- Chapter 3 : In the last chapter, I talk about the technology transfer work I did with the company Tecnogreen. Initially, I describe the context in which the company works, and then I focus on the measurements and data analysis that I carried out in order to create a system that provides decision support for the implementation of new tropical fruit plants in Sicily.

The PhD Board Dean

Prof. Marco Cannas