## Personal information

Name: Marco Compagnoni
Email: marco.compagnoni@polimi.it
Nationality: Italian
Date of birth: 04/25/1980

## Education

Dates: 2005-2009
Title of qualification awarded: Ph.D. in Mathematical Engineering
Principal subjects: Mathematical Physics and Algebraic Geometry
Thesis title: Geometric aspects of D-Branes on noncompact varieties
Principal advisor: Dr. Sergio Luigi Cacciatori, Università dell'Insubria
Secondary advisor: Prof. Enrico Schlesinger, Politecnico di Milano
University: Politecnico di Milano, Milano - Italy

Dates: 1999-2004
Title of qualification awarded: Degree in Physics (MSc Equivalent)
Principal subjects: Theoretical Physics
Thesis title: Supersymmetric integrable models in nonanticommutative geometry (in Italian)
Principal advisor: Prof. Silvia Penati
Secondary advisors: Prof. Luciano Girardello, Dr. Laura Tamassia
Final Mark: 110/110 cum laude
University: Università degli studi di Milano Bicocca, Milano - Italy

## Job Positions

Dates: 2013-
Position: PostDoc
Principal subject: Applied Mathematics - MAT/03
Project title: Engineering of an automatic classifier of cheratinic fibers (CLASH).
Head: Prof. Alessandra Cherubini
Name of organization: Dipartimento di Matematica del Politecnico di Milano, Milano - Italia

Dates: 2012-
Position: Adjunct Professor
Course: Linear Algebra and Geometry
Name of organization: Politecnico di Milano, Milano - Italia

Dates: 2011-2013
Position: PostDoc
Principal subject: Applied Mathematics - MAT/02
Project title: Study of an automatic classifier of cheratinic fibers (CLASH).
Head: Prof. Alessandra Cherubini
Name of organization: Dipartimento di Matematica del Politecnico di Milano, Milano - Italia

Dates: 2005-
Position: Teaching Assistant
Courses: Precalculus, Mathematical Analysis, Linear Algebra and Geometry, Theoretical Mechanics
Name of organization: Politecnico di Milano, Milano - Italia

## Personal skills, competences, qualifications

Mother tongue: Italian

Other languages: English written C1, spoken B2. French A2.

Computer skills: Operating System: Windows, Linux, Mac OS X
Programming Languages: C, Fortran, Java
Scientific Programs: Mathematica, Matlab, Singular.
In particular, I have advanced skills in the processing of digital images.

Qualifications awarded: Qualification aux maîtres de conférences in Mathematics, 2014–2018
Qualification as Adjunct Professor of the Mathematics Department of Politecnico di Milano, 2012–

## Research Collaborations

### Mathematical methods for space–time signal processing

Roberto Notari - GAIA, Dipartimento di Matematica, Politecnico di Milano
Alessia Pini - MOX, Dipartimento di Matematica, Politecnico di Milano
Fabio Antonacci, Augusto Sarti, Stefano Tubaro - ISPG, Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano

### Image processing and pattern recognition

Alessandra Cherubini - GAIA, Dipartimento di Matematica, Politecnico di Milano
Simone Vantini - MOX, Dipartimento di Matematica, Politecnico di Milano
Marco Marcon - ISPG, Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano
Mario Arrigoni Neri - Dipartimento di Ingegneria dell'Informazione e Metodi Matematici, Università degli studi di Bergamo
Alessandro Berlin - IMAX s.r.l., MaxMara Fashion Group.

### Local Mirror Symmetry

Sergio Luigi Cacciatori - Dipartimento di Scienza e Alta Tecnologia, Università dell'Insubria
Stefano Guerra - Department of Mathematics, Oregon State University.

## Participation in Research Project

Dates: 2011-
Project: CLASH "Studio di un classificatore automatico di fibre cheratiniche"
(Study of an automatic classifier of cheratinic fibers)
Financial support: IMAX s.r.l. - MaxMara Fashion Group
Regione Lombardia

Dates: 2012-
Project: PRIN 2010/2011 "Automi e Linguaggi Formali: aspetti matematici e applicativi"
(Automata and Formal Languages: mathematical and applied aspects)
Financial support: MIUR - Italian Ministry for University and Research

Dates: 2010-2012
Project: collaboration to SCENIC "Self Configuring ENviroment-aware Inteligent aCoustic sensing"
Financial support: Seventh Framework Program of the European Community in the ICT area

## Master and Doctoral Thesis Supervision

Dates: 2013-2014
Role: Co–advisor with Alessandra Cherubini and Mario Arrigoni Neri
University: Politecnico di Milano - Dipartimento di Matematica
Student: Silvia Gentili - Master student in Mathematical Engineering
Thesis title: Procedura di feature selection per classificatori neurali e sua applicazione in campo tessile

Dates: 2013-2014
Role: Co–advisor with Roberto Notari
University: Politecnico di Milano - Dipartimento di Matematica
Student: Andrea Ruggiu - Master student in Mathematical Engineering
Thesis title: The geometry of trilateration and the TOA map

Dates: 2012-2013
Role: Co–advisor with Simone Vantini
University: Politecnico di Milano - Dipartimento di Matematica
Student: Marina Riabiz - Master student in Mathematical Engineering
Thesis title: Data driven Sobolev metrics for functional data analysis: an application to natural fibers

Dates: 2011-2012
Role: Advisor for the minor doctoral theme
University: Politecnico di Milano - Dipartimento di Elettronica, Informazione e Bioingegneria
Student: Paolo Bestagini - Graduate student in Information Engineering
Thesis title: Localization of Acoustic Sources through the Fitting of Propagation Cones using Multiple Independent Arrays

## Seminars, Conferences and Schools

Dates: August 2015
Conference: SIAM Conference on Applied Algebraic Geometry
Held at: National Institute for Mathematical Sciences, Daejeon - South Korea
Seminar: The Algebro-Geometric Study of TOA-based Localization Problems

Dates: June 2015
Conference: Algebraic Statistics 2015
Held at: Università degli studi di Genova, Genoa - Italy
Seminar: The geometry of the statistical model for range–based localization

Dates: January 2014
Conference: 3rd Carlo Alberto Stochastics Workshop
Held at: Collegio Carlo Alberto, Moncalieri - Italy
Poster: The geometry of the TDOA based localization and its statistical inference

Dates: August 2013
Conference: SIAM Conference on Applied Algebraic Geometry
Held at: Colorado State University, Fort Collins - USA
Seminar: The geometry of the TDOA based localization

Dates: June 2013
Conference: Effective Methods in Algebraic Geometry MEGA2013
Held at: Goethe Universität, Frankfurt - Germany
Poster: The geometry of the TDOA based localization

Dates: May 2013
Conference: Meeting on Discrete Tomography and Applications
Held at: Politecnico di Milano, Milan - Italy
Seminar: A geometric model for radiant source localization based on TDOA

Dates: March 2013
Conference: G.T.M. Seminar
Held at: Università degli studi di Genova, Genoa - Italy
Seminar: A geometric model for radiant source localization based on TDOA

Dates: April 2011
Conference: Meeting on Discrete Tomography and Applications of Convexity
Held at: Politecnico di Milano, Milan - Italy
Seminar: Localization of Acoustic Sources through the Fitting of Propagation Cones

Dates: June 2008
School: Aspects of moduli theory
Held at: Scuola Normale Superiore, Pisa - Italy

Dates: March 2008
School: Holomorphic symplectic manifolds and derived categories
Held at: Palazzo Feltrinelli, Gargnano del Garda - Italy

Dates: June 2007

Conference: Derived categories in mathematics and physics
Held at: Snowbird conference center, Snowbird (Utah) - USA

Dates: June 2007
School: Derived categories minicourse
Held at: University of Utah, Salt Lake City - USA

Dates: August 2005
School: Scuola Matematica Interuniversitaria
Held at: Universitá di Perugia, Perugia - Italy

## Publications and Research Products

### Mathematical methods for spacetime signal processing

[1] F. Antonacci, A. Canclini, P. Bestagini, M. Compagnoni, A. Sarti, S. Tubaro,
**A Robust and Low-Complexity Source Localization Algorithm for Asynchronous, Distributed Microphone Networks**,
IEEE Transactions on Audio, Speech, and Language Processing, Volume 23 (2015), Issue 10, 1563-1575.

[2] M. Compagnoni, R. Notari, F. Antonacci, A. Sarti,
**A comprehensive analysis of the geometry of TDOA maps in localisation problems**,
Inverse Problems, Vol. 30 (2014), Number 3, Pages 035004.

[3] M. Compagnoni, R. Notari,
**TDOA-based localization in two dimension: the bifurcation curve**,
Fundamenta Informaticae XXI (2014) 1001–1012.

[4] P. Bestagini, M. Compagnoni, F. Antonacci, A. Sarti, S. Tubaro,
**TDOA-Based Acoustic Source Localization in the Space-Range Reference Frame**,
Journal on Multi-Dimensional Systems and Signal Processing, (2014) 25:337-359.

[5] A. Contini, A. Canclini, F. Antonacci, M. Compagnoni, A. Sarti, S. Tubaro,
**Self-calibration of microphone arrays from measurement of Times Of Arrival of acoustic signals**,
5th INTERNATIONAL SYMPOSIUM ON COMMUNICATIONS, CONTROL, AND SIGNAL PROCESSING (ISCCSP 2012), Pages 1-6.

[6] M. Compagnoni, P. Bestagini, F. Antonacci, A. Sarti, S. Tubaro,
**Localization of Acoustic Sources Through the Fitting of Propagation Cones Using Multiple Independent Arrays**,
IEEE Transactions on Audio, Speech, and Language Processing, Volume 20 (2012), Issue 7, 1964-1975.

**Preprints and works in preparation**

[7] M. Compagnoni, R. Notari, A. Ruggiu, A. Sarti,
**The Algebro–Geometric study of Range Maps**,
submitted to Journal of Nonlinear Science.

[8] M. Compagnoni, A. Canclini, P. Bestagini, F. Antonacci, A. Sarti, S. Tubaro,
**TDOA denoising for acoustic source localization**,
arXiv 1509.02380, submitted to Journal on Multi-Dimensional Systems and Signal Processing.

[9] M. Compagnoni, R. Notari, F. Antonacci, A. Sarti,
**The statistical model of the TDOA–based localization**
in preparation.

[10] M. Compagnoni, A. Pini, A. Canclini, P. Bestagini, F. Antonacci, A. Sarti, S. Tubaro,
**Outliers removal in TDOA data**,
in preparation.

**Software**

[11] F. Antonacci, P. Bestagini, A. Canclini, M. Compagnoni, A. Sarti,
**Error propagation toolbox**,
within the SCENIC project.

Local Mirror Symmetry

[12] S.L. Cacciatori, M. Compagnoni, S. Guerra,
**The physical mirror equivalence for the local $\mathbb{P}^2$**,
Communications in Mathematical Physics, 333, 367-388 (2015).

[13] S.L. Cacciatori, M. Compagnoni,
**Supersymmetric standard model, branes and Del Pezzo Surfaces**,
New Developments in the Standard Model (2012), 131-184, Nova Science Publishers.

[14] S.L. Cacciatori, M. Compagnoni,
**On the geometry of $\mathbb{C}^3/\Delta_{27}$ and Del Pezzo surfaces**,
Journal of High Energy Physics, Volume 2010, Issue 5, 1-27.

[15] S.L. Cacciatori, M. Compagnoni,
**D-Branes on $\mathbb{C}^3_6$. Part I. Prepotential and GW-invariants**,
Advances in Theoretical and Mathematical Physics, Volume 13 (2009), Issue 5, 1371-1443.

## Referee Activities

Mathematical Review 2011-, Zentralblatt MATH 2014-, Signal Processing 2014-, IEEE Journal on Selected Areas in Communications 2014-, IEEE Transactions on Audio, Speech, and Language Processing 2015-, Journal of Selected Topics in Signal Processing 2015-.

## Teaching Activities

Since 2005, I have taught several mathematical courses for various undergraduate engineering classes at the Politecnico di Milano, both as Professor, Teaching Assistant and Tutor.

**Adjunct Professor**

Dates: 2015-2016
Course: Linear Algebra and Geometry, Information Engineering, 80 hours

Dates: 2014-2015
Course: Linear Algebra and Geometry, Information Engineering, 80 hours

Dates: 2013-2014
Course: Linear Algebra and Geometry, Information Engineering, 80 hours

Dates: 2012-2013
Course: Linear Algebra and Geometry, Information Engineering, 80 hours

**Teaching Assistant**

Dates: 2014-2015
Course: Mathematical Analysis and Geometry I, Industrial Engineering, Prof. Fabio Cipriani, 48 hours

Dates: 2013-2014
Course: Mathematical Analysis and Geometry I, Industrial Engineering, Prof. Fabio Cipriani, 48 hours

Dates: 2012-2013
Course: Mathematical Analysis and Geometry I, Industrial Engineering, Prof. Fabio Cipriani, 48 hours

Dates: 2011-2012
Courses: Mathematical Analysis and Geometry I, Industrial Engineering, Prof. Fabio Cipriani, 48 hours
Linear Algebra and Geometry, Information Engineering, Prof. Alessandra Cherubini, 30 hours
Theoretical Mechanics, Civil Engineering, Dr. Silvia Lorenzani, 30 hours

Dates: 2010-2011

Courses: Mathematical Analysis and Geometry I, Industrial Engineering, Prof. Fabio Cipriani, 48 hours
Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours
Theoretical Mechanics, Civil Engineering, Dr. Paolo Barbante, 30 hours
Theoretical Mechanics, Civil Engineering, Dr. Silvia Lorenzani, 30 hours

Dates: 2009-2010
Courses: Mathematical Analysis and Geometry II, Industrial Engineering, Prof. Fabio Cipriani, 96 hours
Theoretical Mechanics, Materials Engineering, Prof. Paolo Biscari, 20 hours
Mathematical Analysis and Geometry I, Industrial Engineering, Dr. Gianluca Mola, 48 hours
Mathematical Analysis II, Information Engineering, Prof. Luisa Rossi Costa, 20 hours
Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours
Theoretical Mechanics, Civil Engineering, Dr. Paolo Barbante, 30 hours

Dates: 2008-2009
Courses: Mathematical Analysis and Geometry II, Industrial Engineering, Dr. Marco Boella, 48 hours
Theoretical Mechanics, Materials Engineering, Prof. Paolo Biscari, 20 hours
Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours
Theoretical Mechanics, Biomedical Engineering, Prof. Lorenzo Valdettaro, 40 hours

Dates: 2007-2008
Courses: Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours
Theoretical Mechanics, Materials Engineering, Prof. Lorenzo Valdettaro, 20 hours

Date: 2006-2007
Course: Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours

Dates:2005-2006
Course: Theoretical Mechanics, Civil Engineering, Prof. Giancarlo Spinelli, 40 hours

**Tutor**

Dates: 2010-2011
Course: Precalculus, 48 hours

Dates: 2009-2010
Courses: Mathematical Analysis II, Materials Engineering, 20 hours
Precalculus, 48 hours

Moreover, in 2008-2009 I was involved as a tutor in the project *Progettiamo con la matematica* (projecting with mathematics) of the Politecnico di Milano, devoted to high school students. I supported a group of students in the realization of the projects *A Green Lighting Plant using Automata*, which was later presented at interscholastic scientific contests.

## Research Statement

My research activities focus on the use of geometric methods in the study of physical and engineering problems. In my Master thesis I studied the extension of integrable quantum field theories in non commutative geometry. Then, as graduate student I specialized in the study of the geometric aspects of string theory, in particular in relation with mirror symmetry. In my postdoctoral activities, my interests have been primarily focused on the use of geometry and algebra in engineering, especially for the processing of images and audio signals. In 2013, I cofounded the group Geometry-Algebra in Applications (GAIA[1]), within the Dipartimento di Matematica of the Politecnico di Milano. Currently, I am involved in two main research areas of the GAIA group.

### Mathematical methods for space–time signal processing

In 2010, I started to collaborate with the members of the Image and Sound Processing Group (ISPG) of the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano. In particular, I proposed the use of techniques from differential and algebraic geometry in order to investigate problems coming from audio signal processing area. Our efforts resulted in the publication of several manuscripts [1-10], where I appear mainly as first author, and a software package [11]. On the subject, I supervised one minor doctoral project and one master thesis.

In [1,3,5,6] we addressed the Time Differences Of Arrival (TDOA) localization problem. We reformulated it in terms of surfaces intersection in the Minkowski spacetime, which allowed us to compare the most widespread localization algorithms. Moreover, we proposed a new estimation algorithm working with unsynchronized receivers, based on the fitting of such surfaces.

In [5] we attacked the question of selfcalibration of receiver arrays, i.e. the estimation of the sensor positions through experimental measurements. Using projective geometry, we handled the natural constraints of the problem and we translated the calibration procedure into the optimization of certain homogeneous polynomials.

In [2,3] we turned our attention directly to the geometric propagation model behind the TDOA based source localization. This is a non linear statistical model and it is widely studied in the engineering and physical literature, but its complete mathematical characterization is still lacking. We carried on the analysis started in [3,5], showing that the TDOA localization can be correctly described as a semialgebraic geometric problem in the Minkowski space. Using (real) algebraic geometry and multilinear algebra techniques, we completed the study of the structural identifiability of the model, i.e. the analysis of the existence and uniqueness of the localization, in the minimal scenario with three receivers and a source lying on a plane.

Currently, our work is continuing along several different directions. In [7] we carry out the theoretical study of the main deterministic models used in source localization problems, following the line drawn in [1]. In [9] we analyze the statistical model for the TDOA localization. By using techniques from Algebraic Statistics and Information Geometry, we focus on the definition of effective algorithms for solving Maximum Likelihood Estimation and for computing the error propagation in the estimation of the source position. Finally, in [8,10] we apply our previous results for the problems of noise reduction and outliers removal in TDOA measurements.

### Image processing and pattern recognition

In 2011, I joined a project concerning the control of the quality of textile yarns. This is a well-known and relevant problem in textile industry. Import and export laws often prescribe specific tolerance on the declared composition of cloth tissues, with some specific tolerance to be checked against shipped goods. The case of animal fibers is a significant example, where very expensive cashmere can be often confused with normal wool.

In the last two decades there have been several attempts of defining an automatic and reliable classifier able to evaluate the composition of animal yarns. Our approach to the problem is based on the morphological analysis of the individual fibers composing the yarn, whose images are acquired by high resolution electron microscope.

During the project we addressed many different issues, both theoretical and practical. Firstly, we

[1] http://www.mate.polimi.it/GAIA/

dealt with the implementation of robust algorithms for automatic processing of the digital images of the fibers. Then, we developed a combination of advanced statistical tools and soft computing techniques (e.g. functional data analysis and neural networks) in order to face the classification problem. Finally, at the aim to obtain a completely automatized process, we have recently defined and implemented on the electronic microscope a method for the automatic acquisition of the fiber images.

Currently, the results of our work are bound by a confidentiality agreement, until the submission of the patent application. On the subject, I supervised two master thesis.

### Local Mirror Symmetry

In algebraic geometry, mirror symmetry is a relationship between certain pair of (mirror) Calabi-Yau varieties $X, \check{X}$. The more general approach to mirror symmetry is the one formulated by Kontsevich in 1994, known as Homological Mirror Symmetry (HMS). He proposed that the relation between $X, \check{X}$ could be understood in terms of an equivalence of two particular categories defined over such spaces. In my research, in particular during my doctoral studies, I investigated HMS in the case of non compact varieties.

In [15], we studied the mirror symmetry for the toric orbifold $X = \mathbb{C}^3/\mathbb{Z}_6$. This is a singular, non compact, algebraic variety, admitting multiple crepant resolutions. We proved that the lack of compactness causes ambiguities in the calculation of the Gromov–Witten invariants and we gave a geometric interpretation of this fact. A similar analysis has been conducted in [12] for the orbifold $X = \mathbb{C}^3/(\mathbb{Z}_3 \times \mathbb{Z}_3)$.

In [14], we studied the geometric properties of the open string theory in the context of the bottom-up approach to string phenomenology. We proved the equivalence of the Verlinde–Wijnholt model defined on the tautological cone over a quasi Del Pezzo surface and the one on the non abelian orbifold $\mathbb{C}^3/\Delta_{27}$, whose simplified toric analogous is described in [13].

More recently, in [12] we studied HMS for the local $\mathbb{P}^2_{\mathbb{C}}$, that is the simplest non compact Calabi-Yau threefold. Using the Hosono approach to HMS, we proved that, among all possible functor giving an equivalence of categories, there exists a particular one that preserves the central charges and that is compatible with the computation of the Gromov–Witten invariants.