CURRICULUM VITAE
MARIA LUISA CHIOFALO

PERSONAL DATA

BORN 09/09/1968 IN REGGIO CALABRIA (ITALY)
Citizenship: ITALIAN
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1. EDUCATION AND TRAINING

1.1 ACADEMIC

- **PhD in Physics** (Scuola Normale Superiore – SNS, Pisa,Italy, **70/70 cum laude**). Supervisors professor Giuseppe Iadonisi and professor Franco Bassani
- **MD in Physics** (University of Pisa, Italia,1992, **110/110 cum laude**). Supervisors: professor Giuseppe Iadonisi and professor Franco Bassani.

1.2 HIGH-SCHOOL

- **Diploma in Classic studies** (Liceo Classico “Tommaso Campanella”, Reggio Calabria, Italy, 1986, **60/60**)

1.3 MUSIC STUDIES

- **Diploma in Musical theory and solfège** (Conservatorio “F. Cilea” in Reggio Calabria, **flute class**)
- Member of the **University of Pisa Orchestra** and of the **Filarmonica Pisana Big Band,** playing **Tenor saxophone**
- Private studies in piano playing

1.4 PHYSICS SCHOOLS

- **National School on Condensed Matter Physics** (1993 and 1994)
- **International School of Physics ”Enrico Fermi"** on “Bose-Einstein condensation in Atomic Gases" (Varenna, Italy, **1998**)
- **ICTP School on Continuum Quantum Monte Carlo methods** (Trieste, Italy, **2004**)
- Workshop **Engage – Communicating and outreaching science: Success methods and strategies**, organized by VIS (Firenze, November 2020)

1.5 LANGUAGES

- **LANGUAGE L1: ITALIAN**
- **OTHER LANGUAGES:**

A. ENGLISH

Reading: excellent
Writing: excellent
Spoken: excellent

B. FRENCH

Reading: excellent
Writing: average
Spoken: average

1.6 OPERATIVE SYSTEMS AND PROGRAMMING LANGUAGES

Fortran77: excellent
Fortran90: average
Matlab: average
Mathematica: good
Linux/Unix: good
Windows: good

2. EXPERIENCE

2.1 POSITIONS

A. Associate professor at the Physics Department of the University of Pisa. Scientific sector: Condensed Matter Physics (FIS/03) (**2007-). National Scientific Habilitation as Full professor, sector FIS02/B2 (11/12/2013-11/12/2022).**

B. Grants and Temporary positions obtained after public competitions

- **PhD position at the Scuola Normale Superiore in Pisa (1992-1995)**.
- **Grant INFM-FORUM** on "Bose-Einstein Condensation" (January-April and May-October **1996**), under the scientific responsibility of professor **Mario P. Tosi**.
- **PostDoc grant at the Scuola Normale Superiore di Pisa** (November 1st, **1996**-July 27th, **1998**), under scientific supervision of professor **Mario P. Tosi**.
- **Temporary Researcher position at the Scuola Normale Superiore** (July 28th, **1998** –July 27th, **2002**)
- **Research grant on "General Relativity Tests in Space**" at the **Mathematics Department of the University of Pisa, Space-mechanics group** (August 1st, **2002** – February, 28th **2004**), scientific supervision of professor Anna Nobili.
- **Temporary Researcher position at the Scuola Normale Superiore** (March 1st, **2004** – September 30th, **2007**).
- **Professional collaboration: fixed-term contract with the Institute for Calculus Applications-CNR (Rome)** to realize a simulation code for the dynamics of Bose-Einstein Condensates.

2.2 TEACHING

2.2.1 TEACHING ASSIGNEMENTS AS PROFESSOR IN CHARGE (2007-):

A1. **Many-Body Physics** (6 Credits Units-CFU Code 269BB) - **MD in Materials and Nanotechnology**, University of Pisa (**2017-**).

A2. Many-Body Physics (9 CFU Code 276BB) - **MD** and **PhD School in Physics**, University of Pisa (**2015-**).

A3. **Physics (**6 CFU**) and Chemical-Physics (**3 CFU**)** (9 CFU Code 176BB) – **MD in Chemistry and Pharmaceutical Technologies**, University of Pisa (**2011-**).

A4. **The Physics of Everyday Life (**Code 320BB) – BSC in **Physics (2018**-), aimed at training physicists as teachers in K-14.

A5. **The Physics of Everyday Life** (3 CFU Code 240BB) **– MD in Pharmacy**, University of Pisa (**2013-).**

A6. **Physics and Elements of Mathematics and Statistics** (6 CFU Code 004BA) – **BSC in Sciences of Herbs and Health-care Products**, University of Pisa (**2015-).**

A7. **Many-Body Physics** (6 CFU Code 087BB) - **MD** and **PhD School in Physics**, University of Pisa (**2014-2015**).

A8. Preparatory and empowering courses in **Mathematics and Physics** for students of the Pharmacy Department, University of Pisa (**2009-2015**).

A9. **Mathematics** (6 CFU Code AA086) – **MD in Pharmacy**, University of Pisa (**2007-2009)**.

A10. **The Physics of Everyday Life** (3 CFU Code ZW899and Code 240BB) **– MD in Pharmacy and in** Chemistry and Pharmaceutical Technologies, University of Pisa (**2007-2013**).

A11. **Physics and Elements of Mathematics** (6 CFU, Code 001BA) – **MD in Chemistry and Pharmaceutical Technologies**, University of Pisa (**2009-2011**).

A12. **Physics and Elements of Mathematics (**Codes 002AB and 177BB**) – BSC in Herbal Sciences and Scientific Communication about Drugs**, University of Pisa **(2010-2015**).

A13. Quantum Liquids (Code 382BB, 9 CFU) for the **PhD course in Physics and the MD in Physics** University of Pisa **(2021-).**

A14. Quantum Liquids (Code 394BB, 6 CFU) **for the BS degree in Nanoscience** University of Pisa **(2021-).**

Data up to date:

- **Numbers of hours in classroom-taught lectures: 160 on average per year (2007-)**

- **Number of recorded exams:** (since 2010, as from data available at Statini Unipi site): **1520 as Chair and 1940 in total.**

Other Teaching assignements (selection):

- **Everyday-life Science: outreach how-to and why,** Master in Bio-Health Communication, University of Pisa
- **Educating to scientific thinking as a route for inclusive learning environments,** Master CAFRE "Empowering diverse skills and inclusive teaching" (Pisa, May 22nd, 2020 and May 22nd, 2021)
- **Gender and politics,** with Anna Loretoni (Chair Class of Social Sciences of the Scuola Sant'Anna) at the Piccola Scuola di Politica chaired by Furio Cerutti, Dimitri D'Andrea, and Sonia Lucarelli (Florence, 30 October 2020)
- **Gender and politics,** with Anna Loretoni (Chair Class of Social Sciences of the Scuola Sant'Anna) at the Piccola Scuola di Politica chaired by Furio Cerutti, Dimitri D'Andrea, and Sonia Lucarelli (Florence, 22 October 2021)
- **What a beautiful Quantum World,** Lecture at the 112th Corso di orientamento universitario, Scuola Normale Superiore (23 Luglio 2021).

2.2.2 Co-Teaching assignments in modules (2007-)

B1. Mathematics and Elements of Statistics (Module of **Physics**, Code 001AB, professor in charge: Adele Manes) – **MD in Pharmacy**, University of Pisa (**2009-2011).**

2.2.3 Co-Teaching assignments in modules (-2007)

C1. Physics (module of Mathematics, Statiscs, and Physics, Code 002AB, professor in charge: Adele Manes) **BSC in Herbal Sciences and Scientific Communication about Drugs**, University of Pisa (**2010-2011**).

C2. Design and management of the Lab course for General Physics I (mechanics and thermodynamics) within the General Physics I (professor in charge: Carlo Angelini), **MD- Faculty of Engineering, University of Pisa (1994-1996).**

C3. Training for General Physics I (professor in charge: Paolo Farinella) experimental **MD- in Mathematics, University of Pisa**. Experimental MD coordinated by professot Giovanni Prod**i (1994-1996).**

C4. Training for General Physics I (professor in charge: Luigi Picasso) **MD- in Mathematics, University of Pisa (1996-1997).**

C5. Training for General Physics I (professor in charge: Carlo Angelini), **MD-Nuclear and Aerospace Engineering, University of Pisa (1997-1998).**

C6. Training for General Physics I (professor in charge: Carlo Angelini), **MD-Nuclear and Safety Engineering, University of Pisa (2003-2004).**

C7. Statistical Mechanics, module within the course Introduction to **Structure of Matter for Biologists** (professor in charge: Giuseppe La Rocca), **Scuola Normale Superiore in Pisa (2006-2007).**

2.2.4 Physics Education Research

The teaching activity has steadily been accompanied by deep commitment in physics education research (PER). While referring to the publications section [PER1-PER8] for the list of published works, in the following a few PER examples are selected among those considered most relevant, and listed:

- **Teaching within the experimental (avant-gard) first two years in the MD course in Mathematics, University of Pisa, coordinated by professor Giovanni Prodi** (1994-1996). In essence, the experimental course was including: (a) weekly meetups of the whole academic teaching team, with specific discussions about every single student's performance and evolution; (b) coordinated setting of the weekly homeworks and of the monthly class exams so to formulate cross-disciplinary problems; (c) one single final exam on all subjects, conducted by one single committee embodying all academic teachers involved in a cross-disciplinary setting.
- **The Physics of Everyday life** (inspired to "How Things Work" by Lou Bllomfield, University of Virginia). This is a physics course from Galileo's to quantum physics for students attending all possible course studies, either sciences or humanities. Aim of the course is to light up students' curiosity and empower their motivations for physics studies (especially when aimed at non-physics students, with poor mathematical and formal tools) and focus students' attention on essential ideas and concepts (also and especially when aimed at students with a deep instruction in physics, who master formal mathematical tools). The course discusses the essential ideas in physics and educates to scientific thinking, fully hinging on experimental observation and creativity, while temporarily short-cutting on problems formalization. Since 2018, the course has been inserted in the so-called Italian FIT curriculum, aimed at training physics students as teachers in K14.
- **Education and methodological research,** inspired to and developed within e.g. the physics education training from Knight, and by using inclusive and interactive digital technologies (interactive panels and clickers, since 2007).
- **Training on PER, attending (after being selected) the course *Insegnare a insegnare*,** aimed at training academic instructors and educators on innovative learning/teaching methods **(University of Pisa, 2019-2020)**
- **CAFRE Committee for the selection** of Teaching Innovation Actions, university of Pisa (2020) and for Teachers training (2021)
- **Director of the Discovery section of QPlayLearn www.qplaylearn.com, a multi-level platform for education on quantum science and technologies aimed at everyone (University of Helsinki).**
- **Component of the physics education research group for educational activities on quantum physics** coordinated by Marisa Michelini (M. Michelini, L. Santi, A. Stefanel, C. Foti, S. Maniscalco, M.L. Chiofalo) within Routes for transversal competences for high-school students (Treviso, April 2021).
- **Component of the physics education research group for educational activities on quantum tehcnologies** coordinated by Maria Bondani, Elisa Ercolessi, and Chiara Macchiavello, within the Routes for transversal competences for high-school students (March-May, 2021).

2.3 THESIS SUPERVISION

2.3.1 SUPERVISOR OF THE FOLLOWING THESIS WORKS:

- **"Quantum Fermi Gases with narrow Feshbach resonances", Silvia Musolino, MD in Physics, Department of Physics, University of Pisa.**
- **"Quantum Ground States and Excitations of Fermi Gases in Cavities QED", Elvia Colella, MD in Physics, Department of Physics, University of Pisa.**
- "Spin-Orbit Coupling in Fermi Quantum Gases", **Davide Giambastiani, MD in Physics, Department of Physics, University of Pisa.**
- "Local-field Dielectric Theory of the BCS/BEC Crossover", **Pietro Maria Bonetti, MD in Physics, Department of Physics, University of Pisa.**
- "Quantum phases of Fermi atomic gases in Multimode QED optical cavities: Many-Body Entanglement for metrological use", **Leonardo Lucchesi, MD in Physics, Department of Physics, University of Pisa.**
- **"Non-Markovian dissipative dynamics of fermion fluids in optical cavities", Fabrizio Varchetta, MD in Physics, Department of Physics, University of Pisa. Co-Supervisor: Andrew Daley (Strathclyde, Glasgow, UK).**
- **"Entropy-to-shear viscosity ratio on Black-Holes horizon: an analogue gravity study", Silvia Trabucchi, MD in Physics, Department of Physics, University of Pisa (ongoing).**
- "Open Quantum Systems in Optical Cavities: the idea and its realizations", **Alice Longhena, BSC in Physics, Department of Physics, University of Pisa.**
- "Risonanza Magnetica Nucleare per la diagnostica medica: principi fisici e sviluppi", **Ugo Erba, BSC in Sciences for Herbal and Health-care Products, Department of Pharmacy, University of Pisa.**
- "Quantum Problems Solved Through Games", **Mattia Boscardin, BSC in Physics, Department of Physics, University of Pisa.**
- **Co-supervision of** "Searching for universal behavior in mucoadhesion processes", **Rita Costa, BSC in Sciences for Herbal and Health-care Products, Department of Pharmacy, University of Pisa (ongoing).**
- "QPlayLearn: educating to quantum physics alsi via videogames", **Rachele Porta, BSC in Physics, Department of Physics, University of Pisa.**
- "Anyons: what, where, and why are they important", **Mattia Corbani, BSC in Physics, Department of Physics, University of Pisa** (ongoing).

2.3.2 CO-SUPERVISOR OF THE FOLLOWING THESIS WORKS IN DIFFERENT ITALIAN AND EU SCIENTIFIC INSTITUTIONS

- **"Effect of interactions on the performance of ultracold quantum interferometers", Cosetta Baroni (at SISSA, Trieste, Italia), MD in Physics, Department of Physics, University of Pisa.**
- **"Optical Properties of SrNbO3", Marcello Turtulici (at Centre de Physique Théorique – CPHT- École Polytechnique, Paris, Francia), MD in Physics, Department of Physics, University of Pisa.**
- **"Localization of kinks in discrete classical models", Guglielmo Lami (at SISSA, Trieste, Italia), MD in Physics, Department of Physics, University of Pisa.**

2.3.3 SUPERVISOR OF PHD THESIS WORKS

- **"Quantum Gases as Quantum Simulators for Cosmology Problems", Dr. Carla Signorini, PhD School in Physics, Department of Physics, University of Pisa (2018-2019).**

- **As external supervisor: "Quantum Fermi Gases in Optical Cavities" (provisional title), Dr. Elvia Colella, University of Innsbruck (Austria), Supervisor: Helmut Ritsch (ongoing).**
- **"Dynamical Black Holes and Quantum Measurements: an observation-based approach to quantum gravity", Dr. Nicola Pranzini, PhD in Cotutele with the University of Helsinki, co-supervisors professors Esko Keski-Vakkuri and Sabrina Maniscalco.**
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2.4 THESIS REFEREEING

2.4.1 REFEREE OF THE FOLLOWING PHD THESIS WORKS IN PHYSICS:

- **"Cooling Effect on Fluoride Crystals", Azzurra Volpi, XXVIII cycle, PhD School in Physics, Department of Physics, University of Pisa.**
- **"Towards Atom Interferometry beyond the Standard Quantum Limit with Strontium Atoms", Leonardo Salvi, XXX Cycle, PhD in Physics and Astronomy, University of Florence (Italy).**
- **"Elasticity and Scalings in Amorphous Solids and Thin Polymer Films", Andrea Giuntoli, XXX Cycle, PhD School in Physics, Department of Physics, University of Pisa.**
- **"Management and control of heat currents in superconducting tunnel structures. Proposal for a thermal logic", Giampiero Marchegiani, PhD School in Physics, Department of Physics, University of Pisa.**
- **"A new Experimental Apparatus for Atom Ion Quantum Mixtures", Amelia Detti, XXXII Cycle, PhD in Physics and Astronomy, University of Florence (Italy).**
- **"Experiments with Strongly interacting Yb Atoms in Optical Lattices", Lorenzo Franchi, XXXII Cycle, PhD in Physics and Astronomy, University of Florence (Italy).**
- **"Realization of a Beat-Note Optical Lattice for Interferometry with Bose-Einstein Condensates", Leonardo Masi, XXXII Cycle, PhD in Physics and Astronomy, University of Florence (Italy).**
- **"Analogue Gravity: between analogy and emergence", Giovanni Tricella, A.Y. 2019-2020, SISSA, Trieste (Italy).**
- **Opponent of the PhD thesis "Exploring Connections between Open Quantum Systems, Relativity, and Complex Quantum Networks", Boris Sokolov, A.Y. 2020, University of Turku (Finland).**
- **"Nonequilibrium dynamics of strongly correlated quantum gases: from few to many", Silvia Musolino, A.A. 2021 (Sept 2nd), TU-Eindhoven (NL).**
- **Component (as substitute) of the Committee for the final exam for the PhD in Physics and Astronomy of the University of Florence - XXXIII cycle - for candidates Guglielmo Baccani, Antonio Maria Buccola, Catalin Frosin, Manan Jain and Chiara Mininni (June 2021).**
- **"Low-Dimensional Quantum Gases in Curved and Flat Geometries", Andrea Tononi, PhD in Physics, University of Padova (Italy).**

2.4.2 REFEREE of a number of **MD Thesis** works **in Physics, Department of Physics, University of Pisa.**

2.4.3 TUTORING ACTIVITY

Tutoring activity within the Course studies in Physics, University of Pisa aimed at four first-year students (2015-2016).

2.5 RESEARCH ACTIVITY

2.5.1 SUMMARY AND MAIN FACTS (DETAILS IN ATTACHED CV-A):

The current research is devoted to develop and engineer quantum technologies mainly based on the quantum gases platform, aimed at three purposes:

(i) **Conceive schemes based on many-body entanglement as a paradigm for precision measurements, relevant to fundamental-physics tests,** such as e.g. Equivalence Principle tests, search for Dark Matter and for Gravitational Waves in complementary parameters regions with respect opto-mechanical interferometers (see the cross-disciplinary network Atomic Experiments for Dark-Matter and Gravitation Exploration (AEDGE) including high-energy physics, condensed matter, cosmology, and astrophysics, A24 in Sec. 2.6 and [74, 75, 78, 79, 80, 86])

(ii) Conceive and tailor specific analog quantum simulators to address selected time-dependent, out-of-equilibrium problems relevant for fundamental physics and other sciences, also in the framework of open quantum systems (see the follow-on research at KITP A27-A28 in Sec. 2.6 and [73, 81, 83, PR2]).

(iii) Optimize/solve quantum problems otherwise non-tractable by present computer machines, in particular via a citizen-science gamification approach, as in IQHuMinds proposal [PR1], involving a cross-disciplinary team of quantum physicists, neuroscientists, computer scientists, game researchers and developers, outereach and physics-education research experts of the University of Pisa, Turku University, ICFO-Barcelona, JILA and UCB (Boulder, Co) and the companies VIS, MiTale, Quside, IBM-Zurich and Unity Tech.

Keywords

The research activity has been largely theoretical in the context of **strongly correlated quantum liquids**, and in particular: high-Tc superconductivity [L1-L2, 1-5], charged boson fluids [6-9], quantum gases under extreme degenerate conditions of ultra-low (nK) temperatures, strong interactions and reduced dimensionality [10-42, 46-50, 53-84]. During the years 2004-2007, part of the research activity has been devoted to theoretical and experimental work to conceive the prototype Galileo Galilei on the Ground (GGG) aimed at testing the Equivalence Principle with macroscopic bodies, within the group led by Anna Nobili [43-45, 51-52].

The most cited work (almost 540 citations according to Scopus), “Resonance superfluidity in a quantum degenerate Fermi gas” [27], has predicted the occurrence of high-Tc superfluidity in Fermi gases later realized at JILA (Boulder, Colorado) in Debbie Jin’s group, and has led to a number of developments [31-32, 53, 68-69, 71-72].

2.5.2 FOCUS ON CURRENT RESEARCH

Main collaborations

The main collaborations developed along these leading-edge research lines are with Sabrina Maniscalco (University of Helsinki, University of Aalto, CEO of Algorithmiq, Finnish Center of Excellence for Quantum Technologies), Andrew Daley (Strathclyde, UK), Wolfgang Ketterle (MIT, US), Benjamin Lev (Stanford, Ca, US), Murray Holland and Heather Lewandowski (JILA and University of Colorado at Boulder, Co, US), Lincoln Carr (Colorado School of Mines, Golden, Co, US), Servaas Kokkelmans (TU-Eindhoven, NL), Vladan Vuletic (MIT, US), Giovanna Morigi (Saarbrucken University, Germany), Andrea Ferrara (Scuola Normale Superiore, Pisa), Stefano Liberati (SISSA, Trieste), Andrea Trombettoni (INO.CNR, Trieste), Massimo Mannarelli (INFN-LNGS), the AEDGE network, and the Virgo/Ligo collaboration.

Methods

The research is conducted steadily in strong connection with experiments, by means of analytical, numerical, and quantum simulation methods. These include (Time-Dependent) Density Functional Theory, Local-Field Theories, Quantum Monte Carlo, Density-Matrix Renormalization Group methods, Exact Diagonalization methods and, more recently, Quantum State Diffusion and HOPS for open quantum systems.

Details on current International collaborations

a. Sabrina Maniscalco (Turku University, Finland): (i) Black Holes as open quantum systems (see A28 in Sec. 2.6), (ii) IQHuMinds – Integrating Human and Machine Minds for Quantum Technologies [PR1].
b. Vladan Vuletic (MIT): ion chains and applications to quantum simulations [73, 83].
c. Concetta Morrone (Neuroscientist, University of Pisa) and Marco Cicchini (CNR Pisa) on Quantum models and simulations for visual neuroscience [C61].
d. Paavo Pylkkanen (University of Helsinki), Bert Kappen (Radboud University, Nijmegen, NL) and Sabrina Maniscalco (University of Helsinki, Mind and Matter center, Helsinky) on Mind and Matter.
e. Giovanna Morigi (Saarbrucken, Germany): quantum phases in 1D ion chains [83].
f. Andrew Daley (Strathclyde, Glasgow, UK): within an open quantum systems' framework, (i) non-Markovian dissipative dynamics of Fermi fluids and superfluidity in optical cavities (see thesis work in Sec. 2.3.1), and (ii) state preparation of entangled magnetically-ordered states in optical lattices [81], also in collaboration with Wolfgang Ketterle (MIT, US).
g. Benjamin Lev (Stanford): (i) quantum phases of Dy dipolar bosons in reduced (1D) dimensionality, stemming from the theoretical predictions [56-58]; (ii) quantum phases of fermions in multimode optical cavities [75, 76, 83], also with Jonathan Keeling (St. Andrews University, Edinburgh, UK).
h. Murray J. Holland (JILA, USA): spin-squeezing schemes for atoms in optical cavities, aimed at precision measurements [80, 82].
i. Andrea Trombettoni (SISSA, Italy): atom-interferometry schemes [74].
j. Stefano Liberati (SISSA, Italy), Andrea Trombettoni (INO-CNR, Trieste), and Massimo Mannarelli (INFN-LNGS): analogue gravity (see thesis work in Sec. 2.3.1 and [85,92]).
k. Servaas Kokkelmans (Director Center Quantum Technologies TU-Eindhoven, NL): Analog Quantum Gases and Cosmology for Quantum Computing [PR2].

l. Lincoln Carr (Colorado School of Mines, Golden, Co, US): Complex Quantum Networks (see A27 in Sec. 2.6).
m. Heather Lewandowski (JILA and UCB, Co, US): Physics Education Research (as part of IQHuMinds [PR1]).
n. Massimo Mannarelli (LNGS, Italy) and Dario Grasso (INFN Pisa, Italy): Analog gravity (see [85,92]).
o. Network AEDGE (Atomic Experiments for Dark Matter and Gravity Exploration): white paper and proposal submitted to the ESA call Voyage 2050 for next generation atomic experiments in space for fundamental physics.
p. Virgo/Ligo collaboration: R&D on atomic interferometry.

Present national collaborations

a. OLAGS (Optical Links for Atomic Gravity Sensors), led by Fiodor Sorrentino (INFN-Ge) and funded by INFN-CSN5.

Past national collaborations

b. PRIN “Ultracold Atomic Mixtures in Optical Lattices” (2012-2014), Coordinator: Fabrizio Illuminati (University of Salerno, Italy).

Notice on the continuity of research activity over the years

During ten years (2008-2018) I've been serving the local and national community, being appointed as Deputy-mayor of the Pisa Municipality, taking care of Educational and school policies, Promotion of digital technologies for education, Equal opportunities, Constitution values, Pisa legacy and, in the period 2013-2018, also Science education, realization of the scientific hub and science center Cittadella Galileiana, and Anticorruption action plan and implementation of the ethical code of conduct (see **Sec. 3.3**). These matters, with special reference to the first, implied a direct impact of about 15% on the Municipality budget, approximately amounting to 100,000,000 Euros.

Within this institutional office, I've been elected Chair of the board of the metropolitan Pisa Area for Education and School Policies. I've as well been appointed by the National Association of the Italian Municipalities (ANCI) as a representative in: **(a)** the National Observatory for Infancy and Adolescence, where I've contributed to conceive and write-down the IV National Plan for Infancy and Adolescence Policies; **(b)** the control room board coordinating and monitoring the application of the National plan against violence on women within the Prime Ministry Cabinet; and **(c)** in the Tuscany-Region Observatory on pathological gambling.

Within this administrative and political commitment, I've been responsible for short and long-term complex planning and policy addressing, in particular aimed to maintain and develop the 0-18 years-old educational system, to mainstream and empower equal opportunities and to build up the anticorruption system.

In fact, I've been applying scientific thinking to conceive and realize from scratch tools suited to predict and measure the impact of the policies, to improve planning processes and involve the complex network of public (citizens and institutions) and private stakeholders, relevant for the addressed policies (se Sec. 3.3).

During such ten years period 2008-2018, I've been continuing the teaching activity for an amount of approximately 150-170 hours per year, though my research activity has considerably been slowed down.

c. Advanced Research Project (PRA) of the University of Pisa ANISotropic molecular systEms: Unconventional optical and structural properties (ANISE), coordinated by Dario Pisignano (University of Pisa).

2.5.3 ANALYTICAL DESCRIPTION OF THE RESEARCH ACTIVITY

See Attached CV-A.

2.5.4 PUBLICATIONS

The full list of publications in terms of research articles and books, textbooks, and outreach materials is in Attached CV-A. Here below, a summary is provided:

A1. Books:

1. **M L Chiofalo**, "Screening effects in bipolaron theory and high-temperature superconductivity" (**SNS, 1997**)
2. **G. Iadonisi, G Cantele and M L Chiofalo** "Elements of Solid State Physics and Crystalline Nanostructures" (**Springer, 2014**). The second edition is under preparation under Publisher's request.

3. **Editing**: “Models and Phenomenology for Conventional and High-Tc Superconductivity”, Ed. by **G Iadonisi, R J Schrieffer and M L Chiofalo** (**IOS Press, 1998**)

A2. Research articles: About 80 papers published on peer-review journals, also with high IF, resulting into more than **2549** citations, 7 papers on Conference proceedings or book chapters, and **h-index 23** (Scopus)**.**

A3. Partecipation to International Conferences/Workshop and invited talks: the research activity has been presented in about 50 invited talks as speaker (more than 80 is a very partial number for the total) within Conferences, Workshops, and at National and Internazional Scientific Institutions**.**

2.6 VISITING

In the following are listed the Institutions where the research activity has been conducted over limited periods of time, under invitation (and/or after selection).

A1. Interdisciplinary Research Centre on Superconductivity, Cavendish Laboratory, Cambridge (UK, March-June **1995**).

A2. International Center for Theoretical Physics, Trieste, Italy: (3 weeks during the summer program, during each of the following years: **1994**, **1995**, **1996**, **1997**).

A3. JILA-Joint Institute for Laboratory Astrophysics, University of Colorado at Boulder (CO, USA), groups of Murray Holland or Debbie Jin, within the research activities on Bose-Einstein Condensation and quantum gases started by the Nobel laureates Carl Wiemann and Eric Cornell (whenever not explicit, the month(s) indicated refer to a 4 weeks period):

- August **1996**
- April **1997**
- March-April **1998**
- June-July **2001,** funded by NSF
- April-May **2003**
- April-May **2004**
- June 20th –July 30th **2005**
- 3 weeks in January **2006**
- August **2007**
- February 11th-25th **2009**
- August **2009**
- July 11th-22nd **2016**
- November 22nd-December 7th **2017**
- August 6th- September 15th **(under a Visiting Fellowship)**

A4. Aspen Centre for Physics, Aspen (CO, USA):

- June 17th –July 8th **2001**
- June 5th-19th **2004**

A5. Benasque, Spain, Workshop ”Physics of Ultracold Dilute Atomic Gases" (June 9th-28th **2002**).

A6. European Center for Thoretical Physics, Trento, “BEC summer program" (June 15th-22nd **2002**).

A7. CRS-BEC, Trento:

- November **2003**
- January **2007**

A8. Kavli Institute for Theoretical Physics (Santa Barbara, Ca, US), Workshop “Quantum Gases” (April **2004**).

A9. Gordon Research Conference on Atomic Physics (USA) (June 26th –July 1st **2005**).

A10. Los Alamos National Laboratories (NM, USA), group of Augusto Smerzi (1 week in January **2006**).

A11. Eindhoven University of Technology (TU-Eindhoven, NL), group of Servaas Kokkelmans (April **2007**).

A12. Institut Henri Poincaré, Paris (France), Workshop `”Quantum Gases" (June 24th –July 20th **2007**).

A13. CNRS Grenoble (France), group of Anna Minguzzi (July **2008**).

A14. Beijin (China), Workshop `”Frontiers in Quantum Gases" (1 week, October **2008**).

A15. Harvard University, Boston (USA), group of Eugene Demler (August 27th-28th **2009**), to develop a popular-science project based on the broadcast “Piacere, Scienza!" by Sara Maggi and Marilù Chiofalo

A16. University of Auckland, New Zealand, group of Murray Holland (2 settimane, 2 weeks in February **2012**).

A17. MIT (Cambridge-Boston, USA), group of Vladan Vuletic:

- July 3rd-11th **2016**
- April 29th-May 3rd **2018**

A18. MIKE TOWLER INSTITUTE, School of Quantum Monte Carlo Simulations CASINO, Vallico di Sotto, Italy **(**July 24th-28th **2016).**

A19. University of Stanford (Palo Alto, CA, USA), group of Benjamin Lev **(**July 8th-14th **2018).**

A20. Harvard University (Boston, MA, USA), group of Eugene Demler **(**November 5th-11th **2018).**

A21. University of Strathclyde (Glasgow, UK), group of Andrew Daley **(**November 25th-December 1st **2018).**

A22. KITP (Santa Barbara, Ca, US):

- Workshop "**Open Quantum System Dynamics: Quantum Simulators and Simulations Far From Equilibrium**" (April 15th-May 5th2019)
- Conference "**Exploring Open Quantum Systems in Quantum Simulators**" (20/04/2019-03/05/2019).

A23. ECT Trento "Simulating gravitation and cosmology in condensed matter and optical systems", ECT, Trento (July 22nd-25th 2019**).**

A24. CERN Workshop on Atomic Experiments for Dark Matter and Gravity Exploration (July 22nd-23rd 2019**),** aimed to writeup the white paper **AEDGE** for the **ESA call Voyager 2050.**

A25. International Conference on Quantum Metrology and Sensing, Paris (December 9th-13th 2019**).**

A26. Aspen Center for Theoretical Physics (Aspen, Colorado) "Many'Body Cavity QED" (March 15th-20th 2020) **[Postponed due to Covid19 outbreak].**

A27. KITP (Santa Barbara, CA, USA): visiting for followon research on Complex Quantum Networks (April 18th-May 2nd 2020) **[Postponed due to Covid19 outbreak].**

A28. KITP (Santa Barbara, CA, USA): visiting for followon research on Black holes as open quantum systems (coordinator) (June 8th-22nd 2020**) [Postponed due to Covid19 outbreak].**

A29. Real-time Dynamics in Strongly Correlated Quantum Matter, ICTP (April 8th-9th 2020).

A30. Mind and Matter: the Kankas symposium, Helsinki 15-17 September 2021, organized by Emmy Network Foundation, University of Helsinki and University of Turku.

A31. University of Helsinki, visiting scientist 10-26 September 2021.

2.7 REFEREEING AND PEER REVIEW

A1. Journals: serving **Physical Review Letters, Physical Review X, The Physical Review** (A, B, E), **Nature, New Journal of Physics**, **European Phys. Journal, Europhysics Letters, Universe.**
A2. VQR 2011-2014.
A3. Final round of ERC Starting Grant 2019.
A4. Habilitation de Recherche of professor Valentina Paris, Lab. Kastler Brossel, Paris, July 2019.
A5. Board member of the journal Photonics (February 2020-).
A6. Reviewer to evaluate appointments as Associate Professors at International Academic Institutions (specifically, **Harvard and Stanford).**

2.8 ACADEMIC BOARDS

In the following are listed the numerous Councils, Boards, and Committes of the University of Pisa, which I contribute to, as a member or a member in charge. Whenever the ending year is not explicit, the commitment is intended to be currently running :

A1. Council of Physics Department (**2012-**).
A2. Council of BSC+MD Course in Physics (**2014-**).
A3. Council of PhD School in Physics (**2014-**).
A4. Council of MD Course in Nanoscience (**2017-**).
A5. Council of MD Course in Pharmacy (**2007-2018**).
A6. Council of BSC-Course in SPES-Pharmacy Dept. (**2011-**). Formerly ISF and SER.
A7. Council of MD Course in Chemistry and Pharmaceutical Technologies (**2009-**)
A8. Committee for Admission Tests at the Pharmacy Department BSC and MD Courses (**2007**-).
A9. Elected in the **Evaluation Committee for Research activity Area 2 (Physics)** (**2016-2018**).
A10. Representative of the Physics Department for **K14 teachers' training** (**2017 -2020**).
A11. Board of the Interdisciplinary Center for Peace Sciences (**CISP**) (**2018-**).
A12. Member of the Responsible Research and Innovation (**RRI**) group of the University of Pisa (2019-).
A13. Board of the Center for Training and Education Research (**CAFRE**) of the University of Pisa (**2019-**).
A14. Committee for BSC degree in Physics, Dept. of Physics (June-October **2018**).
A15. Committee for admission at the MD Courses in Pharmacy and CTF and for BSC Course in SPES (2007-).
A16. Committee for admission at the PhD in Physics (**2015-2016**).
A17. Representative for outreach activities of the Pharmacy Faculty (**2008 -2011**).
A18. Outreach Committee of the Pharmacy Department (**2011**).
A19. Council of the Pharmacy Faculty (**2007-2011**).
A20. CAFRE Committee for the selection of Teaching Innovation Actions (**2019-2020**).
A21. Committee for BSC in Physics (2018, 2020).
A22. Committee for the research grant "Quantum Models and Simulations for Visual Neurosciences", University of Pisa **(2020).**
A23. Representative of the Physics Department for **K14 teachers' training** (**2020-**).
A24. Representative of the Physics Department in the G6 for **K14 teachers' training** of Piano Lauree Scientifiche (**2021-**).
A25. Member (elected) of the Executive board of the Physics Department, University of Pisa (2021-).
A26. Component of the BS degree committee, Department of Physics, University of Pisa (September-December 2021)

2.9 OUTREACH

In the following are listed the main outreach activities. Publications data are in the attached CV-A.

A1. Teaching at the Corso di Orientamento, Scuola Normale Superiore in Cortona, aimed at high-school students:

- **1993** "Eternal motion: the superconductivity"
- **1994** "Can apples go back to the trees? (a lecture on irreversibility)"

- **1995** “The color of the sky (that is, a best reason not to watch a sunset with a physicist)”
- **1996** “Presto volando: a brief journey in the world of musical instruments” [D1]

A2. Author of articles on popular-science magazines:

- **Sapere** on the physics of musics and on women and science [**D2, D7, D9**]
- **Il Rintocco del Campano** on Galileo [**D8**]
- **Ingenere.it** on women and science [**D10**]
- **Il Nuovo Saggiatore** on the superfluidity of quantum gases, in Scienza in Primo Piano [**D3**]
- **Scienza in rete,** with Enza Pellecchia (Director of CISP) on A-bombing and nuclear disarmament [**D14**].

A3. Collaboration with radio-broadcasting programmes:

- **Il Terzo Anello Scienza (RAI-Radio 3)** “Conosco i miei poli”
- **Suite (Radio RAI 3)** on the Festival “MusicalMente”

A4. Collaboration with the following magazines and newspapers on science, society, and politics (either write-ups or interviews):

- **Repubblica** on the relevance of scientific outreach, on women and science, on political topics (Repubblica Firenze, RepIdee, and Repubblica interviewed by Concita De Gregorio) [**D11-D12, D22-D25**]
- **Europa** on young researchers [**D6**]
- **Focus Junior** on the physics of Hary Potter.
- **Scienza in Rete** for the 70th anniversary of Hiroshima and Nagasaki A-bombing, and on nuclear disarmament
- **Corriere della Sera** for the series of popular-science booklets “Physics Lectures”, delivered with the newspaper itself (2018-2019): coauthor of the volume “Condensed Matter Physics” [**D16**].
- **Conflitti (**Director Daniele Novara) on violence in daycares [**D28**]
- **DireDonne (Agenzia DIRE)** on Gender thinking: does science need women? (with Anna Loretoni, Chiara Braga, Sandra Zampa)
- **Corriere della Sera – 27esimaora [D29]**
- **Osservatore Romano [D32]**
- **Sole 24Ore [D33]**

A5. Format creator the Musical...mente Festival and **Scientific Director** of two editions **(Sangemini, 208-2009).**

A6. Radio and video popular-science formats and programs

- **Co-author with Sara Maggi and speaker of the radio-broadcasting program** "**Piacere, Scienza**!" (“Hallo, Science!): 4 minutes episodes aimed at disseminating scientific culture. Special series of the program include also “**Perché Nobel?” (“Nobel, Why?”)**, “**Nobel Donna**” (“**Nobel Woman**”) and “**Galileo**”. Overall, **37 episodes,** downloadable from iTunesU or **http://osiris.df.unipi.it/~chiofalo/RADIO/radio.html**). The series has been broadcast in 2008 on Radio Bruno, counting about 50,000 daily listeners, and in 2009 on 5 Tuscany radio broadcasts (Radio Toscana Network, Onda Blu, Controradio, Nova Radio, Radio Siena) counting around 100,000 daily listeners [DPS1-DPS37].

- **Co-author with Sara Maggi of the video** "I go Hydrogen".
- **Co-author with Sara Maggi of the video format "Street Physics",** with the realization of the 0th episode.
- **Popular-science lecture "The Universe in four square meters"** within the collaborative efforts of University of Pisa and TV broadcast 50 Canale, aimed at educating the general public to science in the Covid era.
- **Co-creator of the format Quantum pills and co-creator of the episodes "Quantum Physics" for QPlayLearn** www.qplaylearn.com **and co-creator of the episodes** produced by VIS srl (M. Valdes and Matias Guerra)
    - **"Quantum Physics"** https://youtu.be/j0z2BaHRaVE (M.L. Chiofalo, S. Maniscalco, C. Foti)
    - **"Entanglement"** https://youtu.be/jyjdE_qVk5I (M.L. Chiofalo, S. Maniscalco, C. Foti)
    - **"Heisenberg Principle"** (in the course of publication) (M.L. Chiofalo, S. Maniscalco, C. Foti, P. Verrucchi)

A7. Lectures in High schools:

- **Pianeta Galileo,** popular-science lectures in high-schools within Tuscany Region (**2013-2014-2015-2016-2017-2019-2020**). Topics:
    1. *Time from Galileo to Quantum Physics. The everyday-life physics for Pianeta Galileo*
    2. *Immersions, water bombs, airplanes and the like. The everyday-life physics for Pianeta Galileo*
    3. *Soccer balls*
    4. *Quantum cows and ultracold tiny atoms near absolute zero*
    5. *The concept of Time from Galileo to time travels*
    6. *Mischief managed: Harry Potter's magic spells for muggles*
    7. *The physics of fantasy*

- **Creator of the lecture-event The Physics of Harry Potter, realized for the Association Back to Hogwarts.** The lecture is on four spells (Vingardium leviosa, Invisibility cloak, Portkey, and Time turner) and is now: part of the Course The Physics of Everyday Life, currently exploited for Pianeta Galileo events, and played in events organized by Associations aimed at science education for kids.
- **Lecture Series** at the Liceo Scientifico "Volta" in Reggio Calabria, under invitation of the Scuola di Filosofia di Roccella Jonica on **"Time, from pendulum law to time travels"** and the City public lecture **"The Universe in four squared meters"** (Reggio Calabria, April 4th-6th 2019) [**D17**].
- **Lecture for high schools "Q-Play-Learn! Playing with the ideas of quantum physics and technologies"** for the Solidarity Day 2021 (26 April 2021).
- **Conception and conduction with Elena Trallori of the podcast "Let's talk about STE(A)M"** by RadioFemminilePlurale: weekly ½ hour episodes, since February 11th, 2021.

A8. Outreach events of the University of Pisa and the National Institute for Nuclear Physics (INFN): Shine!, Open Days, Bright-the Researchers Night (**2012-2013-2014-2015-2016-2017-2018-2019**). Selected topics:

- *Ultracold atoms lab and the physics of ultracold atoms for fundamental physics tests and quantum devices*
- *MAGIA-Advanced: atom interferometry to unveil the secrets of gravity*
- *Cartoon physics: ask and tell from a full menu of physics views of cartoons, in tandem with Giovanni Timpano, the official cartoonist of Batman for Marvel*

- *Quantum metrology*

A9. Scientific training and educational events

- **Training science lab "AggiornaMenti" aimed at K14 teachers** organized by INFN-Pisa for K14 teachers (2019 and 2020).
- **Webinar "From safe driving to risk behaviors in adolescents: educating to scientific thinking in (for, as) civic education",** organized by Zanichelli for high school teachers (23 February 2021).

A10. Arts and Science creations

- **Co-creator with Sabrina Maniscalco (Helsinki University) of the outreach project "The Quantum Bit Woman"** on quantum technologies and videogaming.
- **Co-creator with Steve Shore** (Department of Physics), **Luca Biagiotti** and **Federico Guerri** (Pisa Theatre), of the performance **Galileo under the Leaning Tower: the experiment that Galileo never performed (and why),** in Piazza dei Miracoli and on Pisa streets, within the **II International Conference QFC2019.**
- **Co-author with Marco Sozzi, Andrea Ferrara, Sandra Lischi, e Eva Marinai of "Metaorizzonti",** a format for arts and science events aimed at a general public.
- **Co-organizer with Sabrina Maniscalco of the first Quantum Game Jam in Italy – Internet Festival#10 Reset October-December2020,** with more than 50 game developers and quantum physicists, also students from AISF, with the production of 9 videogames on three themes: Quantum computing, Quantum biology, Quantum physics and the Mind.
- **M. Chiofalo, "Time from Galileo to time travel",** Conference for the Florence Astronomical Society (February 2nd 2021).
- **M. Chiofalo "Quantum Physics and The Mind",** panel "Artificial Intelligence: challenges, values, opportunities" at the XXVIII Master CIBA (February 20th 2021).
- **M. Chiofalo, "Wave-like behavior", interview for the Discover series "Tell your granma",** QPlayLearn platform https://youtu.be/4UMzjb5a74w .
- **M. Chiofalo, introduction to "The Function of the World" comics on Vito Volterra by Alessandro Bilotta and Dario Grillotti,** meeting of the authors with the students for the section "Cosmos Award for students" (March 24th 2021).

A11. Scientific Boards

- **Member of the scientific Board of the Cosmos Prize** for popular science (2018-), chaired by Gianfranco Bertone. Other members: Lucia Votano, Sandra Savaglio, Ginevra Trinchieri, Andrea Ferrara, Carlo Rovelli, Amedeo Balbi, Piergiorgio Odifreddi, Pierluigi Veltri, and Paolo Zellini.
- **Member of the scientific Board** of the book series **Culture and training,** edited by Diana Pardini and coordinated by Marco Agujari and Diana Pardini, ISBN 978-8-86528-494-0, Pub. Campano (2019-).
- **Member of the Editorial board of the Magazine CISP –** Sector Rights and Education, http://magazine.cisp.unipi.it/ (2020-)
- **Committee for the INFN prize "Arts and Science"** aimed at high-school Students **(2020).**
- **Component of the Scientific board of ImparaDigitale** – Association for learning innovation (2021-).

A12. Gender Policies and Gender studies

- **Contributed article to the ebook "Smart Cities, Gender and Inclusion"** (Ed. by Maria Sangiuliano and Flavia Marzano, **2013**) [**D13**]
- **Interview in "20 Women, 20 Intelligences for Smart Cities"** (Forum PA Editions) [**D21**].
- **Contributed article to the volume "Intercultural Lexicon"** on **Equal Opportunities** (Ed. by Serena Gianfaldoni, Franco Angeli **2013**) [**D18**].
- **Organization of the panel "Educating to differences" within Beijin+20, Milano (2015).**
- **Contributed article to *#WeTooInScience* –** Sexual Harassment in Higher Education Institutions and Research Organizations**,** with Tiziana Metitieri [**D15**].
- **Seminar "More Women in Science is an opportunity for Women or for Science? The answer is left to Mafalda by Quino"** at the Italian Women and Science Congress (Pontignano, Siena, 2012).
- **Talk at the Workshop "The invisible violence"** at the Scuola Normale Superiore (March 15th, **2018**).
- **Introduction to the booklets "Gender budget of the Pisa Municipality"** and **"The IAMG model for ex-ante evaluation of impact of gender policies"** (Comune di Pisa Ed., **2015**) [**D27**].
- **Speech at the panel STEMpink: Women and technologies**, in occasion of the centennial of Ada Lovelace (Pisa, December 10th, **2015**).
- **Contributed article to the volume "Gender and wellness in sports"** (edited by Fiorella Chiappi, Quaderni della Commissione Pari Opprotunità, Regione Toscana, **2019**) [**D19**].
- **Talk at "An entirely different story. Rita Levi Montalcini: Women and Science",** with Marcella Filippa (Fondazione Nocentini) and Maria Luisa Villa (G.I.U.L.I.A. Women Journalists Association) (Lucca, February 21st, 2020).
- **Gender and Politics,** co-teaching with **Anna Loretoni** (Chair of the Social Sciences Class, **Scuola Sant'Anna**) at the **"Piccola Scuola di Politica", Chairs: Furio Cerutti, Dimitri D'Andrea, and Sonia Lucarelli (Firenze, October 30th, 2020).**
- **'900 stories-Women who change the world @Polo900, care of Fondazione Nocentini.** Marilù Chiofalo e Alberto Cavaglion, Marcella Filippa: **A dialogue on Rita Levi Montalcini: researchm writings, identity (October 2020).**
- **Sport and gender: a change is possible** with Arturo Marzano, Marilu Chiofalo, on. Paola Concia and olympionic Giulia Quintavalle, organized by CORI Association, Patrizia Russo e Fiorella Chiappi **(November 13th 2020).**
- **Introduction and conduction in the event presenting the book "Three Pisa women in the defense line"** by Anna Di Milia Tongiorgi, Paola Pisani Paganelli and Isabella Salvini Calamai (ETS) (26 February 2021)
- **Speech at the Conference "Women in research: potential, value, challenges. Testimonies story-tell"** organized by FIDAPA San Miniato (16 January 2021)
- **Speech in the panel presenting the book "Girls will save the world"** by Annalisa Corrado (15 February 2021).
- March of Women by the Lucca Municipality: **"Ex-ante assessment of gender impact" with Marilù Chiofalo.** Introduces Ilaria Vietina (12 March 2021).
- **"Let us plant Memory", Marilù Chiofalo interviews Vera Vigevani Jarach**, Madres de Plaza de Mayo, for the Solidarity Day 2021.
- **M. Chiofalo TWIST** (Top Women in Science Talk) **interviewed by the PisaPod of 500WOMENSCIENTIST** https://www.youtube.com/watch?v=jSIedyIJR30 (26 March 2021.

- **Speech at the event** conducted by Lucia Votano (guest U. Amaldi, F. Ronchetti, M. Chiofalo) at the **X Feast of Science and Philosophy in Foligno "Re-think the future"** https://www.festascienzafilosofia.it/ (24 April 2021).
- **Invited talk at the panel Les salonnières virtuelles – Sciences**, organized by the Italian **Association Feminine Toponimy** (27 July 2021).

A13. History, Society, and Sciences for Peace:

- **Contribution to the research "Foodlink"** in collaboration with the group of Gianluca Brunori, Agrarian Department, University of Pisa
- **Personal invitation to the International Conference on Nuclear Disarmament (Vatican City, 2017) with welcome from Pope Francis**, organized by the Dicastero Vaticano per lo Sviluppo integrale della Persona, because of her "commitment and contributions to the culture and practice of the integral nuclear disarmament".
- **Contributed article to the volume "San Rossore, September 5th: the evil sprout of racial laws in Italy"** (edited by Mafalda Toniazzi, **2018**) [**D20**].
- **Invited talk at the Conference "Emptying arsenals, building peace",** organized by **Idis-Città della Scienza** and **Italian Union of Scientists for Disarmament (USPID)** (Ischia, April 20th-21st 2018). Chair: Pietro Greco **https://www.scienzainrete.it/articolo/svuotare-gli-arsenali-costruire-pace/pietro-greco/2018-05-18**.
- **Member of the Responsible Research and Innovation Team of the University of Pisa (2019-).**

A14. School and education:

- Since 2011 every year in February-March, **lecturing** at the **CIBA Master** in Communication for Banks and Insurance companies, with **"The theory of Multiple Intelligences by Howard Gardner",** organized by **Eraklito2000** (Pisa).
- **Speaker at the Workshop on Education of Adults**, organized by EDA-Forum (Lucca, 2018).
- **Speaker at the webinar "The Schools' Voice",** organized by Imparadigitale with Sole24Ore and ONU-Italia, on learning innovation processes in the Covid era (May 26th 2020).
- **"The largest operation ever aimed at education to scientific thinking",** video selected for #ideexdomani in the Covid era by Ladynomics.
- **Talk at "Industry 4.0 and educational system: instances and answers",** organized by the Engineering Department of the University of Pisa (October 4th, 2018).
- **CUG at the snack time:** Seminars organized by the CUG of the University of Pisa, devoted to 6-11 yo. kids "Time in physics" (June 23th 2018).
- **States General of the Digital School** (Bergamo, November 27th 2020): **Speaker at the panel** "Trauma and care: what changes before and after the crisis?" and **Conduction of the Workshop** "Educating to Scientific Thinking (in the, for the, as) inclusive teaching".
- **Immersive workshop for teachers "Let's Play with quanta! Quantum physics in high-schools with the QPlayLearn platform"** and stand @ DIDACTA Exhibition (Florence, 16-19 March 2021): M. L. Chiofalo, C. Foti, and S. Maniscalco.
- **Invited speech at the Panel "Greetings from Quantum Scientists"** for the launch event "In the Realm of Quantum il lancio" of the **QplayLearn** platform.

- **Invited speech at the panel of the launch event for the QCards** – the app for the game, 27 July 2021.
- **Invited speech at the panel discussion Let's talk quantum games** organized by QTurkey and QWorld, 28 August 2021.
- **The physics of Harry Potter, Webinar for teachers**, care of M. Chiofalo, C. Foti, and S. Maniscalco, organized by Librì (November 2021).

A15. Forewords to culture and society books:

- **"Cittadinanza è partecipazione"** by Jama Musse Jama [DP1]
- **"La voce della speranza"** by Jacob Aimé Gildas Ouakatoulou [DP2].
- **"Margherita naso all'insù"** by Micol Carmignani [DP3].

3. RESPONSABILITIES OF SCIENTIFIC PROJECTS AND ORGANIZATIONAL COMPETENCES

3.1 Principal Investigator/Head of the following scientific projects:

A1. Principal Investigator for computational projects funded by CINECA

- "Simulation of the dynamics of confined quantum fluids"
- "Quantum Degenerate Atomic Gases with tunable interactions"

A2. Principal Investigator for the research projects funded by the Scuola Normale Superiore for young researchers:

- "MESSY. Mesoscopic Superfluidity: theoretical advances and novel applications" **(2005)**
- "Resonant superfluidity and nature of normal state in highly degenerate atomic gases" (**2006**)
- "Atomtronics" (**2007)**

A3. Principal Investigator for the research project WP4250 funded by the Italian Space Agency within WP4000 on Physics in Space (Coordinator: Anna Nobili)

A4. Leader of the Pisa node of the EU funded Research Project "Digital Schools of Europe" on innovative learning processes **(2015-2018)**

A5. Principal Investigator of the MIT-UNIPI project "Generation of spin-squeezed states for fundamental physics tests by atom interferometry" (2015-2017), funded by **MIT.**

A6. Principal investigator of INFN-Pisa unit (national coordinator Guglielmo Tino) of **MAGIA-advanced** project for the realization of an atomic interferometer for the detection of gravitational waves **(2015-2018)**

A7. Head of the National Physics Team established at CISIA, for the revision of the syllabus and the physics admission tests for Pharmacy BSC and MD Courses (**2016-2020).**

A8. Principal investigator of the MIT-UNIPI project "Quantum Fluctuations in the Paradigm of the Aubry Transition" (2019-2021), funded by **MIT**.

A9. Head of the special education research project "The Physics of everyday life" funded by the University of Pisa **(2019-2020).**

A10. Coordinator of the RISE (Horizon 2020 call) proposal IQHuMinds (**Integrating Human and Machine Minds for Quantum Technologies**), aimed at realizing a quantum problem solver integrating the best of human power (creativity and intuition) and the best of (classical or quantum computer**)** machines in a citizen science approach. the cross-disciplinary team is composed by quantum physicists, computer scientists, neuroscientists, gamification researchers, videogame developers and producers, physics education experts, outreach experts, citizens (videogame players). The intersectoral and international Consortium is composed by the following academic institutions and companies: **University of Pisa (Italy), University of Turku (Finland), ICFO (Spain), JILA (Boulder, Colorado, US), VIS (Pisa, Italy), Mitale (Finland), Quside (Spain), IBM-Zurich, Unity Tech. (San Francisco, US).**

A11. Coordinator with Zeki Seskir of the Pilot (counting 30 partners) on **Outreach and education Quantum Technologies Education for Everyone (QuTE4E)** within the Quantum Technologies Education Coordination and Support Action of **European Quantum Flagship (2021-2022).**

A12. Coordinator of the project Quantum Jungle in collaboration with Sabrina Maniscalco, for the realization of a 2x3 square meters **immersive and interacting installation** visualizing the dynamical evolution of a quantum state on a graph, **funded by Fondazione di Pisa (2021-2022).**

A13. Coordinator for the INFN-Pisa unit of OLAGS – Optical Links for Atomic Gravity Sensors (National Coordinator Fiodor Sorrentino), granted by INFN-Committee 5 (2021-).

3.2 Organizational accountability

3.2.1 Organization of scientific Conferences

A1. Scientific secretariat of the CXXXVI Course of the International School of Physics "Enrico Fermi" (Varenna, June 24th-July 4th, 1997) on "**Models and phenomenology for conventional and high-tempertaure superconductivity**", **Directors R. J.Schrieffer** (Nobel laureate in Physics) and **G. Iadonisi (1996-1997)**

A2. Organization of the Symposium "Mesoscopic Bose-Einstein condensates at nanokelvin tempertaures: an ideal laboratory for mathematical applications" for the SIMAI Congress (Cagliari, May 27th-31st **2002**).

A3. Organisation (member of the Scientific Committee) of the Workshop "Experiments on the Equivalence Principle: from Earth to Space probing General Relativity", (Pisa-Florence, May 27th-29th **2002)**

A4. Conception and organization of the Festival "Musical...Mente" in the context of the Campus of arts in Sangemini (**2008** and **2009**)

A5. Organization (member of the Scientific Committee) of the National Conference of the Association Women and Science (Pontignano, Siena, October 4th-th **2012)**

A6. Organization (Chair) of the series Conferences on Quantum gases, Fundamental interactions, and Cosmology

- I Edition QFC2017-Pisa, October 25th-27th **2017** https://agenda.infn.it/event/QFC2017
- II Edition QFC2019-Pisa, October23th-25th **2019** https://agenda.infn.it/event/QFC2019
- III Edition QFC2023 – Pisa, October **2023**, in the course of organization

A7. Organization (member of the Scientific Committee) of the National Conference of the Association Women and Science (Pisa, September 20th-22nd **2018).**

A8. Organization (member of the Scientific Committee) of ECAMP 2018 (April 8th-12th, 2018).

A9. Member of the Editorial Board of the CISP Magazine - Section on Right and Education (2020-).

A10. Contribution to the organization (member of the coordinators board for the working groups) of "Which Physics Training for Teachers of Primary School?", Piano Nazionale Lauree Scientifiche-Fisica Group G6 - University of Catania **(February 12th 2021).**

A11. Coordinator of the Working Thematic Group "Games with the purpose (GWAP) of Physics Education and Physics Education research" at GIREP (International Group for Research Education in Physics) **(January 2021-).**

A12. Component of the organization committee for the RRI training activity for PhD students of the University of Pisa (June 12th 2020).

A13. Component of the Local organizing committee of the Workshop Cold Atom Technology in Space organized by AEDGE, 23-24 September 2021 https://indico.cern.ch/event/1064855/

A14. Chair of the Symposium on Quantum Games for Physics Education at the 3rd World Conference on Physics Education, Hanoi 13-17 December 2021.

A15. Component of the Local organizing committee of the International School on Astroparticle Physics **ISAPP2023**.

A16. Conception, organization, and coordination of the panel "Educating to Scientific Thinking" at the **States General of the Digital School** (Bergamo, 27 November 2021) with Andrea Ferrara (SNS), Claudia Giudici (Reggio Children), Cristina Lazzeroni (Birmingham U.), Sabrina Maniscalco (Helsinki U.), Marisa Michelini (Udine U.), Stefano Sandrelli (INAF), the Q&A session with the 2001 Nobel laureate Carl Wieman and the interview to Howard Gardner on his latest work A Synthesizing Mind.

3.2.2 Chairing Evaluation Committees

B1. Chair of the Commettee for the selection of young tutors and teachers for empowering courses on physics at the Pharmacy BSC and MD Course studies

B2. President of the Evaluation Committee for the PhD in Physics at the University of Pisa, Thesis of Dr. Giampiero Marchegiani (Pisa, February 28th 2019)

B3. Chair Committee for best poster at superfluctuations 2019

3.3 INSTITUTIONAL OFFICES AND ADDRESSING POLITICAL PROGRAM

3.3.1 INSTITUTIONAL OFFICES

A1. Elected President of the City Council for Equal Opportunities of the City of Pisa (2003-2008).

A2. Appointed Deputy Mayor of the Municipality of Pisa, with responsibility to address Educational and School Policies, Promotion of Digital Technologies for training, Science Education, Equal Opportunities, City Legacy, Constitution, Memory and Culture of Legality, Action plans to contrast corruption in Public Administrations and implementation of the Charter of Pisa (ethical code of conduct) (**Councils 2008-2013 and 2013- June 24th 2018).**

A3. Served as President (elected) of the Educational Conference of Mayors for the Pisa Area (Councils 2008-2013 and 2013- June 24th 2018).

A4. Conception and coordination of the Agreement Pisa City of Science among Pisa Municipality, University of Pisa, Scuola Normale Superiore, Scuola Superiore Sant'Anna, CNR-Pisa, INFN-Pisa, INGV-Pisa, EGO, Stella Maris **(2017-2018)**.

A5. Member of the National Commission of the National Association of Municipalities of Italy (ANCI) on school and education (2011- June 24th 2018).

A6. Member of the National Commission of the National Association of Municipalities of Italy (ANCI) for equal opportunities (2011- June 24th 2018).

A7. Member (on ministerial appointment) of the National Observatory on Childhood and Adolescence, representing ANCI (14 February 2017-17 October 2018).

A8. Member (on Ministry appointment) of the Control room for the monitoring of the National Plan against gender violence at the Prime-Ministry Cabinet, representing ANCI (March 28th 2017-June 24th 2018).

A9. Member (on Tuscany-Region Council appointment) of the Regional Observatory (Tuscany) against gambling, in relation to the Coastal Vast Area **(10 November 2016-23 June 2018).**

A10. Member (on Pisa Municipality appointment) of the Board of Galileo Foundation (2013-2018).

A11. Component (regional appointment) of the **Board of the Foundation of the Tuscany Regional Orchestra (January 2021-).**

3.3.2 Political addressing functions

Responsible for conducting the program of the Mayor of Pisa in two consecutive Councils (2008-2013 and 2013-2018), for the following areas with the related planning tools:

- **Educational and School Policies***:* Zerosei (0-6) Educational Services. Non-formal Education Services (CIAF, Summer camps, Children's and Parents House in San Rossore). School support services (cafeteria, school transport, inclusion of differences and diversity management). Rights in education. Program "Pisa Children's City"; Music training network. Program "Culturèducazione" on dissemination of childehood culture and education. Education Research Action "Teaching as an educational relationship". Plan for the Improvement of Childcare Services. In the office of (elected) President (Chair) of the Educational Conference of the six Municipalities of the Pisa Area: School Network, Zonal Educational Plans (segment 0-6 years-old and segment 3-18 years-old) of action for the training of educators and teachers (in particular, on pedagogy, sciences, music, gender differences, under zonal pedagogical coordination), for inclusive teaching, inclusion services (listening desk, linguistic mediation, diversity), education to non-verbal languages (music, art, theater).

- **Promotion of Digital Technologies for Training:** City Plan for Internet Connectivity of Schools "Chloe", Smart School and Smart Inclusion 2.0, Socrates (for Specific Learning Disorders), Digital Schools of Europe (Erasmus+).

- **Science Education:** Pisa City of Science, Science-Technology Hub, Science Center, and Digital Manifactures for Movies at the Cittadella Galileiana.

- **Equal Opportunities***: Nondasola* Program to contrast gender and domestic violence against women, and related four-dimensional actions: (1) enhance awareness and promote education (as coordinator), (2) train health care, police, and association operators*,* (3) recognize and analyze the phenomenon through surveys and data statistics, (4) develop welfare and assistance programs. March Women's Programme. Gender Policy Assessment Tools (Gender Assessment, Ex-ante IAMMG Model Impact Assessment). Integrated Action Plan of the National and Regional READY Network for Combating Discrimination by Sexual Orientation. Tempi in Area (guidelines to integrate life-work time scheduling in a suited Plan for the Pisa Area). Guidelines for the development of gender equality bodies (City Council for Equal Opportunities and CUG of the City of Pisa, network of citizens CUGs). As a member of the States General of Women, organization of the panel on "Education and Gender" at the Women's Conference "Beijing +20" within EXPO2015 (Milan).

- **City Legacy, Constitution, Memory, and Culture of Legality**. Program Pisa NonDimentica to nourish collective Memory and Legacy about: Racial Laws of 1938; UN Convention on Children's Rights; abolition of the Death Penalty in Tuscany and the campaign Hands Off Cain; Universal Declaration of Human Rights; Day in Memory of Auschwitz death camp disclosure; Day in Remembrance of the Foibe; first free elections in Pisa after the war; Liberation of Italy from Nazifascism; massacres and victims of mafias and national and international terrorism; National Memorial Day of the Italian Republic; Resistance; Liberation of Pisa; actions for the dissemination and awareness of European Citizenship. Plan to contrast pathological gambling. Programmes and projects for the culture of peace (with the National Coordination of Local Authorities for Peace and, in Palestine, with the project 100 Cities for the Middle East), for international cooperation (in particular in Iraq for the construction of youth

and women centres), and for nuclear disarmament (70th anniversary of the A-bombing

Definition and implementation of planning, quantitative measurement and/or qualitative-quantitative policy evaluation tools.

My commitment in public administration and political addressing has been characterized by a scientific approach, operating since the beginning (2008-) in a context where scientific thinking is not the norm in everyday administrative culture, the tools for planning introduced by law were limited and those for assessment rare. I proposed and helped to conceive and design:

(i) in collaboration with the Istituto degl'Innocenti, the **tool to assess the pedagogical and management quality of the educational childcare services**, an idea that then spread on a regional and national scale;

(ii) with the research group of ex-ante impact assessment (Dept. of Political Sciences, University of Pisa), the **tool to assess the impact of gender policies**, subsequently extended to Childhood policies;

(iii) **the assessment tool for the implementation of the Ethics Code** of the Municipality of Pisa.

In all cases one is dealing with **innovative tools**, introduced – as for ANCI knowledge – for the first time ever in Italy. In cases (i) and (ii), the results of the work were published. In addition, I have addressed definition of quantitative service analysis tools to be used in structural planning. I have helped to develop long-term plans of actions for education (Zonal Educational Plans, School Network Plan, Zerosei National Plan, National Plan for Childhood and Adolescence), equal opportunities (National Plan to contrast Combating Gender Violence), legality and anti-corruption (Regional Plan for the Fight against Gambling and Municipal Plan Anti-corruption).

on Hiroshima and Nagasaki and the most recent invitation of the Vatican Dicastery for Integral Human Development, Vatican 10-11 November 2017).

- **Actions to contrast corruption in Public Administrations and implementation of the Charter of Pisa (ethical code of conduct):** Transparency and Anti-corruption Plan. Monitoring Tools for the implementation of the Code of Ethics/ Charter of Pisa. Staff training tools also in accordance with the Anti-corruption Master of Unipi.

4 PRIZES AND AWARDS

4.1 PRIZE for young MD students, assigned by the Italian Physics Society (1997)

4.2 The work "Time-dependent linear response of an inhomogeneous Bose superfluid: microscopic theory and connection to current-density functional theory" has been awarded by an international referees' committee to be published in **INFM Highlights (1998)**

4.3 Award – after a public selection – of *una tantum* incentives by the University of Pisa (2012-2016, every second year**)**

4.4 PRIZE "CULTURE OF SOLIDARITY" (Pistoia, **2014**)

4.5 PRIZE "SUCCESSFUL WOMEN" assigned by Sportello Donna in Pavia in collaboration with Fondazione Gaia (Milan, March 31st **2016**, within Beijin 20+ World contest).

4.6 Appointed within the project "100Experts", women expert in different fields, selected in collaboration with the Centro Genders of Milan University for the STEMs, with the Bocconi University for the Economics and Finance area and with the Istituto ISPI for International Politics.

5 DEVELOPMENT OF SOFT AND LIFE-SKILLS IN LEADING DIVERSE WORKING GROUPS

A1. Educational and training relationship within the framework of the teaching activity (referred to in the work experience section)

A2. Group work and management as part of research activities (referred to in the work experience section)

A3. Associationism

- Co-founder of the Pisa-section of MAMI (Italian expression of the World Alliance for Breastfeeding Actions from UNICEF) on the subjects of natural motherhood, represented in the City Council for Equal Opportunities of the City of Pisa (1998-2002)
- Contributor to the Comitato 13 February, born with SNOQ (If Not Now When?)
- Member of the States General of Women
- Member committed to the activities of the National Association of Italian Partisans (ANPI)-section of Pisa. Member of the Guarantee Board of ANPI (2019-).
- Member committed to the activities of the Association of Women and Science
- Member of the Board of the Normalisti Association (2012-)
- Member of the Italian Union of Scientists for Disarmament (USPID) (2020-)
- Member of 500WomenScientists http://gage.500WOEMSCIENTISTS.ORG and related Pisapod (2020-)
- Member of the Association 24MarzoOnlus for Human Rights (2021-)

A4. Political activity

- Member of the Board of Directors first, and then of the Provincial Executive of La Margherita-Democrazia è Libertà (from 2004 to the PD foundation PD)

- Contributed to the national working group of La Margherita on University and Research
- Co-founder of the Association for the Democratic Party of Pisa
- Founder of the Pisan PD
- Elected to the first National Constituent Assembly of the Democratic Party, in the contituency of San Miniato, Pisa (2007)
- Member of the municipal and provincial bodies of Pisa of the PD (since PD foundation)
- Member of the Regional Directorate PD Toscana (Autumn 2018-)
- Deputy Mayor of Pisa (2008-2013 and 2013-2018)
- As Deputy Mayor of Pisa and representative of ANCI, member of the control room for the monitoring of the National Plan antiviolenza at the Cabinet of the Italian Prime Ministry
- As Deputy Mayor of Pisa and representative of ANCI, member of the National Observatory on Childhood and Adolescence
- As Deputy Mayor of Pisa and representing the vast coastal area, member of the Regional Observatory on pathological gambling, established by the Regional Council of Tuscany
- Elected as Pisa delegate at the National Conference of Dem Women of the PD (2019)
- Elected one of the 150 most influential feminists by Ladynomics magazine (2020)

A5. Practised sports at professional or amateur level

- Volleyball (professional, setter, C2 championship)
- Basketball (amateur, playmaker)
- Soccer at 11, 7 and 5 (amateur)
- Table tennis (amateur, Calabria Champion in Youth Games)
- Half-marathon (amateur)
- Horse riding (amateur)

-

A6. Playing tenor saxophone in:

- University of Pisa Orchestra
- Filarmonica pisana
- Big Band of the group Clown Doctors (playing e.g. in Pediatric sections of City Hospital)

ATTACHED CV-A
RESEARCH ACTIVITY AND PUBLICATIONS

MARIA LUISA CHIOFALO

1. SUMMARY

The research activity carried out since the MD Thesis (1992) to date has been diversified along the following main lines: microscopic models for high-temperature superconductivity [L1, L3, 1-5, 41, P.1, P.5]; charged boson fluids (as to Refs. [6] to [9]); the dynamics of Bose-Einstein (BEC) condensates of Bosonic alkali atoms (as to Refs. [10-24, 33-35, 42, 47, 46, P.2-P.3, P.6]) and ultracold vapours of Fermionic alkali atoms (as to Refs. [25-26]); the superfluidity of trapped alkali fermionic atom vapours (referred to in [27,31-32, 37-38, 46, 48, 50, 53, 68, 71, 72, P.4]); tests of the Principle of Equivalence with experiments on Earth and in space with macroscopic bodies (referred to in [43-45, 51-52, P.7]); metrology and fundamental physics tests with ultracold atoms (referred to in [24, 55, 59-61, 63, 74, 75, 78-82, 85, 92]); theory for the realization of super-strongly correlated ultra-cold atomic gases in reduced dimensions, and their applications (as to Refs. [54, 56-58, 62, 64-69, 70, 73, 75, 81-83, 84]); development of ideas and tools for quantum simulators and quantum problem solvers (referred to in [PR1-PR2]). The development of numerical methods for the study of cold atoms and Bose-Einstein condensates was also part of the activity (referred to in [28-30, 39, 40]).

The results of the research work were also the subject of seminars under invitations at Italian and International scientific institutions, and were presented as invited reports in a number of national and international conferences, as indicated in a dedicated section of the bibliography.

Current and emerging lines of research. As anticipated in Sec. 2.5.2 of the main CV document, starting from 2018 and after an almost ten years break due to institutional commitments, the new research line on **quantum technologies** has been activated**,** with particular reference to the use of the platform of quantum atomic gases as quantum simulators or precision-measurements environment for fundamental physics (see also the cycle of Conferences on Quantum Gases, Fundamental Interactions and Cosmology, conducted as Chair. see section 3.2.1 of the main CV) and for quantum simulators [PR2] and computing (see in particular the IQHuMinds proposal [PR1]). Current research work carried out along these lines includes: **(a)** the exploration of **gravity under analog models**, in particular engineering an experiment to probe the universal relationship between shear viscosity and entropy on the horizon of a black hole, in collaboration with Massimo Mannarelli (LNGS, Italy) and Dario Grasso (INFN) [85, 92] and exploring the information paradox in black holes, within the framework of open quantum systems (referred to in the follow-on funded by KITP, conducted as coordinator- see section 2.6 in the main CV document); **(b)** the citizen-science research for the realization of a quantum problem solver *Integrating Human and Machine Minds for Quantum Technologies* in tight collaboration with Sabrina Maniscalco (Helsinki University) (referred to in the proposal submitted to the MSCA call RISE 2020 **IQHuMinds**, Ref. PR1 and section 3.1 in the main CV document); **(c)** the development of **quantum models and simulations for visual neurosciences**, in collaboration with Concetta Morrone (neuroscientist, University of Pisa); **(d)** the physics of **quantum complex networks** (referred to in the follow-up to the KITP coordinated by Lincoln Carr-see section 2.6 of the main CV document); **(e)** studies of TRED/DR1 molecules dispersed in polymers for optoelectronic applications (within the PRA of Ateneo ANISE, coordinator Dario Pisignano-see section 2.5.2 of the main CV); **(f)** within IQHuMinds the existing activity on outreach and on **Physics Education Research (PER)** has been empowered, specifically dedicated to quantum physics, in collaboration with Sabrina Maniscalco (Helsinki University), the PER group of Heather Lewandowski (JILA and UCB, Boulder, Co, US) and Marisa Michelini (Udine University, Italy); finally, **(g)** since 2019, part of this research activity on quantum technologies is carried out within the **VIRGO-LIGO** collaboration (see [87-91,94-95]).

In the following, a detailed and reasoned description of the research results is provided, with larger space devoted to earlierand well-established results.

2. INTERNATIONAL COLLABORATIONS

The activity has been diversified along the following main directions: the study with theoretical methods and quantum simulation of quantum states of strongly degenerate fermionic atoms, in collaboration with the theoretical group of Murray Holland and the experimental group of Debbie Jin (JILA of Boulder, Colorado, US), Servaas Kokkelmans (Dip. of Physics, University of Eindhoven, The Netherlands), Stefano Giorgini (CRS-BEC CNR-INFM and Dip. Physics, University of Trento), and with Stefania De Palo in particular for the part of quantum simulation (CRS-Democritos CNR-INFM of Trieste); the use of the dynamic and coherent properties of ultracold bosonic and fermionic atoms to engineer atomtronics devices, in collaboration with Giuseppe La Rocca (Scuola Normale Superiore di Pisa) and Maurizio Artoni (Università di Brescia), Augusto Smerzi (CNR-INO of Florence), Roberto Onofrio and Lorenza Viola (Dartmouth College, New Hampshire, US); use of cold atoms for fundamental physics tests, in collaboration with Guglielmo Tino (LENS, Florence), Murray Holland (JILA, Boulder, Co, USA), Vladan Vuletic (MIT, Boston, USA), Andrea Trombettoni (SISSA, Trieste), more recently in the framework of the MIT-Unipi Program, of MAGIA-Advanced (Commission 2 INFN), OLAGS (Commission 5 INFN), international network AEDGE, Virgo/Ligo

collaboration; the study of atomic gas physics with long-range interactions in conditions of strong quantum degeneration, in collaboration with Stefania De Palo, Roberta Citro (University of Salerno), Edmond Orignac (ENS of Lyon) and Paolo Pedri (Paris), Benjamin Lev (Stanford, US); 1D ion systems as quantum simulators, with Vladan Vuletic (MIT, Boston, US) and Giovanna Morigi (Saarbrucken, Germany); open quantum systems with Sabrina Maniscalco (Turku University, Finland), Andrew Daley (Strathclyde, Glasgow, UK), Jonathan Keeling (St. Andrews, Edinburgh, UK), Benjamin Lev (Stanford, US), Wolfgang Ketterle (MIT, Boston, US), Lincoln Carr (Colorado Mines University, Golden Co, US) in particular for complex quantum networks; analogue gravity with Andrea Trombettoni (SISSA, Trieste), Stefano Liberati (SISSA, Trieste), Massimo Mannarelli (INFN-LNGS), Dario Grasso (INFN-Pisa); Heather Lewandowski (JILA and UCB, Bouledr, Co, US) and Marisa Michelini (University of Udine, Italy) on Physics Education Research.

3. DESCRIPTION OF RESEARCH ACTIVITY

A. Critical high temperature superconductivity (HTSC)

Motivations

Hhigh-Tc superconductors are very complex materials, for both their unusual normal-state and superconducting properties: the small coherence lengths and the high critical temperatures (on the Fermi temperature scale) measured classify the transition type as middle way between a condensation of Cooper pairs and a Bose-Einstein condensation of pairs of strongly-bound fermions in real space. After more than fifteen years since the discovery of Bednorz and Müller, there is still no fully accepted theory that accounts for all the phenomenology of the HTSC.

Contributions

Within this research topic the following main contributions are highlighted, obtained with both theoretical and numerical methods:

(a) **Existence and stability of bipolarons.** The existence, stability as bound states (referred to in [1], [P.1]) or resonances (referred to in [2]) and mobility (referred to in [3]) of bipolarons (i.e., electron pairs or holes with reticular deformation due to ionic polarization) have been demonstrated in ionic and heavily doped compounds, considered as a model system for high temperature superconductors.

(b) **Coexistence of bipolarons and polarons in the boson-fermion model and application to Htscs.** The existence of resonant bipolaronic states suggests the study of the many polaron system in the presence of a potential short-range attraction, in terms of an effective Hamiltonian - proposed by R. Friedberg and T. D. Lee - in which bosons (bipolarons) and fermions (polarons) coexist. By inserting into this effective Hamiltonian the microscopic properties calculated in (a), it was possible to determine a universal, compound-independent curve for the critical temperature as a function of the density of holes, and the critical temperature as a function of London's penetration length, as well as thechemical potential in normal and superconducting conditions. The results obtained are in very good agreement with the available experimental data ([4], [P.5]).

The coexistence model between bosons and fermions also allows to qualitatively reproduce the combined experimental data on resistivity and relaxation time of copper nuclei (mentioned in [5]).

(c) A scheme has been proposed to use the Density Functional Theory to treat electron gas strongly interacting in the presence of electron-phonon interaction. This approach is relevant for the study of charged density waves and Wigner crystal of electrons in the presence of phonons (see [41]).

Reviews

Volume [L1] collects a review of the phenomenology of high-temperature superconductors, together with the results obtained within this line of research. The volume [L3] is a collection of works edited along with Giuseppe Iadonisi and Robert J. Schrieffer within the CXXXVI Course of the International School of Physics "Enrico Fermi".

B. Fluids of charged bosons

Motivations

Strongly-interacting charged boson fluids can be relevant as model systems in high temperature superconductors, in two-dimensional electron gases under conditions of strong quantum degeneration (and quantum Hall effect), and in some systems of astrophysical interest, such as white dwarfs - consisting of ions of 4He.

Contributions

Two main contributions are related to this research line:

(a) Local field dielectic theories. The calculation of the properties of a single particle and the structure of the fluid by means of local static field theories for the dielectric function, which allowed to highlight the effects of the statistics in comparison with the analogous properties, already well known and studied, of charged fermions [6] and to conclude that the local-field theory of Vashishta and Singwi is the quantitatively most reliable one in comparison with available Monte Carlo simulation data [7].

(b) Rules of sum. The systematic study of the role of single and many particle excitations in determining the known problem of infrared divergences, by using sum rules for the operator density fluctuation and single-particle operators [8-9].

C. Bose-Einstein condensation and superfluidity of alkali fermionic atoms

Motivations

The Bose-Einstein condensation of diluted vapors of trapped alkaline atoms is an extremely active and frontier research field, since in 1995 the groups of Eric Cornell and Carl Wieman at JILA in Boulder (Co) and Wolfgang Ketterle at MIT managed to realize and observe the clearest evidence of the original idea of Bose and Einstein, obtaining the Nobel Prize in Physics 2001. In early experiments, a few thousand of Rubidium or Sodium atoms are cooled to temperatures below tens of nanokelvins and behave as if they constitute a single macroscopic molecule with quantum coherence properties. Current experiments have reached temperatures up to 450 pK, to which is added the ability to confine atomic gases in 3D down to 1D optical lattices, realize quantum gases possessing strong magnetic moments, thus interacting via long-range dipolar interactions, place them into sinthetiv gauge fields, and producing synthetic dimensions. Therefore, the ability to manipulate in highly controlled theoretical and experimental manner and almost at will temperatures, dimensionality, strength and range of the interactions, tailor external gauge fields, has made these systems a platform to engineer quantum technologies at the cross-disciplinary meetup of many-body physics, quantum atomic optics, quantum computing and atomtronics, as well as their potential use as quantum simulators to explore concepts of fundamental physics, such as the nature of gravitational forces over small distances.

Finally, the experimental processing techniques acquired in BEC have been used to achieve the long-awaited superfluidity of the fermionic isotopes of Potassium or Lithium alkali atoms. Several experiments have been competing around the world, starting with the first realization of a degenerate gas of Potassium fermionic atoms at JILA, and then of Lithium at ENS in Paris, at Rice University, at MIT and Duke University, and of Potassium at LENS in Florence. The level of degeneracy that can be achieved was at the beginning limited to temperatures just below 0.1 T_F (T_F being the Fermi temperature). The presence of Feshbach resonances has opened the route to realize a normal state characterized by the formation of molecules of two fermionic atoms. This same mechanism determines the transition to the superfluid state at a very high critical temperature, up to a tenth of

the Fermi temperature. One relevant effort in present experiments corresponds to realize non-trivial quantum states also in reduced dimensionality, which might mimick the physics of high-temperature superconductors, especially in their normal (non-superconducting) state.

Contributions

Since 1996, the main scientific results have been obtained in this field of research, often in collaboration with researchers from different groups including the theoretical and experimental group of JILA in Boulder.

(0a) Modelling of data in early experiments. In collaboration with JILA, a simple model has been developed for the reconstruction of the dynamic and thermodynamic properties of the condensate starting from the measurement of the directly accessible quantity in the experiment, or the absorption of coherent light from the atoms [10]. This model has become of common use in laboratory practice: it allows a quantitatively meaningful comparison between theory and experiment without the aid of fitting parameters.

(0b) Thermodynamics of confined system. Studies have been carried out on the thermodynamic properties [11-12] and the collective excitations [13] of condensates confined in harmonic traps, and generalized hydrodynamics has been formulated at finite frequency [14].

(i) Development of theoretical methods. A microscopic formulation of the Landau-Khalatnikov equations was developed for the first time for a weakly non-homogeneous, time-dependent and finite-temperature superfluid, using time-dependent density functional theory (TD-DFT) and the systematic inclusion of all additional principles of invariance and Ward identities characterizing the superfluid [15-16, P.6]. The Kohn and Sham scheme has been derived for Bose superfluids, eventually leading to the generalized Landau-Khalatnikov equations [15], and the theorems of existence of the TD-DFT have been demonstrated [16].

This theory is relevant since it provides a complete methodological response to a very complex problem to deal with, namely the dynamic mutual behavior of the non-homogeneous superfluid and normal Bose fluid, strongly interacting and at finite temperature. In fact, this work has been selected among the INFM Highlights 1998-1999.

(ii) BEC Dynamics and Hydrodynamics. Studies have been carried out using both theoretical and simulational methods to determine the dynamical behavior of condensates confined in almost one-dimensional optical lattices, obtaining an excellent agreement with the available experiments and providing predictions for possible future experiments [17-24, 33, 35, P.2-P.3]. In particular:

--The coherent emission of matter waves from condensates confined in periodic potentials has been studied by simulational techniques, highlighting the connection between a pulsed laser and the Bloch oscillations of the condensate in an optical lattice [17-18]. The numerical study was initiated by the theoretical analysis of the band structure of condensates in periodic potentials and their transport properties, using the Wannier's presentation [19]. This has made possible to discuss on a conceptual basis the phase and density nature of the excitations of the condensate in a lattice and to predict their observability, after simulating three different experimental methods that can be performed in the laboratory [20].

-- The superfluid behavior of a dynamically driven condensate in optical lattices was studied in collaboration with the BEC group of professor Inguscio (LENS, Florence). The excitation of the Kohn mode of the condensate in a combined harmonic trap with periodic potential has allowed to observe a dissipative regime in which a progressive depletion of the superfluid part is maintained as the maximum speed of the condensate increases. This depletion has been interpreted quantitatively in terms of dissipation of the superfluidity for emission of sound waves above the threshold given by

the Landau criterion [21, 34].

-- It has been suggested that the experimental configuration at LENS could lead to the analog of a Josephson effet, with possible applications to precision measurements, the engineering of atom lasers [24], as well as to the observation and characterization of the transition to the chaotic phase [33, 35, 40, P.3].

-- It has been suggested to use rapidly oscillating laser light barriers in space, in order to achieve external field/induced transparency conditions for a Bose-Einstein condensate, at energies at which the stationary barrier would be completely opaque. This mechanism could also be useful for the production of amplified side bands for atomic lasers [42, 47]. The presence of interactions between the atoms allows to regulate the energy at which the barrier offers maximum transparency, and to realize for the atoms conditions of optical bistability analogous to those of known for light [49]. The results can be relevant for the design atomtronics devices.

-- Studies have been carried out using quantum simulation techniques and theoretical methods, on the ground state of bosonic condensates with dipolar interactions in reduced dimensionality, and their crossover from a liquid state at low densities to an almost ordered state at high densities. It has been shown that in the entire crossover, the dipolar gas behaves like a Luttinger liquid, predicting the possibility of observing the entire crossover in dipolar molecular gases during experimental implementation (such as SrO molecules) as well as the behaviour of observables such as the static structure factor and the excitation spectrum, and the dynamical light scattering [54, 56-58]. These predictions are today being probed by advanced experiments with dipolar Dy atoms in 1D, e.g. in the group of Benjamin Lev at Stanford, whom a collaboration is active with.

(iii) Fermi gases in 1D. The study of the dynamics of cold fermionic atoms in one dimension, nowadays relevant for current experiments, was carried out in earlier times, and has allowed to demonstrate that the density fluctuations and excitation frequencies of the collective modes of a one-dimensional spin-polarized Fermi gas confined in an harmonic potential, coincide in the hydrodynamic and in the non-collisional regimes, in analogy to what happens for the sound waves in the homogeneous system [25-26].

(iv) Theory of resonant superfluidity. In collaboration with JILA, a theory has been proposed and studied that, including fluctuations around the BCS field, places the transition to the superfluid state of strongly-interacting Fermi alkaline atoms within an experimentally accessible range of temperatures, up to 0.5 T_F [27, P.4], even much higher than in high-Tc superconductors, where this is of the order of 10^{-2} T_F.

It has been shown that superfluidity becomes observable by extremely direct methods [31] and that the BEC-BCS crossover, from tightly-bound to Cooper pairs superfluidity, can be investigated in a controlled manned by tuning the interactions via a Fano-Feshbach resonance mechanism, a goal not attainable in other physical systems.

The proposed theory was applied the case of 40K (JILA experiment in the lab of Debbie Jin) and of 6Li (MIT experiment in the lab of Wolfgang Ketterle), obtaining critical temperatures equal to a few tenths of T_F, provided that the theory includes the correct modeling of interatomic microscopic potentials [32].

This theoretical work has been carried out in tight connection with Debbie Jin's lab. In fact, these results have boosted the experimental efforts to observe high-Tc superfluidity and BEC-BCS crossover physics in quantum Fermi gases, which has been soon achieved at JILA and MIT.

Following subsequent experiments, where the formation of molecules composed of two fermions was clearly observed, the theory of resonant superfluidity has been extended to include the correlations between fermionic molecules. In a collaborative work with the Chicago University group of Kath Levin, we predicted the possibility of observing the pseudogap - in analogy with what is

found in high-Tc superconductors - for a gas of fermionic atoms in thermodynamic equilibrium [46]. The inclusion of dynamic effects makes the system directly comparable with the realistic situation of the experiment, providing the possibility to reproduce the data and make predictions on the observability of the transition to the superfluid state [53-54]. The use of quantum simulational techniques can guide the experiments and help in validating the approximations characterizing the different proposed theories to describe the superfluidity in the presence of a Fano-Feshbach resonance. With this method it was proposed to calculate the fundamental state properties and the structure of the fluid, starting from a model for two-particle interactions that is able to reproduce all the essential characteristics of the Fano-Feshbach resonance [48, 50]. The possibility of a universal behavior in the presence of Fano-Feshbach resonances narrower than the dimensions of Fermi's energy was explored using the correlation length as a universal parameter [68].

This idea has been extended to the case where spin-orbit coupling occurs. In the context of the GG0 theory of Kadanoff and Martin, subsequently developed by Levin et al., the effect of the range of interactions and the conditions of universality in the BCS-BEC crossover in the presence of spin-orbit coupling was studied [71, 77].

More recently, it has therefore been formulated a self-consistent theory beyond mean-field, in order to study the BCS-BEC crossover with variable widths of the Fano-Feshbach resonance. The theory extends to the boson-fermion model and to the presence of spontaneous symmetry breaking, the local field theories successfully used around the 1970s to study the low-density, strongly correlated electron fluid. The theory covers the range of Fano-Feshbach resonance parameters from narrow up to intermediate widths, where no mean-field theories or Quantum Monte Carlo simulation approaches are easily available [72].

Finally, the spin and density nature of the quantum phase diagram of a 1D spinful fermion fluids effectively interacting via mediating QED optical-cavity photons, has been investigated by combined mean-field, exact diagonalization, and bosonization methods. Evidence has been found of a continuous transition from a spin-density wave to an atomic (analogous to charge-)-density wave and/or superfluid phase (in 1D sense), depending on the detuning of the cavity photons with respect to the atomic transition. The latter can be varied from positive values -where the effective interaction mediated by cavity photons is attractive in the particle-particle channel - to negative values - where the effective interaction is attractive in the particle-hole channel [69, 70].

It has then been studied the case of short-range interactions, such as those that can be realized for example in a multimode cavity in the group of Benjamin Lev at Stanford, with whom a collaboration is underway. In a first work, the phase diagram of the modeled system was studied with DMRG using a tUJ model. The rich phase diagram has been found, which includes superfluid, spin-density wave, ferromagnetic and antiferromagnetic XY, as well as cluster phases. The degree of many-body entanglement and its quantum metrology use as a new paradigm for precision measurements, has been characterized after calculating the Quantum Fisher Information (QFI) [75, 81], finding that the ferromagnetic cluster phase as the most promising. Further studies are instead aimed at finding a different producibility estimator than QFI in the case of mixed states, in fact more conveniently handable in experimental measurements and numerical simulations [93].

(v) Development of numerical codes and methods. In support of point (ii), in collaboration with Dr. Sauro Succi, Dr. Francesca Pistella and Dr. Maria Mercede Cerimele of the Institute for the Applications of Calculation of the CNR in Rome, codes have been developed the simulation of the BEC dynamics [28-30, 36], with applications to problems of physical interest. This collaboration has been focused on the study of chaotic condensate behaviour and the dynamics of mixtures of fermionic and bosonic cold atoms.

Reviews

The contributions relating to the dynamics of condensates in potential periodicals are collected in two reviews [22-23] and a review article for non specialists [D3].

D. Tests of the Principle of Equivalence in Earth and space experiments

Motivations

Tests of the Principle of Equivalence are essential to verify the foundations of cosmological theories and general relativity. After Galileo's celebrated experiment, reaching an accuracy of 10^{-3}, later formulated by Newton in terms of equivalence between inertial mass and gravitational mass, the Principle of Equivalence (in its weak and strong forms) was placed by Einstein at the basis of general relativity.

For about thirty years, an intense research activity has been aimed at increasing the accuracy of experiments, based on the predictions that the Principle of Equivalence should be violated at the level of 10^{-17} - 10^{-18}. Following Eötvös' fundamental experiment with a torsion balance reaching an accuracy of 10^{-9}, the level of 10^{-12} obtained by Dicke and then Braginski through the use of signal-modulation techniques, was only slightly improved in Earth experiments at nearly 10^{-13} in the Adelberger group. Experiments in space would allow to automatically gain a factor of 3 due to the fact that the signal would be larger. On the other hand a completely new conception of the torsion balance is necessary, capable of flying.

In this context, theoretical and partly experimental support has been devoted to the experiment Galileo Galilei on the Ground (GGG) prototype of the space experiment GG planned to fly. This was one out of the three space experiments proposed worldwide to improve the accuracy by many orders of magnitude. The Galileo Galilei on the Ground project, led by professor Anna Nobili, funded by INFN among Group 2 activities, is the only existing prototype of space experiment. It is versatile, since it aims to reach 10^{-13} in the Earth experiment, being then able to fly with the needed modifications to achieve an accuracy of 10^{-17}. This is a relevant aspect, since the theoretical predictions currently available still differ by orders of magnitude.

Contributions

As part of this research line, the calculation has been performed of magnetic effects that are part of the error budget of the space experiment [43]. The main original contribution concerns the study of the dynamic response of the instrument on Earth, by means of theoretical, simulative, and experimental methods. The normal modes of the rotor GGG are in excellent agreement with the experimental data at all instrument rotation frequencies, from the subcritical to the supercritical limit (that is, under normal operating conditions) [47, 54]. The developed method has also allowed to predict optimal working conditions to improve the system rejection properties [55], which are an essential ingredient to control external disturbances of a tidal [48] or seismic [P.7] nature.

The setup simulation environment is user-friendly and can be interfaced with the experiment, in order to effectively design the changes necessary to optimize the instrument.

E. Equivalence Principle and Fundamental-Physics Test with Quantum States

Motivations

The accurate experimental control and the possibility of obtaining conditions of negligible interactions between atoms (using appropriate atomic transitions or resorting to Fano-Feshbach resonances), has increased the interest on theoretical and experimental studies on ultracold atomic vapors aimed at exploring concepts of fundamental physics, the accurate control of quantum transport processes, gravity measurements with quantum objects, and applications of metrology.

Accurate control of quantum transport mechanisms is also of great importance for applications in the engineering of miniaturized devices based on atomtronics.

Gravity measurements on the other hand, in addition to having possible technological applications (such as GPS systems and tools for geological studies and tests), can be used for General Relativity tests, starting from the Equivalence Principle. The extremely significant issue here is that tests of the Principle of Equivalence are carried out with non-macroscopic objects, particularly with states that behave in a purely quantum way. Such studies are of great importance for establishing a deeper understanding of the relationship between gravitation and quantum mechanics, one of the great problems still open in contemporary physics.

All this physics becomes particularly interesting when atomic vapors are confined in optical lattices, i.e. periodic potentials obtained with stationary waves of laser light. Under these conditions, the possibilities of engineering and manipulating the system in a controlled manner can considerably increase, and many models of solid state physics, for long time more than abstract, become realizable in the laboratory.

Contributions

In this context, it was proposed to use the dynamic properties of Bose-Einstein condensates of alkaline atoms in optical lattices as an experimental scheme for the realization of precision measurements of external forces, such as the gravitational ones. Within the overall project funded by the Italian Space Agency (of which I've been principal investigator for the WP4250 module on theoretical aspects of quantum gravity with ultracold atoms in space), a collaboration has been established with the group of professor Tino at LENS in Florence. Here, frontier experiments have been successfully conducted to measure the universal gravitational constant G, and experiments have been devised to realize atomic clocks and to test Newton's law over small distances.

In particular, a scheme for measuring the local acceleration of gravity g with ultracold bosonic Sr atoms has been proposed and studied experimentally and theoretically, improving by more than one order of magnitude the accuracy in the measurement of g. To this purpose, consistent Wannier-Stark intraband transitions of 88Sr atoms were used for the first time in an optical lattice arranged vertically in the direction of gravity, obtained by subjecting the lattice to a phase modulation. An advantage in the use of 88Sr atoms is that they can be trapped in a state where atomic interactions are negligible. The atomic wavepacket, once in the lattice under the action of the gravity force, performs Bloch oscillationswith frequency dictated by f and by the lattice constant. In the absence of modulation, the translational symmetry breaking determined by gravity in turn breaks the energy band of the lattice into Wannier-Stark resonances separated in frequency by integer multiples of the Bloch frequency: tunneling between adjacent sites is suppressed and the atomic packet is located. The phase modulation of the lattice, at frequencies resonant with the integer multiples of the Bloch frequency, switches back the tunneling processes between sites that are separated by a number given by the integer multiplying the Bloch frequency by which the lattice is modulated. Resonances up to the fourth harmonic were observed with this technique. These resonances correspond to a coherent state, as it can be demonstrated by looking at thir width being below the Fourier limit. This results in a coherent delocalization of the atom wavepacket, over a region that can become extended up to 50 times the size of the wavepacket before modulation, at the highest order resonance that is observed. Under these conditions, it is therefore possible to operate reversibly and precisely a switch between a localized Wannier-Stark state and a state delocalized over many sites, by means of a coherent-tunneling mechanism.

The consequences of applying this concept are considerable. First, this is a basic operation for accurate control of quantum transport of atomic wavepackets into optical lattices and possible quantum-devices engineering for atomtronics. In addition, the quality factor of the resonance line increases by a factor equal to the resonance index (at the multiple of the Bloch frequency) or,

alternatively, the Bloch period becomes substantially shorter than the same factor. This has allowed the experiment to improve by almost an order of magnitude, reaching up to 2 ppm, the accuracy in the measurement of g [55, 63].

The theoretical understanding of the phenomenon can be completed if one also considers the possibility of modulating the lattice in either the amplitude or the phase. In both cases, the real-space picture is clear and the resulting dynamical delocalization of the wavepacket is coherent. In momentum space, one can demonstrate how the atomic wavepacket in the dynamically modulated lattice behaves as if it were an atomic packet in a static lattice with a sinusoidal energy band whose width, periodicity, and phase can be engineered and controlled at will. The frequency of the band is reduced by a factor equal to the multiple of the modulation frequency, the phase is controlled by the timing at which the modulation is started, and the bandwidth is determined by the tunneling rate. It turns out that in the case of amplitude modulation bears the advantage that the bandwidth can be varied in a linear manner depending on the amplitude of the modulation.

All this may lead to significant applications. First of all, it has been demonstrated the possibility to invert in a controlled way the group velocity of an atomic packet in the lattice, implementing an echo-like scheme (Loschmidt echo). In this scheme, a sequence is applied to the lattice, in which two identical modulation operations are lit-up for a few hundred Bloch periods, resulting in coherent delocalization of the wavepacket, and separated by a variable interval of time during which the tunneling is suppressed and Bloch oscillations take place. Different choices of the time interval separating the two pulses determine different effects. The scheme can be used to operate spectroscopy of strongly correlated systems, study decoerence phenomena and high-fidelity conditions for quantum systems, and of course also for transport applications. For example, in the experiment, an atom mirror was created by placing the switch-off time mid-way during the Bloch period. Under possible conditions in this system, the mirror has features of especially high coherence, since the quasi-momentum and therefore the velocity of all the atoms in the Brilluoin zone are reversed simultaneously. With respect to precision measurements, such as gravity measurements, an accuracy similar to the case of phase modulation is obtained. The advantage here is to have geometrically favourable conditions to implement the lattice modulation in close proximity to a surface. Thus, measurements of the force of gravity could be implemented over micrometric distances, also leading to the possibility of investigating Casimir-Polder forces [59].

A different scheme to increase the signal/noise ratio (SNR) in local gravity measurements with atoms in vertical optical lattices has been proposed and studied in collaboration with the theoretical group of Professor Holland at JILA in Boulder, also thanks to interesting discussions with Professor Jun Ye for experimental aspects.

The basic idea is to reveal the dynamics of atoms, as determined by external forces that one might want to measure, through the photons dynamics. To this purpose, we have proposed to realize a scheme where atoms are coupled to a QED (Quantum Electrodynamics) cavity via the optical dipole potential. In particular, a ring cavity is proposed, in which the modes of two traveling and counter-moving waves of laser light interact with a gas of ultracold atoms. At the same time, a conservative field works as a periodic potential on which the atoms move, and a much weaker field is present with the function of testing the atomic dynamics. The probe field is that which comes out of the cavity and which is revealed: the dynamics of the photons is slaved and, under certain conditions, is also completely determined by the dynamics of the atoms, with obvious expected advantages in the measurements accuracy. In particular, a heterodyne scheme is envisaged, to further improve the SNR. The advantages of this scheme are obvious: first, the method develops in situ and, given the weak interaction with the probe field, the measurement becomes highly non-destructive, that is without significantly altering the atomic dynamics. The probe field already exists in the system, it is

part of the setup necessary to have the optical reticule, and therefore no other external fields are necessary that might perturb the system while the measurement is operated. Finally, the SNR remains sufficiently high. The limits of this scheme, at least in its simplest and immediately suitable version to guide the experiment, are given by the need to maintain negligible the effects that atomic dynamics can have on both optical lattice and probe fields. The parameters that govern the process, that are the lattice height, the light-to-atom coupling, the number of atoms, and the cavity linewidth must meet specific and well-known conditions with respect to the external force parameters that determine the atomic dynamics.

The scheme has been applied to simulate the detection Bloch oscillations for atoms in a vertical lattice, demonstrating the possibility of achieving a significantly high SNR, about 10^4. Under these conditions, the scheme can be conceived to be used for gravity measurements. Other interesting applications are in the field of spectroscopy, adapting the measurement scheme to the presence of external potentials variable in time or to the possibility of modulating the lattice in phase or amplitude. In addition, it is possible to extend the method to the measurement of photon correlation functions of order higher than the first, thus obtaining more information on atomic dynamics in cavities [60].

It is clear that the research field connecting ultracold atoms to precision measurements and fundamental physics tests keepsbeing very timely. The knowledge acquired by the scientific community in recent years begins to converge in large joint projects, both in Europe and in the United States, where all theoretical and experimental skills and knowledge can be integrated. The creation of networks in this field is essential, in order to make the last qualitative leap, in large part possible if experiments and theories are brought into space. This requires, in addition to the knowledge acquired by the community, also a considerable amount of resources. In this sense the Matter Wave Explorer of Gravity network had been conceived, which has formulated a proposal to bring in space in about ten years atomic interferometry in space [61]. More recent proposals have been elaborated in the context of interdisciplinary collaborations, in particular SAGE-**A Proposal for a Space Atomic Gravity Explorer [**78] and AEDGE**-Atomic Experiment for Dark Matter and Gravity Exploration in Space** [79, 86], the latter submitted as a white paper to the ESA call for Voyager 2050.

More recently, theoretical research in this field has been carried out in support of the experiment MAGIA Advanced (LENS, Florence, project funded by INFN-Commission 2) for the realization of an atomic interferometer with large-momentum transfer and reduced quantum noise for tests of Principles of Equivalence and Detection of Gravitational Waves. In particular, it is planned to (i) create the environment for simulating the dynamics of atomic packets in the interferometer, and also within a project funded by the MIT-Unipi programme – the design of schemes for (ii) an effective spin squeezing of the input states in the interferometer, in order to reduce quantum noise, and (iii) non-destructive measurements of the ouput of the interferometer in order to increase the signal-to-noise ratio. A first speculative scheme for the realization of squeezed states in spin through the interaction with photons of a QED cavity was investigated [69, 70], that hinges on the entirely new paradigm of exploiting strong correlations among the atoms to improve the sensitivity in the phase determination. The many-body entanglement properties of 1D fermions for metrological purposes have been explored by studying the behavior of the Quantum Fisher Information (QFI) in the case of short range interactions, such as those that can be realized in a Fermi-Hubbard simulator (Markus Greiner lab at Harvard) or in a multimode optical cavity (Ben Lev lab at Stanford): it has been found that the QFI greatly works as an order parameter to identify the quantum phases as a function of onsite and nearest-neighbor interactions (phases like superfluid, ferro and antiferromagnetic also in the form of droplets, density and spin density wave), with ferromagnetic and cluster phases characterized by a very interesting scaling with the particle number [75-76]. The continuation of these works focuses on the study of the effects of dissipation in the most realistic open quantum system, and is the focus of an MD thesis work within the present collaboration with Andrew Daley,

Jonathan Keeling, and Benjamin Lev.

The possibility to realize an interferometer performing in an innovative manner by directly squeezing momentum (Bragg) states, has been engineered on the needs of the experiment at LENS in a proof-of-concept study in collaboration with LENS and JILA [80]. This idea is the subject of further development in a Raman-Nath configuration, analog to a system with synthetic dimensions SU(N) [82].

In the perspective of a different strategy, in collaboration with Andrea Trombettoni (SISSA, Trieste), we have investigated the effects of collisions between bosonic atoms on the sensitivity of an atomic interferometer, simulating the whole interferometric sequence and evaluating the possible applications to devise an atomic gyroscope [74].

Superfluids can as well be exploited to investigate open problems of cosmological and astrophysical interest in the context of analogue gravity. Along these lines, a kinetic theory has been developed that connects the Hawking temperature and phonon emission in acoustic black holes [85,92].

Since 2019, part of this research activity is carried out within the VIRGO-LIGO collaboration in terms both of internal review and in the perspective of R&D activities for Advanced Virgo [87-91,94-95] and the OLAGS project funded by INFN for the development of a system of atomic interferometers connected to fiber optics (since 2021 with responsibility of the coordination of the INFN Pisa research unit).

F. Theory for predicting the behavior of 1D super-strongly correlated ultracold atoms with long-range interactions or with spin-orbit coupling

Motivations

The basic requirement in engineering innovative technological applications is the possibility of achieving extreme quantum degeneracy under controlled conditions. This is an extraordinary property of ultracold atomic gases. A number of laboratories around the world conduct experiments with atomic species possessing large magnetic moments, which imply significant long-range dipolar tails in atom interaction potentials.

In a seminal experiment conducted in the group of Tilman Pfau, the BEC of Cr atoms has bee observed, with Cr atoms having a strong magnetic moment, and currently several experiments deal with dipolar Dy atoms or are aimed at producing ultracold or even superfluid vapors of polar molecules. The possible use of such systems for applications has been proposed by a number of authors, and among them L. Santos, S. Giovanazzi, G. Shlyapnikov. Especially in the case of effectively 1D dipolar gases, Rabl and Zoller have predicted the possibility of realizing quantum memories. Lozovik et al. have in turn predicted that a boson gas may evolve from a low-density Tonks-Girardeau liquid to a high-density quasi-solid system, using numerical techniques. A theoretical understanding of this phenomenon, which could then provide quantitative predictions and analytical expressions as a guide for ongoing experiments, was however lacking.

Moreover, methods for the realization of so-called artificial magnetic fields have become experimentally accessible: these mimic Hamiltonians formally equivalent to the well known representing a spin-orbit coupling. In this case, the coupling would take place between a form of pseudospin for atoms in particular inner states and their external degrees of freedom. The result is the possibility of accessing a new class of fundamental quantum states of great interest for both speculative and applicative purposes. For example, in an experiment carried out in the group of I.

Bloch with bosonic atoms in two different internal states and in one dimension forming a ladder, a transition has been observed from a superfluid state characterized by the analog of Meissner currents to a state of vortices, as would be the case in a superconductor of type II.

Contributions

(a) Dipolar interactions. In this context, it has been shown for the first time that a quantum gas of ultracold bosonic atoms in the presence of dipolar interactions and reduced dimensions – in fact in a 1D geometry - is in super-strong, i.e. more strongly correlated interaction conditions than a Tonks-Girardeau liquid. Using a combination of theoretical bosonization methods and simulative Reptation Quantum Monte Carlo methods, it has been shown that Luttinger's liquid theory describes the system throughout its evolution from a Tonks-Girardeau-like liquid to a quasi-ordered system analogous to a Charge-Density-Wave, in which the atoms are arranged in an apparently quasi-crystalline structure. It has been suggested that such a system and its evolution from the liquid to the most strongly correlated quasi-ordered system, can be observed in experiments being carried out with polar molecules. Analytical predictions have also been provided for observable quantities such as momentum distribution and the static structure factor, which can be verified and be a useful guide in experiments under way [54].

Then, a hydrodynamic theory for the Luttinger liquid has been developed, that is capable of predicting the behaviour of the dipolar gas in experimental conditions in which the inomogeneity of the system, due to the typical harmonic confinements, is not negligible. The method used is that of the density functional: the energy and its derivative were first determined by the Quantum Monte Carlo simulation method (QMC), and therefore used within the local-density approximation to predict the oscillation frequencies of the atoms as a function of the parameter governing the interactions. In a more refined work where also the short-range part of the dipolar interactions is included via a variational Bethe-Ansatz approximation, has allowed to determine the breathing-mode frequencies and obtain a good agreement with the experimental data from the experiment performed in Benjamin Lev's group at Stanford [84]. The QMC technique used is a variant of the Path Integral QMC at zero temperature, the Reptation Quantum Monte Carlo, which has also allowed the determination of the energy derivatives. The solutions obtained are in perfect agreement with those derived independently through the use of sumrules. The solutions are partly semi-analytical, especially useful to compare with experimental data [56].

Two aspects of predominantly theoretical interest were therefore addressed, leading to an accurate understanding of the behavior of the excitations in the homogeneous system with RQMC techniques. The RQMC allows to determine the correlation functions in imaginary time and therefore to obtain, within a single-mode approximation, the dynamic structure factor. In particular, we have rigorously determined: the absence of a roton minimum in correspondence of the first Brillouin zone, and therefore of superfluidity according to Landau criterion, and the absence of a real long-range order. As density increases, and the system evolves towards a quasi-ordered state, gaps can be opened at the second Brillouin zone and beyond. These conclusions represent a further evidence that the system is in a Luttinger liquid state and that the Feynman excitation spectrum, which could be obtained from the static structure factor and the quasi-particles excitation energy, provides in most cases an inaccurate description. In particular, the dynamic effects appear to be significant [58].

The question on which are the observables to be measured then arises, in order to test the theory. This issue has been addressed in [62, 64]. Including a new property that is brought to light here, as a result of the fact that the one-dimensional dipolar gas is always in a super-strong correlation condition: the parameter K of Luttinger is always $K < 1$ with varying the density from the Tonks regime-Girardeau to quasi-crystal phase. Under these conditions, it can be shown that a barrier against which a 1D dipolar atomic beam would impinge, would always be opaque. This property can be useful for atomtronic applications.

The overall knowledge obtained up to this point, along with the details on the hydrodynamic theory of Luttinger's Liquids are contained in an invitation-based review work in a special issue of the New Journal of Physics [57].

(b) Interactions with artificial magnetic fields. The study of quantum atomic gases in reduced dimensions (1D), in the presence of a spin-orbit coupling realized by means of so-called artificial magnetic fields, has become available from experiments. Atoms with bosonic statistics are confined in a 1D lattice, where they can occupy two different spin states, defining an effective 1D ladder 1D. In the experiment, a term formally identical to that which describes a spin-orbit coupling is produced by means of suited Raman transitions. Thus, atoms in the ladder behave as if they were subjected to a magnetic-field flux, which can be varied in the experiment. The phase diagram of this system has been studied with combined bosonization and simulative Density-Matrix Renormalization Group methods. From the study [62] results - as also found in the experiment - the phase diagram composed of a Meissner phase and one with the appearance of vortices, in analogy with what would happen in a superconductor of type II while increasing the magnetic flux. Unlike the experiment, however, which is performed with weakly interacting bosons, in the study [62] the highly repulsive interactions introduced on the individual sites favor the Meissner phase: there is a critical value of the coupling between the two ladder chains, above which the Meissner phase persists at any value of the magnetic flux. In [63, 64] the study is extended to different filllings of the ladder sites, finding a second incommensurate phase, in addition to vortex phase, occurring whenever the magnetic flux approaches or is equal to π times the filling.

(c) Cold ions and quantum effects in the Aubry transition.

The observability of quantum effects in the Aubry transition has been studied by means of Path-Integral Monte Carlo methods, in collaboration with Vladan Vuletic (MIT) and in close connection with the experiment running in his lab. Here, the Aubry transition of an harmonically confined a chain of Yb ions was observed for the first time, while varying the underlying optical lattice with period incommensurate with respect to the average ions distance. The PIMC simulation has allowed to identify the indicators to be used in order to observe the quantum effects [73]. In a collaboration with Giovanna Morigi at Saarbrucken, the universality class of the transition is being identified by means of a suited mapping procedure [83].

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[D20] M. L. Chiofalo, Introduzione, **"San Rossore, 5 Settembre 1938. Il seme cattivo delle leggi razziali in Italia**", a cura di Mafalda Toniazzi, Pisa University Press (2018) ISBN 978-88-3339-078-9.

[D21] M. L. Chiofalo in **"20 donne, 20 intelligenze per la città",** contributo in Smart City in ottica di genere? Riflessioni in rosa, ma non troppo, di Alessia Anzelmo - Edizioni Forum PA, ISBN 9788897169246 - Contenuti sono rilasciati nei termini della licenza Creative Commons 2.5 Italia.

[D22] **Il PD è un figlio che ha preso solo i difetti dei genitori,** Marilù Chiofalo intervistata da Concita De Gregorio, su **Repubblica** ISSN 2499-0817 (25 Marzo 2018). "Ascolto, condivisione, e cura: cosa è mancato alla sinistra": intervista nell'ambito di RepIdee, Bologna (9 Giugno 2018).

[D23] M. L. Chiofalo, **Modi differenti per risolvere i problemi sono la vera ricchezza**, su **Repubblica** ISSN 2499-0817 (2 Ottobre 2018) (intervento su invito).

[D24] M. L. Chiofalo, Date alle donen di Towanda la gestione della crisi, su **Repubblica** ISSN 2499-0817 (14 Dicembre 2018) (intervento su invito).

[D25] M. L. Chiofalo, **Tre colori per una politica che guardi avanti**, su **Repubblica** ISSN 2499-0817 (29 Agosto 2019) (intervento su invito).

[D26] M. L. Chiofalo, **Introduzione in: Bilancio di genere del Comune di Pisa** (Stampato Settembre 2015).

[D27] M. L. Chiofalo**, Introduzione in: Il Modello IAMG per la Valutazione Ex-ante di Impattopotenziale delle politiche di genere**, di G. Tomei, S. Burchi, F. Ciucci (Stampato Agosto 2015).

[D28] **Nascere oggi. Un caso: l'asilo nido del quartiere CEP di Pisa,** Paolo Carli intervista Maria Luisa Chiofalo, su Conflitti (Rivista Italiana di Ricerca e Formazione PsicoPedagogica, Direttore Daniele Novara, Anno 15 n. 4, 2016).

[D29] G. Badalassi e M. L. Chiofalo, **Covid19 and Recovery Funds: It's time for a different responsability of the Women for the Country,** on Corriere della Sera-27esimaora ISSN 1120-4982 (October 2020).

[D30] Caterina Foti, Marilù Chiofalo and Sabrina Maniscalco, **Quantum physics, a mystery that works**, https://weareenergy.enel.com/it/magazine/

[D31] M. Chiofalo, Video for the training course on the Agenda2030 organized by SKILLA: **Goal 11 – Sustainable Cities and Communities** (September 2021)

[D32] M. Chiofalo and P. Rossi, **The discrete appeal of spectrometry**, Interview by Silvia Camisasasca on the book La tigre di Noto- story of the physicist Marianna Ciccone, Osservatore Romano, 28 July 2021.

[D33] M. Chiofalo, **Physics – the art of scientific thinking**, Blog Sole24Ore, https://imparadigitale.nova100.ilsole24ore.com/2021/08/31/fisica-larte-del-pensiero-scientifico/ 31 August 2021.

Forewords

[DP1] M. L. Chiofalo, Prefazione, **"Cittadinanza è partecipazione"** di Jama Musse Jama, Biancaevolta Ed., ISBN **978-88-96400-48-7.**

[DP2] M. L. Chiofalo, Prefazione, **"La voce della speranza"** di Jacob Aimé Gildas Ouakatoulou, Youcanprint (2019), **ISBN-10:** 8831613944.

[DP3] M. L. Chiofalo and S. Degl'Innocenti, Prefazione, **"Margherita naso all'insù"** di Micol Carmignani, Carmignani Ed. (2020), **ISBN: 9788893831482.**

5. OUTREACH MULTIMEDIA PRODUCTS

Piacere, Scienza! (Hallo, Science!)

[DPS1] CHIOFALO MARIA LUISA, Maggi Sara, Lo Spectrum Project, Università di Pisa e WOW onlus, 2008.

[DPS2] CHIOFALO MARIA LUISA, Maggi Sara, Le proteine florescenti, Università di Pisa e WOW onlus, 2008.

[DPS3] CHIOFALO MARIA LUISA, Maggi Sara, La geotermia, Università di Pisa e WOW onlus, 2008.

[DPS4] CHIOFALO MARIA LUISA, Maggi Sara, Piacere Scienza NEWS 1, Università di Pisa e WOW onlus, 2008.

[DPS5] CHIOFALO MARIA LUISA, Maggi Sara, Piacere, Scienza NEWS 2, Università di Pisa e WOW onlus, 2008.

Piacere, Scienza! Speciale Perché Nobel (Nobel, Why?)

[DPS6] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per la letteratura a Doris Lessing, Università di Pisa e WOW onlus, 2008.

[DPS7] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per la pace a IPCC e Al Gore, Università di Pisa e WOW onlus, 2008.

[DPS8] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per la medicina a Capecchi, Evans e Smithies, Università di Pisa e WOW onlus, 2008.

[DPS9] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Turing per l'informatica a Frances Allen, Università di Pisa e WOW onlus, 2008.

[DPS10] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Abel per la matematica a Srinivasa Varadhan, Università di Pisa e WOW onlus, 2008.

[DPS11] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per la fisica a Fert e Gruenberg, Università di Pisa e WOW onlus, 2008.

[DPS12] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per l'economia a Urwicz, Maskin e Myerson, Università di Pisa e WOW onlus, 2008.

[DPS13] ABATE MARCO, CHIOFALO MARIA LUISA, Maggi Sara, Il premio Nobel per la chimica a Ertl, Università di Pisa e WOW onlus, 2008.

Piacere, Scienza! Speciale Orientamento (University guidance) I

[DPS14] CHIOFALO MARIA LUISA, Maggi Sara, Il nanoabaco, Università di Pisa e WOW onlus, 2008.

[DPS15] CHIOFALO MARIA LUISA, Maggi Sara, I farmaci biologici, Università di Pisa e WOW onlus, 2008.

[DPS16] CHIOFALO MARIA LUISA, Maggi Sara, Materia e antimateria: l'origine dell'Universo, Università di Pisa e WOW onlus, 2008.

[DPS17] CHIOFALO MARIA LUISA, Maggi Sara, La chirurgia robotica, Università di Pisa e WOW onlus, 2009.

[DPS18] CHIOFALO MARIA LUISA, Maggi Sara, Il Laser a Terahertz, Università di Pisa e WOW onlus, 2009.

Piacere, Scienza! Speciale Orientamento (University guidance) II

[DPS19] CHIOFALO MARIA LUISA, Maggi Sara, La biochimica della mente: l'ABC del cervello, Università di Pisa e WOW onlus, 2008.

[DPS20] CHIOFALO MARIA LUISA, Maggi Sara, La biochimica della mente, Università di Pisa e WOW onlus, 2008.

[DPS21] CHIOFALO MARIA LUISA, Maggi Sara, Fonti energetiche rinnovabili: l'ABC della termodinamica, Università di Pisa e WOW onlus, 2008.

[DPS22] CHIOFALO MARIA LUISA, Maggi Sara, Fonti energetiche rinnovabili, Università di Pisa e WOW onlus, 2008.

[DPS23] CHIOFALO MARIA LUISA, Maggi Sara, GLAST/Enrico Fermi: l'ABC sui raggi gamma, Università di Pisa e WOW onlus, 2008.

[DPS24] CHIOFALO MARIA LUISA, Maggi Sara, GLAST/Enrico Fermi, Università di Pisa e WOW onlus, 2008.

[DPS25] CHIOFALO MARIA LUISA, Maggi Sara, La robotica di servizio, Università di Pisa e WOW onlus, 2008.

Piacere, Scienza! Speciale Nobel Donna (Nobel Woman)

[DPS26] CHIOFALO MARIA LUISA, Maggi Sara, Tema: Premio Nobel per la Medicina 2004 a Linda Buck (con Richard Axel), Università di Pisa e WOW onlus, 2008.

[DPS27] CHIOFALO MARIA LUISA, Maggi Sara, Premio Nobel per la Chimica 1964 a Dorothy Crowfoot Hodgkin, Università di Pisa e WOW onlus, 2009.

[DPS28] CHIOFALO MARIA LUISA, Maggi Sara, Premio Nobel per l'Economia - la grande assente Joan Robinson, Università di Pisa e WOW onlus, 2009.

[DPS29] CHIOFALO MARIA LUISA, Maggi Sara, Premio Nobel per la Letteratura 2004 a Elfiriede Jelinek, Università di Pisa e WOW onlus, 2009.

[DPS30] CHIOFALO MARIA LUISA, Maggi Sara, Premio Nobel per la Fisica 1963 a Maria Goppert-Mayer (con J] H. Jensen e E. P. Wigner), Università di Pisa e WOW onlus, 2009.

[DPS31] CHIOFALO MARIA LUISA, Maggi Sara, Premio Nobel per la Pace 2004 a Wangari Maathai, Università di Pisa e WOW onlus, 2009.

[DPS32] CHIOFALO MARIA LUISA, Maggi Sara, L'esperimento Galileo Galilei on the Ground, Università di Pisa e WOW onlus, 2008.

Piacere, Scienza! Speciale Galileo

[DPS33] CHIOFALO MARIA LUISA, Maggi Sara, Galileo e il metodo scientifico, Università di Pisa e WOW onlus, 2009.

[DPS34] CHIOFALO MARIA LUISA, Maggi Sara, Galileo e gli atomi freddi, Università di Pisa e WOW onlus, 2010.

[DPS35] CHIOFALO MARIA LUISA, Maggi Sara, Galileo e l'arte, Università di Pisa e WOW onlus, 2010.

[DPS36] CHIOFALO MARIA LUISA, Maggi Sara, Galileo e la musica, Università di Pisa e WOW onlus, 2010.

[DPS37] CHIOFALO MARIA LUISA, Maggi Sara, Io vado a idrogeno, Video divulgativo del progetto "H3 - idrogeno come vettore energetico" (2011).

6. PARTICIPATION TO CONFERENCES AND INVITED TALKS

Invited talks as speaker (incomplete list)

[C1] G. Capone, V. Cataudella, M.L. Chiofalo, R. Di Girolamo, G. Iadonisi, F. Liguori and D. Ninno, A model for the exciton and the large bipolaron problems: description of the method and comparison with some experimental data, relazione su invito (speaker) alla Conference on Vacuum elementary excitations, dressed states and radiative effects: common concepts in QED and Solid State Physics, Pisa, 9-10 May 1994.

[C2] M.L. Chiofalo, Playing with the T.D. Lee Boson-Fermion model for high Tc's, relazione su invito (speaker) al Miniworkshop on Strong Correlations and Quantum Critical Phenomena, tenuto all' International Centre for Theoretical Physics in Trieste, 4-22 July 1994.

[C3] M.L. Chiofalo, S. Conti and M.P. Tosi, Charged boson fluids in static local field theories, relazione su invito (speaker) al Research Workshop on Condensed Matter Physics (Quantum and Classical Fluids group), International Centre for Theoretical Physics in Trieste (Italy), 13 June-19 August 1994.

[C4] V. Cataudella, M.L. Chiofalo, G. Iadonisi and D. Ninno, Some superconducting and normal-state properties in the large polaron-bipolaron model, relazione (speaker) al Research Workshop on Condensed Matter Physics (Quantum and Classical Fluids group), International Centre for Theoretical Physics in Trieste (Italy), 12 June-8 August 1995.

[C5] M. L. Chiofalo, A. Minguzzi, S. Conti, M. P. Tosi, Thermodynamics of a trapped interacting Bose gas, relazione su invito (speaker) alla Conferenza dell' Istituto Nazionale di Fisica della Materia, Cagliari 19--23 May 1997.

[C6] M. L. Chiofalo, A. Minguzzi, M. P. Tosi, Generalized quantum hydrodynamics of a trapped dilute Bose gas, seminario su invito (speaker) presso il JILA, Boulder (CO), 19 March 1998.

[C7] M. L. Chiofalo, Time-dependent linear response of an inhomogeneous Bose superfluid: microscopic theory and connection to current-density functional theory, seminario su invito (speaker) presso la Scuola Normale Superiore di Pisa, Pisa, 2 July 1999.

[C8] M. L. Chiofalo, Dynamics of Bose superfluids within the current-density functional theory, relazione su invito (speaker) al XVIII Convegno di Fisica Teorica e Struttura della Materia, Fai della Paganella, 28-31 March 1999.

[C9] M. L. Chiofalo, Dynamics of an inhomogeneous Bose superfluid within the current-density functional theory, relazione su invito (speaker) all'International Workshop Macroscopic Quantum Coherence Phenomena , Trieste, 5-9 July 1999.

[C10] M. L. Chiofalo and M. P. Tosi, Interacting Bose condensate in a periodic potential: band structure and Bloch oscillations, Minicolloquium (speaker) alla 19esima General Conference of the Condensed Matter Division, Montreux, 13-17 March 2000.

[C11] M. L. Chiofalo, Alcuni aspetti della dinamica di condensati di Bose-Einstein confinati: metodologia, teoria e simulazione del trasporto, seminario su invito (speaker) presso il Dip. di Scienze Fisiche dell'Università di Napoli, Napoli, 4 Maggio 2000.

[C12] M. M. Cerimele, M. L. Chiofalo and F. Pistella, Numerical solution of the stationary Gross-Pitaevskii equation: tests of a combined Imaginary-time-marching technique with splitting, relazione su invito (speaker) al World Congress of Non-Linear Analysis, Catania 18-26 July 2000.

[C13] M. L. Chiofalo and M. P. Tosi, Coherent transport in a Bose-Einstein condensate inside an optical lattice, seminario su invito (speaker) al Workshop on Theory of Quantum Gases and Quantum Coherence, Salerno, 3-5 June 2001.

[C14] M. L. Chiofalo, Measurement of the superfluid density in a trapped Bose-Einstein condensate, informal talk at the long workshop on Fundamental issues in quantum degenerate gases, Aspen Centre for Physics, Aspen (Co), 17 June-8 July 2001.

[C15] M. L. Chiofalo, Transport behaviour of quantum coherent atomic gases by an explicit time-marching algorithm, seminario su invito (speaker) al workshop IMACS/ISGG, MASCOT- Meetings on Applied Scientific Computing and Tools, Roma, 22-24 October 2001.

[C16] M. L. Chiofalo, relazione su invito come chairman della sessione Fenomeni Nonlineari , al XXI Convegno di Fisica Teorica e Struttura della Materia, Fai della Paganella, 21-24 marzo 2002.

[C17] M. L. Chiofalo, M. Artoni, and G. C. La Rocca, Resonant tunnelling through moving light barriers , contributo al congresso della Società Italiana di Fisica, Parma 2003.

[C18] M. L. Chiofalo, M. Artoni, and G. C. La Rocca, Resonant tunneling of matter waves across time-dependent optical barriers seminario presso il LENS, Florence, Febrraio 2004.

[C19] M. L. Chiofalo, M. Artoni, and G. C. La Rocca, Resonant tunneling of matter waves across time-dependent optical barriers seminario su invito presso il CRS-BEC di Trento, Novembre 2004.

[C20] D. Embriaco, M. L. Chiofalo, M. Artoni, and G. C. La Rocca, Resonant tunneling of atomic condensates across time-dependent optical barriers: a numerical approach, relazione su invito a MASCOT meeting, Florence, November 2004.

[C21] M. L. Chiofalo, Resonance effects on the crossover of bosonic to fermionic superfluidity, seminario presso il JILA, April 2004.

[C22] M. L. Chiofalo, Resonance effects on the crossover of bosonic to fermionic superfluidity, contributo su invito at KITP Conference on Quantum Gases, Santa Barbara, May 2004.

[C23] M. L. Chiofalo, Resonance effects on the crossover of bosonic to fermionic superfluidity, relazione su invito al Mini-Colloquium on Novel Phenomena in Atomic Quantum Gases, General Conference of the EPS, Prague, July 2004.

[C24] M. L. Chiofalo, Superfluidity in quantum degenerate Fermi gases seminario su invito, Dip. di Fisica, Università di Salerno, 25 Maggio 2005.

[C25] M. L. Chiofalo, Non-equilibrium dynamics in quantum Fermi gases in the BCS-BEC crossover, seminario su invito a LANL (NM, USA) (12 Gennaio 2006).

[C26] M. L. Chiofalo, S. Giorgini, and M. Holland, Released Momentum Distribution of a Fermi Gas in the BCS-BEC Crossover, seminario su invito al MASCOT meeting (Ottobre, 2006).

[C27] M. L. Chiofalo, R. Citro, S. De Palo and E. Orignac, Evidence of Luttinger liquid behavior in one-dimensional dipolar quantum gases, seminario su invito al CRS-CNR-INFM BEC di Trento (22 Gennaio 2007).

[C28] M. L. Chiofalo, R. Citro, S. De Palo and E. Orignac, On the observability of Luttinger liquid behavior in one-dimensional dipolar quantum gases, seminario su invito alla TU-Eindhoven, The Netherlands (Aprile 2007).

[C29] M. L. Chiofalo, R. Citro, S. De Palo and E. Orignac, On the observability of Luttinger liquid

behavior in one-dimensional dipolar quantum gases, seminario su invito al Workshop on Quantum Gases, IHP, Paris, Luglio 2007.

[C30] M. L. Chiofalo, R. Citro, S. De Palo and E. Orignac, On the observability of Luttinger liquid behavior in one-dimensional dipolar quantum gases, seminario su invito al Workshop MASCOT07, Roma, Settembre 2007.

[C31] M. L. Chiofalo, Più donne nella scienza: un'opportunità per le donne o un'opportunità per la scienza? , seminario su invito al Workshop MASCOT07, Roma, Settembre 2007.

[C32] S. De Palo, R. Citro, E. Orignac, P. Pedri, M.L. Chiofalo Applications of confined 1D ultracold Bose gases with dipolar interactions MASCOT08 Roma, 23-25 Ottobre 2008 seminario su invito, speaker.

[C33] R. Citro, S. De Palo, E. Orignac, P. Pedri, M. L. Chiofalo, Luttinger hydrodynamics of confined one-dimensional Bose gases with dipolar interactions, JILA and University of Colorado at Boulder (Boulder, Co, USA), Agosto 2009, seminario su invito, speaker.

[C34] B. M. Peden, D. Meiser, M. L. Chiofalo, and M. J. Holland, Non-destructive cavity QED probe of Bloch oscillations in a gas of ultracold atoms seminario su invito, speaker, LENS, Firenze (Italy), 12 Febbraio 2010.

[C35] Edmond Orignac, Mario Di Dio, Stefania De Palo, Maria Luisa Chiofalo, Roberta Citro, Phase transitions of 1D spin-coupled bosons Oral presentation-invited Minicolloquim Low Temperatures - Quantum Physics I: Mesoscopic physics and quantum gases: General European Conference of the Condensed Matter Division CMD25 JMC14, Paris, August 24th-29th 2014, Contributo orale, speaker.

[C36] Edmond Orignac, Mario Di Dio, Stefania De Palo, Maria Luisa Chiofalo, Roberta Citro, Phase transitions of one-dimensional spin-orbit coupled bosons, SIF 2014 (Pisa, Italy), speaker

[C37] E. Orignac, R.Citro, S. De Palo, M. Di Dio, M. L. Chiofalo, Incommensurate phases of a bosonic two-leg ladder under a flx, MIT (Boston, USA), Luglio 2016 seminario su invito, speaker.

[C38] E. Colella, R. Citro, M. Barsanti, D. Rossini, M. L. Chiofalo, Quantum Phases of Spinful Fermi Gases in Optical Cavities, JILA (Boulder, Colorado, USA), 30 Novembre 2017 seminario su invito, speaker.

[C39] E. Colella, R. Citro, M. Barsanti, D. Rossini, M. L. Chiofalo, Quantum Phases of Spinful Fermi Gases in Optical Cavities, Trento (Italy), 8 Febbraio 2018, seminario su invito, speaker.

[C40] E. Colella, R. Citro, M. Barsanti, D. Rossini, M. L. Chiofalo, Quantum Phases of Spinful Fermi Gases in Optical Cavities, MIT (Boston, USA), 2 Maggio 2018 seminario su invito, speaker.

[C41] E. Colella, R. Citro, M. Barsanti, D. Rossini, M. L. Chiofalo, Quantum Phases of Spinful Fermi Gases in Optical Cavities, University of Innsbruck (AUSTRIA) (June 27th, 2018), seminario su invito, speaker.

[C42] E. Colella, R. Citro, M. Barsanti, D. Rossini, M. L. Chiofalo, Quantum Phases of Spinful Fermi Gases in Optical Cavities, Talk su invito (speaker) al Workshop “Dynamics and Dissipation in Quantum Simulation”, SPRC, Stanford (Palo Alto, CA, USA), 8-10 Luglio 2018. Seminario su invito, speaker.

[C43] M. L. Chiofalo, Universality in the BCS-BEC Crossover, seminario su invito al JILA, University

of Colorado at Boulder, Boulder (CO, USA) (August 30th, 2018), seminario su invito, speaker.

[C44] M. L. Chiofalo, Local-field Dielectric Theory of the BCS-BEC Crossover in Quantum Fermi Gases, Harvard University (MA, USA) (November 7, 2018), seminario su invito, speaker.

[C45] M.L. Chiofalo, Squeezing Forty Orders of Magnitude in Four Squared Meters, Strathclyde University (Glasgow, UK) (November 28, 2018), colloquium su invito, speaker.

[C46] M. L. Chiofalo, Many-Body Entanglement of Fermi Gases with Short-Range Interactions, Strathclyde University (Glasgow, UK) (November 29, 2018), seminario su invito, speaker.

[C47] M.L. Chiofalo, Squeezing Forty Orders of Magnitude in Four Squared Meters, INO-CNR (Pisa, Italy) (January 30, 2019), seminario su invito, speaker.

[C48] M. L. Chiofalo, Universality in the BCS-BEC Crossover, Simposio di Materia Condensata in onore di G. Grosso (Pisa, Italy) (27-28 September 2018), seminario su invito, speaker.

[C49] M. L. Chiofalo, Universality in the BCS-BEC Crossover, colloquio su invito per gli Appunti di Fisica, Università di Messina (Italy) (May 14 2019), seminario su invito, speaker.

[C50] M. L. Chiofalo, Tailoring Quantum States of Matter for Many-Body Physics and Precision Measurements, Seminario Teorico Dipartimento di Fisica, Università di Pisa (30 May 2019), seminario su invito, speaker.

[C51] M. L. Chiofalo, La fisica di tutti i giorni: educare al pensiero scientifico ritagliando l'intervento formativo sui diversi talenti ad ogni età, Convegno Didattica universitaria per la Generazione Z, CAFRE, 20 June 2019, seminario su invito, speaker.

[C52] M. L. Chiofalo, Many-Body Entanglement in Fermi Gases for Quantum Metrology, ECT Trento workshop on "Simulating gravitation and cosmology in condensed matter and optical systems", ECT, Trento, 22-25 July 2019, seminario su invito, speaker.

[C53] M. L. Chiofalo, Universality and Fluctuations in the BCS-BEC Crossover for quantum gases with narrow-to-broad Fano-Feshbach resonances, Workshop on Superfluctuations, Padova 2-4 September 2019, talk su invito, speaker.

[C54] M. L. Chiofalo, Many-Body Entanglement in Fermi Gases for Quantum Metrology, talk su invite presso l'Aspen Center for Theoretical Physics (Aspen, Colorado), winter program "Many'Body Cavity QED", 15-20 March 2020 [Postponed due to Covid19 Outbreak].

[C55] M. Abate and M. L. Chiofalo, "Pisa-University Vision and training of young-recruited professors", Talk under invitation at the Conference ASDUNI "Teaching, professional recognition, and innovation in Universities", Virtual room University of Bari, 24-25 June 2020.

[C56] M. L. Chiofalo, "Quantum Physics and The Mind", keynote at the first Quantum Game Jam in Italy – Internet Festival#10 Reset (October 2020).

[C57] M. L. Chiofalo "Quantum contemporary Science and the breaking of disciplinary walls", keynote in occasion of the PhD thesis defense of Dr. Boris Sokolov, University of Turku (Finland) (December 5th, 2020).

[C58] M. L. Chiofalo, "The Physics of Everyday Life", Talk at the Conference "Contributing to the professional development of secondary school teachers", organized by group G6 (teachers training) of Piano Lauree Scientifiche (University of Catania, 9-10 February 2021).

[C59] M. L. Chiofalo, "Squeezing Forty Orders of Magnitude in Four Squared Meters", invited

physics colloquium, Scuola Normale Superiore, 25 June 2021.

[C60] M. L. Chiofalo, “The Physics of Everyday Life Toolbox for Basic Physics Courses”, talk at the HELMeTO2021-3rd International Workshop on Higher Education Learning Methodologies and Technologies Online (9-10 September 2021).

[C61] J. Yago Malo, G. M. Cicchini, M. C. Morrone and M. Chiofalo, A quantum model for visual neuroscience, invited talk at Mind and Matter: the Kankas symposium, Helsinki 15-17 September 2021, organized by Emmy Network Foundation, University of Helsinki and University of Turku.

[C62] M. Chiofalo (chair), M. Michelini (discussant), and J. Sherson, S. Maniscalco, C. Lazzeroni, Z. Seskir (panelists), Games for Physics Education, Symposium on at the 3rd World Conference on Physics Education, Hanoi 13-17 December 2021.

More invited talks delivered by co-Authors (largely incomplete list)

[CC1] G. Iadonisi, M.L. Chiofalo, V. Cataudella and D. Ninno, Plasmon-phonon cooperative effects in the dilute large bipolaron gas: a possible mechanism for high Tc superconductivity , relazione su invito alla I Euroconference on Physics and Chemistry of Unconventional Materials, Pisa, January 1993.

[CC2] G. Capone, V. Cataudella, M.L. Chiofalo, R. Di Girolamo, G. Iadonisi, F. Liguori and D. Ninno, Theory of dynamical screening effects in the exciton and bipolaron formation; an application to strongly photoexcited semiconductors and to the bipolaron model for High-Tc Superconductivity, relazione su invito all'International Workshop on Superconductivity and strongly correlated electronic systems, held in Amalfi (Italy), 14-16 October 1993.

[CC3] G. Iadonisi, G. Capone, V. Cataudella and D. Ninno, M.L. Chiofalo, relazione su invito alla Conferenza della Società Italiana di Fisica, Perugia, 2-6 October 1995.

[CC4] G. Iadonisi, V. Cataudella, D.Ninno and M.L. Chiofalo, On the boson--fermion model of superconductivity , relazione alla 15ma General Conference of the European Physical Society, Stresa, 22--25 April 1996.

[CC5] V. Cataudella, G. Iadonisi, D.Ninno, M.L. Chiofalo and G. De Filippis, Polarons, bipolarons and the boson-fermion model of superconductivity , relazione su invito all' VIII Congresso nazionale sulla Superconduttività ad alta temperatura di transizione, SATT8, Como, 1-4 October 1996.

[CC6] M. L. Chiofalo, A. Minguzzi, M. P. Tosi, Generalized quantum hydrodynamics of a trapped dilute Bose gas , relazione al March Meeting della American Physical Society, Los Angeles, 16-20 March 1998.

[CC7] M. M. Cerimele, M. L. Chiofalo, F. Pistella, S. Succi and M. P. Tosi, Numerical study of Bose-Einstein condensates dynamics in optical lattices, relazione al March Meeting (2000) dell'APS.

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Pisa, 20 April 2021

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