Curriculum Vitæ of Leonardo Gualtieri

Personal Data:

Address:	Università "Sapienza", Dipartimento di Fisica, Piazzale A.Moro 2, 00185 Roma, Italy
E-mail:	leonardo.gualtieri@roma1.infn.it
Telephone/Fax:	+390649694247/+39064957697
Birth:	Rome, 9/10/1971
Military Service:	Civilian service (substitutive of military service) Oct. 1995 - Sept. 1996

Research Interests:

Variuos aspects of gravitational theory:
General Relativity and Gravitational Waves (presently my main interest),
Supergravity and String Theory, Gravity as a Gauge Theory

Education and Research:

From Mar 2006	Permanent position as a researcher at "La Sapienza" University of Rome
Oct 2005 - Feb 2006	Enrico Fermi fellowship at "La Sapienza" University of Rome
Jun 2005 - Sep 2005	Postdoc position (Contratto di Collaborazione Coordinata e Continuativa) at "La Sapienza" University of Rome
Jun 2003 - May 2005	Postdoc position (Assegno di Ricerca) at "La Sapienza" University of Rome
May 2001 - Apr 2003	Postdoc position (Assegno di Ricerca) at "La Sapienza" University of Rome
Nov. 1999 - Apr. 2001	Postdoc position (Assegno di Ricerca) at Université Libre de Bruxelles
Mar. 1997 - Oct. 1999	Ph.D. studies in Theoretical Physics at University of Turin Title of the Thesis: "Harmonic Analysis and Superconformal Gauge Theories in Three Dimensions from AdS/CFT Correspondence"
Dec. 1995	Laurea degree in Physics (110/110 cum laude) at "La Sapienza" University of Rome Title of the Thesis: "Effetti Gravitomagnetici su Particelle Cariche"

Teaching:

2011/2012:	Undergraduate course "Fisica" for Natural Science students
2009/2010:	Undergraduate course "Relatività Generale"
From 2007:	Phd course "Buchi Neri in Relatività Generale"
From 2003:	Support teaching to various undergraduate courses
2001/2003	Support teaching to the PhD course "Relatività Generale"

Computing experience:

Linux, Windows and MacOS environments, Fortran, Mathematica, Maple

Languages spoken:

English (fluent), French (good knowledge), Italian (mother language)

Awards and Grants:

2012	Research Grant from “Sapienza” University
2011	IRSES Grant from European Commission, within the FP7 Program
2007	“Honorable Mention” from the Gravity Research Foundation
2003	Research Grant “Progetto Giovani Ricercatori” from Italian University Ministry
1996	“Luca Branca” fellowship for recent graduates in Astrophysics
1992	“Persico” fellowship for Physics students from Accademia Nazionale dei Lincei

Member of the organizing committee of the following Conferences:

2012	Problemi Attuali di Fisica Teorica Vietri sul Mare, Salerno (Italy)
2011	Numerical Relativity and High Energy Physics Madeira (Portugal)
2010	Neutron Stars as Gravitational Wave Sources Monte Porzio, Rome (Italy)

International Collaborations Presently Active:

Departament de Fisica Aplicada, Universitat d'Alacant (Spain)
Department of Cosmology and Gravitation, University of Portsmouth (UK)
Centro Multidisciplinar de Astrofisica, Lisboa (Portugal)
Department of Physics and Astronomy, University of Mississippi, MS (USA)
Max Planck Institut fur Gravitaionsphysik, Potsdam (Germany)

Publication List

Articles in refereed journals:

R56 "Tidal interaction in compact binaries: A post-Newtonian affine framework"
V. Ferrari, L. Gualtieri, A. Maselli
arXiv:1111.6607, Phys. Rev. D85 (2012) 044045

R55 "Floating and sinking: the imprint of massive scalars around rotating black holes"
V. Cardoso, S. Chakrabarti, P. Pani, E. Berti, L. Gualtieri
arXiv:1109.6021, Phys. Rev. Lett. 107 (2011) 241101

R54 "Higher-dimensional puncture initial data"
M. Zilhao, M. Ansorg, V. Cardoso, L. Gualtieri, C. Herdeiro, U. Sperhake, H. Witek
arXiv:1109.2149, Phys. Rev. D84 (2011) 084039

R53 "Oscillations of hot, young neutron stars: Gravitational wave frequencies and damping times"
F. Burgio, V. Ferrari, L. Gualtieri, H.-J. Schultze
arXiv:1106.2736, Phys. Rev. D84 (2011) 044017

R52 "Gravitational waves from extreme mass-ratio inspirals in Dynamical Chern-Simons gravity"
P. Pani, V. Cardoso, L. Gualtieri
arXiv:1104.1183, Phys. Rev. D83 (2011) 104048

R51 "Structure, Deformations and Gravitational Wave Emission of Magnetars"
L. Gualtieri, R. Ciolfi, V. Ferrari
arXiv:1011.2778, Class. Quant. Grav. 28 (2011) 114014

R50 "Head-on collisions of unequal mass black holes in D=5 dimensions"
H. Witek, V. Cardoso, L. Gualtieri, C. Herdeiro, U. Sperhake, M. Zilhao
arXiv:1011.0742, Phys. Rev. D83 (2011) 044017

R49 "Black hole-neutron star coalescing binaries"
V. Ferrari, L. Gualtieri, F. Pannarale
Int. J. Mod. Phys. D19 (2010) 1241

R48 "Numerical relativity for D dimensional space-times: head-on collisions of black holes and gravitational wave extraction"
H. Witek, M. Zilhao, L. Gualtieri, V. Cardoso, C. Herdeiro, A. Nerozzi, U. Sperhake
arXiv:1006.3081, Phys. Rev. D82 (2010) 104014

R47 "Gravitational signature of Schwarzschild black holes in dynamical Chern-Simons gravity"
C. Molina, P. Pani, V. Cardoso, L. Gualtieri
arXiv:1004.4007, Phys. Rev. D81 (2010) 124021

R46 "Structure and deformations of strongly magnetized neutron stars with twisted torus configurations"
R. Ciolfi, V. Ferrari, L. Gualtieri
arXiv:1003.2148, Mon. Not. Roy. Astron. Soc. 406 (2010) 2540

R45 “Numerical relativity for D dimensional axially symmetric space-times: formalism and code tests”
M. Zilhao, H. Witek, U. Sperhake, V. Cardoso, L. Gualtieri, C. Herdeiro, A. Nerozzi
arXiv:1001.2302, Phys. Rev. D81 (2010) 084052

R44 “Neutron star tidal disruption in mixed binaries: the imprint of the equation of state”
V. Ferrari, L. Gualtieri, F. Pannarale
arXiv:0912.3692, Phys. Rev. D81 (2010) 064026

R43 “Threshold anomalies in Horava-Lifshitz-type theories”
G. Amelino-Camelia, L. Gualtieri, F. Mercati
arXiv:0911.5360, Phys. Lett. B686 (2010) 283

R42 “Comment on ‘Kerr Black Holes as Particle Accelerators to Arbitrarily High Energy’ ”
E. Berti, V. Cardoso, L. Gualtieri, F. Pretorius, U. Sperhake
arXiv:0911.2243, Phys. Rev. Lett. 103 (2009) 239001

R41 “Perturbations of Schwarzschild black holes in Dynamical Chern-Simons modified gravity”
V. Cardoso, L. Gualtieri
arXiv:0907.5008, Phys. Rev. D80 (2009) 064008

R40 “Relativistic models of magnetars: the twisted-torus magnetic field configuration”
R. Ciolfi, V. Ferrari, L. Gualtieri, J.A. Pons
arXiv:0903.0556, Mon. Not. Roy. Astron. Soc. 397 (2009) 913

R39 “A Semi-relativistic Model for Tidal Interactions in BH-NS Coalescing Binaries”
V. Ferrari, L. Gualtieri, F. Pannarale
arXiv:0801.2911, Class. Quant. Grav. 26 (2009) 125004

R38 “ Transformation of the multipolar components of gravitational radiation under rotations and boosts”
L. Gualtieri, E. Berti, V. Cardoso, U. Sperhake
arXiv:0805.1017, Phys. Rev. D78 (2008) 044024

R37 “The Return of the membrane paradigm? Black holes and strings in the water tap”
V. Cardoso, O.J.C. Dias, L. Gualtieri
arXiv:0705.2777, Int. J. Mod. Phys. D17, (2008) 505

R36 “Relativistic models of magnetars: structure and deformations”
A. Colaiuda, V. Ferrari, L. Gualtieri, J. A. Pons
arXiv:0712.2162, Mon. Not. Roy. Astron. Soc. 385, 2080 (2008)

R35 “Quasi-normal modes and gravitational wave astronomy”
V. Ferrari, L. Gualtieri
arXiv:0709.0657, Gen. Rel. Grav. 40, 945 (2008)

R34 “New approach to the study of quasinormal modes of rotating stars”
V. Ferrari, L. Gualtieri, S. Marassi
arXiv:0709.2925, Phys. Rev. D76 (2007) 104033

R33 “Unstable g-modes in proto-neutron stars”
V. Ferrari, L. Gualtieri, J. A. Pons
arXiv:0709:0403, Class. Quant. Grav. 24 (2007) 5093

R32 “Quark matter imprint on gravitational waves from oscillating stars”
O. Benhar, V. Ferrari, L. Gualtieri, S. Marassi
astro-ph/0603464, Gen. Rel. Grav. 39 (2007) 1323

R31 “Equilibrium configurations of fluids and their stability in higher dimensions”
V. Cardoso, L. Gualtieri
gr-qc/0610004, Class. Quant. Grav. 23 (2006) 7151

R30 “Hybrid approach to black hole perturbations from extended matter sources”
V. Ferrari, L. Gualtieri, L. Rezzolla
gr-qc/0606059, Phys. Rev. D73 (2006) 124028

R29 “Coupling of radial and axial non-radial oscillations of compact stars: gravitational waves from first-order differential rotation”
A. Passamonti, M. Bruni, L. Gualtieri, A. Nagar, C. F. Sopuerta
gr-qc/0601001, Phys. Rev. D73 (2006) 084010

R28 “Hawking emission of gravitons in higher dimensions: non-rotating black holes”
V. Cardoso, M. Cavaglià, L. Gualtieri
hep-th/0512116, J.H.E.P. 0602 (2006) 021

R27 “Black hole particle emission in higher dimensional spacetimes”
V. Cardoso, M. Cavaglià, L. Gualtieri
hep-th/0512002, Phys. Rev. Lett. 96 (2006) 071301

R26 “Perturbative approach to the structure of rapidly rotating neutron stars”
O. Benhar, V. Ferrari, L. Gualtieri, S. Marassi
gr-qc/0504068, Phys. Rev. D72 (2005) 044028

R25 “Relativistic r-modes and shear viscosity: regularizing the continuum spectrum”
J.A. Pons, L. Gualtieri, J.A. Miralles, V. Ferrari
astro-ph/0504062, Mon. Not. Roy. Astron. Soc. 363 (2005) 121

R24 “Coupling of radial and non-radial oscillations of relativistic stars: gauge-invariant formalism”
A. Passamonti, M. Bruni, L. Gualtieri, C. Sopuerta
gr-qc/0407108, Phys. Rev. D71 (2005) 024022

R23 “Gravitational Wave asteroseismology reexamined”
O. Benhar, V. Ferrari, L. Gualtieri
astro-ph/0407529, Phys. Rev. D70 (2004) 124015

R22 “Non-adiabatic oscillations of compact stars in general relativity”
L. Gualtieri, J.A. Pons, G. Miniutti
gr-qc/0405063, Phys. Rev. D70 (2004) 084009

R21 “Nonlinear N–parameter spacetime perturbations: gauge transformations”
C. Sopuerta, M. Bruni, L. Gualtieri
gr-qc/0306027, Phys.Rev. D70 (2004) 064002

R20 “Gravitational waves from rotating proto–neutron stars”
V. Ferrari, L. Gualtieri, J.A. Pons, A. Stavridis
astro-ph/0409578, Class. Quant. Grav. 21 (2004) S515

R19 “Rotational effects on the oscillation frequencies of newly born proto–neutron stars”
V. Ferrari, L. Gualtieri, J.A. Pons, A. Stavridis
astro-ph/0310896, Mon. Not. Roy. Astron. Soc. 350 (2004) 763

R18 “Gravitational energy loss in high–energy particle collisions:
ultrarelativistic plunge into a multidimensional black hole”
E. Berti, M. Cavaglià, L. Gualtieri
hep-th/0309203, Phys. Rev. D69 (2004) 124011

R17 “Two–parameter non–linear spacetime perturbations:
gauge transformations and gauge invariance”
M. Bruni, L. Gualtieri, C. Sopuerta
gr-qc/0207105, Class. Quant. Grav. 20 (2003) 535

R16 “Non–radial oscillation modes as a probe of density discontinuities in neutron stars”
G. Miniutti, J.A. Pons, E. Berti, L. Gualtieri, V. Ferrari
astro-ph/0206142, Mon. Not. Roy. Astron. Soc. 338 (2003) 389

R15 “Are Post–Newtonian templates faithful and effectual in
detecting gravitational signals from neutron star binaries?”
E. Berti, J.A. Pons, G. Miniutti, L. Gualtieri, V. Ferrari
gr-qc/0208011, Phys. Rev. D66 (2002) 064013

R14 “Gravitational signals emitted by a point mass
orbiting a neutron star: effects of stellar stucture”
J.A. Pons, E. Berti, L. Gualtieri, G. Miniutti, V. Ferrari
gr-qc/0111104, Phys. Rev. D65 (2002) 104021

R13 “Gravitational signals emitted by a point mass
orbiting a neutron star: a perturbative approach”
L. Gualtieri, E. Berti, J. A. Pons, G. Miniutti, V. Ferrari
gr-qc/0107046, Phys. Rev. D64 (2001) 104007

R12 “Non–semisimple gaugings of $D = 5$ $\mathcal{N} = 8$ supergravity”
L. Andrianopoli, F. Cordaro, P. Frè, L. Gualtieri
hep-th/0012203, Fortsch.Phys. 49, 511 (2001)

R11 “An exotic theory of massless spin–two fields in three dimensions”
N. Boulanger, L. Gualtieri
hep-th/0012003, Class. Quant. Grav. 18 (2001) 1485

R10 “Non-Semisimple Gaugings of $D = 5$ $\mathcal{N} = 8$ Supergravity and FDA.s”
L. Andrianopoli, F. Cordaro, P. Frè, L. Gualtieri
hep-th/0009048, Class. Quant. Grav. 18 (2001) 395

R9 “Inconsistency of interacting, multi-graviton theories”
N. Boulanger, T. Damour, L. Gualtieri, M. Henneaux
hep-th/0007220, Nucl. Phys. B597 (2001) 127

R8 “The structure of $\mathcal{N}=3$ multiplets in AdS_4 and the complete
$Osp(3|4)\times SU(3)$ spectrum of M-theory on $AdS_4\times N^{010}$”
P.Frè, L.Gualtieri, P.Termonia
hep-th/9909188, Phys. Lett. B471 (1999) 27

R7 “$3D$ superconformal theories from Sasakian seven-manifolds:
new nontrivial evidences for AdS_4/CFT_3”
D.Fabbri, P.Frè, L.Gualtieri, C.Reina, A.Tomasiello, A.Zaffaroni, A.Zampa
hep-th/9907219, Nucl. Phys. B577 (2000) 547

R6 “$Osp(\mathcal{N}|4)$ supermultiplets as conformal superfields on
∂AdS_4 and the generic form of $\mathcal{N}=\in$, $d=3$ gauge theories”
D.Fabbri, P.Frè, L.Gualtieri, P.Termonia
hep-th/9905134, Class. Quant. Grav. 17 (2000) 55

R5 “M-theory on $AdS_4\times M^{111}$: the complete
$Osp(2|4)\times SU(3)\times SU(2)$ spectrum from harmonic analysis”
D.Fabbri, P.Frè, L.Gualtieri, P.Termonia
hep-th/9903036, Nucl. Phys. B560 (1999) 617

R4 “Stellar Pulsations excited by a scattered mass”
A.Borrelli, V.Ferrari, L.Gualtieri
gr-qc/9901060, Phys. Rev. D59 (1999) 124020

R3 “$N=8$ BPS Black Holes with 1/2 or 1/4 Supersymmetry
and Solvable Lie Algebra Decomposition”
G.Arcioni, A.Ceresole, F.Cordaro, R.D’Auria, P.Frè, L.Gualtieri, M.Trigiante
hep-th/9807136, Nucl. Phys. B542 (1999) 273

R2 “$N=8$ Gauging Revisited: an Exaustive Classification”
F.Cordaro, P.Frè, L.Gualtieri, P.Termonia, M.Trigiante
hep-th/9804056, Nucl. Phys. B532 (1998) 245

R1 “On the Perturbations of a Nonrotating Star Excited by a Massive Source.
I. The Matching Conditions at the Surface of the Star”
V.Ferrari, L.Gualtieri
Int. J. Mod. Phys. D6, 3 (1997) 323

Contributions to conference proceedings:

C10 "Numerical relativity in D dimensional space-times: collisions of unequal mass black holes"
H. Witek, V. Cardoso, L. Gualtieri, C. Herdeiro, U. Sperhake, M. Zilhao
Proceedings of the Spanish Relativity Meeting (ERE 2010)
Granada, Spain, September 2010
Published in: Journ. Phys. Conference Series, 314, 012104, 2011

C9 "Simulations of black holes in compactified spacetimes"
M. Zilhao, V. Cardoso, L. Gualtieri, C. Herdeiro, A. Nerozzi, U. Sperhake, H. Witek
Proceedings of the Spanish Relativity Meeting (ERE 2010)
Granada, Spain, September 2010
Published in: Journ. Phys. Conference Series, 314, 012103, 2011

C8 "Black holes in a box"
H. Witek, V. Cardoso, L. Gualtieri, C. Herdeiro, A. Nerozzi, U. Sperhake, M. Zilhao
Proceedings of the Spanish Relativity Meeting (ERE 2009)
Bilbao, Spain, September 2009
Published in: Journ. Phys. Conference Series, 229, 012072, 2010

C7 "Numerical relativity in higher dimensions"
M. Zilhao, H. Witek, U. Sperhake, V. Cardoso, L. Gualtieri, C. Herdeiro, A. Nerozzi
Proceedings of the Spanish Relativity Meeting (ERE 2009)
Bilbao, Spain, September 2009
Published in: Journ. Phys. Conference Series, 229, 012074, 2010

C6 "Relativistic r-modes and shear viscosity"
L. Gualtieri, J. A. Pons, J. A. Miralles, V. Ferrari, gr-qc/0702040
Proceedings of the Albert Einstein Century International Conference,
Paris, France, July 2005
Published in: AIP Conference Proceedings, 861, 638, 2006

C5 "Coupling of radial and non-radial oscillations of neutron stars"
A. Passamonti, M. Bruni, L. Gualtieri, C. F. Sopuerta, gr-qc/0411021
Proceedings of the NATO Advanced Study Institute on
the Electromagnetic Spectrum of Neutron Stars
Marmaris, Turkey, June 2004

C4 "Gravitational waves from neutron stars described by modern EOS"
O. Benhar, V. Ferrari, L. Gualtieri, gr-qc/0410140
Proceedings of the XVI SIGRAV conference
Vietri sul Mare, Salerno, Italy, September 2004

C3 "Non–linear relativistic perturbation theory with two parameters"
C. Sopuerta, M. Bruni, L. Gualtieri, gr-qc/0211080
Proceedings of the Spanish Relativity Meeting (ERE 2002)
Mao, Menorca, Spain, September 2002

C2 "No consistent cross-interactions for a collection of massless spin-2 fields"
N. Boulanger, T. Damour, L. Gualtieri, M. Henneaux, hep-th/0009109
Proceedings of the Meetings:
"Spring School in QFT and Hamiltonian Systems" Calimanesti, Romania, May 2000,
"Quantization, Gauge Theory and Strings" Moscow, Russia, June 2000

C1 "On the perturbation of non–rotating compact objects excited by massive sources"
A. Borrelli, L. Gualtieri, V. Ferrari
Proceedings of the 8th Marcel Grossmann meeting (MG8), Jerusalem, Israel, Jun 1997
Published in "Jerusalem 1997, Recent developments in theoretical and experimental general relativity, gravitation, and relativistic field theories"

Presentations at conferences:

Dec 2011 IV Workshop on Black Holes
Aveiro (Portugal)
"Gravitational wave sources in dynamical Chern-Simons gravity"

Sep 2011 Parma Workshop on Numerical Relativity and Gravitational Waves
Parma (Italy)
"Tidal interaction in compact binaries: a post-Newtonian affine framework"

May 2011 Compstar 2011: Gravitational waves and electromagnetic radiation from compact stars
Catania (Italy)
"Stellar oscillations of hot, young neutron stars"

Mar 2011 Rencontres de Moriond 2011
La Thuile, Aosta (Italy)
"Neutron stars as gravitational wave sources"

Sep 2010 19^{th} SIGRAV Conference on General Relativity and Gravitational Waves
Pisa (Italy)
"Neutron star equation of state and gravitational wave emission: magnetars, tidal disruption, stellar oscillations"

Jul 2010 19^{th} International Conference of General Relativity and Gravitation (GR19)
Mexico City (Mexico)
"Structure and deformations of magnetars with twisted torus fields"

Jul 2010 19^{th} International Conference of General Relativity and Gravitation (GR19)
Mexico City (Mexico)
"Black hole oscillations in dynamical Chern-Simons gravity"

Mar 2010 Problemi Attuali di Fisica Teorica
Vietri sul Mare, Salerno (Italy)
"Structure and deformations of magnetars with twisted torus fields"

Jan 2010 14^{th} Gravitational Wave Data Analysis Workshop
Roma (Italy)
"Structure and deformations of magnetars with twisted torus fields"

Dec 2009 2^{nd} Workshop on Black Holes
Lisbon (Portugal)
"Oscillations and stability of black holes in dynamical Chern-Simons gravity"

Feb 2008 Neutron Star Dynamics Meeting
Gregynog (UK)
"Relativistic models of magnetars"

Oct 2007 4^{th} ILIAS Meeting
Tubinga (Germany)
"Stable and unstable g-modes in proto-neutron stars"

Sep 2007 Matter at Extreme Densities and Gravitational Waves from Compact Objects
Trento (Italy)
"Relativistic models of magnetars"

Apr 2007 Problemi Attuali di Fisica Teorica
Vietri sul Mare, Salerno (Italy)
"Unstable g-modes in proto-neutron stars"

Dec 2006 3^{rd} ILIAS/N6-ENTApP Meeting
Paris (France)
"Unstable g-modes in proto-neutron stars"

Sep 2006 17^{th} SIGRAV Conference on General Relativity and Gravitational Waves
Turin (Italy)
"Gravitational waves from oscillations of relativistic stars"

Sep 2006 Mini-workshop "Understanding Neutron Stars"
Alicante (Spain)
"Unstable g-modes in proto-neutron stars"

Feb 2006 3^{rd} ILIAS Meeting
LNGS, Assergi (Italy)
"Gravitational wave asteroseismology with strange stars"

Aug 2005 International School of Subnuclear Physics, 43^{th} Course
Erice (Italy)
"Gravitational waves from rotating compact stars"

Jul 2005 Albert Einstein Century International Conference
Paris (France)
"Relativistic r-modes and shear viscosity"

Jun 2005 Hydro-MiniWorkshop of the SFB/TR7
Tübingen (Germany)
"Relativistic r-modes and shear viscosity"

Apr 2005 1^{th} Virgo-EGO Scientific Forum Meeting
Pisa (Italy)
"Study of the r-modes instabilities in rotating neutron stars"

Sep 2004 16^{th} SIGRAV Conference on General Relativity and Gravitational Waves
Vietri sul Mare, Salerno (Italy)
"Gravitational waves from neutron stars described by modern EOS"

Jul 2004 17^{th} International Conference of General Relativity and Gravitation (GR17)
Dublin (Ireland)
"Gravitational waves from non-adiabatic stellar oscillations"

Apr 2004 Problemi Attuali di Fisica Teorica
Vietri sul Mare, Salerno (Italy)
"Gravitational waves from non-adiabatic oscillations of relativistic stars"

Sep 2003 Advanced School and Conference on Sources of Gravitational Waves
S.I.S.S.A., Miramare, Trieste (Italy)
"Neutrino-transport effects on proto-NSs oscillations and on GW frequencies"

Jul 2003 "5th Edoardo Amaldi Conference on Gravitational Waves"
University of Pisa, Tirrenia, Pisa (Italy)
"Gravitational waves from rotating proto–neutron stars"

Sep. 2002 Theoretical Foundations of Sources for Gravitational Wave Astronomy of the Next Century
University of Palma, Palma de Mallorca (Spain)
"Gauge issues in non-linear relativistic perturbation theory with two parameters"

Oct. 2000 The Quantum structure of Spacetime and the Geometric nature of Fundamental Interactions
Humboldt University, Berlin (Germany)
"Non–semisimple gaugings of $D = 5$ $\mathcal{N} = 8$ supergravity"

Apr. 1997 Problemi Attuali di Fisica Teorica
Vietri sul Mare, Salerno (Italy)
"Perturbations of a non-rotating star excited by a massive source"

Past and Present Research Actitivity

My research field is gravitational theory, in its different aspects: classical general relativity (presently my main research interest), superstring theory, gravity as a gauge theory.

Classical general relativity and gravitational waves

In the last years, I focused onto the problem of understanding gravitational wave emission from astrophysical objects. My experience in the field has mainly developed working in the group of prof. V.Ferrari. The main lines of research I have investigated in this field are the following.

- One of the most promising sources of gravitational waves is the coalescence of neutron stars, but a complete description of this process is still far from reaching. Some interesting information, however, can be derived using a perturbative approach that we have applied to study the gravitational signals emitted when a mass m_0 is orbiting around a neutron star of mass $M \gg m_0$ [R1], [R4], [C1], [R13], [R14]. This study has been carried out by assuming that the perturbations of the gravitational field and of the fluid composing the star are excited by the stress–energy tensor of a pointlike mass, solving the equations of stellar structure in general relativity perturbed to first order. This approach constitutes a progress with respect to the commonly used assumption that both stars are point-like masses, since we treat at least one of the two stars as an extended object with internal dynamics. We found that the quasi–normal modes of the star can be excited during the latest phases of the coalescence.

  In [R15], by comparing the signal derived in [R13], [R14] with the postnewtonian templates commonly used in the data analysis of interferometric antennas, we have shown that when 3^{rd} generation interferometers, very sensitive in the kHz frequency band will be available, the effects of stellar structure will need to be taken into account in the data analysis if we want to efficiently extract the signal from noise.

  In [R39], [R44], [R49] we have studied the coalescence of black hole-neutron star binary systems. We have modeled such systems using a semi-analytic approach, called affine approximation, in which the star is treated as an ellipsoid, deformed by the tidal field of the black hole. In its original formulation, this approach describes the stellar orbit as a geodetic of the black hole metric, the tidal field in terms of the Riemann tensor of the black hole metric, and the internal structure of the star using Newtonian gravity. We have improved this approach by including relativistic corrections in the treatment of the stellar structure, and by describing the orbital motion with a post-Newtonian framework. With our model, we have been able to study the conditions under which the star is disrupted by the black hole tidal field before falling into the black hole; in this case, a short gamma-ray burst may form. Furthermore, we have shown that the emitted gravitational wave signal would be characterized by a cut-off frequency; if the gravitational signal is detected, the measure of the cut-off frequency would allow to estimate the neutron star radius with great accuracy, providing valuable information on the equation of state of the matter composing the star. In [R56] We have improved the model, merging in a consistent framework the post-Newtonian and the affine approaches. Our equations describe, in a unified framework, both the system orbital evolution, and the neutron star deformations. The deformations are driven by the tidal tensor, which we have expand at 1.5 post-Newtonian order.

- A very interesting line of research in gravitational astrophysics is the so-called "gravitational wave asteroseismology". Compact stars like neutron stars are expected to pulsate in damped oscillations (quasi-normal modes), which are associated to the emission of gravitational waves. The detection of these signals will allow to measure the frequencies and damping times of such oscillations, which carry information on the structure of the star and on the equation of state of matter in its core. This would offer a unique opportunity to study the behaviour of matter at supranuclear density, in such extreme conditions that cannot be reproduced in a laboratory. Our uncertainty on the equation of state in neutron star interiors reflects the present lack of knowledge on the interactions among hadrons. Therefore, the detection of gravitational waves from neutron star oscillations could shed light also on the nature of hadronic interactions.

  In [R16] we have studied how the quasi-normal modes of a neutron star are affected by a phase transition occurring in its core, which may occurr due to pion/kaon condensation or to quark deconfinement. We found that there exists a class of gravity-modes associated with that transition, whose frequency depends on the amplitude of the density discontinuity.

A sistematic study has been carried out in [R23], [C4], where several possible equations of state of nuclear matter have been considered, and the frequencies and damping times of the most relevant quasi-normal modes have been computed. We have used the most recent equations of state proposed to model matter at supranuclear densities, involving alternatively only nucleons, nucleons and hyperons, nucleons and quarks, or only quarks. We show that the identification in the spectrum of a detected gravitational signal of a sharp pulse corresponding to the excitation of the fundamental mode or of the first pressure-mode, combined with the knowledge of the mass of the star - the only observable on which we may have reliable information - would allow to gain interesting information on the composition of the inner core.

This study has been extended in [R32], by considering in more detail the possibility that what are believed to be neutron stars are instead quark stars, that is, stars constituted by deconfined quark matter. The present knowledge of the equation of state of quark matter is much smaller than that of the equation of state of nuclear matter. In [R32] we have studied sistematically the parameter space of the quark star equation of state, computing the frequencies and damping times of the quasi-normal modes. We have found that a GW-detection from a candidate neutron star/quark star oscillating in its quasi-normal modes will enable us both to discriminate if it is a neutron star or a quark star, and to constrain the quark matter equation of state.

In [R53] we have studied the quasi-normal modes of hot, young neutron stars. We have employed an equation of state recently developed to describe the neutron star matter in presence of high temperature and neutrino diffusion. We have determined how the mode freuqency depends on the entropy profile and the lepton composition, finding that, in the very early stages, gravitational wave emission efficiently competes with neutrino processes in dissipating the star mechanical energy residual of the gravitational collapse. This work has been done in collaboration with F. Burgio and H.-J. Schultze, of INFN (Catania).

We have written a review [R35] on quasi-normal modes in stars and black holes and gravitational wave astronomy.

- Another line of research we are developing regards the perturbations of rotating stars, which are a promising source of gravitational waves. In particular, in [R19], [R20] we have studied how the frequencies and damping times of the oscillation modes of a hot, lepton-rich, rotating proto-neutron star born in a gravitational collapse change during the first minute of life, and their dependency on the rotation rate. We have studied the secular instability of the gravity-modes, that appear in the oscillation spectrum because of the intense entropy and composition gradients that develop in the stellar interior, finding that such modes are unstable; however, the growth time of the modes is very large, and the instability is more likely to be damped by internal viscous processes rather than by gravitational wave emission.

  In [R26] we have studied, using a perturbative approach developed to third order in the angular velocity, the equilibrium structure of rapidly rotating neutron stars. As we show, our perturbative approach is as good as the numerical integration of the exact Einstein's equations, but it is much simpler, and gives a better physical insight. We have studied various astrophysically relevant quantities, like the maximum allowed rotation rate of the star, and the momentum of inertia, considering the most recent equations of state which have been proposed for neutron stars. These equilibrium structures can be taken as a starting point to study oscillations of rotating stars.

  In [R34] we have developed a new method to study the oscillation modes of rapidly rotating neutron star. Indeed, all approaches present in the literature have serious problems, and such oscillations are still poorly understood. In our approach the oscillations are treated as perturbations in the frequency domain of the stationary, axisymmetric background describing a rotationg star. The perturbed equations are integrated using spectral methods in the (r, θ)-plane. We have tested our approach in the case of slowly rotating stars.

- In collaboration with the Departament de Fisica Aplicada, Universitat d'Alacant (Spain), we are studying the structure and oscillations of neutron stars, including more and more physical effects in our models to make them as realistic as possible.

  In particular, we have been studying how dissipative effects modify the oscillation properties of a relativistic star and the corresponding gravitational wave emission. Up to now, dissipative effects have been taken into account in the relativistic theory of stellar perturbations only "a posteriori", by solving the equations for the perturbations of a perfect fluid, and then deriving the dissipative quantities in terms of such perturbations. In this way, only qualitative estimates can be given on the gravitational wave emission. To overcome this problem, we have been considering directly the equations for perturbations of a dissipative fluid. In our approach, the perturbed Einstein + hydrodynamical equations around a stationary background are studied, and the perturbed stress–energy tensor appearing in these equations describes a dissipative fluid. This approach can be applied to various physical contexts.

In [R22] we have studied non-adiabatic, non-radial perturbations of relativistic stars, by including the effects on thermal and chemical diffusion. Our results show that the frequencies and damping times of the quasi-normal modes can be substantially altered with respect to the standard, adiabatic case. These effects can have implications on the gravitational emission of newly born neutron stars and of strange stars with a superconducting core.

In [R25], [C6] we have studied the effects of viscosity to the instability of quasi–normal modes of rotating stars (in particular, the so–called r-modes), by including the effects of viscosity in the equations describing stellar perturbations. We computed the viscous damping time of the r-mode oscillations, more accurately than in previous works published in the literature. Furthermore, we found that a small amount of viscosity can regularize the equations for the r-modes, avoiding unphysical divergences which appears using perturbation theory.

The unstable g-modes in proto-neutron stars, and their coupling with oscillatory g-modes, have been studied in [R33], where their role in supernova explosions has been analyzed.

In [R36] we have developed a relativistic model of strongly magnetized neutron stars ("magnetars"), including poloidal and toroidal magnetic fields, different possible field structures, different equations of state and masses. We have considered stationary, axisymmetric configurations, and we have determined the stellar deformation produced by the magnetic field. The solution we find crucially depends on a parameter, which represents the relative strength of toroidal and poloidal magnetic fields; for some ranges of such parameter, the interior field can be much larger than the exterior field, thus the stellar deformation (and the consequent gravitational emission) can be larger than previously expected. We have then further developed the study of stationary configurations of magnetars in [R40,R46,R51], where we have considered more realistic magnetic field configurations, with the so-called twisted-torus shape. In this configuration, the poloidal field extends throughout the entire star and in the exterior, whereas the poloidal field is confined in a torus-shaped region inside the star. There is growing evidence that this is indeed the actual configuration of magnetic field in young magnetars. We have determined the stellar deformation induced by the twisted-torus magnetic field, and extimated the corresponding gravitational wave emission.

- In collaboration with the Department of Cosmology and Gravitation of the University of Portsmouth (UK), we have been studying the fundamenta of perturbation theory in general relativity (and more generally in spacetime theories). A better understanding of perturbation theory is crucial in order to predict the features of gravitational waves emitted by astrophysical sources. In particular, we have studied N–parameter non–linear perturbation theory in general relativity [R17], [C3], [R21]. We found the general expression for gauge transformations, and a characterization for gauge invariance, at any perturbative order.

  This approach can be very useful in the study of non-linear phenomena in relativistic astrophysics. We have applied it to study the coupling between radial and non-radial oscillations of a compact star, which could be very relevant for the emission of gravitational waves, due to resonance effects between these different kinds of oscillations. In [R24], [C5] we have derived the equations which describe such non-linear oscillating system, and in [R29] we have numerically integrated such equations, in the case where the non-radial oscillations are axially symmetric. We have found that this coupling can strongly enhance the emitted gravitational signal when the frequency associated to the radial oscillation is close to the frequency of one of the axial non-radial quasi-normal modes of the star.

- Another line of research is the study of the general properties of gravitational radiation. In [R38] we have derived the transformation properties of the multipolar decomposition of gravitational radiation under rotations and boosts. Our result allows a more complete interpretation of the outcome of fully relativistic simulations of gravitational wave sources, like the simulations of black hole-black hole coalescences.

Superstring Theory

During my Ph.D. studies in Turin, working in the group of prof. P.Frè. I mainly studied superstring theory.

The most promising candidate for the unification of all the fundamental interactions is the string theory, and a fundamental ingredient in string theory is supersymmetry. String theory includes supergravity, that is the supersymmetric extension of general relativity, as low energy limit. Therefore string theory (or, more precisely, the still misterious eleven dimensional *M–theory*, whose different perturbative limits are the string theories), inherits and incorporates all the deeper successes, problems and issues of the theory of general relativity and of its quantization. This $M-$theory includes not only strings, but also extended objects of diverse dimensions, called $p-$branes, that play a crucial role in the understanding and in the developing of this theory.

In the first part of my Ph.D. studies, I focused on four dimensional maximal supergravity, studying its possible gaugings [R2], and its BPS saturated black hole solutions [R3]. We found the complete classification of the gauged maximally supersymmetric supergravities in four dimensions, and of the black hole solutions preserving 1/2 and 1/4 of the maximal supersymmetry in four dimensions. Afterwards, we have been studying the possible gaugings of five dimensional supergravity [R10] [R12], in the perspective of brane world theories (see below). We have found a new gauged supergravity.

It is particularly relevant the conjectured, and partially proved, AdS/CFT correspondence. According to this correspondence, there is the possibility of describing the quantum nonperturbative regime of a conformal field theory living on the worldvolume of a $p-$brane by means of a classical supergravity on anti De-Sitter space AdS_{p+2} in $p+2$ dimensions. These correspondences are not only at a pure calculational level, they are correspondences between entire conceptual categories. This new field of inquiry promises to conjugate problems of nongravitational quantum field theory with problems typically gravitational, with profit of both disciplines.

My last Ph.D. year (and my Ph.D. thesis) has been devoted to an exaustive analysis of a particular version of AdS/CFT correspondence, from the derivation of the supergravity spectrum to the construction of the dual conformal theory [R5], [R6], [R7], [R8]. In this way, we found new nontrivial evidences for the validity of the AdS/CFT correspondence.

String-Inspired approaches to Gravity

In recent years, an exciting perspective has been opened by the so–called Brane World scenario, which states that we live in a four dimensional brane in a higher dimensional universe. In this model, the standard model fields live on the brane, while gravity lives in the higher dimensional space. This scenario, which is inspired from string theory and hopefully can be found to arise as an M–theory solution (the works [R10], [R12] are also in this perspective), may solve the problem of the mass hierarchy, and leads to sensible phenomenological consequences.

In the context of the Brane–World scenario, it has been suggested that, if the true energy scale for gravity is ∼TeV, it could be possible the formation of mini–black holes in high energy particle colliders. Recently I have been studying the gravitational wave emission that whould arise in such an event, in which the black hole can be treated, with good approximation, as a multi-dimensional black hole, since it lives in the higher dimensional space; a first estimate is given by the gravitational emission due to a particle plunging into a multi–dimensional black hole [R18]. Furthermore, in [R27], [R28] we have studied Hawking emission in multi–dimensional black holes, computing the absorption cross-sections for gravitons and the relative emissivities and power output. In [R31], [R37] we have studied the possible analogy bewteen black objects and fluids with surface tension in more than four dimension. In [R45] we have developed a framework to model processes involving black holes in higher dimensions using numerical relativity, i.e. by numerical integration of the fully non-linear Einstein's equations. Using this formalims, in [R48, R50, R54] we have studied head-on collision of black holes in five dimensional spacetimes, determining the emitted gravitational energy.

Another possible extension of General Relativity, inspired by string theory and by other quantum theories of gravity, is Chern-Simons gravity. In [R41], [R47]; we have proven the stability of spherically symmetric black holes in Chern-Simons gravity, and we have determined their quasi-normal modes. As we have shown, detection of black hole quasi-normal modes may allow to set strong limits on the parameters which characterize Chern-Simons gravity. In [R52], we studied how the signal from an extreme mass-ratio inspiral in Chern-Simons gravity differs from the signal of the same process in General Relativity, showing that detection of such signal in the space-based gravitational detector LISA could discriminate between General Relativity and Chern-Simons gravity in a wide region of the parameter space. In [R55] we have studied how massive scalar fields couple to matter in orbit around black holes; we found that such coupling would lead to the appearance of "floating orbits", in which an orbiting body would remain without inspiralling, extracting rotational energy from the black hole. This effect would allow to perform accurate tests of modified general relativity using space-based detectors of gravitational waves.

In [R43] we have studied a model of quantum gravity recently proposed by Horava, in which Lorentz invariance is broken by an anisotropic scaling, and is restored in the infrared limit. We have investigated the phenomenological consequences of this scenario, related to modifications in the dispersion relation.

Gravity as a gauge theory

During my first postdoc experience, in Brussels, working in the group of prof. M.Hennaux, I mainly studied gravitational theory as a spin-two field theory.

Gauge theory techniques like BRST formulation and Batalin Vilkovisky approach can be useful to investigate several aspects of spin–two theories, and of higher spin theories. With these techniques it is possible to work out all the possible consistent interactions among massless fields in arbitrary dimensions.

We found that, restricting ourselves to interactions with at most two derivatives and without ghosts, general relativity is the only consistent interaction of massless spin–two fields, and that cross–interactions for a collection of such fields are not allowed [R9], [C2]. However, there is an exception in $D = 2 + 1$ case, where an "exotic" theory is allowed [R11].