CURRICULUM VITAE

RICCARDO PIOVANI

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PERSONAL INFORMATION

Name and Surname: Riccardo Piovani
Date and place of birth: 30 December 1994, Parma
Citizenship: Italian
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PRESENT POSITION

Since: 16/12/2021, postdoctoral researcher (assegnista di ricerca)
At: Università degli studi di Parma, Dipartimento di Scienze Matematiche, Fisiche e Informatiche, Parco Area delle Scienze, 7/A, 43124 Parma
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PAST POSITIONS

- 01/11/2021-15/12/2021 High school teacher of Mathematics at I.I.S.S. Berenini, Fidenza.
- 01/11/2018-31/10/2021 PhD fellow in Mathematics at University of Pisa.

EDUCATION

- 01/11/2018-31/10/2021 University of Pisa, PhD in Mathematics 03/12/2021, Ottimo cum laude, title of the thesis "Differential operators on complex manifolds", advisor Prof. Adriano Tomassini.
- 2016/17-2017/2018 University of Parma, Master degree in Mathematics 26/07/2018, grade 110/110 cum laude, title of the thesis "Harmonic forms on complex manifolds", advisor Prof. Adriano Tomassini.
- 2013/14-2015/16 University of Parma, Bachelor degree in Mathematics 15/09/2016, grade 110/110 cum laude, title of the thesis "An introduction to symplectic topology", advisor Prof. Adriano Tomassini.
- 2008/09-2012/13 Liceo Scientifico Giacomo Ulivi, Parma, indirizzo PNI, grade 100/100.

AWARDS, GRANTS AND PROJECTS

- 08/01/2024-01/02/2024 fellowship at the Warwick Mathematics Institute, Coventry, UK, funded by INdAM.
- Abilitazione Scientifica Nazionale for Associate Professor in Geometria e Algebra, 01/A2, seconda fascia, 24/10/2023-24/10/2034.
- 2023 Prize "Franco Tricerri" for PhD thesis in Differential Geometry, funded by UMI. https://umi.dm.unibo.it/premi-old/premio-franco-tricerri/

- 2023 Coordinator of the project "On invariant cohomology and harmonic forms of homogeneous almost complex manifolds", Progetto di Ricerca GNSAGA - INdAM, CUP_E55F22000270001, 2500€.
- 2018-2023 Participation at the project "Real and Complex Manifolds: Topology, Geometry and Holomorphic Dynamics" PRIN 2017, first as a PhD student and then as a postdoc funded by the project.

Teaching experiences

- Lecturer (Docente) for the "Mathematics" course, 7 CFU, Bachelor degree in Gastronomic Sciences at University of Parma, September 2023-December 2023, 48 hours.
- High school teacher of Mathematics at I.I.S.S. Berenini, Fidenza, 01/11/2021-15/12/2021.
- 31/07/2021 High school teaching license in Mathematics (A026).
- Teaching assistant (Esercitatore) for the "Geometry 3" course, 9 CFU, of professor Adriano Tomassini, Bachelor degree in Mathematics at University of Parma, October 2019-January 2020.
- Teaching assistant (Esercitatore) for the "Geometry" course, 9 CFU, of professor Costantino Medori, Bachelor degree in Civil engineering at University of Parma, March 2018-May 2018.
- Teaching assistant (Esercitatore) for the "Geometry 1A" course, 6 CFU, of professor Leonardo Biliotti, Bachelor degree in Mathematics and Physics at University of Parma, October 2017-January 2018.
- Teaching assistant (Tutor) for the "Mathematical Analysis 1" course, 15 CFU, of professors Marino Belloni and Luca Lorenzi, Bachelor degree in Mathematics and Physics at University of Parma, September 2017.

Other

- Reviewer for Mathematical Reviews of 7 papers from 2022.
- Reviewer for Zentralblatt Math of 4 papers from 2022.
- 2012 FCE First Certificate in English, level B2.

Invited talks

- 22 June 2023, Roma: "Harmonic forms on compact almost complex manifolds", conference "Real and Complex Manifolds: Topology, Geometry and Holomorphic Dynamics".
- 05 May 2023, Parma: "Hilbert complexes on complex manifolds", Geometry seminars.
- 31 March 2023, Parma: "Weak Dolbeault and Bott-Chern decompositions of Sobolev spaces on non compact Kähler manifolds", Geometry seminars.
- 26 January 2023, Trento: "Dolbeault Harmonic $(1,1)$-forms on 4-dimensional compact quotients of Lie Groups with a left invariant almost Hermitian structure", conference "Cohomology of Complex Manifolds and Special Structures - III".
- 30 November 2022, Parma: "L^2 Hodge theory on complete Riemannian manifolds", BAT-MAT seminars.
- 10 June 2022, Parma: "Primitive decomposition of Bott-Chern and Dolbeault harmonic (k,k)-forms on compact almost Kähler manifolds", Geometry seminars.
- 03 February 2022, Cogne: "Bott-Chern and Dolbeault harmonic forms on almost Hermitian manifolds", conference "Informal Geometry Workshop in Paradiso".

- 02 November 2021, Parma: "Deformations of special Hermitian metrics 2", conference "Balanced metrics and Monge-Ampère masses".
- 05 July 2021, Levico Terme: "$W^{1,2}$ Bott-Chern harmonic forms and weak decomposition on non-compact Hermitian manifolds", conference "Cohomology of Complex Manifolds and Special Structures - II".
- 14 November 2019, Firenze: "Aeppli cohomology and Gauduchon metrics", Geometry and Complex Analysis seminars.
- 11 April 2019, Pisa: "Real, complex and L^2 Hodge theory", Baby Geometri seminars.
- 25 January 2019, Parma: "Bott-Chern harmonic forms on complete Hermitian manifolds", Geometry seminars.

Attended conferences

- 29 November 2023, Firenze: "In ricordo di Paolo de Bartolomeis".
- 11-12 September 2023, Milano: "Geometria in Bicocca".
- 21-23 June 2023, Roma: "Real and Complex Manifolds: Topology, Geometry and Holomorphic Dynamics".
- 22-26 May 2023, Lecce: 7th Workshop "Complex Geometry and Lie Groups".
- 17-19 May 2023, Torino: "A Complex Differential Geometry Meeting at UniTo".
- 23-27 January 2023, Trento: "Cohomology of Complex Manifolds and Special Structures - III".
- 02-05 February 2022, Cogne: "Informal Geometry Workshop in Paradiso".
- 10-12 January 2022, Parma: "Recent advances in Complex and Symplectic Geometry".
- 02-05 November 2021, Parma: "Balanced metrics and Monge-Ampère masses".
- 05-09 July 2021, Levico Terme: "Cohomology of Complex Manifolds and Special Structures - II".
- 29 June-02 July 2021, Pisa (online): "Real and complex manifolds - the mathematical heritage of Edoardo Vesentini".
- 07-11 June 2021, Levico Terme (online): "CIRM-ICTP Complex Analysis and Geometry - XXV".
- 01-05 July 2019, Cortona: "SMI Summer Course "Holomorphic isometries between Kähler manifolds and related topics" by Ngaiming Mok and Sui-Chung Ng".
- 27-28 May 2019, Firenze: "Max LX - miniworkshop on Non-Kählerian Geometry".
- 21-23 February 2019, Pisa: "Workshop su varietà reali e complesse: geometria, topologia e analisi armonica".
- 19-21 June 2018, Levico Terme: "Cohomology of Complex Manifolds and Special Structures".

Research interests

I am interested in complex differential geometry, and in particular in cohomological and metric properties of (possibly non compact) (almost) complex manifolds. On complex manifolds the exterior derivative on forms decomposes as $d = \partial + \overline{\partial}$, yielding $\partial^2 = \overline{\partial}^2 = \partial\overline{\partial} + \overline{\partial}\partial = 0$. If the complex manifold is compact then Hodge theory implies that the Dolbeault cohomology $\frac{\ker \overline{\partial}}{\operatorname{im} \overline{\partial}}$ (resp. the Bott-Chern cohomology $\frac{\ker \partial \cap \ker \overline{\partial}}{\operatorname{im} \partial\overline{\partial}}$) is isomorphic to the space of Dolbeault (resp. Bott-Chern) harmonic

forms, namely differential forms lying in the kernel of a second order (resp. fourth order) elliptic and formally self adjoint operator called Dolbeault (resp. Bott-Chern) Laplacian. The dimension of these spaces is finite and provide useful invariants of complex manifolds. Moreover, Dolbeault and Bott-Chern cohomologies coincide on Kähler manifolds by Hodge theory, therefore the study of Bott-Chern cohomology is especially useful in non Kähler geometry.

L^2 and $W^{1,2}$ Bott-Chern harmonic forms on (non compact) complete Hermitian manifolds have been of central interest in 1), 2) and 5). In 1) and 2) the usual characterisation of Bott-Chern harmonic forms holding on compact Hermitian manifolds has been generalised on special families of complete Hermitian manifolds; this is achieved building suitable families of cut off functions with bounds on first and second order derivatives. In 5) I have proved, on Kähler manifolds, a Dolbeault and a Bott-Chern weak orthogonal decompositions (similar to the L^2 weak Kodaira decomposition) of a Hilbert space of $W^{1,2}$ differential forms introduced by Andreotti and Vesentini; this decompositions are related respectively to $W^{1,2}$ Dolbeault and Bott-Chern harmonic forms. My newest contribution in this setting is 13), where introduce the L^2 Hilbert complex associated to Bott-Chern cohomology and study its fundamental properties, focusing in the cases of complete Kähler manifolds and Galois coverings of compact complex manifolds.

In 3) and 4), on non Kähler compact complex manifolds, the relation between Bott-Chern cohomology (and its dual Aeppli cohomology) and natural properties of special Hermitian metrics has been analysed. In particular it has been studied the vanishing of the Aeppli-Gauduchon cohomology class and the stability, for a curve of Hermitian metrics, of the SKT condition along a family of complex manifolds.

In 1954 Kodaira and Spencer asked if, on an almost complex manifold, the dimension of the space of Dolbeault harmonic forms is independent on the choice of the almost Hermitian metric. In 2020 Holt and Zhang answered negatively to the above question, showing that this dimension can vary with the metric on the Kodaira-Thurston manifold. In 2018, Cirici and Wilson introduced a new notion of Dolbeault cohomology on almost complex manifolds, which is metric independent but unfortunately can be infinite dimensional even when the manifold is compact. Looking for invariants of compact almost complex manifolds, in 6) we introduced the study of Bott-Chern harmonic forms on almost Hermitian manifolds, in 7) and 11) we analysed the behaviour of Bott-Chern and Dolbeault harmonic forms with respect to the primitive decomposition of forms, while 8) and 9) are devoted to an in depth examination of Dolbeault harmonic $(1,1)$-forms in dimension 4, especially on compact quotients of Lie groups. The survey 10) summarises the recent results about Dolbeault, Bott-Chern and Hodge harmonic $(1,1)$-forms in dimension 4. Finally, 12) concerns the properties of several almost complex and almost Kähler invariants in any dimension, while in 14) we develop computational techniques which allow us to calculate the Kodaira dimension as well as the dimension of spaces of Dolbeault harmonic forms for left-invariant almost complex structures on the generalised higher dimensional Kodaira-Thurston manifolds.

Papers and preprints

1) R. Piovani, A. Tomassini, Bott-Chern harmonic forms on Stein manifolds, *Proc. Amer. Math. Soc.* **147** (2019), no. 4, pp. 1551-1564. https://doi.org/10.1090/proc/14334

2) R. Piovani, A. Tomassini, Bott-Chern harmonic forms on complete Hermitian manifolds, *Internat. J. Math.* **30** (2019), no. 5, 1950028, 17 pp. https://doi.org/10.1142/S0129167X19500289

3) R. Piovani, A. Tomassini, Aeppli cohomology and Gauduchon metrics, *Complex Anal. Oper. Theory* **14** (2020), no. 1, Art. 22, 15 pp.
https://doi.org/10.1007/s11785-020-00984-6

4) R. Piovani, T. Sferruzza, Deformations of Strong Kähler with torsion metrics, *Complex Manifolds* **8** (2021), no. 1, pp. 286-301.
https://doi.org/10.1515/coma-2020-0120

5) R. Piovani, $W^{1,2}$ Bott-Chern and Dolbeault decompositions on Kähler manifolds, *J. Geom. Anal.* **33** (2023), n. 281.
https://doi.org/10.1007/s12220-023-01271-4

6) R. Piovani, A. Tomassini, Bott-Chern Laplacian on almost Hermitian manifolds, *Math. Z.* **301** (2022), pp. 2685–2707.
https://doi.org/10.1007/s00209-022-02975-z

7) R. Piovani, N. Tardini, Bott-Chern harmonic forms and primitive decompositions on compact almost Kähler manifolds, *Ann. Mat. Pura Appl.* (2023).
https://doi.org/10.1007/s10231-023-01338-7

8) R. Piovani, A. Tomassini, On the dimension of Dolbeault harmonic $(1,1)$-forms on almost Hermitian 4-manifolds, *Pure Appl. Math. Q.* **18** (2022), no. 3, pp. 1187-1201.
https://dx.doi.org/10.4310/PAMQ.2022.v18.n3.a11

9) R. Piovani, Dolbeault Harmonic $(1,1)$-forms on 4-dimensional compact quotients of Lie Groups with a left invariant almost Hermitian structure, *J. Geom. Phys.* **180** (2022), 104639.
https://doi.org/10.1016/j.geomphys.2022.104639

10) R. Piovani, Harmonic $(1,1)$-forms on compact almost Hermitian 4-manifolds, *Riv. Mat. Univ. Parma* **13** (2022), 671-692.
http://www.rivmat.unipr.it/vols/2022-13-2/15-piovani.html

11) T. Holt, R. Piovani, Primitive decomposition of Bott-Chern and Dolbeault harmonic (k,k)-forms on compact almost Kähler manifolds, *Eur. J. Math.* **9** (2023), no. 73.
https://doi.org/10.1007/s40879-023-00666-5

12) T. Holt, R. Piovani, A. Tomassini, Invariants of almost complex and almost Kähler manifolds, 2023, arXiv:2209.07286.
https://arxiv.org/abs/2209.07286

13) T. Holt, R. Piovani, The L^2 Aeppli-Bott-Chern Hilbert complex, 2023, arXiv:2310.08993.
https://arxiv.org/abs/2310.08993

14) T. Holt, R. Piovani, Left-invariant almost complex structures on the higher dimensional Kodaira-Thurston manifolds, 2023, arXiv:2310.09027.
https://arxiv.org/abs/2310.09027

PHD THESIS

R. Piovani, *Differential operators on complex manifolds*, PhD thesis, University of Pisa, 2021. Available here: https://sites.google.com/view/riccardo-piovani