

Part A. PERSONAL INFORMATION

CV date

09/09/2024

First and Family name	Miguel Sánchez Caja		

(*) *Optional*

(**) *Mandatory*

A.1. Current position

Name of University/Institution	Universidad de Granada		
Department	Geometría y Topología		
Address and Country	Facultad Ciencias, C Fuentenueva s/n. E-18071 Granada (Spain)		
Phone number	609133431	E-mail	sanchezm@ugr.es
Current position	Catedrático Univ. (Full professor)	From	07/07/2007
Key words	Differential Geometry, Mathematical Relativity, Lorentzian, Riemannian and Finslerian Geometries, Analysis on Manifolds		

A.2. Education

PhD, Licensed, Graduate	University	Year
Licenciatura en C. Físicas	Granada	1989
Doctor en Matemáticas (PhD)	Granada	1994

A.3. General indicators of quality of scientific production (see instructions)

1.- Included in the *Ranking of the World Scientists: World's Top 2% Scientists*, Plos Biol. (2020, 2021 & 2022) doi.org/10.1371/journal.pbio.3000918io.3000918

2.- Five research periods (six years each one) approved by the Spanish National Agency CNEAI: 1990-95, 1996-01, 2002-07, 2008-13, 2014-19. Six teaching periods (starting at Sept. 1990) approved by U. Granada.

3.- Thesis supervised last 10 years: four (eight in total).

4.- Scopus Data for the full research: 93 documents, 2 753 citations, h-index 28.

Part B. CV SUMMARY (max. 3500 characters, including spaces)

I am currently a Professor in the area of Geometry and Topology at the U. Granada and the Director of the Institute of Mathematics of the University of Granada (IMAG), which is a center with the Seal of Excellence "María de Maeztu" from the Spanish Government (since September 2023).

As a researcher in Differential Geometry, I have a special interest in classical Riemannian Geometry and in the Lorentzian one, as well as in geometric foundations of General Relativity. For me, the latter has been both, an excellent motivation for applications and a fruitful source of inspiration for new mathematical results and techniques. Recently, I have also moved to topics in Finslerian geometry with both, geometric and physical motivations, including practical applications.

My first research (1992/2000) included geodesic completeness, including applications to Mechanics, constant mean curvature submanifolds in Lorentzian manifolds and integral inequalities related to intrinsic and extrinsic curvatures (see, for example, [RS95]). These topics re-appear in my research, as in [CRS13] or recent [EFSZ24].



In 2000/2010, after a stay at U. Bari (Italy), I made a strong effort to combine the techniques of Global Analysis on Manifolds and the global conformal geometry of Lorentzian manifolds (the latter with its nice physical interpretation as the “causality” of spacetimes). This led to an intrinsic infinite dimensional approach for the study of Lorentzian geodesics, including the spacelike ones (see for example [CFS08]) and sharp results on the trajectories of particles accelerated by electromagnetic fields [MS08].

Along this period too, a major issue was the systematic study and revision of the causality of spacetimes, including the solution of some classical (“folk”) problems which had remained open along several decades. These concern the smoothability of certain functions and splitting of spacetimes (see [BS03, BS05]). The approach was non-trivially extended to other problems as Nash type embeddings [MS11] or, more recently, the case with boundary [AFS21].

Since 2011, we have developed a relation between Lorentzian Geometry and Finslerian Geometry starting at [CJS11] which was fruitful in both fields. Indeed, we developed exhaustively the relativistic causal boundary [FHS13b] and, consistently, introduced a new type of boundary for any Finslerian manifold. This was meticulously compared with more classical ones by Gromov and Busemann [FHS13] (two stays of several months at IHES were relevant). Recently, a step forward has been achieved with the introduction and development of *wind Finsler structures*, whose applications include classical Zermelo’s navigation [CJS24] or the classification of some classes of Finsler manifolds.

At that epoch I also started to study certain geometric features of gravitational waves [FSS13]. Recently, we have given a partial solution to a relevant conjecture in this field, the Ehlers-Kundt one [FH20]. I have also introduced a spacetime model [Sa23], which contradicts some commonly accepted physical claims on symmetry in Cosmology (as stressed by R. Ávalos, in *Lett. Math. Phys.* '23). Currently, I am studying these topics actively.

In a natural way, the combination of Lorentz and Finsler Geometries leads to the study of cone structures and Lorentz-Finsler metrics [JS20]. Currently, we are developing properties of Lorentz-Finsler metrics with two aims: (1) natural extensions of General Relativity, to face well-known cosmological problems [JVS22] and (2) the propagation of waves in anisotropic media [PJS21] with applications to the computation of the fronts for seisms or wildfires [PJS23].

Part C. RELEVANT MERITS (sorted by typology)

C.1. Publications

This is a sampler containing my 20 references cited above (half of them published in the last five years 2020-24). The full list of articles and other research documents are available at <http://gigda.ugr.es/sanchezm/research.php>

[CJS24] E. Caponio, M. A. Javaloyes, M. Sánchez: Wind Finslerian structures: from Zermelo’s navigation to the causality of spacetimes. *Memoirs of the AMS*, vol. 300, Amer. Math. Soc., Providence, RI (2024) pp. 1-121.

[EFSZ24] A. Elshafei, A. C. Ferreira, M. Sánchez, A. Zeghib: Lie groups with all left-invariant semi-Riemannian metrics complete. *Trans. AMS*, 377 (2024), pp. 5837-5862.

[JPS23] M. A. Javaloyes, E. Pendás Recondo, M. Sánchez: A general model for wildfire propagation with wind and slope. *SIAM Journal on Applied Algebra and Geometry (SIAGA)*, 7, 2 (2023) 414–439.

[Sa23] M. Sánchez: A class of cosmological models with spatially constant sign-changing curvature. *Portugaliae Mathematica*, 80 No. 3/4 (2023) 291-313.

[JSV22] M. A. Javaloyes, M. Sánchez, F.F. Villaseñor: The Einstein-Hilbert-Palatini formalism in Pseudo-Finsler Geometry. *Adv. Theor. Math. Phys.* 26, 10, (2022) 3563–3631.

[S22] M. Sánchez: Globally hyperbolic spacetimes: slicings, boundaries and counterexamples, *Gen. Relat. Grav.* 54, 124 (2022) (52 pp.). Topical Collection: *Singularity theorems, causality, and all that SCRI21* (A tribute to Roger Penrose).



- [AFS21] L. Aké, J.L. Flores, M. Sánchez: Structure of globally hyperbolic spacetimes with timelike boundary, *Rev. Matem. Iberoamericana*, Volume 37, Issue 1 (2021) pp. 45–94.
- [JPS21] M. A. Javaloyes, E. Pendás Recondo, M. Sánchez: Applications of cone structures to the anisotropic rheonomic Huygens' principle. *Nonlinear Analysis* 209 (2021), 112337 (29pp)
- [FS20] J.L. Flores, M. Sánchez: Ehlers-Kundt Conjecture about Gravitational Waves and Dynamical Systems, *J. Differential Equations*, 268, Issue 12 (2020) 7505-7534.
- [JS20] M. A. Javaloyes, M. Sánchez: On the definition and examples of cones and Finsler spacetimes, *Rev. R. Acad. Cienc. Ex. Fís. Nat. Ser. A. Mad. (RACSAM)* 114, 30 (2020).
- [FHS13] J.L. Flores, J. Herrera, M. Sánchez: Gromov, Cauchy and causal boundaries for Riemannian, Finslerian and Lorentzian manifolds, *Memoirs AMS* 226 (2013) No. 1064.
- [BSS13] O.F. Blanco, M. Sánchez and J.M.M. Senovilla: Structure of second-order symmetric Lorentzian manifolds, *J. Eur. Math. Soc. (JEMS)* 15, 595–634 (2013).
- [CRS13] A.M. Candela, A. Romero, M. Sánchez: Completeness of the Trajectories of Particles Coupled to a General Force Field, *Arch. Rational Mech. Anal. (ARMA)* 208, Issue 1 (2013) 255-274.
- [MS11] O. Müller, M. Sánchez: Lorentzian manifolds isometrically embeddable in L^{∞} . *Trans. Amer. Math. Soc.* **363** (2011), 5367-5379.
- [FHS11] J.L. Flores, J. Herrera, M. Sánchez: On the final definition of the causal boundary and its relation with the conformal boundary. *Adv. Theor. Math. Phys.* 15, 4 (2011), 991-1058.
- [CJS08] A.M. Candela, J.L. Flores, M. Sánchez: Global hyperbolicity and Palais–Smale condition for action functionals in stationary spacetimes. *Adv. Math.* **218** (2008) 515–536.
- [MS06] E. Minguzzi, M. Sánchez: Connecting solutions of the Lorentz force equation do exist. *Commun. Math. Phys.* 264 (2006) 349-370
- [BS05] A. N. Bernal, M. Sánchez : Smoothness of time functions and the metric splitting of globally hyperbolic space times. *Commun. Math. Phys.* **257**, (2005) 43–50.
- [BS03] A. N. Bernal, M. Sánchez : On smooth Cauchy hypersurfaces and Geroch splitting theorem. *Commun. Math. Phys.* 243 (2003) 461-470.
- [ARS98] L.J. Alías, A. Romero, M. Sánchez: Uniqueness of complete spacelike hypersurfaces of constant mean curvature in Generalized Robertson-Walker space-times. *Gen. Relat. Grav.* **27** (1995) 71-84.

C.2. Research projects

Projects in vigor since 2011 where I am the Principal Investigator (all of them leaded from U. Granada, with the participation of other institutions).

- 1- Title: Geometría semi-riemanniana y flujos geométricos en Física-Matemática.
Reference: PID2020-116126GB-I00. Funding body: MICINN-FEDER. (Co-IP F. Martín.)
Funding amount: 108 900 € (+1 FPI predoc grant). Start/end dates: 1-10-2021 / 30/09/2025.
- 2- Title: Geometría semi-riemanniana y problemas variacionales en Física Matemática.
Reference: MTM2016-78807-C2-1-P. Funding body: MINECO-FEDER.
Funding amount: 82 200 €. Start/end dates: 1-1-2017 / 31-12-2020.
- 3- Title: Geometría semi-riemanniana y problemas variacionales en Física Matemática.
Reference: MTM2013-47828-C2-1-P. Funding body: MINECO-FEDER.
Funding amount: 75 375 € (+1 FPI predoc grant). Start/end dates: 1-1-2014 / 28-02-2018.
- 4- Title: Geometría semi-riemanniana y problemas variacionales en Física Matemática.
Reference: MTM2010-18099. Funding body: MICINN–FEDER. Funding amount: 93 775 € (+1 FPI predoc grant). Start/end dates: 1-1-2011 / 28-02-2015.
- 5- Title: Proyecto de Excelencia Geometría de Lorentz y Gravitación.
Reference: P09-FQM-4496. Funding body: Consejería de Innovación, Ciencia y Empresa (J. Andalucía, Spain). Funding amount: 181 524 €. Start/end dates: 3-02-2010 / 2-02-2014.



C.5. Labor as a scientific expert

1.- Director of the Institute of Mathematics of U. Granada (IMAG), since Dec. 2023, <https://wpd.ugr.es/~imag/es/>

2.-Editor of *Mediterranean J. Mathematics* since October, 2016.

3.-Member of the Panel “R&D Units Evaluation 2017-18” of the Fundação para a Ciência e a Tecnologia (FCT, Ministerio de la Ciencia, Tecnología y Enseñanza Superior, Portugal) for the evaluation of the Portuguese centers of research in Mathematics (February-November, 2019).

4.-Services for Spanish National organizations. AEI: evaluation of research projects and Commission for Ramón y Cajal. ANECA (for scientific accreditation): supervisor of three commissions of evaluation in 2017-18. [Previous services: ANEP (for research projects) Member of the Commission for Mathematics 2006-2008 and FECYT (for the promotion of science and technology): expert for the panel “Mathematics, Physics and Space Science” at FECYT (2007) for the design of the Spanish national strategy of I+D+I 2008-2011.]

5.- Referee of projects for the following international agencies: (a) Italian Ministry for Universities and Research (MUR, 2022), (b) Netherlands Organisation for Scientific Research (NWO, 11/2017, 02/2019), (c) National Research, Development and Innovation Office (NKFIH, Hungary, 04/2018), (d) Austrian Science Foundation (09/2012, 07/2013, 09/2015, 09/2017, 01/2022), (e) Fonds National de la Recherche (Luxembourg 09/2014), (f) Fundação para a Ciência e a Tecnologia (Portuguese Government, 06/2011).

6.-Member of commissions for hiring university researchers outside of Spain: (a) U. Trento september-december 2020 [Department of Mathematics, academic recruitment field 01/A4 (Mathematical Physics)], (b) Tenured position (Profesor Associato) at U. Milano (2016).

7.-Evaluations of habilitations and PhD theses out of Spain: (a) reports for habilitations at U. Brasov 11/2022, U. Vienna, 05/2019, U. Hamburg, 04/2018, (b) member of the Commissions for PhD theses: A. Ohanyan, Viena (2024), S. Heefer, Eindhoven (2024), Leonardo García-Heveling, U. Nimega (2023) B. Schinnerl, Vienna (2022), A. Elshafei, Braga (2022), Souza, Fortaleza (2019), L. Brunswic, U. Avignon (2017), D. Schliebner, Humboldt U. Berlin (2015), (c) external reports for PhD theses: J. Hedicke, (U. Bochum, 2021) G. Stancarone (U. Bari, 2016), G. Albanese (U. Milano, (2015), M. D. Monclair (ENS-Lyon, 2014).

9.- Organization of congresses and scientific meetings:

(a) Promoter/member of the Scientific or organizing Committees of the series “Int. Meeting on Lorentzian Geometry” started in 2001, including Granada (2011), Sao Paulo (2013), Málaga (2016), Varsovia (2018) Córdoba (online, 2021) and Mérida (México, 2024).

(b) Member of the Steering Committee of de series “Int. Fall Workshop on Geometry and Physics” since 2014, including Granada (2014, also organizer), Zaragoza (2015), Madrid (2016), Braga (2017), Sevilla (2018), Madrid (2019), Covilha (online, 2020), Madrid (2022).

(c) Organizer of sessions of meetings of the Spanish RSME, including: (1) Session “Lorentzian Geometry and its Applications” II Joint Meeting RSME-SEMA-SMB-SBMAC, Cádiz (España), 11-14/12/2018, (2) Session “Geometry and Physics” del 7th Iberoamerican Cong. on Geometry, Valladolid, 22-26 enero, 2018, (3) Session “Lorentzian Geometry and its applications”, Joint Meeting SMB-SBMAC-RSME, Fortaleza, Brasil, 7-10/12/2015, (4) Sesión “Geometría Diferencial y Aplicaciones” cong. bienal RSME, Granada febrero 2015.

(d) Organizer of the events at U. Granada: (1) “Encuentro Iberoamericano de Geometría en Granada” (10-12/06/2019), (2) Meeting and School “Lorentz-Finsler Geometry and Applications” (14-17/01/2019), “Finsler Geometry: Riemannian foundations and relativistic applications” (7-18 enero, 2019), (3) Jornada de Presentación y Seguimiento de proyectos de investigación para jóvenes investigadores (PYR-2014) in GENIL (Granada Exc. Net. Inn. Lab), 16/06/2014.