Part A. Personal Information

DATE	11/05/2015

Surname(s)	Sánchez Caja
Forename	Miguel
Researcher ID	G-6424-2015
Open Researcher and Contributor ID (ORCID)	0000-0003-0677-1482

A.1. Professional Situation Now

Post/ Professional Category	Professor	
UNESCO Code	120404 (Differential Geometry)	
Key Words	Differential Geometry, Mathematical Relativity, Lorentzian and Riemann Geometries, Analysis on Manifolds	
Name of Institution	Universidad de Granada	
	Department/Center	Geometría y Topología
	Full Address	Facultad de Ciencias, Campus de Fuentenueva s/n, E-18071 Granada (Spain)
	Email Address	sanchezm@ugr.es
	Phone Number	958 24 63 96 / 609 133 431
Start date	07/07/2007	

A.2. Academic Preparation *(title, institution, date)*

1989	University of Granada	First Degree	Licenciatura en Ciencias Físicas
1991	University of Granada	Masters	Grado de Licenciado (tesina Depto. Geometría y Topología)
1994	University of Granada	PhD	Doctor en Ciencias Matemáticas

A.3. **Indicators of Quality** in Scientific Production *(See the instructions)*

Data for the period 2011-2015 (JCR2014 articles; data on 25/07/2015)
- Normalized impact (2011-2014): 5.56 (Scopus)
- Normalized impact (2011-2014): 3.46 (WoS)
- Articles JCR in 2011-2015. Total: 13. Q1: 10 (77%). D1: 3 (23%).

Data for the full research (all the publications until 25/07/2015)
- WoS: 62 publications, 941 citations, 15.18 citations per publication, h-index 15.
http://www.researcherid.com/rid/G-6424-2015
- Scopus (25/07/2015): 69 documents, 974 citations, h-index 15,
http://www.scopus.com/authid/detail.url?authorId=35402225800
-MathSciNet: 84 publications, 734 citations by 245 authors, h-index 14,
http://www.ams.org/mathscinet/search/author.html?mrauthid=154010
-Scholar Google: 2272 citations (1272 since 2010), h-index 25 (17 since 2010)
https://scholar.google.es/citations?user=3TrRMLkAAAAJ&hl=es

Four research periods (six years each) approved by the Spanish National Agency ANECA: 1990-95, 1996-01, 2002-07, 2008-13.

Part B. Free Summary of CV *(Max. of 3.500 characters, including spaces)*

I am a researcher in Differential Geometry with a special interest in semi-Riemannian Geometry. This is a generalization of classical Riemannian Geometry which notably includes Lorentzian Geometry, i.e., the mathematical framework of General Relativity. For me, the latter as well as other branches of Mathematical Physics, have been both, an excellent motivation for applications and a fruitful source of inspiration for new results and techniques.

My first research (1992/2000) included geodesic completeness, integral inequalities and constant mean curvature submanifolds in Lorentzian manifolds. I have moved to other topics, but they re-appear sometimes in my research; indeed those results are still highly studied (for example, my joint paper with LJ. Alías and A. Romero in Gen. Relat. Gravit '95 is cited 84 times in WoS, and many of the citations are recent).

In 2000/2010, I made a strong effort to combine the techniques of Global Analysis on Manifolds and the conformal geometry of Lorentzian manifolds (which has a nice physical interpretation as the "causality" of a spacetimes). This led to develop a new intrinsic infinite dimensional approach to the study of Lorentzian geodesics, with highlights such as J. Diff. Eq. '03,'04 or Advances Math. '08. The interaction with some Italian groups of analysts about these topics was very fruitful for both sides (indeed, the PhD thesis of an Italian researcher was defended in Granada under my supervision in that epoch). However, the greatest impact came from a better understanding of the conformal structure of Lorentzian manifolds, including a revision of the causality of spacetimes and the solution of some classical ("*folk*") problems; the latter concerned the smoothability of certain functions and splittings of spacetimes, and they had remained unsolved during more than three decades (see my joint publications with A.N. Bernal in Comm. Math Phys '03, '05, Class. Quant. Grav. '07 and Lett. Math. Phys. '08 plus the one with O.Müller, published in Trans. AMS '11).

In 2011/2015, I have studied quite a few further topics. Perhaps the most surprising discovery is that the viewpoint of Lorentzian Geometry is also useful to obtain results in Riemannian Geometry and, even more, in the much more general setting of Finslerian Geometry. This was established in a highly cited recent paper in Rev. Matem. Iberoam. '11. As a relevant consequence, a subtle new element (a sort of Busemann boundary) was defined for any Finslerian manifold; notable properties of this boundary were proved in Memoirs AMS'13 (see the precise references on this period in the next section). My two stays at IHES (August 2010, August-October 2013) were very important for the comparison of this boundary with a classical one introduced by M. Gromov.

There is a vast number of related possibilities to develop in the future. On the one hand, Finsler Geometry is the natural framework to study problems such as Zermelo navigation one, where the Lorentz/Finsler viewpoint have already yielded a long list of very interesting results (see arxiv:1407.5494). On the other, it seems that, now, all the previous results plus further possible applications explored by physicists, make convenient to develop systematically a Global Lorentz-Finsler Geometry. A different prospective topic is Ehlers-Kundt conjecture on gravitational waves, a foundational relativistic problem technically related to my previous research on geodesic completeness.

Part C. Accomplishments *(Order by typology)*
C.1. Publications

Ten most representative publications of the period (2011-2015):

1.- Caponio, A.V. Germinario, M. Sánchez: Convex regions of stationary spacetimes and Randers spaces. Applications to lensing and asymptotic flatness, *J. Geometric Anal.* (2015), DOI : 10.1007/s12220-015-9572-z

2.- M.A. Javaloyes and M. Sánchez: On the definition and examples of Finsler metrics, *Ann. Sc. Norm. Super. Pisa, Cl. Sci.* (5), Vol. XIII (2014), 813-858.

3.- J.L. Flores, J. Herrera and M. Sánchez: Gromov, Cauchy and causal boundaries for Riemannian, Finslerian and Lorentzian manifolds, *Memoirs Amer. Mat. Soc.* 226 (2013) No. 1064.

4.- O.F. Blanco, M. Sánchez and J.M.M. Senovilla: Structure of second-order symmetric Lorentzian manifolds, *J. Eur. Math. Soc.* 15, 595–634 (2013).

5.- A.M. Candela, A. Romero, M. Sánchez: Completeness of the Trajectories of Particles Coupled to a General Force Field, *Arch. Rational Mech. Anal.* 208, Issue 1 (2013) 255-274.

6.- L. Flores, J. Herrera and M. Sánchez: Computability of the causal boundary by using isocausality, *Class. Quant. Grav.,* 30 (2013) 075009 (36pp).

7.- E. Caponio, M. A. Javaloyes, M. Sánchez: On the interplay between Lorentzian causality and Finsler metrics of Randers type, *Rev. Mat. Iberoam.* 27 (2011) no. 3, 919–952

8.- R. Bartolo, E. Caponio, A. V. Germinario and M. Sánchez: Convex domains of Finsler and Riemannian manifolds, *Calculus of Variations and PDE* 40 (2011) 335–356.

9.- J.L. Flores, J. Herrera and M. Sánchez: Isocausal spacetimes may have different causal boundaries *Class. Quant. Grav.*, 28 (2011) 175016.

10.- O. Müller, M. Sánchez: Lorentzian manifolds isometrically embeddable in L^N, *Trans. Amer. Math. Soc.* 363 (2011), 5367-5379.

C.2. Projects

Only projects where I am the Principal Investigator (all of them leaded from U. Granada, with the participation of other institutions)

- TITLE: Geometría semi-riemanniana y problemas variacionales en Física Matemática.
REFERENCE: MTM2010--18099
FUNDING BODY: Ministerio de Investigación, Ciencia e Innovación (MICINN, Spain)
FUNDING AMOUNT: 93 775 € plus one pre-doctoral grant (contract FPI).
START/END DATES: 1-1-2011 / 28-02-2015

- 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 € (including all associated contracts).
START/END DATES: 3-02-2010 / 2-02-2014

- TITLE: Geometría Semi-Riemanniana y Modelos no lineales en Física-Matemática
REFERENCE: MTM2007-60731
FUNDING BODY: Ministerio de Investigación, Ciencia e Innovación (MICINN, Spain)
FUNDING AMOUNT: 87 241 € plus one pre-doctoral grant (contract FPI).
START/END DATES: 1-10-2007 / 28-02-2011

- TITLE: Acción Integrada "Métodos variacionales y topológicos en Análisis no-lineal y Geometría con Aplicaciones"
REFERENCE: HI2008-0106
FUNDING BODY: Ministerios de Ciencia y Tecnología de España e Italia (Spain/Italy).
FUNDING AMOUNT: 11 700 €
START/END DATES: 01-01-2009 / 31-12-2010

C.3. Contracts / C.4. Patents
C.5 Thesis supervised

I have supervised four PhD Thesis: R. Bartolo (2000), JL Flores (2002), J. Herrera (2011) and O. Fdez. Blanco (2012) and I am supervising a fifth one to L. Aké (student supported by the Mexician National Agency CONACYT). Detailed data of the PhD Thesis in 2011-2015:
(1) NAME: Oihane Fernández Blanco
    TITLE: Brinkmann and second order Lorentzian symmetric spaces
    PLACE AND DATE OF DEFENSE: U. Granada, 13-06-2012.
(2) NAME: Jonatán Herrera Fernández
    TITLE: The causal boundary of a spacetime and new boundaries in Differential Geometry.
    PLACE AND DATE OF DEFENSE: U. Málaga, 14-04-2011.
I have supervised nine Master Thesis, three of them in the period 2011-2015: Pablo Morales Alvarez, Máster Fisymat (2014/15); Pablo Galindo Salgado, Máster Fisymat (2013/14); Antonio R. Martínez Fernández, Máster Fisymat (2011/12).

C.6. Labor as a scientific expert

Member of the Comission of the Spanish ANEP (national agency for scientific evaluation) in the period 2006-2008 as well as expert for the pannel "Mathematics, Physics and Space

Science" at FECYT for the dessign of the Spanish national strategy of I+D+I. (Ocasional referee for ANEP since then.)

Expert for the following international agencies in 2011-2015:
- Fonds National de la Recherche (Luxemburg, 09/2014)
- Austrian Science Fundation (09/2012 and 07/2013)
- Fundaçao para a Ciência e a Tecnologia (Portugal, 06/2011).

Member of the comission for the evaluation of four PhD theses in Spain and three abroad in the period 2011-2015 (the latter: M. D. Monclair, ENS-Lyon, 2014; D. Schliebner, Humboldt U. Berlin, 2015; G. Albanese, U. Milan, expected date in october 2015).

Referee for around 40 scientific journals and reviewer for Math. Reviews.

C.7. Plenary lectures

Last five plenary lectures (2015-2013)

TITLE: Some links between Lorentzian and Finslerian geometries
CONGRESS: General Relativity: 100 years after Hilbert
ORGANIZER: Lepage Research Institute (Czech Rep.)   University of Prešov (Slovakia), Jagiellonian University in Kraków (Poland), Eötvös Loránd University (Hungary), University of Hradec Králové (Czech Rep.)
PLACE AND DATE: Stará Lesná (Slovakia), 17-21 August, 2015.

TITLE: Wind Finsler structures and the connection between Lorentzian and Finslerian geometries
CONGRESS: Lorentzian and Conformal Geometry
ORGANIZER: Alfried-Krupp-Wissenschaftskolleg
PLACE AND DATE: Greifswald (Germany), 18-21 March, 2014.

TITLE: Wind Finsler structures: from Zermelo's navigation to the causality of spacetimes
CONGRESS: Second Japanese-Spanish workshop on Differential Geometry.
ORGANIZADOR: Tokyo Inst. Technology
PLACE AND DATE: Tokyo (Japan), 5-10 February, 2014.

TITLE: On the classification of Lorentzian r-th symmetric spaces.
CONGRESO: Workshop on Lorentzian homogeneous spaces
ORGANIZADOR: U. Complutense de Madrid
PLACE AND DATE: Madrid (Spain) from 7/3/2013 to 8/3/2013.

TITLE: Recent progress and connections in Riemannian, Finslerian and Lorentzian Geometries
CONGRESS: XXII International Fall Workshop on Geometry and Physics
ORGANIZER: U. Evora
PLACE AND DATE: Evora, from 2/09/13 to 5/09/13.