CURRICULUM VITAE

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Diplomae

• **PhD :** 10th January 1994, Bordeaux 1 university, suma cum laude. Specialty : applied mathematics. Supervisor : A. Bachelot. Referees : C. Bardos, J. Ginibre, G. Métivier. Jury members : Y. Choquet-Bruhat (President), A. Bachelot, J. Ginibre, B. Hanouzet, J.-L. Joly, G. Métivier, V. Petkov. *Title of dissertation : Non linear Klein-Gordon equation and linear Dirac system on Schwarzschild-type metrics.*
• **Habilitation thesis :** 26th January 1999, Bordeaux 1 university. Specialty : mathematics. Supervisor : A. Bachelot. Referees : C. Gérard, V. Petkov, D. Robert. Jury members : J.-M. Bony (President), A. Bachelot, C. Gérard, V. Petkov, D. Robert. *Title of dissertation : A study of scalar and spinorial fields on some space-times of general relativity.*

Career history

• **Teaching position during the preparation of the PhD :** 10/1991 – 09/1993.
• **Post-doctoral position :** 01/1994 – 12/1994. Under the supervision of R. Penrose. Mathematical Institute, Oxford University, England. Lavoisier fellowship of the french Ministry of Foreign Affairs and european Human Capital and Mobility fellowship.
• **Appointment as Maître de conférences, applied mathematics :** (permanent position, equivalent to lecturer) 1st january 1995, Bordeaux 1 university.
• **CNRS delegation :** (temporary pure research position) 09/1998 – 08/2000, CMAT (Centre de Mathématiques), Ecole Polytechnique, Palaiseau, France.
• **Appointment as Professor, pure mathematics, differential geometry :** 09/2007, University of Brest.
• **CNRS delegation :** 09/2011 – 01/2012, University of Brest.
• **Promotion to the first class of University Professors :** 09/2015.

Scholarships and grants

• **Post-doctoral training :** Lavoisier fellowship of the french Ministry of Foreign Affairs and Human Capital and Mobility european fellowship, for the post-doctoral training in Oxford in 1994.
• **Grant for research and doctoral supervision (PEDR) :** awarded for 4 years in september 1999, 2003 and 2007.
• **ANR (french National Research Agency) project :** 34000 € granted for a three year "young researchers" project entitled "Hyperbolic Equations and General Relativity". Projet bearer : D. Häfner. • **ANR project AARG, ANR-12-BS01-0012-01 :** projet bearer. 119 000 € granted for 4 years for the project "Asymptotic analysis in general relativity", 01/2013–12/2016.
• **Grant for scientific achievments (PES, equivalent to the PEDR) :** 09/2012 – 08/2016.

Supervision of PhD theses

• Thierry Daudé, "scattering for the massive charged Dirac equation on flat space-time and outside rotating or non rotating black holes", 12/2004, he is now a lecturer at Université Cergy-Pontoise, France.
• Y. Stadnicki, "scattering of Maxwell and Dirac fields by extreme black-holes", 02/2008.
• J. Joudioux, "asymptotic behaviour of spinor fields in General Relativity : a conformal approach", 06/2010. • Jan-Hendrik Treude, "decay in Outgoing Null Directions of Solutions of the Massive Dirac Equation in Certain Asymptotically Flat, Static Spacetimes", in co-supervision with Felix Finster, Regensburg University, Germany, 04/2016, suma cum laude.
• Since September 2012, Mokdad Mokdad, "decay of Maxwell fields and conformal scattering on the De Sitter-Reissner-Nordstrom spacetime", submitted to the referees.
• Since February 2015, Pham Truong Xuan, "Peeling and conformal scattering in the spacetimes of general relativity".

Supervision of post-docs

• 10/2015–09/2016, Callum Sleigh, postdoctoral position on the ANR contract ANR-12-BS01-0012-01.

Participation to PhD thesis jurys

• Jury for the thesis of Fabrice Melnyk, Bordeaux 1 University, supervisor : Alain Bachelot, 12^{th} 12/2002.
• Referee for Davide Catania's thesis, University of Pisa, Italy, supervisor : Vladimir Georgiev, 01/2008.
• Referee for Julien Loizelet's thesis, University of Tours, France, supervisor : Piotr Chrusciel, 24^{th} 06/2008.
• Member of the jury for Dietrich Häfner's habilitation, University of Bordeaux, 12/2008.
• Referee for Zakaria Hachemaoui's thesis, University Paris 13, France, supervisor : Fabrice Planchon, 30^{th} 01/2009.
• Member of the jury for Mohammad Webbe's thesis, University of Brest, supervisor : Paul Baird, 11/2009.
• Referee for Calvin Tadmon's thesis, University of Yaoundé, Cameroon, supervisor : Marcel Dossa, 10/2010.
• President of the jury for Mekki Houbad's thesis, University of Rennes, supervisor : Christophe Cheverry, 11/2010.
• Referee for Roger Tagné Wafo's thesis, University of Yaoundé, supervisors : Piotr Chrusciel and Marcel Dossa, 01/2011.
• Referee for Jean-Charles Ponsignon's thesis, University of Reims, 06/2013, "Fuchsian methods and asymptotic analysis".
• President of the jury for Patrick Bouvier's thesis, University of Paris 11 (Orsay), supervisor : Christian Gérard, 12/2013.
• President of the jury for Guillaume Idelon-Riton's thesis, Joseph Fourier University, Grenoble, supervisor : Dietrich Häfner, 07/2016.

Administration

• Correspondant of my laboratory at the Bordeaux research library committe from 1995 till 2007.
• Member of a committee for planning electronic subscriptions of the whole Bordeaux university in 2004. Correspondant of mathematics at the Common Documentation Service of the university 2005–2007.
• Member of the applied mathematics appointing committee at Bordeaux University, 1995–2007. From 1998 until 2001, I have held the position of vice-president B (i.e. at the level of lecturers) of this committee.
• Member of the governing body of my laboratory at Bordeaux University, 2003–2006.
• Member of the "Theses committee" of the Western Mathematical Doctoral Network since May 2008.
• Head of the mathematics research library at the University of Brest since May 2008.
• Member of the appointing committee for a lecturer position in "PDE analysis and applications", University of Rennes, spring 2010.
• Mathematics correspondant at the Common Documentation Service of the University of Brest since May 2010.
• Head of the PMRC degree (Parcours Mathématiques Renforcées et Concours) at the University of Brest, 2010–2012.
• Local correspondant of the Quantum Dynamics CNRS Research Group, member of its scientific committee since 2012.
• Member of the appointing committee for a lecturer position in geometry, University of Brest, spring 2013.
• "Open access" correspondant for Couperin at the University of Brest since 2013.

Teaching activities

• Classes in the theory of distributions, partial differential equations, spectral theory, complex analysis, to first year graduate students. Classes in analysis, differential calculus, integration, commutative algebra and numerical analysis to third year undergraduates, in real and complex analysis, theory of probabilities, linear algebra and differential calculus, to first and second year undergraduates.
• Lecture courses in linear algebra, analysis, algebra and integration to first and second year undergraduates, in differential calculus, integration, Fourier series to third year undergraduates, in spectral theory, complex analysis and functional analysis to first year graduate students.
• Advanced graduate lecture course in mathematics at the University of Rennes, "Black holes and geometrical methods in general relativity", 2010 and 2011.
• Invited advanced graduate lecture course : "partial differential equations and conformal scattering" to second year graduates in mathematics, Vietnam National University in Hanoi, 2012.
• Supervision of first and second year graduate students research projects (these are pre-thesis research projects).
• Advanced post-graduate lecture courses : "geometry of Schwarzschild and Kerr metrics" Bordeaux 2001, "General Relativity : fundamental notions and asymptotic structures" Bordeaux 2007 and Brest, "conformal asymptotic analysis" Brest 2014.

Organisation of conferences

• Graduate students conference, 14 and 15 december 1992, Bordeaux, member of the scientific committee.
• "Scattering days", Bordeaux, 28 and 29 january 1993, in collaboration with A. Bachelot, B. Hanouzet, J.-L. Joly and V. Petkov.
• "Scattering days II", Bordeaux, 12 and 13 juin 1995, in collaboration with A. Bachelot, B. Hanouzet, J.-L. Joly and V. Petkov.
• "Hyperbolic equations in relativity", Bordeaux, 16$^{\text{th}}$ june till 19$^{\text{th}}$ june 2008, in collaboration with Dietrich Häfner.
• "Black holes, general relativity and waves", Roscoff 8–10 November 2010, in collaboration with Dietrich Häfner.
• "First AARG meeting", June 2013, University of Cergy-Pontoise, in collaboration with Thierry Daudé and Dietrich Häfner, http://www.u-cergy.fr/fr/laboratoires/agm/archives/archives_conf/anr-aarg.html.
• "Quantum dynamics research group meeting, 2014", February 2014, Roscoff Station Biologique, einn collaboration with Frédéric Hérau, Alain Joye and Stéphane Nonnenmacher, http://pageperso.univ-brest.fr/~jnicolas/DynQua2014/DynQua2014.html.
• Summer school : "Asymptotic Analysis in General Relativitynalyse Asymptotique en Relativité Générale", Grenoble, June-July 2014, in collaboration with Thierry Daudé and Dietrich Häfner, http://if-summer2014.sciencesconf.org/.
• The Aber Wrac'H Autumn Schools : autumn schools in mathematical physics, two sessions sofar, in 2014 (quantum field theory, course given by, Brussels free University and International Solvay Institutes, Belgium) and 2015 (supersymmetry, course given by Luc Frappat, University of Savoie, Annecy, France), in collaboration with Johannes Huisman, http://pageperso.univ-brest.fr/~jnicolas/AberWracH/AW.html.
• Asymptotic analysis in General relativity, Roscoff, Biological Station, 3-7 October 2016, final conference of the AARG project, in collaboration with T. Daudé and D. Häfner.

1 Research orientations

My work concerns the study of solutions of partial differential equations in the framework of general relativity[1]. Two aspects are developed :

• **existence and uniqueness theorems :** Cauchy problem or Goursat problem (characteristic Cauchy problem) ;

• **asymptotic analysis :** existence of simplified asymptotic behaviour, time-dependent scattering theory (analytic or via conformal methods), peeling, superradiance.

The techniques I use belong to two broad types with the recent addition of numerical analysis as a third approach :

• **functional analytic techniques :** Sobolev spaces, semi-group theory, Sobolev embeddings, time-dependent scattering theory (involving spectral analysis, trace-class perturbation methods, Mourre theory, positive commutator methods), weak convergence and compactness methods ;

• **geometrical techniques :** conformal compactification, $3+1$ decomposition, Newman-Penrose and Geroch-Held-Penrose formalisms, 2-spinor formalism, geomeric energy estimates (sometimes referred to as vector field methods) ;

[1]The list of publications to which the following citations refer can be found in section 2.

• **numerical methods :** finite difference schemes for hyperbolic evolution equations on spherically symmetric backgrounds.

My past research as well as my projects are oriented along three main directions :

• **Black hole spacetimes** The purpose is to get a precise understanding of the geometry of black hole spacetimes and its influence on the behaviour of fields. The existence of ergoregions is related to the phenomenon of superradiance by which a field can extract energy from the black hole ; it exists for charged scalar fields outside a charged spherical black hole, and for fields of integral spin outside a rotating black hole. We now have a partial understanding of rotation-induced superradiance but when the driving mechanism is charge interaction, many questions remain open, including a rigorous theoretical estimate of the amount of energy that is possible to extract. Our knowledge of the conformal structure of black hole spacetimes is incomplete, more precisely concerning the nature of the singularities of the conformal metric, both for asymptotically flat spacetimes and in the presence of a cosmological horizon ; these informations are essential for the asymptotic analysis of field equations.

• **Conformal compactification and asymptotic analysis.** Penrose's conformal compactification is a tool that gives a synthetic geometrical description of asymptotic informations. Combining this with precise analytic methods, we obtain results that are more general than through purely analytic methods, and more precise than what a purely geometrical approach allows. Among such results are the development of an alternative approach to scattering theory (allowing a natural extension to time-dependent equations and to non linear problems) and the fine analysis of peeling properties (fall-off laws in powers of r^{-1} at infinity).

• **Spin 3/2 field equations.** Spin 3/2 field equations (Rarita-Schwinger) are closely related to the vacuum equations. First, the vanishing of the Ricci curvature is a consistency condition for the Rarita-Schwinger equations, they are thus meaningful only on vacuum space-times. Second, the spin connection of an Einstein metric is a pure gauge spin 3/2 field, whose conserved quantity is the ADM energy of the spacetime. Finally, there exists a Lax pair relation between spin 3/2 fields and an Einstein metric, even though we are not dealing with a fully integrable system. All this indicates that the Rarita-Schwinger equations are an important tool for the analysis of the Einstein vacuum equations, and since they are linear, their analysis is much simpler than that of the Einstein equations.

1.1 Completed works

Black hole spacetimes

The Kerr (or Kerr-Newman) metric is a realistic model of black hole ; it describes the geometry of spacetime outside an eternal, rotating, uncharged (or charged) black hole, and it is an exact solution of the Einstein vacuum (or Einstein-Maxwell electrovac) equations. The main difficulties related to the geometry are its lack of symmetry, its non stationarity and the nature of the horizon. For simpler models with spherical symmetry (Schwarzschild, Reissner-Nordstrøm), only the third difficulty remains. There are three essential ways of describing the geometry :

1. **Static observer at infinity.** We use a coordinate system in which the metric is time-independent ; this is natural for scattering theory. Using this approach, I have solved the Cauchy problem for a non linear Klein-Gordon equation, for spin 3/2 fields, and developed a scattering theory for Dirac fields, outside a spherical black hole (works [1, 2, 3, 5, 6, 7, 8, 9]). Our collaboration with D. Häfner (CNRS researcher in Bordeaux) on the scattering of massless Dirac fields by a Kerr black hole (papers [17, 18]) uses this approach in a fundamental way, but also the next two.

2. **3+1 decomposition.** We decompose the geometry and the equations tangentially and orthogonally with respect to a foliation by Cauchy hypersurfaces. This is ideal for obtaining a positive definite (but not conserved) energy that can be used for energy estimates, even in cases where superradiance is present. The decomposition technique is described in memoir [14], with applications to the Cauchy problem for symmetric hyperbolic systems in Sobolev-type function spaces, on asymptotically flat spacetimes ; the case of Dirac fields on the Schwarzschild and Kerr metrics is treated in details. I have used this method to solve the global Cauchy problem for a non linear Klein-Gordon equation on the Kerr metric (paper [15]). The $3+1$ decomposition plays a crucial part in the construction of a Newman-Penrose tetrad that is adapted to scattering theory in [17, 18].

3. **Penrose's conformal compactification.** It provides a description of infinity as a regular null hypersurface for the conformal metric. It is a natural tool for proving the existence of asymptotic profiles and Sommerfeld-type radiation conditions for conformally invariant equations. I have applied these techniques to a non linear Klein-Gordon equation outside a spherical black hole (works [1, 2, 5]) and a Kerr black hole (paper [15]). The conformal compactification of Schwarzschild and Kerr metrics is described in details in memoir [14]. It is used in [22] in combination with vector field methods to give a complete description of the peeling for the wave equation on the Schwarzschild metric.

Conformal compactification and asymptotic analysis

This is a research programme that has recently started. In collaboration with L. Mason (Professor in Oxford), we have developed a scattering theory for non stationnary, asymptotically simple spacetimes, by means of conformal methods (works [16, 19]). A conformal compactification translates the existence of a scattering operator as the well-posedness of a Goursat problem (characteristic Cauchy problem) at infinity. This gets rid of stationarity constraints that are attached to spectral techniques. The construction is done for scalar fields (treated in [22]), Dirac and Maxwell fields ; its reinterpretation in terms of wave operators shows the equivalence with analytic scattering theories, in a framework where spectral methods cannot be used. In papers [20, 21], I have studied the Goursat problem on background metrics with very weak regularity ; these works generalize theorems obtained by Hörmander in a regular framework. This type of result is essential for the extension of the above scattering construction to more general spacetimes.

The description of the asymptotic behaviour of fields by expansions in powers of $1/r$ (peeling property) is a very controversial question. The peeling model was proposed by Penrose in the 1960's based on the behaviour in flat spacetime. Since then, examples have been put forward of physically natural data giving rise to solutions for which the peeling does not seem to occur. In a collaboration with L. Mason, we give a complete answer to this question for the wave equation on the Schwarzschild metric. Using conformal techniques in combination with vector field methods analogous to Klainerman's, we classify the spaces of data that garantee a peeling of order k and this for any integer k. These spaces are the same as in the case of Minkowski space, this validates Penrose's model at all orders and shows that the counter-examples that have been proposed were mislead. This work is published [22].

Spin 3/2 fields and Einstein's equations

The first step in this project is the analysis and the understanding of the Rarita-Schwinger equations. I have first studied these equations in the Dirac gauge on the Schwarzschild metric (publications [8, 9]). It then appeared that the conserved quantity is not positive definite in

this gauge. In a collaboration with L. Mason (works [10, 11, 13]), using $3+1$ decomposition techniques and the ideas of Witten's proof of the positive energy theorem, we have made a new gauge choice (referred to as Witten's gauge) giving a positive definite conserved quantity. A non local potential appears, involving the inverse of the Witten operator on the spacelike slices. We have solved the Cauchy problem for all regularities on general asymptotically flat spacetimes.

1.2 Research projects

Black hole spacetimes

1. **De Sitter black holes.** Recent observations indicate that the cosmological constant of the universe is positive. It becomes essential to study precisely De Sitter black holes, satisfying the Einstein equations with a positive cosmological constant. We shall start by extending results already known in the asymptotically flat case. Geometrical properties of these spacetimes, such as stationarity, regularity of conformal infinity, will also be investigated. Due to the presence of two horizons, conformal scattering techniques have good chances of being naturally applicable to such metrics.

2. **Superradiance.** A numerical study for charged scalar fields is in progress in collaboration with L. Di Menza (Professor in Reims). De Sitter-Reissner-Nordstrøm black holes will then be studied, using a combined numerical and analytical approach. A fine analysis of the phenomenon of superradiance will be tackled once precise results have been obtained concerning resonances.

Conformal methods and the Goursat problem

1. **Conformal scattering.** We shall extend the results already obtained to fields of arbitrary spin (spin 3/2, Bianchi) and to non linear equations (the extension to non linear wave equations and Yang-Mills fields is in progress, by Jérémie Joudioux in his PhD thesis), in view of an extension to the Einstein equations. We shall also widen the set of spacetimes considered : spherically symmetric black holes can be treated using conformal methods in combination with recent results by Dafermos and Rodnianski ; an extension to Kerr black holes will then be studied ; similar constructions will be obtained for much less regular spacetimes, such as the spacetimes of Christodoulou and Klainerman, using the results of [20, 21].

2. **The Goursat problem** must be analysed in depth. Already, integral representation formulae for the solutions of Dirac, Maxwell and higher spin fields have been obtained by Jérémie Joudioux in his thesis, based on Friedlander's results for the wave equation. The study of the Goursat problem for Dirac fields on general cones is in progress in collaboration with Dietrich Häfner. The approach is different from the one adopted by Jérémie Joudioux, it is based on Hörmander's work.

3. **Peeling.** The extension of our first result to Dirac and Maxwell fields is in progress [**?**]. It will be followed by extensions to the Kerr metric and to space-times that are merely asymptotic to Schwarzschild or Kerr, as well as to other spinorial fields (Rarita-Schwinger, Bianchi). The use of Fuchsian techniques developed by Kichenassamy and Rendall, for the study of peeling in non conformally invariant cases, will then be investigated. The purpose is a systematic verification of the validity of the peeling model in physically realistic situations.

Spin 3/2 fields and Einstein's equations.

The main priority is the study of linearized gravity on the Kerr metric. This is an equation similar to the Bianchi system but with a source involving the connection. This in turn satisfies

the Rarita-Schwinger equation. In a collaboration with Pieter Blue and Lars Andersson, we shall combine vector field methods with spectral methods and spin-lowering techniques to obtain local decay on the Kerr metric for this coupled Bianchi/Rarita-Schwinger system.

To push further the analysis of spin 3/2 equations, we shall develop scattering theories : on black hole spacetimes, via techniques analogous to the ones we used with D. Häfner (Mourre estimate, positive commutator methods) ; on asymptotically simple spacetimes, via conformal methods. The peeling properties of spin 3/2 fields is also a totally open question that shall be studied using conformal techniques coupled with vector field methods. More general applications to the analysis of Einstein's equations will then be investigated, using the a priori estimates given by these equations as well as the Lax pair properties.

2 Publications

[1] A. Bachelot, J.-P. Nicolas, (1993) *Equation non linéaire de Klein-Gordon dans des métriques de type Schwarzschild*, C. R. Acad. Sci. Paris, t. 316, Série 1, p. 1047-1050.

[2] J.-P. Nicolas, (1993) *Nonlinear Klein-Gordon equation on Schwarzschild-like metrics*, Proceedings of the conference : "Nonlinear hyperbolic problems : theoretical, applied, and computational aspects" (Taormina, 1992), p. 449-456, Notes Numer. Fluid Mech., 43, Vieweg, Braunschweig.

[3] J.-P. Nicolas, (1994) *Opérateur de diffusion pour le système de Dirac en métrique de Schwarzschild*, C. R. Acad. Sci. Paris, t. 318, Série 1, p. 729-734.

[4] J.-P. Nicolas, PhD thesis, Université Bordeaux 1, Mathématiques Appliquées, "L'équation non linéaire de Klein-Gordon et le système linéaire de Dirac en métrique de type Schwarzschild ", January 1994.

[5] J.-P. Nicolas, (1995) *Non linear Klein-Gordon equation on Schwarzschild-like metrics*, J. Math. Pures Appl., 74, p. 35-58.

[6] J.-P. Nicolas, (1995) *Scattering of linear Dirac fields by a spherically symmetric Black-Hole*, Ann. Inst. Henri Poincaré - Physique Théorique, 62, 2, p. 145-179.

[7] J.-P. Nicolas, (1995) *Spin 3/2 zero rest-mass fields in the Schwarzschild space-time*, Twistor Newsletter 39, p. 6-10.

[8] J.-P. Nicolas, (1997) *Problème de Cauchy global pour les équations linéaires sans masse de spin* 3/2 *en métrique de Schwarzschild*, C. R. Acad. Sci. Paris, t. 325, Série 1, p. 277-282.

[9] J.-P. Nicolas, (1997) *Global exterior Cauchy problem for spin 3/2 zero rest-mass fields in the Schwarzschild space-time*, Commun. in PDE, 22, 3&4, p. 465-502.

[10] L.J. Mason, J.-P. Nicolas, (1998) *Résultats globaux pour les équations de Rarita-Schwinger en espace-temps d'Einstein asymptotiquement plat*, C. R. Acad. Sci. Paris, t. 327, Série 1, p. 743-748.

[11] J.-P. Nicolas, *Champs de spin* 3/2 *et relativité générale*, Partial Differential Equations Seminar, Ecole Polytechnique, Palaiseau, France, 17th November 1998.

[12] J.-P. Nicolas, Habilitation thesis, *Une étude de champs scalaires et spinoriels dans des espaces-temps de la relativité générale*, Université Bordeaux 1, 26th January 1999.

[13] L.J. Mason, J.-P. Nicolas, (1999) *Global results for the Rarita-Schwinger equations and Einstein vacuum equations*, Proc. London Math. Soc., 3, 79, p. 694–720.

[14] J.-P. Nicolas, *Dirac fields on asymptotically flat space-times*, Dissertationes Mathematicae **408**, 2002, 85 pages.

[15] J.-P. Nicolas, *A non linear Klein-Gordon equation on Kerr metrics*, Journal de Mathématiques Pures et Appliquées, **81** (9) (2002) p. 885–914.

[16] J.-P. Nicolas, *Dirac fields on asymptotically simple space-times*, Jean Leray '99 Conference Proceedings, Maurice de Gosson editor, May 2003.

[17] D. Häfner, J.-P.Nicolas, *Théorie de la diffusion pour l'équation de Dirac sans masse dans la métrique de Kerr. (French) [Scattering theory for the massless Dirac equation in the Kerr metric]*, Partial Differential Equations Seminar, 2002–2003, Talk No. XXIII, 15 pp., Ecole Polytechnique, Palaiseau, 2003.

[18] D. Häfner, J.-P. Nicolas, *Scattering of massless Dirac fields by a slow Kerr black hole*, Reviews in Mathematical Physics **16**(1) (2004), p. 29–123.

[19] L.J. Mason, J.-P. Nicolas, *Conformal scattering and the Goursat problem*, Journal of Hyperbolic Differential Equations, **1** (2) (2004), p. 197–233.

[20] J.-P. Nicolas, *On Lars Hörmander's remark on the characteristic Cauchy problem*, Annales de l'Institut Fourier, **56** (2006), 3, p. 517–543.

[21] J.-P. Nicolas, *On Lars Hörmander's remark on the characteristic Cauchy problem*, Note to the Comptes Rendus of the Academy of Sciences, Série 1, Comptes Rendus Mathématique, **344** (mai 2007), 10, p. 621-626.

[22] L.J. Mason, J.-P. Nicolas, *Regularity at spacelike and null infinity*, J. Inst. Math. Jussieu, **8** (2009), 1, p. 179-208.

[23] D. Häfner, J.-P. Nicolas, *The characteristic Cauchy problem for Dirac Fields on curved backgrounds*, J. Hyperbolic Differ. Equ. **8** (2011), 3, 437–483.

[24] L. Andersson, P. Blue, J.-P. Nicolas, *A decay estimate for a wave equation with trapping and a complex potential*, I.M.R.N, 2013, 548-561, publié en ligne Int. Math. Res. Notices (2012) doi: 10.1093/imrn/rnr237.

[25] L.J. Mason, J.-P. Nicolas, *Peeling of Dirac and Maxwell fields on a Schwarzschild background*, J. Geom. Phys. **62** (2012), 867–889.

[26] J.-P. Nicolas, *Conformal scattering on the Schwarzschild metric*, arXiv:1312.1386, to appear in Annales de l'Institut Fourier.

[27] L. Di Menza, J.-P. Nicolas, *Superradiance on the Reissner-Nordstrøm metric*, arXiv:1411.3988, Class. Quantum Grav. **32** (2015), 145013 (28pp).

[28] J.-P. Nicolas, *The conformal approach to asymptotic analysis*, arXiv1508.02592, 2015.

[29] C. Markakis, K. Uryū, E. Gourgoulhon, J.-P. Nicolas, N. Andersson, A. Pouri, V. Witzany, *Conservation laws and evolution schemes in geodesic, hydrodynamic and magnetohydrodynamic flows*, arXiv:1612.09308, 2016.

[30] A. R. Gover, J.-P. Nicolas, *Conformal scattering of Maxwell potentials*, in preparation.

[31] A. R. Gover, J.-P. Nicolas, C. Sleigh, *Projective scattering for the Klein-Gordon equation*, in preparation.

3 Seminars and invitations

1. Fourth International Conference on Hyperbolic Problems, Taormina, Sicily, from the 3rd to the 8th April 1992.

2. University of Bonn, Germany, Applied Mathematics Seminar, May 1992. On a personal invitation by Vladimir Georgiev and Pedro Schirmer.

3. Sixth International Workshop on General Relativity, Gregynog, Wales, from the 23rd to the 26th August 1993.

4. Max Planck Institut für Astrophysik, München, Germany, General Relativity Seminar, November 1993, on a personal invitation by Bernd Schmidt.

5. Mathematical Institute, Oxford, England, Mathematical Physics Seminar, February 1994.

6. Mathematical Institute, Oxford, England, Quantum Fields Theory Seminar, November 1994.

7. Edinburgh University, Scotland, Geometry Seminar, December 1994, on a personal invitation by Toby Bailey.

8. University of Nantes, France, Scattering Theory Seminar, 28th April 1995.

9. 14th International Conference on General Relativity (GR14), Florence, Italy, from the 6th to the 12th August 1995, Workshop "Twistors, new variables and complex methods" (Chairman : Lionel Mason).

10. 14th International Conference on General Relativity (GR14), Florence, Italy, from the 6th to the 12th August 1995, Workshop "Mathematical studies of relativistic fields" (Chairman : Jim Isenberg).

11. International Workshop on Microlocal Analysis and the General Theory of Partial Differential Equations, International Centre for Theoretical Physics, Trieste, Italy, first two weeks of september 1995, Session "Partial Differential Equations and Applications".

12. Invitation to participate for two weeks in the Workshop "Spaces of Geodesics and Complex Structures in General Relativity and Differential Geometry", Vienna, Austria, Erwin Schrödinger Institut. From the 21st June to the 6th July 1997.

13. Mathematical Institute, Oxford, England, Mathematical Physics Seminar, 27th january 1998, During a two weeks stay on a personal invitation by Lionel Mason.

14. Partial Differential Equations Seminar, Ecole Polytechnique, 17th november 1998.

15. Invited Speaker at the Semi-Classical Days, Nantes, France, february 1999.

16. Partial Differential Equations Seminar, University of Rennes, France, 25th march 1999.

17. Invited speaker at the Conference in Honour of Jean Leray, from the 29th august to the 4th september 1999, University of Blekinge, Karlskrona, Sweden.

18. Mathematical Institute, Oxford, England, Mathematical Physics Seminar, 12th november 1999, during a 10 days stay on a personal invitation by Lionel Mason.

19. Mathematical Institute, Oxford, England, Mathematical Physics Seminar, 24th november 2000, during a one week stay on a personal invitation by Lionel Mason.

20. Invitation to take part in the programme "Scattering theory" organised by V. Petkov, A. Vasy and M. Zworski. Erwin Schrödinger International Institute for Mathematical Physics, Vienna, Austria. One week in june 2001.

21. Partial Differential Equations and Mathematical Physics Seminar, university of Reims, 31st january 2002.

22. Rotating Seminar on Spectral Problems in Physics, CEA Saclay, 11th february 2002.

23. Mathematical Physics and Geometry Seminar, University of Lille, 12th march 2002.

24. Numerical Analysis Seminar, CMAP, Ecole Polytechnique, personal invitation by Philippe Le Floch, 13th january 2004.

25. Analysis seminar, university of Nantes, personal invitation by Wang Xue Ping, 2nd april 2004.

26. Workshop on Geometry and General Relativity, Regensburg, Germany, July 19-21 2004.

27. Relativity seminar, Mathematical Institute, Oxford, England, personal invitation by Lionel Mason, 2nd november 2004.

28. Geometry and Analysis seminar, University of Bath, England, 4th february 2005.

29. Analysis seminar, University of Cergy-Pontoise, 23$^{\text{rd}}$ may 2005.

30. Mathematics colloquium, University of Regensburg, Germany, 17th june 2005, during a one week stay on a personal invitation by Felix Finster.

31. invitation to stay for 3 weeks at the Newton Institute, Cambridge, England, from the 22nd August to the 11th september, on the occasion of the semestre "Global problems in Mathematical Relativity".

32. Partial Differential Equations and Mathematical Physics Seminar, university of Reims, october 2005.

33. Mathematical physics seminar, Regensburg, 30$^{\text{th}}$ june 2006, personal inviation for a week by Felix Finster.

34. Mathematics seminar, Cambridge University UK, november 2006, personal inviation for a week by Mihalis Dafermos.

35. Mathematics seminar, University of Pisa, february 2007, personal inviation for a week by Vladimir Georgiev.

36. Analysis seminar, University of Rennes, France, November 2007.

37. Algebra and geometry seminar, University of Brest, France, October 2008.

38. Mathematical Physics seminar, Mathematical Institute Oxford, UK, October 2008.

39. Invitation for a month at the Mittag-Leffler institute, Stockholm, Sueden, for a relativity programme, November 2008.

40. Mathematical Relativity day at the Meudon Observatory, France, 14 january 2009, invited speaker.

41. Geometry seminar, University of Avignon, France, june 2009.