Curriculum vitae

Name: Jacek Jezierski
Birthdate: 24 September 1958
Birthplace: Warsaw, Poland
Citizenship: Citizen of Poland
married, two daughters (born 1984, 1985)

- Office:

  University of Warsaw,
  Department of Mathematical Methods in Physics,
  00-682 Warsaw, ul. Hoża 74, Poland
  phone: 4822–6217757, fax: 4822–6224508
  e-mail: Jacek.Jezierski@fuw.edu.pl

- Home:

  ul. Gwiaździsta 31 m 170, 01-651 Warsaw, Poland
  phone: 4822–8332967

- Education:

  Habilitation, Mathematical Physics: University of Warsaw; April 1999
  Habilitation Topic: Bondi Mass in Classical Field Theory

  Ph. D., Physics: University of Warsaw; December 1988
  Thesis Advisor: Jerzy Kijowski
  Thesis Topic: Unconstrained Degrees of Freedom of Gravitational Field

  M. Sc., Physics: University of Warsaw, Poland; July 1982 (with Award from Ministry of Education)

- Teaching Experience:

  Assistant (1982-1988), Assistant Professor (1989 to 1998), Associate Professor (1999-2002), University Professor (2003 to present): University of Warsaw, Physics;
  (Rector's Awards: 1985, 1989, 1997, 2002, 2003, 2004, 2006); Worked as a lecturer for the following courses:

  1. Calculus, Integration, Ordinary Differential Equations, Differential Forms, Holomorphic Functions, Distributions
  2. Algebra
  3. Mathematical Methods of Physics, Partial Differential Equations
  4. Differential Geometry and Topology

- Conferences and Workshops (contributed talks, lectures or organizer)

  July 1989: General Relativity 12, Boulder, Colorado, USA
  June 23-29, 1991: The Sixth Marcel Grossmann Meeting, Kyoto
  July 30 – August 9, 1991: 10th International Congress on Mathematical Physics, Leipzig
  Dec. 12-17, 1993: Cornelius Lanczos International Centenary Conference, Raleigh, NC, USA
  September 4-10, 1997: Gauge Theories of Gravitation, Jadwisin, Poland
  March 30 – April 4, 1998: Internat. Seminar on Math. Cosmology, Potsdam, Germany
  July 3-9, 1998: XVII Workshop on Geometric Methods in Physics, Białowieża, Poland
  July 21, 2000: CCS Complex Symposium IX, NCU, Chung-Li, Taiwan
  July 24-26, 2000: International Workshop on Geometric Physics, NCTS, Hsinchu, Taiwan
  June 7-19, 2001: Workshop On Canonical and Quantum Gravity III, Banach Center, Polish Academy of Sciences, Warsaw, Poland (organizer)
  August 10-15, 2003: Seventh Hungarian Relativity Workshop, Sárospatak
  September 10-14, 2007: Encuentros Relativistas Españoles 2007, Puerto de la Cruz, Tenerife
  June 25-28, 2008: 40th Symposium on Mathematical Physics "Geometry & Quanta", Toruń, Poland

September 14-19, 2008: Encuentros Relativistas Españoles 2008, Salamanca, Spain
June 15-19, 2009: String Phenomenology '09, Warszawa, Poland
September 6-10, 2010: Encuentros Relativistas Españoles 2010, Granada, Spain
September 16-18, 2010: CONFORMAL STRUCTURES AND ODEs, Centrum Banacha, Warszawa

- Seminars, summer schools, conferences or research:

September 1985: Centre de Physique Theorique CNRS, Marseille, France (one month)
July 15-31, 1986: Gravitation in Astrophysics, Cargese, France
May 1987: Geometrical Methods in Theoretical Physics, Ferrara, Italy (10 days)
March 1988: UC Cork, Ireland (2 weeks); UC Cardiff, Wales (2 days); QMC London (5 days)
September 1988: Universite de Paris XI, Centre d' Orsay (2 weeks)
May 1989: "Moments de Geometrie Symplectique", Marseille (10 days)
July 1989: GR12, Boulder, Colorado (1 week); University of Chicago (1 week); Yale University, New Haven (1 week)
March 1990: KTH Stockholm (1 week); Universitet i Lynköping (1 week)
May/June 1991: Universität Wien, Universita di Milano, Institut für Astrophysik Garching b. München, Universität Göttingen, ASI für Mathematische Physik TU Clausthal
June 23-29, 1991: The Sixth Marcel Grossmann Meeting, Kyoto
July 30 – August 9, 1991: 10th International Congress on Mathematical Physics, Leipzig
Sept./Oct. 1992: University of Leipzig (one month)
June 1993: University of Leipzig (one month)
Jan./Febr. 1994: Lab. de Gravitation et Cosmologie Relativistes, Paris, (4, pl. Jussieu); Centre de Physique Theorique, Marseille–Luminy (one month)
June 1994: Univerzity Karlovy, Praha (one week)
July 25-30, 1994: conference on "Mathematical Relativity", Wien
Dec. 1994: University of Leipzig (2 weeks)
Febr. 1995: Hungarian Academy of Sciences, Budapest (one week)
June/July 1995: University of Leipzig, Jena (5 weeks)
Sept.95–March 96: VW Stiftung, Leipzig Universität (Jena, Potsdam)
March–August 1996: bourse post–doc, Université de Tours (Paris, Zaragoza)
January 1998: AEI Potsdam (one week)
March/April 1998: ISMC conference, Potsdam
April/May 1998: MIS Leipzig; Universität Freiburg
Sept. 7-11, 1998: 201. WE-Heraeus-Seminar, Bad Honef
April 16-30, 1999: Université de Tours, Tours (2 weeks)
May/June 1999: Londyn, Oxford, Southampton (4 weeks)
4-10 July 1999: Budapeszt, Twistors Conference (5-7 July) + KFKI (one week)
11-25 Sept. 1999: Weimar "Journées Relativistes" + Jena (2 weeks)
24 April – 2 May 2000: Université de Tours, Tours (one week)
17-31 July 2000: Int. Workshop on Geometric Physics, NCTS, Hsinchu, Taiwan
14-19 August 2000: Levoča, Math. Structure of Gen. Relativity
4-11 February 2001: Budapest, KFKI
28 April – 5 May 2001: Université de Tours, Tours (one week)
13-19 September 2001: Budapest, KFKI
30 Sept. – 30 Dec. 2001: Poste de Chercheur Associé, Université de Tours; Lisbon, Bilbao
January 2002: Universität Bern, Bern
15-28 September 2002: Albert-Einstein-Institut, Golm
June-July 2003: Penrose inequalities, ESI Wien
25 April – 15 May 2004: Albert-Einstein-Institut, Golm
26 July – 8 August 2004: Penrose inequalities, ESI Wien
September 2004: MIS, Leipzig
12 Sept. – 26 Nov. 2005: QMUL London, Britgrav5 Oxford, INI Cambridge
30 Oct. – 12 Nov. 2006: Université de Tours
October 18-20, 2007: Myron Mathisson: his life, work, and influence on current research, Banach Center, Warsaw, Poland
August 25-29, 2008: Geometry and Analysis, KTH, Stockholm, Sweden

April 6-8, 2009: Conference on Geometry, IMPAN, Warszawa
26 April – 9 May 2009: Albert-Einstein-Institut, Golm
8-9 October 2009: Space, Time and Beyond, AEI, Golm
12-16 October 2009: Algebra, Geometry, and Mathematical Physics, Będlewo
27 April – 13 May 2010: Albert-Einstein-Institut, Golm
13-15 May, 2010: Uniwersytet Szczeciński, Szczecin, 2 talks
May 17-21, 2010: Road to Reality, IMPAN, Warszawa, UJ, Kraków
September 19-23, 2011: Operator Algebras and Quantum Groups, Banach Center, KMMF, Warszawa

- Research Experience:
I am a University Professor at the Department of Mathematical Methods in Physics, University of Warsaw. I got my Master degree in July 1982 at the Physics Department, University of Warsaw. At the end of 1982 I got a position at the Institute for Mathematical Physics of this University. My Diploma thesis was related to the hamiltonian description of the dissipative processes like friction and heat conductivity. My Ph.D. thesis (under the supervision of prof. Jerzy Kijowski) was a study of the hamiltonian structure of General Relativity and related problems (the positivity of gravitational energy and the problem of "true degrees of freedom" of gravitational field). After Ph.D. I have continued the subject and the results were published in papers [5, 7, 8, 11, 12, 13] (please find enclosed my publication list).

I have proposed a new definition of asymptotic flatness. Intuitively, asymptotic flatness corresponds to a "sufficiently fast fall-off at infinity of the true degrees of freedom of the gravitational field". Many authors tried to translate this intuition into a mathematically correct definition but the question is still open. In particular, the phenomenon of supertranslations remains always obscure. The analysis of the linear theory leads us in a natural way to a new definition of a strong asymptotic flatness, which I have introduced in [14]. According to this definition, a spacetime is asymptotically flat if it admits maximal (i.e. 14-dimensional) space of asymptotic solutions of CYK equations. I have proved in [15] that "schwarzschildean" class of metrics fulfill stronger asymptotic conditions, and supertranslations ambiguities disappear.

I have been also interested in the proper notion of energy at null infinity which seems to me a key to understanding the gravitational radiation [16]. A well known candidate for that notion is the so-called Bondi mass, which is well known to be monotonically decreasing in time. In collaboration with P. Chruściel (Univ. de Tours) and M. MacCallum (London Univ.) we have been working on a criterion which would single out the Bondi mass as a unique expression amongst a large family of candidate expressions. We have proved a uniqueness of the Bondi mass, as the unique (in a specified class) monotonously decreasing functional of the fields [17-18].

The Hamiltonian role of the Trautman-Bondi mass is exhibited in the monograph [24]. We develop a geometric Hamiltonian formalism adequate for a canonical description of field theories in the radiation regime, extending previous work of Kijowski and Tulczyjew. The formalism is applied to the massless scalar field in Minkowski space-time at null infinity, and to general relativity at null infinity. Formulae for energy, momentum, angular-momentum, as well as for the Hamiltonians for boosts and supertranslations are derived. Several natural phase spaces are constructed, one of those leads to time-dependent Hamiltonians, an appropriate limit of which is the Trautman-Bondi energy at Scri. Another choice of phase spaces leads to time-independent Hamiltonians; in that case some ambiguities arise in the Hamiltonian, and we give an exhaustive description of those. One of the Hamiltonians for the gravitational field, which occur in this context, is again the Trautman-Bondi mass. We argue that one can get rid of the ambiguity in the definition of energy by adding the condition of monotonicity of the Hamiltonian with respect to motion of the reference hypersurface to the future, again singling out the Trautman-Bondi mass. We show that the Hamiltonian approach gives naturally a definition of angular momentum at null infinity, which is free of supertranslation ambiguities. (see also [16,21,23]).

I have also developed a new approach for the linearized gravitational field on a spherically symmetric background. In particular, four-dimensional spherically covariant gauge-invariant quasilocal framework for the perturbation of the Schwarzschild metric is given in [19-20]. An important ingredient of the analysis is the *concept of quasilocality*, which does duty for the separation of angular variables in the usual approach. Moreover, there is no need to represent perturbations by normal modes (with time dependence $\exp(-ikt)$). We consider fields in spacetime and the Cauchy problem for them is well defined outside the horizon. A precise and full analysis for the "mono-dipole" part of the theory is presented. Direct construction (from the constraints) of the reduced canonical structure for the initial data and explicit formulae for the gauge-invariants are proposed. The reduced symplectic structure explains the origin of the axial and polar invariants. This enables one to introduce an energy and angular momentum for the gravitational waves, which is invariant with respect to the gauge transformations. An explicit expression for the energy and new proposition for angular momentum is introduced, in particular, compatibility of the Christodoulou-Klainerman S.A.F. condition with well-possedness of our functionals is checked. Both generators (energy and angular momentum) represent quadratic approximation of the ADM nonlinear formulae in terms of the perturbations of the Schwarzschild metric. The boundary-initial value problem for the linearized Einstein equations on a Schwarzschild background outside the horizon is formulated. The previously known results are presented in a new geometric and self-consistent way. Both degrees of freedom fulfill the generalized scalar wave equation. For the axial degree of freedom the radial part of the equation corresponds to the Regge-Wheeler result and for the polar one we get Zerilli result.

A complete description of the linearized gravitational field on a flat background is continued in terms of gauge-independent quasilocal quantities in [26]. This is an extension of the results from [20]. Asymptotic spherical quasilocal parameterization of the Weyl field and its relation with Einstein equations is presented. The field equations are equivalent to the wave equation. A generalization for Schwarzschild background is developed and the axial part of gravitational field is fully analyzed. In the case of axial degree of freedom for linearized gravitational field the corresponding generalization of the d'Alembert operator is a Regge-Wheeler equation. Finally, the asymptotics at null infinity is investigated and strong peeling property for axial waves is proved.

A complete Lagrangian and Hamiltonian description of the theory of self-gravitating light-like matter shell, which is *not* spherically symmetric, is given (in terms of gauge-independent geometric quantities) in [22,25]. For this purpose the notion of an extrinsic curvature for a null-like hypersurface is discussed and the corresponding Gauss–Codazzi equations are proved. These equations imply Bianchi identities for spacetimes with null-like, singular curvature. Energy-momentum tensor density of a light-like matter shell is unambiguously defined in terms of an invariant matter Lagrangian density. Noether identity and Belinfante–Rosenfeld theorem for such a tensor density is also proved. Finally, the Hamiltonian dynamics of the interacting system: "gravity + matter" is derived from the total Lagrangian, the latter being an invariant scalar density.

1. *The Trautman-Bondi mass of hyperboloidal initial data sets*
From a Hamiltonian point of view, it is natural to assign a Hamiltonian to an initial data set (Σ, g, K), where Σ is a three-dimensional manifold, without the need of invoking a four-dimensional space-time. If there is an associated space-time the procedure is straightforward: one considers hypersurfaces Σ in M with the property that their completion $\bar{\Sigma}$ in the conformally completed space-time with boundary $\bar{M}$ meets future null infinity in a sufficiently regular, say differentiable, section S. Such hypersurfaces are called hiperboloidal. The resulting mass $m(S)$ is then interpreted as the mass of the initial data on Σ. It would, however, be preferable to have a definition which does not involve any space-time constructions. For example, for non-vacuum initial data sets an existence theorem might be lacking. Further, the initial data might not be differentiable enough to be able to obtain an associated space-time. Next, there might be loss of differentiability during evolution which will not allow one to perform the space-time constructions needed for the space-time definition of mass. Finally, a proof of uniqueness of the definition of mass of an initial data set could perhaps be easier to achieve than the space-time one. For all those reasons it seems of interest to obtain a definition of mass, momentum, etc, in an initial data setting.

2. *CYK Tensors, Maxwell Field and Conserved Quantities for Spin-2 Field*
Starting from an important application of Conformal Yano–Killing tensors for the existence of global charges in gravity (which has been performed in [14,15]), some new observations at future null infinity are given. They allow to define asymptotic charges (at future null infinity) in terms of the Weyl tensor together with their fluxes through *scri*. It occurs that some of them play a role of obstructions for the existence of angular momentum. Moreover, new relations between solutions of the Maxwell equations and the spin-2 field are given. They are used in the construction of new conserved quantities which are quadratic in terms of the Weyl tensor. The obtained formulae are similar to the functionals obtained from the Bel–Robinson tensor and they seem to be applicable in Christodoulou–Klainerman method to control asymptotic behaviour of the initial data for Einstein equations.

3. *Geometry of crossing null shells*
New geometric objects on null thin layers are introduced and their importance for crossing null-like shells are discussed. Continuity properties of these objects through a crossing sphere are proved. In the case of spherical symmetry Dray–t'Hooft–Redmount formula results from continuity property of the corresponding object.

4. *Spacetimes foliated by Killing horizons*
It seems to be expected, that a horizon of a quasi-local type, like a Killing or an isolated horizon, by analogy

with a globally defined event horizon, should be unique in some open neighborhood in the spacetime, provided the vacuum Einstein or the Einstein-Maxwell equations are satisfied. The aim of our paper is to verify whether that intuition is correct. If one can extend a so called Kundt metric, in such a way that its null, shear-free surfaces have spherical spacetime sections, the resulting spacetime is foliated by so called non-expanding horizons. The obstacle is Kundt's constraint induced at the surfaces by the Einstein or the Einstein-Maxwell equations, and the requirement that a solution be globally defined on the sphere. We derived a transformation (reflection) that creates a solution to Kundt's constraint out of data defining an extremal isolated horizon. Using that transformation, we derived a class of exact solutions to the Einstein or Einstein-Maxwell equations of very special properties. Each spacetime we construct is foliated by a family of the Killing horizons. Moreover, it admits another, transversal Killing horizon. The intrinsic and extrinsic geometry of the transversal Killing horizon coincides with the one defined on the event horizon of the extremal Kerr-Newman solution. However, the Killing horizon in our example admits yet another Killing vector tangent to and null at it. The geometries of the leaves are given by the reflection.

5. *Dynamics of gravitational field in a finite volume with null boundary and its application to black holes thermodynamics*
A complete Lagrangian and Hamiltonian description of gravitational field controlled on the null boundary is given. The general result is applied to prove the laws of black holes thermodynamics in a quasi-local way.

6. *Conformal Yano-Killing tensor for the Kerr metric and conserved quantities*, (with M. Łukasik), Classical and Quantum Gravity **23** (2006) 2895–2918; *Conformal Yano-Killing tensors for the Taub-NUT metric* (with M. Łukasik), Classical and Quantum Gravity **24** (2007) 1331–1340

7. *Energy-minimizing two black holes initial data*, (with J. Kijowski and S. Łęski), Physical Review D **76** (2007) 024014; *Ground state of the two black holes system* (with J. Kijowski and S. Łęski), in Dynamics and Thermodynamics of Black Holes and Naked Singularities, an international workshop (2007), eds. L. Fatibene, M. Francaviglia, R. Giambo, G. Magli; ?? (Milano 2007)

8. *Asymptotic conformal Yano-Killing tensors for asymptotic anti-de Sitter spacetimes and conserved quantities*, Acta Physica Polonica B **39** (2008) 75–114; *A simple construction of conformal Yano-Killing tensors in anti-de Sitter spacetime*, in ERE 2007 Relativistic Astrophysics and Cosmology, EAS Publications Series, Vol. 30, Edited by A. Oscoz, E. Mediavilla and M. Serra-Ricart (EDP Sciences, Les Ulis 2008), p. 249–252; *Conformal Yano-Killing tensors in anti-de Sitter spacetime*, Class. Quantum Grav. **25** (2008) 065010

9. *On the existence of Kundt's metrics and degenerate (or extremal) Killing horizons*, Class. Quantum Grav. **26** (2009) 035011 (11pp); *On the existence of Kundt's metrics with compact sections of null hypersurfaces*, in ERE 2008

- Papers in preparation:

1. *Unconstrained degrees of freedom for gravitational waves, β–foliations and spherically symmetric initial data*, (with J. Kijowski), ESI preprint 1552 (2004)

2. *On the existence of rigid spheres in four-dimensional spacetime manifolds*, (with J. Kijowski and H.-P. Gittel)

3. *On the stability of degenerate axially symmetric Killing horizon*

4. *Rigid spheres in Riemannian spaces*, (with S. Łęski, J. Kijowski and H.-P. Gittel),

- References:
1. Prof. Piotr T. Chruściel (Départemente de Mathematiques, Universitè de Tours, Parc de Grandmont, 37200 Tours, France)
2. Prof. Jerzy Kijowski (CFT PAN, Al. Lotników 32/46, 02-668 Warsaw, Poland)
3. Prof. Malcolm A.H. MacCallum (School of Mathematical Sciences, Queen Mary and Westfield College, University of London, Mile End Road, London E1 4NS, U.K.)
4. Prof. Andrzej Trautman (Institute for Theoretical Physics, University of Warsaw, ul. Hoża 69, 00-681 Warsaw, Poland)
5. Prof. Eberhard Zeidler (MIS, 04103 Leipzig, Inselstr. 22-26, Germany)