

# The Submanifold Geometries associated to Grassmannian Systems

Martina Brück, Xi Du, Joonsung Park, and Chao-Lian Terng\*

## Abstract

There is a hierarchy of commuting soliton equations associated to each symmetric space  $U/K$ . When  $U/K$  has rank  $n$ , the first  $n$  flows in the hierarchy give rise to a natural first order non-linear system of partial differential equations in  $n$  variables, the so called  $U/K$ -system. Let  $G_{m,n}$  denote the Grassmannian of  $n$ -dimensional linear subspaces in  $R^{n+m}$ , and  $G_{m,n}^1$  the Grassmannian of space-like  $m$ -dimensional linear subspaces in the Lorentzian space  $R^{n+m,1}$ . In this paper, we use techniques from soliton theory to study submanifolds in space forms whose Gauss-Codazzi equations are gauge equivalent to the  $G_{m,n}$ -system or the  $G_{m,n}^1$ -system. These include submanifolds with constant sectional curvatures, isothermic surfaces, and submanifolds admitting principal curvature coordinates. The dressing actions of simple elements on the space of solutions of the  $G_{m,n}$  and  $G_{m,n}^1$  systems correspond to Bäcklund, Darboux and Ribaucour transformations for submanifolds.

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\* Research supported in part by NSF Grant DMS 9626130

# Submanifold Geometries Associated To Grassmannian Systems

**Martina Brück**



## **Submanifold Geometries Associated To Grassmannian Systems:**

**The Submanifold Geometries Associated to Grassmannian Systems** Martina Brück, 2002 This work is intended for graduate students and research mathematicians interested in differential geometry and partial differential equations The Submanifold Geometries Associated to Grassmannian Systems Martina Brück, 2014-09-11 This work is intended for graduate students and research mathematicians interested in differential geometry and partial differential equations *The Submanifold Geometries Associated to Grassmannian Systems* Martina Brück, 2002-01-04 *Integrable Systems, Geometry, and Topology* Chuu-lian Terng, 2006 The articles in this volume are based on lectures from a program on integrable systems and differential geometry held at Taiwan's National Center for Theoretical Sciences As is well known for many soliton equations the solutions have interpretations as differential geometric objects and thereby techniques of soliton equations have been successfully applied to the study of geometric problems The article by Burstall gives a beautiful exposition on isothermic surfaces and their relations to integrable systems and the two articles by Guest give an introduction to quantum cohomology carry out explicit computations of the quantum cohomology of flag manifolds and Hirzebruch surfaces and give a survey of Givental's quantum differential equations The article by Heintze Liu and Olmos is on the theory of isoparametric submanifolds in an arbitrary Riemannian manifold which is related to the  $n$  wave equation when the ambient manifold is Euclidean Mukai Hidano and Ohnita present a survey on the moduli space of Yang Mills Higgs equations on Riemann surfaces The article by Terng and Uhlenbeck explains the gauge equivalence of the matrix non linear Schrödinger equation the Schrödinger flow on Grassmannian and the Heisenberg Ferromagnetic model The book provides an introduction to integrable systems and their relation to differential geometry It is suitable for advanced graduate students and research mathematicians Information for our distributors Titles in this series are copublished with International Press Cambridge MA

Differential Geometry and Integrable Systems Martin A. Guest, Reiko Miyaoka, Yoshihiro Ohnita, 2002 Ideas and techniques from the theory of integrable systems are playing an increasingly important role in geometry Thanks to the development of tools from Lie theory algebraic geometry symplectic geometry and topology classical problems are investigated more systematically New problems are also arising in mathematical physics A major international conference was held at the University of Tokyo in July 2000 It brought together scientists in all of the areas influenced by integrable systems This book is the first of three collections of expository and research articles This volume focuses on differential geometry It is remarkable that many classical objects in surface theory and submanifold theory are described as integrable systems Having such a description generally reveals previously unnoticed symmetries and can lead to surprisingly explicit solutions Surfaces of constant curvature in Euclidean space harmonic maps from surfaces to symmetric spaces and analogous structures on higher dimensional manifolds are some of the examples that have broadened the horizons of differential geometry bringing a rich supply of concrete examples into the theory of integrable systems Many of the articles

in this volume are written by prominent researchers and will serve as introductions to the topics. It is intended for graduate students and researchers interested in integrable systems and their relations to differential geometry, topology, algebraic geometry, and physics. The second volume from this conference, also available from the AMS, is *Integrable Systems, Topology and Physics*, Volume 309, CONM 309, in the Contemporary Mathematics series. The forthcoming third volume will be published by the Mathematical Society of Japan and will be available outside of Japan from the AMS in the Advanced Studies in Pure Mathematics series.

***$S$ -Modules in the Category of Schemes*** Po Hu, 2003. Gives a theory of  $S$ -modules for Morel and Voevodsky's category of algebraic spectra over an arbitrary field  $k$ . This work also defines universe change functors as well as other important constructions analogous to those in topology, such as the twisted half smash product.

***The Moduli Space of  $N=1$  Superspheres with Tubes and the Sewing Operation*** Katrina Barron, 2003. Within the framework of complex supergeometry and motivated by two-dimensional genus zero holomorphic  $N=1$  superconformal field theory, this book defines the moduli space of  $N=1$  genus zero super Riemann surfaces with oriented and ordered half-infinite tubes modulo superconformal equivalence.

***The Rational Function Analogue of a Question of Schur and Exceptionality of Permutation Representations*** Robert M. Guralnick, Peter Müller, Jan Saxl, 2003. Investigates the analogous question for rational functions. This book describes the Galois theoretic translation based on Chebotarev's density theorem, which leads to a certain property of permutation groups called exceptionality.

***Generalized Whittaker Functions on  $SU(2,2)$  with Respect to the Siegel Parabolic Subgroup*** Yasuro Gon, 2002. Obtains an explicit formula for generalized Whittaker functions and multiplicity one theorem for all discrete series representations of  $SU(2,2)$ .

***Homotopy Theory of Diagrams*** Wojciech Chachólski, Jérôme Scherer, 2002. In this paper, the authors develop homotopy theoretical methods for studying diagrams. In particular, they explain how to construct homotopy colimits and limits in an arbitrary model category. The key concept introduced is that of a model approximation. A model approximation of a category  $\mathcal{C}$  with a given class of weak equivalences is a model category  $\mathcal{M}$  together with a pair of adjoint functors  $\mathcal{M} \rightleftarrows \mathcal{C}$  which satisfy certain properties. The key result says that if  $\mathcal{C}$  admits a model approximation, then so does the functor category  $\text{Fun}(I, \mathcal{C})$ .

***Numerical Control over Complex Analytic Singularities*** David B. Massey, 2003. Generalizes the Le cycles and numbers to the case of hyper-surfaces inside arbitrary analytic spaces. This book defines the Le-Vogel cycles and numbers and proves that the Le-Vogel numbers control Thom's  $a_f$  condition. It describes the relationship between the Euler characteristic of the Milnor fibre and the Le-Vogel numbers.

***The Lifted Root Number Conjecture and Iwasawa Theory*** Jürgen Ritter, Alfred Weiss, 2002. This paper concerns the relation between the Lifted Root Number Conjecture as introduced in GRW2 and a new equivariant form of Iwasawa theory. A main conjecture of equivariant Iwasawa theory is formulated, and its equivalence to the Lifted Root Number Conjecture is shown, subject to the validity of a semi-local version of the Root Number Conjecture, which itself is proved in the case of a tame extension of real abelian fields.

***Connectivity***

*Properties of Group Actions on Non-Positively Curved Spaces* Robert Bieri, Ross Geoghegan, 2003 Generalizing the Bieri Neumann Strebel Renz Invariants this Memoir presents the foundations of a theory of not necessarily discrete actions  $\rho$  of a suitable group  $G$  by isometries on a proper CAT 0 space  $M$  The passage from groups  $G$  to group actions  $\rho$  implies the introduction of Sigma invariants  $\Sigma_k \rho$  to replace the previous  $\Sigma_k G$  introduced by those authors Their theory is now seen as a special case of what is studied here so that readers seeking a detailed treatment of their theory will find it included here as a special case We define and study controlled  $k$  connectedness  $CC_k$  of  $\rho$  both over  $M$  and over end points  $e$  in the boundary at infinity  $\partial_\infty M$   $\Sigma_k \rho$  is by definition the set of all  $e$  over which the action is  $k+1$  connected A central theorem the Boundary Criterion says that  $\Sigma_k \rho \neq \emptyset$  if and only if  $\rho$  is  $CC_{k+1}$  over  $M$  An Openness Theorem says that  $CC_k$  over  $M$  is an open condition on the space of isometric actions  $\rho$  of  $G$  on  $M$  Another Openness Theorem says that  $\Sigma_k \rho$  is an open subset of  $\partial_\infty M$  with respect to the Tits metric topology When  $\rho$  of  $G$  is a discrete group of isometries the property  $CC_{k+1}$  is equivalent to  $\ker \rho$  having the topological finiteness property type  $F_k$  More generally if the orbits of the action are discrete  $CC_{k+1}$  is equivalent to the point stabilizers having type  $F_k$  In particular for  $k=2$  we are characterizing finite presentability of kernels and stabilizers Examples discussed include locally rigid actions translation actions on vector spaces especially those by metabelian groups

**A Stability Index Analysis of 1-D Patterns of the Gray-Scott Model** A. Doelman, Robert A. Gardner, Tasso J. Kaper, 2002 This work is intended for graduate students and research mathematicians interested in partial differential equations The Based Ring of Two-Sided Cells of Affine Weyl Groups of Type  $\widetilde{A}_{n-1}$  Nanhua Xi, 2002 In this paper we prove Lusztig's conjecture on based ring for an affine Weyl group of type  $\widetilde{A}_{n-1}$

**Kac Algebras Arising from Composition of Subfactors: General Theory and Classification** Masaki Izumi, Hideki Kosaki, 2002 This title deals with a map  $\alpha$  from a finite group  $G$  into the automorphism group  $\text{Aut } \mathcal{L}$  of a factor  $\mathcal{L}$  satisfying i  $G \times H$  is a semi direct product ii the induced map  $g$  in  $G$  to  $\alpha_g$  in  $\text{Out } \mathcal{L}$   $\text{Aut } \mathcal{L} \rightarrow \text{Out } \mathcal{L}$  is an injective homomorphism and iii the restrictions  $\alpha|_N, \alpha|_H$  are genuine actions of the subgroups on the factor  $\mathcal{L}$  The pair  $(\mathcal{M}, \alpha)$   $\mathcal{M} \supseteqq \mathcal{N} \supseteqq \mathcal{L}$   $\text{DEGREES } \alpha|_N$  of the crossed product  $\mathcal{M} \rtimes_\alpha H$  and the fixed point algebra  $\mathcal{M}^{\text{DEGREES } \alpha|_N}$  gives an irreducible inclusion of factors with Jones index  $[G]$  The inclusion  $\mathcal{M} \supseteqq \mathcal{N}$  is of depth 2 and hence known to correspond to a Kac algebra of dim

*Smooth Molecular Decompositions of Functions and Singular Integral Operators* John E. Gilbert, 2002 Under minimal assumptions on a function  $\psi$  the authors obtain wavelet type frames of the form  $\psi_{j,k} \otimes \psi_r$   $\text{DEGREES } 1 \leq j \leq n$   $\psi_r$   $\text{DEGREES } j \leq k \leq j+1$  in integer  $k$  in integer  $\text{DEGREES } n$  for some  $r \geq 1$  and  $s \geq 0$  This collection is shown to be a frame for a scale of Triebel Lizorkin spaces which includes Lebesgue Sobolev and Hardy spaces and the reproducing formula converges in norm as well as pointwise a.e The construction follows from a characterization of those operators which are bounded on a space of

smooth molecules This characterization also allows us to decompose a broad range of singular integral operators in ter

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**Homotopy Theory of the Suspensions of the Projective Plane** Jie Wu, 2003 Investigates the homotopy theory of the suspensions of the real projective plane This book computes the homotopy groups up to certain range It also studies the decompositions of the self smashes and the loop spaces with some applications to the Stiefel manifolds

*Submanifolds and Holonomy* Jurgen Berndt, Sergio Console, Carlos Enrique Olmos, 2016-02-22 Submanifolds and Holonomy Second Edition explores recent progress in the submanifold geometry of space forms including new methods based on the holonomy of the normal connection This second edition reflects many developments that have occurred since the publication of its popular predecessor New to the Second Edition New chapter on normal holonom

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