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Bi-slant Submanifolds of Para Hermitian Manifolds

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Abstract

In [3], B.-Y. Chen introduced slant submanifolds of an almost Hermitian manifold, as those submanifolds for which the angle θ between JX and the tangent space is constant, for any tangent vector field X. They play an intermediate role between complex submanifolds ($\theta = 0$) and totally real ones ($\theta = \pi/2$). Since then, the study of slant submanifolds has produced an incredible amount of results and examples. Moreover, some generalizations of them have also been defined, such as semi-slant, bi-slant or generic submanifolds.

On the other hand, many authors have studied slant submanifolds in different environments: Sasakian manifolds, almost product manifolds. The study of slant submanifolds in a semi-Riemannian manifold was also initiated: Lorentzian complex space forms, neutral Kaehler manifolds, neutral almost contact pseudo-metric manifolds, LP-contact manifolds, Lorentzian Sasakian and para Sasakian manifolds.

In [1], we introduced slant submanifolds of para Hermitian manifolds. These ambient spaces have a rich structure, similar to that of almost Hermitian ones, but also with very interesting differences. Now we continue intruducing bi-slant submanifolds of Para Hermitian Manifolds.

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2

On L_∞-bialgebroids and Courant algebroids

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Abstract

We show that Courant algebroids corresponds to new constructions of (curved) L_∞-algebroids and generalizations of L_∞-bialgebroids.

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3

$*$-slant submanifolds

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Abstract

It was proven by A. Ros and F. Urbano [3] that if M^m is a Lagrangian submanifold of $\mathbb{C}^n$, with mean curvature vector H and scalar curvature τ, then $|H|^2 \geq \frac{2(m+2)}{m^2(m-1)}\tau$, with equality if and only if M is either totally geodesic or a (piece of a) Whitney sphere. Moreover, it was proven that M^m satisfies the equality case at every point, if and only if its second fundamental form σ is given by

$$\sigma(X,Y) = \frac{m}{m+2}\{g(X,Y)H + g(JX,H)JY + g(JY,H)JX\}, \tag{1}$$

for any tangent vector fields X, Y.

Later, D. E. Blair and A. Carriazo [1] established an analogue of the above result for anti-invariant submanifolds in $\mathbb{R}^{2m+1}$ with its standard Sasakian structure and they gave a characterization by using the second fundamental form, similar to the equation (1) given by A. Ros and F. Urbano in [3].

We introduce the notion of $*$-slant submanifold as that slant submanifold whose second fundamental form satisfies the equality case of an inequality between its mean curvature and its scalar curvature of a generalized Sasakian space form $\widetilde{M}^{2m+1}(f_1, f_2, f_3)$ whose structure is (α, β) trans-Sasakian. In addition to that, we give several interesting examples about these submanifolds.

These submanifolds generalize the $*$-*Legendrian submanifolds* of a Sasakian space form $\widetilde{M}^{2m+1}(c)$, which were studied by G. Pitiş in [2]. They are invariant submanifolds, of dimension m, whose second fundamental form satisfies the equality case in a similar inequality between τ and H.

Finally, we obtain an equality for the Ricci curvature of a $*$-slant submanifold involving its mean curvature in a generalized Sasakian space form $\widetilde{M}^{2m+1}(f_1, f_2, f_3)$ whose structure is (α, β) trans-Sasakian.

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4

A note on Haantjes tensors

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Abstract

Haantjes tensors are $(1,1)$-tensors that have integrable generalized eigenvector distributions. They generalize Nijenhuis tensors and are used in the study of separable integrable systems. In this work, we relate Haantjes tensors with Frolicher-Nijenhuis bracket and prove that combinations of functions and commuting compatible Nijenhuis tensors are Haantjes tensors. In particular, we obtain that multiply twisted products of Nijenhuis tensors are Haantjes tensors.

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Quantum Hall effect and Macdonald polynomials

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Abstract

Jack polynomials have many applications in physics, in particular in statistical physics and quantum physics, due to their relation to the many-body problem. In particular, fractional quantum Hall states of particles in the lowest Landau levels are described by such polynomials. In that context, some properties, called clustering properties, are highly relevant and means that the Jack polynomial vanishes when s distinct clusters of $k+1$ equal variables are formed. Coming from theoretical physics, the study of these properties raises very interesting problems in combinatorics and representation theory of the affine Hecke algebras. More precisely, the problem is studied in the realm of Macdonald polynomials which form a (q,t)-deformation of the Jack polynomials. Instead of stating the results in terms of clustering properties, we prefer to state them in terms of factorizations. Indeed, clustering properties are shown to be equivalent to very elegant formulas involving factorizations of Macdonald polynomials.

Starting with a brief account on the physics motivations, we would like to present some special cases of specializations for which the factorizations present very interesting properties. As a consequence of the singularity of some quasistaircase Macdonald polynomials proved in [4], we deduce factorizations from the results of Feigen et al [3] and we illustrate our results by proving a conjecture stated by Bernevig and Haldane [1]. Work in progress, [2].

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Applications of the two-parameter invariant function $\bar{\psi}^0_{\mathfrak{g}}(\alpha,\beta)$ to filiform Lie algebras

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Abstract

Continuing with the research followed in previous papers by different authors ([2, 3], for instance) and by ourselves [1], we introduce in this communication a new two-parameter invariant function of algebras, denoted by $\bar{\psi}^0_{\mathfrak{g}}(\alpha,\beta)$, show its main properties and compute its value in the particular case of filiform Lie algebras, for certain values of the parameters α and β.

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7

Metrics on Whitney sum of sphere bundles over a submanifold induced from a g-natural one

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Abstract

The geometry of the tangent sphere bundle over a Riemannian manifold (N, g), with nondegenerate g-natural metric, has been studied by many authors.

Let M be a manifold isometrically immersed into a Riemannian manifold (N, g) and let (TN, G) be the tangent bundle of N, endowed with a g-natural, possibly degenerate, metric G. We investigate the curvature properties of the direct sum of two sphere bundles $TS_{r_1} \oplus TS_{r_2}$ over the submanifold M. The first one is a bundle of vectors of constant length r_1 tangent to M, while the second one consists of vectors normal to M and of constant length r_2. The metric on $TS_{r_1} \oplus TS_{r_2}$ is a nondegenerate g-natural one induced from the metric G.

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8

Type D conformal initial data

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Abstract

We construct inital data for the vacuum conformal Friedrich equations in 4-dimensions such that the data development admits a Weyl tensor of Petrov type D. Our starting point for this task is a vacuum initial data set for the Einstein field equations and we carry out a conformal rescaling (conformal compactification) of these vacuum data. This gives rise to initial data for the (vacuum) conformal equations. When will the data development under the conformal equations be a conformal extension of a type D solution? In this work we answer this question following techniques similar to those of [1]. A number of initial data sets for the conformal equations are explored. Recall that vacuum type D solutions of the Einstein equations contain cases as important as the Schwarzschild and the Kerr solution.

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Differential invariants of Fedosov structures

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Abstract

Local differential invariants of Fedosov structures are studied, following the style of the study begun in [1]. We present *normal developments*, in a similar manner to [2] or [3]. These are used to prove that the space of differential invariants can be identified with a certain space of smooth functions invariant under the action of the symplectic group.

Then, this result allows us to provide a description of natural tensors of order r associated with Fedosov structures, and we can also state and prove a pair of simple corollaries:

1. There is no differential scalar invariant of a Fedosov structure which is linear on the second derivatives of the 2-form.

2. On a Fedosov manifold, the only natural 2-tensors which are linear on the second derivatives of the 2-form are the constant multiples of the Ricci tensor.

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Material distributions

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Abstract

A groupoid, called *material groupoid*, is associated in a natural way over a general non uniform body (see [1]). Due to the lack of differentiability properties of the material groupoid (it is not, generally, a Lie groupoid), we need to introduce new tools in order to study the general case. Is in this context where the *material distributions* are introduced. As a first result, the material distributions and its associated singular foliations result in a rigorous and unique subdivision of the material body into strictly smoothly uniform components (see, for instance [2]). Thus, the constitutive law induces a unique partition of the body into smoothly uniform sub-bodies, laminates, filaments and isolated points.

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Einstein's equation on a Weyl geometry

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Abstract

A *Weyl geometry* is a triple $(X, \langle g\rangle, \nabla)$, where X is a smooth manifold, $\langle g\rangle$ is a conformal semiriemannian structure, and ∇ is a compatible symmetric linear connection; that is to say, a symmetric linear connection such that, for any representative g of the conformal structure, there exists a 1-form α such that $\nabla g = \alpha \otimes g$.

Following the ideas presented in [3], we study natural 2-tensors associated to a Weyl structure. We pay special attention to those tensors that are *divergence-free*, and discuss their relation with a relativistic field equation on a Weyl spacetime ([1], [2]).

In particular, we prove that the existence of a divergence-free, natural 2-tensor that is *symmetric* implies the local triviality of the Weyl structure; that is to say, the existence of a representative g on the conformal structure such that ∇ is the Levi-Civita connection of g.

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ESQPTs and thermal phase transition in the Dicke model

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Abstract

It is well known from the 70s that the Dicke model undergoes a thermal phase transition [1]. Also, recently it has been found that this model displays a Quantum Phase Transition (QPT) as well as an Excited State Quantum Phase Transition (ESQPT) [2]. We study the thermodynamic of the full version of the Dicke model and we look for joint features between the thermal phase transition and the ESQPT. We find a common order parameter for both transitions [3].

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High-order geometric integrators for nonholonomic systems

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Abstract

In this talk I present a newly obtained family of geometric, arbitrarily high-order partitioned Runge-Kutta integrators for nonholonomic systems, both on vector spaces and Lie groups. These methods differ from those of J. Cortés and S. Martínez [1] in that we do not require that a discretisation of the constraint be provided, and contrary to L. Jay's SPARK integrators [2] we do not require extraneous combinations of constraint evaluations. Our methods preserve the continuous constraint exactly and can be seen to extend those of M. de León, D. Martín de Diego and A. Santamaría [3].

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14

Curvature Effects in Flocking Dynamics: A Cucker-Smale type model on Riemannian Manifolds

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Abstract

The dynamics of the Cucker-Smale model [1, 2] facilitate the flocking of a group of particles in disordered motion into a coordinated one where all particle move parallelly with the center of mass. It illustrates not only the flocking of animals but also the general emergence of collective behaviour in a wide range of subjects. While their work already received much attention over the last decade, those efforts focused on particles moving in a Euclidean space.

We generalise the model to complete Riemannian manifolds and establish theorems about the convergence of the particles to a flocked state. On a Riemannian manifold the notion of parallelism is intimately related to curvature and the geometry constrains the final flocked state into specific patterns. Next to this interesting phenomenology, our work also is a contribution towards the flocking realizability problem as described in [3]. Given a manifold and a group of particles, this problem asks for a dynamical system that leads to a collective movement as a flock at least asymptotically. This project is joint work with Seung-Yeal Ha and Doheon Kim from Seoul National University.

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Persistent Homology and Physical Applications

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Abstract

Topological data analysis is an emerging field which seeks to discover the underlying space of a data sample. Due to the omnipresence of data in current science and society, it has been applied in numerous fields. In physics, the possible outcome of an experiment is constrained to its configuration space which is usually a differentiable manifold.
In particular, one of the most important qualitative features of a manifolds are its Betty numbers. They describe in a simple way its global structure and there exist plenty of analytical strategies to compute them. Despite this, problems arises when the geometric object is too complex or there are not concrete analytical methods for a specific case. In the beginning of this century a change of paradigm happened with the discovery of persistent homology.
This allows us to deduce the Betti numbers of a manifold from a dense enough finite point sample of it. Then, this strategy has a constructive nature and can be solved by computers. This gives persistent homology an interesting double utility: it can helps to understand a rather complicated geometric object computing its Betti numbers and facilitating a posterior analytical study or it can be used to actually compare the topological features of your analytical model with finite samples obtained from a real world experiment.
Our aim is to provide a review of this techniques and how they have been applied in recent years to the Cosmic Web [1], to the string vacua [2] and to the analysis of phase transitions [3]. In addition, we will analyse new possibilities from both, the physical and the topological point of view.

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Some Myers-Type Theorems for Transverse Ricci Solitons on Sasaki Manifolds

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Abstract

An important problem in Riemannian geometry is to investigate the relation between topology and geometric structure on Riemannian manifolds. The celebrated theorem of S. B. Myers (Duke Math. J. 8 (1941)) guarantees the compactness of a complete Riemannian manifold under some positive lower bound on the Ricci curvature. This theorem may be considered as a topological obstruction for a complete Riemannian manifold to have a positive lower bound on the Ricci curvature. On the other hand, J. Lohkamp (Ann. Math. 140 (1994)) proved that in dimension at least three, any manifold admits a complete Riemannian metric of negative Ricci curvature. Hence, in dimension at least three, there are no topological obstructions to the existence of a complete Riemannian metric of negative Ricci curvature. To give an interesting compactness criterion for complete Riemannian manifolds is one of the most important problems in Riemannian geometry, and the Myers theorem has been widely generalized in various directions by many authors.

The aim of my poster is to discuss the compactness of transverse Ricci solitons. The notion of Ricci solitons were introduced by R. Hamilton in 1982 and are natural generalizations of Einstein manifolds. They correspond to self-similar solutions to the Ricci flow and often arise as singularity models of the flow. The importance of Ricci solitons was demonstrated by G. Perelman, where Ricci solitons played crucial roles in his affirmative resolution of the Poincaré conjecture.

In my poster, I would like to generalize the notion of Ricci solitons to the case of sub-Riemann geometry, and define the notion of transverse Ricci solitons for Riemannian foliations. After we have reviewed basic facts on Myers theorems for Ricci solitons, we shall establish some new Myers theorems for transverse Ricci solitons on Sasaki manifolds. Our results may be regarded as natural generalizations of the Myers theorems due to W. Ambrose (Duke Math. J. 24 (1957)), J. Cheeger, M. Gromov, and M. Taylor (J. Diff. Geom. 17 (1982)), M. Fernández-López and E. García-Río (Math. Ann. 340 (2008)), M. Limoncu (Arch. Math. (Basel) 95 (2010), Math. Z. 271 (2012)). Z. Qian (Q. J. Math. 48 (1997)). the author (Diff. Geom. Appl. 44 (2016), Pacific J. Math. 294 (2018)), and G. Wei and W. Wylie (J. Diff. Geom. 83 (2009)).