ONE-DAY WORKSHOP ON

DIFFERENTIAL GEOMETRY AND ITS APPLICATIONS

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Dedicated to the late
"Professor Nabil Labib Youssef "

ABSTRACT BOOKLET

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Application of Differential Geometry in Astronomy: N. L. Youssef Contributions

Dr. Abdelrahman M. Sherif
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The application of differential geometry in modern astronomy has offered powerful frameworks for interpreting the gravitational and astrophysical phenomena. Among the notable contributions in this direction is the work of N. L. Youssef, whose research integrates geometric structures with field- theoretic principles. Youssef's contributions began with the introduction of the W-tensor and W-scalar, which can be considered as a Lagrangian for the unified field theories. This construction represents a geometric alloy of curvature and torsion, aligning closely with the broader geometrization philosophy that seeks to describe physical interactions through intrinsic geometric objects. Building on this foundation, Wanas and Youssef identified a new differential identity within Absolute Parallelism (AP) geometry. This advancement significantly impacts the internal consistency and physical interpretation of geometric field theories. Ultimately, this advancement enabled the formulation of a novel field theory that is based on both the discovered identity and the W-scalar framework. This presentation highlights the mathematical structure, physical motivation, and astronomical relevance of Youssef's work, underscoring its role in enriching geometric approaches to Youssef's work significantly enhances geometric approaches to gravitational and cosmological modeling.

Keywords:
DIFFERENTIAL GEOMETRY; ABSOLUTE PARALLELISM GEOMETRY; UNIFIED FIELD THEORIES; W-TENSOR; W-SCALAR; GEOMETRIC GRAVITATION

10:50 AM – 11:20 AM

Higher-Curvature Corrections and Spacetime Singularities

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We study the effect of higher-order curvature corrections of Gauss–Bonnet terms on spacetime singularities in five dimensions. For FLRW-like cosmologies, we show that Gauss–Bonnet corrections can replace the big bang/crunch singularity with a weaker sudden singularity, where the Hubble rate remains finite while the higher derivatives terms diverge. We show the possibility of explicit extension of non-spacelike geodesics beyond the singularity while ensuring the field equations junction conditions. This leads to the construction of a geodesically complete bouncing spacetime with a well-defined surface stress–energy.
For the Boulware–Deser black hole, we find that Gauss–Bonnet terms soften the central singularity along purely radial geodesics so that the Tipler and Kr olak criteria indicate a weak singularity. Non-radial geodesics remain strongly singular due to centrifugal effects. These results suggest that higher-curvature corrections can weaken both cosmological and black hole singularities.

Keywords:
GAUSS–BONNET GRAVITY; SPACETIME SINGULARITIES; HIGHER-DIMENSIONAL COSMOLOGY; GEODESIC COMPLETENESS; BLACK HOLE SINGULARITIES

11:20 AM – 12:40 AM

Three Faces of Gravity

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The General Relativity (GR) theory of gravitation explains gravitational phenomenon as a space-time curvature corresponds to a particular distribution of matter source. Curvature R, torsion T and non-metricity Q allow us to define three different, but physically equivalent versions of GR. They are called the teleparallel equivalent of general relativity (TEGR) and the symmetric teleparallel equivalent of general relativity (STEGR). In this talk, I will review the three representations and their extensions to modify the GR theory.

Keywords: GENERAL RELATIVITY; SPACETIME GEOMETRY; TELEPARALLEL GRAVITY; SYMMETRIC TELEPARALLEL GRAVITY; MODIFIED GRAVITY

11:40 AM – 12:00 AM

F-Term Hybrid Inflation with T-Model Kähler Geometry and Beyond

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We analyze F-term Hybrid inflation (FHI) within various grand unified theories (GUTs) in the presence of a Kähler potential which parameterizes the Kähler manifolds U (1)R $\times$ (SU (1, 1)/U (1)) or U (1)R $\times$ (SU (2)/U (1)). Results compatible with the current data can be obtained by constraining the curvature of the internal space to values of order 0.001 increasing with the dimensionality of the GUT gauge group adopted. In the largest part of the available parameter space acceptable results are achieved without generating maxima and minima along the inflationary path and the scale of the GUT-symmetry breaking may assume its SUSY value. The production of cosmic strings is also investigated and their possible observational signatures are discussed.

Keywords: HYBRID INFLATION; GRAND UNIFIED THEORIES; KÄHLER GEOMETRY; SUPERSYMMETRY; COSMIC STRINGS

1230 PM – 12:50 PM

Spherically Symmetric Solutions to the Unicorn Problem

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The existence of non-Berwaldian Landsberg metrics, commonly referred as *unicorns*, remains a central problem in Finsler geometry due to their rarity and intricate geometric structure. In this paper, we construct and analyze four new explicit families of non-regular spherically symmetric Finsler metrics of the form $F = u\,\phi(r, s)$ on $B^n(r_0) \subset^n$, where ϕ depends on the radial distance $r = |x|$ and the directional variable $s = \langle x, y\rangle/|y|$. For each class, we compute the associated spray coefficients and rigorously verify the Landsberg condition and we show that these metrics are not Berwaldian. These results contribute new examples of explicit and simple non-Berwaldian Landsberg metrics and further demonstrate the richness of the spherically symmetric framework in Finsler geometry.

Keywords: FINSLER GEOMETRY; LANDSBERG METRICS; NON-BERWALDIAN METRICS; SPHERICALLY SYMMETRIC METRICS; SPRAY COEFFICIENTS

12:50 PM – 1:20 PM

New Results on the Holonomy of Finsler Manifolds

Prof. Zoltán Muzsnay ,
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ABSTRACT WILL BE ANNOUNCED LATER

Keywords:

1:20 PM – 1:40 PM

Dr. Ahmad Moursy,
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Grand unified theories (GUTs) predict proton decay, and superheavy magnetic monopoles that may survive inflation and occur at an observable level. Other topological defects such as domain walls, cosmic strings, intermediate mass monopoles and various composite structures can appear in GUTs, depending on the symmetry breaking patterns, with rank greater than four. We explore various cosmological implications of topological defects that survive inflation.

Keywords: GRAND UNIFIED THEORIES; TOPOLOGICAL DEFECTS; MAGNETIC MONOPOLES; COSMIC STRINGS; COSMOLOGICAL IMPLICATIONS

1:40 PM – 2:00 PM

Anisotropic Conformal Change of Finsler Spaces

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We study anisotropic conformal transformations of conic pseudo-Finsler spaces, where the conformal factor depends on both position and direction. Such transformations do not generally preserve the pseudo-Finsler structure, so we derive necessary and sufficient conditions for a surface to map to another pseudo-Finsler surface. In general dimensions, expressing the anisotropic conformal change of the inverse metric tensor in tensorial form is highly challenging, but on Finsler surfaces a modified Berwald frame allows this. We identify non-homothetic transformations that preserve the geodesic spray and characterize when a Riemannian surface can be anisotropically conformally transformed into Berwald or Landsberg surfaces.

Keywords: PSEUDO-FINSLER GEOMETRY; ANISOTROPIC CONFORMAL TRANSFORMATIONS; GEODESIC SPRAY; BERWALD SURFACES; LANDSBERG SURFACES

3:00 PM – 3:30 PM

The Finsler-Friedmann Equation

Prof. Nicoleta Voicu ,
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Finsler spacetime geometry provides a natural extension of Lorentzian geometry, based on a most general notion of arc length. In this talk, I will address: - The notion of Finsler spacetime and related geometric concepts. - A Finslerian model of the gravitational field produced by a kinetic gas. Under cosmological symmetry, this framework results in an exponentially expanding spacetime, without invoking a cosmological constant or introducing additional ingredients.

Keywords: FINSLER SPACETIME; LORENTZIAN GENERALIZATION; KINETIC GAS; FINSLER GRAVITY; COSMOLOGICAL EXPANSION

3:30 PM – 3:50 PM

On Some Topics of Finsler Geometry

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This collection of investigations adopts the pullback approach to global Finsler geometry to explore various properties and classifications of Finsler spaces and connections. The investigation focuses intrinsically on special Finsler spaces, particularly those defined by properties related to the Berwald connection, such as Finsler spaces of scalar curvature and their reduction conditions to Finsler spaces of constant curvature. Additionally, several new classes of special Finsler spaces are introduced, including Ricci, generalized Ricci, projectively recurrent, and m-projectively recurrent spaces, with their properties and interrelations studied. Recurrence phenomena are further categorized into three main classes simple, Ricci, and concircular recurrence (each comprising four types) and a new concept, generalized concircular recurrence, is highlighted. Finally, the study of connections focuses on horizontally recurrent Finsler connections, establishing a uniqueness theorem (generalizing the Cartan connection result) for an h-recurrence form A, and examining properties of the specific special HRF-connection.

Keywords: FINSLER GEOMETRY; PULLBACK APPROACH; SPECIAL FINSLER SPACES; RECURRENCE PROPERTIES; FINSLER CONNECTIONS

3:50 PM – 4:10 PM

New Path Equations in Einstein Nonsymmetric Geometry

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Adopting Bażański's approach, two new classes of path equations are derived in Einstein nonsymmetric geometry. The first class is the path equations of a test particle moving in a gravitational field, while the second class represents path equations of charged particles. The quantum features of this geometry appear in both classes. The path equations of charged particles give rise to Lorentz force. Moreover, these path equations may represent an interpretation of some interactions between torsion and electromagnetic potential even if the electromagnetic force vanishes. It is to be noted that the above two classes of paths are formulated in terms of Einstein nonsymmetric connection. An explicit formula of such a connection, satisfying the Einstein metricity condition, is obtained by localizing the global formula given recently by Ivanov-Zlatanović.

Keywords: EINSTEIN NON-SYMMETRIC GEOMETRY; PATH EQUATIONS; BAŻAŃSKI APPROACH; TORSION AND ELECTROMAGNETISM; LORENTZ FORCE

4:10 PM – 4:40 PM

String Theory and Orbifold Geometry

Prof. Shaaban Khalil ,
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Orbifold geometry offers a simple and powerful approach to compactification in string theory. By describing singular spaces as discrete quotients of smooth manifolds, orbifolds allow controlled constructions of gauge symmetries and chiral matter. This talk presents a concise introduction to orbifolds and highlights their role in building phenomenologically relevant string models.

Keywords: ORBIFOLD GEOMETRY; STRING COMPACTIFICATION; GAUGE SYMMETRIES; CHIRAL MATTER; STRING PHENOMENOLOGY

5:10 PM – 5:30 PM

Differential Geometry as a Language for Quantum Theory

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Modern quantum theory is traditionally formulated in terms of Hilbert spaces, operators, and probabilistic postulates. However, beyond this algebraic description lies a rich geometric structure that provides a deeper and more intuitive understanding of quantum phenomena. In this talk, I will explore how differential geometry serves as a natural language for quantum theory, allowing quantum states, dynamics, and measurements to be described in geometric terms. I will present quantum states as points on curved manifolds, particularly the projective Hilbert space, and show how geometric structures such as metrics, symplectic forms, and connections arise naturally in quantum mechanics. Within this framework, quantum dynamics can be interpreted as flows or geodesic motions on state manifolds, while quantum uncertainty and distinguishability acquire precise geometric meanings through distance measures and curvature.

Keywords: GEOMETRIC QUANTUM MECHANICS; DIFFERENTIAL GEOMETRY; PROJECTIVE HILBERT SPACE; QUANTUM DYNAMICS; QUANTUM STATE MANIFOLDS