1. Knot Theory

Lorena Armas Sanabria *Instituto de Matematicas, UNAM* An example of a hyperbolic 3-manifold realizing a bound on Dehn fillings

abstract Let M be a compact, orientable, irreducible 3-manifold with an incompressible torus boundary T and γ a longitudinal slope on T, which bounds a surface F of genus 2. Suppose there exists a slope r that produces an essential 2-sphere S_1 by Dehn filling. Let q be the minimal geometric intersection number between the essential 2-sphere and the core of the Dehn filling. Matignon and Sayari proved that either $q = 2$ or the minimal geometric intersection number between γ and r is bounded by 3. In this talk we construct an example of a hyperbolic 3-manifold realizing that bound.

Javier Arsuaga *UCSF Comprehensive Cancer Center* DNA knots reveal a chiral organization of DNA in phage capsids

abstract It is believed that all icosahedral bacteriophages package their double-stranded DNA genomes to near-crystalline density in similar fashion. Nevertheless despite numerous studies, the organization of DNA inside viruses such as lambda, T4, T7, P2, P4, and Phi29 is still unknown. We propose a new approach to this problem. We recently showed that most DNA molecules extracted from bacteriophage P4 are highly knotted due to the cyclization of the linear DNA molecule confined inside the viral capsid. Here we show that these knots provide information about the global arrangement of the DNA inside the phage. We analysed the viral distributions of DNA knots by high-resolution gel electrophoresis and performed Monte Carlo computer simulations of random knotting confined to spherical volumes. A rigorous proof of non-random packaging of the phage DNA is given by comparing the knot distributions obtained by both techniques. Furthermore, our results indicate that the packaging geometry of the DNA inside the viral capsid is writhe directed

Masayuki Asaoka *Kyoto University, Japan* Geometry of projectively Anosov flows and bi-contact structures on 3-manifolds

abstract A **bi-contact structure** on a 3-manifold is a pair of mutually transverse positive and negative contact structures, which was introduced by Mitsumatsu, and Eliashberg and Thurston independently. Mitsumatsu found such a structure in his construction of new examples of symplectic 4-manifold by using Anosov flows on 3 manifolds. Eliashberg and Thurston also found it in their study on deformation of foliations into contact structures. Both of them observed that the intersection of the plane fields of a bi-contact structure defines a flow which preserves a pair of integrable plane fields with a special property. Since such a flow is a kind of generalizations of an Anosov flow, they call it a **projectively Anosov ($\mathbb{P}$A) flow** (or a **conformally Anosov flow** in some literatures). They also showed that a bi-contact structure is obtained by a 'linear deformation' of one invariant plane field of a $\mathbb{P}$A flow by another one. It can be shown that the correspondence of bi-contact structures and $\mathbb{P}$A flows is one-to-one up to homotopy of these objects. Hence, one can study these objects from the view points both of contact geometry and of dynamical systems.

One of the main aim of the talk is to define and study some invariants of the above homotopy classes form the view point of dynamical systems. In fact, we define cohomology groups of a cochain complex generated by tori invariant under flow.n

One of the appliaction of such invariants is that if some of them do not vanish then the flow is not homotopic to an Anosov flow, admit no smooth invariant foliations, and must have two periodic orbits. Because an analog of invariants for two dimensional $\mathbb{P}$A diffeomorphisms has a simple geometric meaning, we will explain the case for two dimensional diffeomorphisms in detail instead of three dimensional flows.

It is known that the plane fields invariant under a $\mathbb{P}$A flow are not smooth in general. In the context of deformation of foliations, it is important to ask when both of the invariant plane fields generate foliations. The same problem for Anosov flows has been considered from the view point of the rigidity of smooth foliations and was solved by Ghys. In fact, he showed that an Anosov flow with smooth invariant foliations is essentially equivalent to one of the classical examples: the suspensions of hyperbolic toral automorphisms or some kinds of deformation of geodesic flows on the unit tangent bundle of a surface of negative constant curvature. The second aim of the talk is to see that a similar rigidity result holds for $\mathbb{P}$A flows. In fact, any $\mathbb{P}$A flow with smooth invariant foliations is equivalent to an Anosov flow or can be decomposed into a finite number of so-called $\mathbb{T}^2 \times I$ models.

Mario Eudave Muñoz *IMUNAM* Essential tori after Dehn surgery

abstract We consider the following problem: How many disjoint, non-parallel, incompressible tori there can be after Dehn surgery on a hyperbolic knot in S^3 ?

We construct examples of hyperbolic knots k, such that for certain slope r, the r-surgered manifold $M_k(r)$ contains 2 or 3 disjoint, non-parallel, incompressible separating tori.

J. Manuel Garcia-Islas *CIMAT, Centro de Investigación en Matemáticas* Observables in 3-dimensional quantum gravity and topological invariants

abstract This talk is based on a recent publication on which we describe a way to get topological invariants of graphs and knots embedded on 3-dimensional manifolds, based on a definition of observables in 3-dimensional quantum gravity. There is an intimate relation between knot theory, 3-dimensional manifold invariants and the physics of quantum gravity. We present this relation and then go further to describe the way in which we get our observable topological invariants. This gives a beatiful picture of how pure maths is related to the physics of the 21st century.

José-Carlos Gómez-Larrañaga *CIMAT* What we know about Lusternik-Schnirelmann type invariants in dimension three?

abstract In this talk we introduce what Clapp and Puppe call Lusternik-Schnirelmann type invariants for manifolds. Then we present what is known about these problems in dimension three including some new results by F. J. González-Acuña, W. Heil and the speaker.

Francisco González Acuña *IMATE-UNAM* Three-manifolds with S^1-category two

abstract (with José Carlos Gómez Larrañaga) An open subset U of a manifold M is S^1-contractible (in M) if there are maps $f : U \to S^1$, $\alpha : S^1 \to M$ such that αf is homotopic to the inclusion map. The smallest number m such that M can be covered with m open S^1-contractible subsets is denoted by $S^1 - cat(M)$ and is called the S^1-category of M.

Thm. If M^3 is a closed 3-manifold, $S^1 - cat(M3) = 2$ if and only if $\pi_1(M^3)$ is cyclic.

Gabriela Hinojosa *Universidad Autonoma del Estado de Morelos* Some topological properties of dynamically defined wild knots.

abstract Dynamically defined wild knots are wild knots in the sense of Artin and Fox, which are been obtained as limit sets of a Kleinian group. We say that a knot $K \subset \mathbb{S}^3$ is homogeneous, if given two points p, $q \in K$, there exists a homeomorphism $\psi : \mathbb{S}^3 \to \mathbb{S}^3$ such that $\psi(K) = K$ and $\psi(p) = q$. In general, wild knots are not homogeneous. The purpose of this talk is to show that dynamically defined wild knots are homogeneous. We will also show that the complement of a dynamically-defined fibered wild knot can not be a complete hyperbolic 3-manifold.

Mikami Hirasawa *Gakushuin Univ.* The flat basket presentation of Seifert surfaces and a new coding algorithm for links

abstract This is a joint work with T. Kobayashi (Nara Women's Univ) and Rei Furihata (Yosami Junior High School)

We introduce a new standard form of a Seifert surface F. In that standard form, F is obtained by successively plumbing flat annuli to one disk, where the gluing regions are all in the disk. We show that any link has a Seifert surface in the standard form, and thereby present a new way of coding a link.

Kazuhiro Ichihara *Osaka Sangyo University* Hyperbolicity of sections in surface bundles

abstract We consider the hyperbolicity of knots appearing as sections in 3-manifolds which fiber over the circle. In fact, on such knots, some sufficient conditions for being hyperbolic are given in terms of their projections on the fiber surface.

Atsushi Ishii and Taizo Kanenobu *Osaka University, Osaka City University* A relation between the LG polynomial and the Kauffman polynomial

abstract We give an explicit formula for the fact given by Links and Gould that a one variable reduction of the LG polynomial invariant coincides with a one variable reduction of the Kauffman polynomial. This implies that the crossing number of an adequate link may be obtained from the LG polynomial by using a result of Thistlethwaite. We also give some evaluations of the LG polynomial.

Edgar Jasso *IMATE-UNAM* Incompressible surfaces in tunnel number one link complements

abstract We construct for each n a tunnel number one link such that in its complement there exists a standardly embedded genus n surface that separates the components of the link. This is joint work with Mario Eudave-Muñoz.

Mercedes Jordán Santana *IMATE UNAM* Biquandle and Virtual Knots

abstract The birack is a set with two operations that provides a solution to the Yang Baxter equations. A biquandle is a particular case of a birack. Given a virtual knot we can use elements from a biquandle to give a labelling of the knot. It comes out that this labelling is an invariant of the knot. We give some examples of biquandles and virtual knots where the biquandle detects the non-triviality of the knot.

Naoko Kamada *Osaka City University (OCAMI)* Some relations on Miyazawa's virtual knot invariant

abstract Y. Miyazawa introduced a polynomial invariant for a virtual link at the regional conference in Yamagata, Japan, on January 2004. It is valued in $\mathbf{Z}[A, A^{-1}] + \mathbf{Z}[A, A^{-1}]h$, which is derived from virtual magnetic graph diagrams. The Jones-Kauffman polynomial (f-polynomial) is obtained from Miyazawa's polynomial by substituting 1 for h. For a virtual link diagram D_+ with a positive crossing p, D_- or D_v is the virtual link diagram obtained from D_+ by replacing a positive crossing p with a negative crossing or a virtual crossing, respactively. We call (D_+, D_-, D_v) a virtual skein triple. Some relations for virtual skein triple on the Jones-Kauffman polynomials were found. We discuss some relation for virtual skein triple on Miyazawa's polynomial.

Seiichi Kamada *Hiroshima University* Graphic descriptions of monodromy representations

abstract Various topological objects; 2-dimensional braids, Lefschetz fibrations of 4-manifolds, algebraic curves, hyperplane arrangements, etc., are treated by use of their monodromy representations. We introduce a graphic method to describe monodromy representations.

Akio Kawauchi *Osaka City University* Topological Imitations and Reni-Mecchia-Zimmermann's Conjecture

abstract We first explain the theory of topological imitations which has been developed since the speaker's paper in 1989. In particular, we explain the concepts of an AID imitation and a strongly AID imitation. We show how this imitation theory is applied to the hyperbolic 2-fold branched covering space of a knot. By M. Reni's work, it is known that there are at most nine inequivalent knots in the 3-sphere (or more generally at most nine inequivalent knots in Z_2-homology 3-spheres) with the same hyperbolic 2-fold branched covering. M. Mecchia and B. Zimmermann applied the imitation theory to show that there exist just nine inequivalent knots in Z-homology 3-spheres with the same hyperbolic 2-fold branched covering, and also showed by a similar method that there are six knots in the 3-sphere with the same hyperbolic 2-fold branched covering. Thus, it is naturally conjectured that there exist just nine inequivalent knots in the 3-sphere with the same hyperbolic 2-fold branched covering.

The main result in this talk is to solve their conjecture affirmatively by combining the strongly AID imitation theory with Mecchia-Zimmermann's method.

Christian Laing *Florida State University* The Writhe of a Polygonal Curve on a Lattice

abstract Given a polygonal closed curve on a lattice, we describe a method for computing the writhe of the curve as the average of weighted linking numbers of the polygon with pushoffs in a few directions. These directions are determined by the lattice, and the weights are determined by areas of regions on the unit 2-sphere, where the regions are formed by the tangent indicatrix to the polygonal curve. We discuss applications to ring polymers.

Daniel Moskovich *University Of Kyoto, RIMS* A Surgery Presentation for Irregular Branched Dihedral Covering Spaces of Knots

abstract This is joint work with Andrew Kricker. We describe a method to obtain surgery presentations for irregular branched dihedral covering spaces of knots, and we find such presentations explicitly for certain special knots and for the special case where the dihedral group is of order 3.

Yasutaka Naakanisi *Kobe University* Local moves and Gordian complices

abstract After their works of Gusarov and Habiro, it is known that a local move called C_n move is strongly related to Vassiliev invariants of order less than n. In this talk, we will consider the relationship is natural or not. Let K be a knot, and K^{C_n} the set of knots obtained from a knot K by a single C_n move. Let $\mathcal{V}_m$ be the set of Vassiliev invariants of order less than or equal to m ($m \geq 2$), and $\mathcal{V}_m\mathcal{K}$ the value set $\{(v, \{v(K)\}_{K\in\mathcal{K}})\}_{v\in\mathcal{V}_{\Updownarrow}}$ for a set of knots $\mathcal{K}$. Our main result is the following: If m_1, m_2 are sufficiently greater than n, then there exists a pair of knots K_1, K_2 such that $\mathcal{V}_{m_1}K_1 = \mathcal{V}_{m_1}K_2$, and $\mathcal{V}_{m_2}K_1^{C_n} \neq \mathcal{V}_{m_2}K_2^{C_n}$. In other words, the C_n Gordian complex is not homogeneous with respect to Vassiliev invariants.

Max Neumann *IMATE-UNAM* Minimal lenght, minimal area and minimal intersections of curves and surfaces in dimensions 2 and 3.

abstract Geometry and topology are intimately related in 2 and 3 dimensional manifolds. Examples of this relationship are the connections between the geometric ideas of minimal lenght (or area) for immersed curves (or surfaces) and the topological idea of minimal intersections.

Víctor Núñez *Cimat* A couple of universal knots

abstract We show that two very interesting knots are universal, namely, $p(-2, 7, 7)$ and $p(-2, 11, 11)$. We review a classical method to draw preimages of knots in branched coverings.

Enrique Ramírez Losada *CIMAT* There exist infinitely many twocomponent links which are 2-universal

abstract A link or knot l is 2-universal if every closed orientable 3-manifold is a covering of S^3 branched along l, and all branched indices are one or two. We give a family of two component links which are 2-universal

Jesús Rodríguez Viorato *IMATE-UNAM* Dihedral coverings of Montesinos Knots.

abstract We show that many Montesinos knots are universal by understanding their dihedral coverings.

Toshio Saito *Osaka University* Dehn surgery on $(1, 1)$-knots in lens spaces which yields the three sphere

abstract It is one of the unsolved problems to decide the knots in the 3-sphere which admit Dehn surgery yielding lens spaces. The concept of doubly primitive knots is introduced by Berge, and he proved that any doubly primitive knot admits Dehn surgery yielding a lens space. It is conjectured that Berge's list is complete. He also proved that the dual knots of the doubly primitive knots are $(1, 1)$-knots. This implies that it is crucial to study $(1, 1)$-knots with Dehn surgery yielding the three sphere. In this paper, we give some necessary conditions for $(1, 1)$-knots in lens spaces which admit integral surgery yielding the 3-sphere. As an application, we can obtain a partial answer on a conjecture by Bleiler-Litherland.

Reiko Shinjo *Waseda University* Bounding disks to a spatial graph

abstract We consider Seifert surfaces of knots in a spatial graph whose interiors are mutually disjoint. We give the upper bound of the number of such surfaces. Then we show that for a given abstract graph there is a spatial embedding of the graph which realizes the upper bound.

Makoto Tamura *Osaka Sangyo University* Combinatorics on p-starred automatic groups

abstract We discuss the following question posed by Gersten: Is every (bi)automatic group which does not contain any Z+Z subgroup, hyperbolic? To study this question, we define the notion of "n-track of length n", which is a structure like Z+Z, and show its existence in the Cayley graph of non-hyperbolic automatic groups with mild conditions. Using this structure, we answer the above question affirmatively for p-starred automatic groups for prime integer p. (This is a joint work with Y. Nakagawa and Y. Yamashita (Nara Women's Univ.))

Masakazu Teragaito *Hiroshima University* On hyperbolic knots realizing the maximal distance between toroidal surgeries

abstract For a hyperbolic knot in the 3-sphere, the distance between toroidal surgeries is at most 5, except the figure eight knot. We determine all hyperbolic knots that admit two toroidal surgeries at distance 5. They are Eudave-Muõz knots $k(2,-1,n,0)$ for $n \neq 1$, and the toroidal slopes at distance 5 are $25n-16$ and $25n-37/2$. Also, we show that any Eudave-Muñoz knot admits at most three toroidal surgeries.

Yukihiro Tsutsumi *Sophia University, Japan* On Dehn surgery along ribbon knots of 1-fusion and the double branched covers

abstract A knot in S^3 is called a ribbon knot if it bounds an immersed disk whose singular set consists of ribbon singularities. J. Osoinach discovered an infinite sequence of knots K_i such that the 0-surgery manifolds $\chi(S^3;(K_i,0))$ are mutually homeomorphic and the volumes $\mathrm{vol}(K_i)$ converge on the volume of some link. We note that some results of Osoinach's construction are ribbon knots of 1-fusion. In this talk, we study some algebraic invariants for such knots. We give an infinite sequence of ribbon knots K_i of 1-fusion such that for any distinct integers $i \neq j$, (1) the 0-surgery manifolds $\chi(S^3;(K_i,0))$, $\chi(S^3;(K_j,0))$ are homeomorphic, (2) the double branched cover $\Sigma^2_{K_i}$ of S^3 branched along K_i is not homeomorphic to $\Sigma^2_{K_j}$. To show the second property we use the Casson-Walker invariant and Mizuma's formula for $J'_{K_i}(-1)$, the first derivative at -1 of the Jones polynomial.

Yoshiaki Uchida *Yamagata University* Double torus knots, tunnel number one knots, and essential disks

abstract Let W be a genus two handlebody, D essential disk, where if D is essential, D is properly embedded disk in W and not ∂-pararell in W. Cutting W along D, then we get a solid torus or two solid tori. In case of a solid torus, its core is a tunnel number one knot, in case of two solid tori, its core is a tunnel number one links. From this view, we will characteristic some tunnel number one knot.

Luis G. Valdez Sánchez *University of Texas at El Paso* Crosscap number two, tunnel number one knots without (1,1) decompositions

abstract Any genus one, tunnel number one hyperbolic knot in the 3-sphere admits a (1,1) decomposition and is, in fact, a 2-bridge knot. This is the content of the Goda-Teragaito conjecture, recently established by M. Scharlemann. In this talk we consider the similar case of crosscap number two, tunnel number one hyperbolic knots, give a simple classification of all such knots admitting (1,1) decompositions, and use this classification to construct an explicit infinite family of such knots without (1,1) decompositions. This is joint work with Enrique Ramirez (CIMAT, Mexico).

Mariel Vázquez *University of California at Berkeley* Enzymes that change the topology of DNA.

abstract (joint with De Witt Sumners, Sean D Colloms and Javier Arsuaga) DNA topology is the study of geometrical (supercoiling) and topological (knotting) properties of DNA loops and circular DNA molecules. Virtually every reaction involving DNA is influenced by DNA topology, or has topological effects. Site-specific recombinases and topoisomerases are enzymes able to change the topology of circular DNA by breaking the DNA and introducing one or more crossing changes. In this talk I will discuss mathematical and computational analyses of several enzymatic actions. These enzymes produce or remove DNA knots and links. We use knot theory and tangles to model the reactions and shed some light on the underlying biological processes.

Tsukasa Yashiro *Osaka City University* Crossing distances of surface-knots

abstract A surface–knot is an embedded oriented closed surface in 4–space. The unknotting number of a surface–knot is defined as the minimal number of handles attached to obtain a trivial surface. We define a distance between surface–knots as the minimal number of crossing components for all regular homotopy tracks between them. In this talk we will show that the crossing distance between a surface–knot and a trivial surface with the same genus is bounded below by the unknotting number of the surface–knot. Using this, we will determine distances for some surface–knots.

Gengyu Zhang *Tokyo Institute of Technology* 2-irreducibility of spatial graphs

abstract(Fengchun Lei,Kouki Taniyama and Gengyu Zhang)

An embedded graph G in the 3-sphere S^3 is called 2-irreducible if there are no separating spheres, cutting spheres, singular separating spheres, singular cutting spheres and 2-cutting spheres of G. Let D be a 2-disk in S^3 that is very good for G. Let G' be an embedded graph in S^3 obtained from G by contracting D to a point. We show that if G' is 2-irreducible then G is 2-irreducible. By this criterion certain graphs are easily shown to be 2-irreducible. As an application we show a pair of embedded graphs in the 3-sphere which is distinguished by 2-irreducibility.