1. Geometric Topology

Tatsuya Arai *Tsukuba College of Technology* P-chaos implies distributional chaos and chaos in the sense of Devaney with positive topological entropy

abstract Tatsuya Arai(speaker) and Naotsugu Chinen . Let f be a continuous map from a compact metric space X to itself. The map f is called to be P-chaotic if it has the pseudo-orbit-tracing property and the closure of the set P(f) of all periodic points for f is equal to X. We show that every P-chaotic map from a continuum to itself is chaotic in the sence of Devaney and distributionally chaotic with positive topological entropy.

Sergey A. Antonyan *Facultad de Ciencias, Universidad Nacional Autónoma de México* Characterizing equivariant ansolute retracts

*abstract*For a compact Lie group G, we give a characterization of G-ANR's and G-AR's in terms of the H-fixed point sets, where H runs the family of closed subgroups of G. Applications will be presented.

Alexander Bykov *Universidad Autńoma de Puebla* Equivariant Cotelescopes and Fibrant Spaces

abstract The general approach to the concept of *a fibrant object* is the following: if in a category $\mathcal{C}$ some class Σ of morphisms is specified then an object Y of $\mathcal{C}$ is called Σ-fibrant if for every morphism $s \in \Sigma$, $s : A \to X$, and every morphism $f : A \to Y$ there is a morphism $F : X \to Y$ such that $F \circ s = f$. The classical fibrant objects appear in [5] for the closed model categories where Σ is the class of trivial cofibrations. *A fibrant space* in the sense of F.Cathey is a Σ-fibrant object, where Σ is the class of $SSDR$-maps in the category of metrizable spaces ([2]). In the talk we provide an equivariant version of a fibrant space. It is well-known ([4]) that every compact metrizable group can be represented as an inverse limit of a sequence of Lie groups bonded by fibrations, and therefore it is already a fibrant space in the sense of F.Cathey. On the other hand, due to R.Palias ([3]), every compact Lie group G is a G-ANR and hence it is a G-fibrant space. These are the basic facts utilized in the proof of our result: every compact metrizable group G is a G-fibrant space. Also equivariant fibrants naturally appear as cotelescopes of inverse sequences of G-ANRs. Equivariant cotelescopes as well as equivariant $SSDR$-maps and the results of [1] can be used in the construction of the equivariant strong shape category following the way of F.Cathey. All these facts justify the consideration of equivariant fibrant spaces.

[1] S.Antonyan, S. Mardešić, *Equivariant Shape*, Fund. Math., 127, 1987, 213-224

[2] F. Cathey, *Strong shape theory*, in: Shape Theory and Geometric Topology, Lecture Notes in Math. 870, Springer, Berlin, 1981, 216-239.

[3] R.S.Palais, The classification of G-spaces, Memoirs AMS, 36, 1960

[4] L.S. Pontrjagin, Topological groups, Princeton Univ. Press, 1939

[5] D.G.Quillen, Homotopical algebra, Lecture Notes in Math. 43, Springer, 1967

Robert Cauty *Université de Paris VI, Pierre et Marie Curie* Algebraic ANRs

abstract Lefschetz's criterion characterizes ANRs among metrizable spaces in terms of realizations of simplicial complexes. They are continuous maps from simplicial complexes into the space. We study the class of metrizable spaces which one obtains replacing in this criterion the continuous maps from complexes K to

the space X by chain morphisms from the ordered chain complex of K to the singular chain complex of X. This new class contains the ANRs but also all locally equiconnected metric spaces.

Robert J. Daverman *University of Tennessee* Manifolds homotopically determined by their fundamental groups *abstract* A manifold N is said to be homotopically determined by its fundamental group if each map $f : N \to N$ which induces a π_1-isomorphism is a homotopy equivalence. Aspherical manifolds obviously have this feature. More generally, in a 1974 paper G. A. Swarup characterized the closed, orientable 3-manifolds with this property as those having a connected sum decomposition with at least one aspherical factor. This talk will explore examples, non-examples and construction techniques in all dimensions. A typical Theorem is the following near-generalization of Swarup's result: If $N = N_1 \# N_2$ is a closed, orientable, Hopfian n-manifold such that N_1 is aspherical and $\pi_1(N_2)$ has no free factor in any free product decomposition, then N is homotopically determined by its fundamental group. Much of the work on the topic is joint with Y. Kim.

Tadeusz Dobrowolski *Pittsburg State University, U.S.A.* Near-selections and extensions without local convexity *abstract* The aim of the talk is to characterize the AR-property in convex subsets of metric linear spaces without local convexity. This will be done in terms of certain near-selections. Roughly speaking, the characterization theorem states that a convex set in a metric linear space is an AR if and only if lower semi-continuous functions with finite-dimensional compact convex values admit near selections. Applications will be presented. This is a joint work with Jan van Mill.

Alexander Dranishnikov *University of Florida at Gainesville, USA* Dimension theory approach to the Novikov Conjecture

abstract Asymptotic dimension $asdim X$ of a metric space X was introduced by Gromov as a concept which gives an invariant of finitely generated groups. Discrete groups here are considered as metric spaces taken with the word metric. This invariant proved to be useful for the Novikov Higher Signature conjecture. First, Gouliang Yu proved the (rational) Novikov Conjecture for groups Γ with $asdim \Gamma < \infty$. Later the integral Novikov Conjecture for asymptotically finite dimensional groups was proved independently by A. Bartels, Carlsson-Goldfarb (algebraic K-theory) and D-Ferry-Weinberger. Our approach uses the Higson compactification of groups.

E. Elfving *University of Helsinki* G-ANR's and G-CW complexes for proper actions of Lie groups.

abstract In [2] proper locally linear actions of Lie groups on topological manifolds were studied. Proper locally linear actions form a generalization of smooth proper actions. In the case of smooth proper actions of Lie groups it is known that every smooth proper G-manifold can be given an equivariant triangulation and hence in particular a G-CW complex structure, see [3].

In [2] the main theorem was

Theorem 1. Let G be a Lie group and M a proper locally linear G-manifold. Then M has the G-homotopy type of a G-CW complex.

In [1] we studied adjunction spaces and unions of G-ANE's for actions of a locally compact group G. We established equivariant versions of the Borsuk-Whitehead-Hanner theorem and of the Kodama theorem. As an application we proved that every proper G-CW complex is a G-ANE if G is a Lie group.

Our aim is to generalize the above mentioned Theorem 1 to arbitrary G-ANR's. This is joint work with S. Antonyan.

References.

[1] S. Antonyan, E. Elfving and A. Mata-Romero: *Adjunction spaces and unions of G-ANE's*, Topology Proceedings, Vol. 26, No. 1, 1–28 (2001–2002).

[2] E. Elfving: *The G-homotopy type of proper locally linear G-manifolds II*, manuscripta math. 105, 235–251 (2001).

[3] S. Illman: *Existence and uniqueness of equivariant triangulations of smooth proper G-manifolds with some applications to equivariant Whitehead torsion*, J. Reine Angew. Math. 524, 129–183 (2000).

Jerzy Dydak *University of Tennessee* Algebras derived from dimension theory

abstract The dimension algebra of graded groups is introduced. With the help of known geometric results of extension theory that algebra induces all known results of the cohomological dimension theory. Elements of the algebra are equivalence classes $\dim(A)$ of graded groups A. There are two geometric interpretations of those equivalence classes:
1. For pointed CW complexes K and L, $\dim(H_*(K)) = \dim(H_*(L))$ if and only if the infinite symmetric products $SP(K)$ and $SP(L)$ are of the same extension type (i.e., $SP(K) \in AE(X)$ iff $SP(L) \in AE(X)$ for all compact X).
2. For pointed compact spaces X and Y, $\dim(\mathcal{H}^{-*}(X)) = \dim(\mathcal{H}^{-*}(Y))$ if and only if X and Y are of the same dimension type (i.e., $\dim_G(X) = \dim_G(Y)$ for all Abelian groups G).

Dranishnikov's version of Hurewicz Theorem in extension theory becomes $\dim(\pi_*(K)) = \dim(H_*(K))$ for all simply connected K.

The concept of cohomological dimension $\dim_A(X)$ of a pointed compact space X with respect to a graded group A is introduced. It turns out $\dim_A(X) \le 0$ iff $\dim_{A(n)}(X) \le n$ for all $n \in Z$. If A and B are two positive graded groups, then $\dim(A) = \dim(B)$ if and only if $\dim_A(X) = \dim_B(X)$ for all compact X.

Hanspeter Fischer *Ball State University* Generalized universal covering spaces and the shape group

abstract It is known that if a topological space X admits a (classical) universal covering space, then the natural homomorphism $\varphi : \pi_1(X) \to \check{\pi}_1(X)$ from its fundamental group to its first shape homotopy group is an isomorphism. We present a partial converse: a path connected topological space X admits a *generalized* universal covering space if $\varphi : \pi_1(X) \to \check{\pi}_1(X)$ is injective. This generalized notion of universal covering $p : \tilde{X} \to X$ at which we arrive, enjoys most of the usual properties with the possible exception of evenly covered neighborhoods. It is universally characterized by the following three properties:

(1) $\tilde{X}$ is path connected, locally path connected and simply connected;
(2) $p : \tilde{X} \to X$ is a continuous surjection;
(3) for every continuous $f : (Y, y) \to (X, x)$, with Y path connected, locally path connected and simply connected, and for every $\tilde{x}$ in $\tilde{X}$ with $p(\tilde{x}) = x$, there exists a *unique* continuous lift $g : (Y, y) \to (\tilde{X}, \tilde{x})$ with $f = p \circ g$.

Additional properties of this generalized universal covering include:

(i) $\mathrm{Aut}(\tilde{X} \stackrel{p}{\to} X) \cong \pi_1(X)$;
(ii) $p : \tilde{X} \to X$ is open if and only if X is locally path connected;
(iii) if X is locally path connected and semilocally simply connected, then $p : \tilde{X} \to X$ agrees with the usual universal covering.

Spaces X for which $\varphi : \pi_1(X) \to \check{\pi}_1(X)$ is known to be injective include all subsets of the Euclidean plane, all 1-dimensional compacta, as well as boundaries of certain Coxeter groups.

Tetsuya Hosaka *Utsunomiya University, Japan* On splitting theorems for CAT(0) spaces

abstract In this talk, we introduce some splitting theorems for CAT(0) spaces and compact geodesic spaces of non-positive curvature. A *geometric* action on a CAT(0) space is an action by isometries which is proper and cocompact. We first proved the following splitting theorem which is an extension of a result in [1].

Theorem 1 Suppose that a group $\Gamma = \Gamma_1 \times \Gamma_2$ acts geometrically on a CAT(0) space X. If Γ_1 acts cocompactly on the convex hull $C(\Gamma_1 x_0)$ of some Γ_1-orbit, then there exists a closed, convex, Γ-invariant, quasi-dense subspace $X' \subset X$ such that X' splits as a product $X_1 \times X_2$ and there exist geometric actions of Γ_1 and Γ_2 on X_1 and X_2, respectively. Here each subspace of the form $X_1 \times \{x_2\}$ is the closed convex hull of some Γ_1-orbit.

Using this theorem, we showed some splitting theorems for CAT(0) spaces which are extensions of some results in [1]. As an application of these splitting theorems, we obtain the following theorem.

Theorem 2 Let Y be a compact geodesic space of non-positive curvature. Suppose that the fundamental group of Y splits as a product $\Gamma = \Gamma_1 \times \Gamma_2$ and that Γ has trivial center. Then there exists a deformation retract Y' of Y which splits as a product $Y_1 \times Y_2$ such that the fundamental group of Y_i is Γ_i for each $i = 1, 2$.

A CAT(0) group Γ is said to be *rigid*, if Γ determines the boundary up to homeomorphism of a CAT(0) space on which Γ acts geometrically. Then we denote $\partial\Gamma$ as the boundary of the rigid CAT(0) group Γ. Concerning rigidity of products of rigid CAT(0) groups, we obtained the following theorem.

Theorem 3 If Γ_1 and Γ_2 are rigid CAT(0) groups, then so is $\Gamma_1 \times \Gamma_2$, and the boundary $\partial(\Gamma_1 \times \Gamma_2)$ is homeomorphic to the join $\partial\Gamma_1 * \partial\Gamma_2$ of the boundaries of Γ_1 and Γ_2.

[1] M. R. Bridson and A. Haefliger, *Metric spaces of non-positive curvature*, Springer-Verlag, Berlin, 1999. [2] T. Hosaka, *On splitting theorems for CAT(0) spaces and compact geodesic spaces of non-positive curvature*, preprint.

Sören Illman *University of Helsinki* Hilbert's fifth problem and the very-strong C^∞ topology

abstract First we discuss Hilbert's fifth problem and then we go on to describe a technical point in the proof of the author's contribution to the fifth problem.

In his fifth problem Hilbert asks the following. Given a continuous action

$$\Phi \colon G \times M \to M$$

of a locally euclidean group G on a locally euclidean space M, can one choose coordinates in G and M so that the action Φ is real analytic?

In the special case when $G = M$ there is an affirmative answer. This is the celebrated result, due to Gleason, Montgomery and Zippin, which says that every locally euclidean group is a Lie group.

The answer to Hilbert's question in complete generality is no. However the following result was proved by the author.

Theorem. *Let G be a Lie group which acts on a smooth manifold M by a smooth proper action (in fact smooth Cartan action is enough). Then there exists a real analytic structure β on M, compatible with the given smooth structure on M, such that the action of G on M_β is real analytic.* Here smooth means C^∞ smooth, and the result is given in this form in [1]. The theorem also holds when smooth means C^r smooth, $1 \leq r < \infty$, by essentially the same proof. It is in fact the proof in the C^∞ case that is more demanding, since it requires the use of the very-strong C^∞ topology, instead of the more common strong C^∞ topology.

In the C^∞ case the proof of the fact that the found real analytic structue β is compatible with the given smooth structure on M, makes use of the very-strong topology. It is in the following glueing lemma, where one glues together two C^∞ maps to obtain a C^∞ map, that one needs to use the very-strong C^∞ topology.

Lemma (see [2]). *Let $f\colon M \to N$ be a K-equivariant C^∞ map between C^∞ K-manifolds, where K is a compact Lie group. Then there exists an open neighborhood $\mathcal{N}$ of $f|U$ in $\mathrm{C}^{\infty,K}_{\mathrm{vS}}(U,N)$ such that the following holds: If $h \in \mathcal{N}$ and we define $E(h)\colon M \to N$ by*

$$E(h)(x) = \begin{cases} h(x), & x \in U \\ f(x), & x \in M - U, \end{cases}$$

then $E(h)$ is a K-equivariant C^∞ map. Furthermore $E\colon \mathcal{N} \to \mathrm{C}^{\infty,K}_{\mathrm{vS}}(M,N)$, $h \mapsto E(h)$, is continuous.

[1] S. Illman, *Every proper smooth action of a Lie group is equivalent to a real analytic action: a contribution to Hilbert's fifth problem*, Ann. Math. Stud. **138** (1995), 189–220.

[2] S. Illman, *The very-strong C^∞ topology on $\mathrm{C}^\infty(M,N)$ and K-equivariant maps*, Osaka J. Math. **40** (2003), 409–428.

James Keesling *University of Florida* Inverse Limits of Tent Maps

abstract It has been a long-standing problem to classify the inverse limits of the form (I, f_s) where f_s is a member of the tent family, $f_s(x) = \min\{s \cdot x, s \cdot (1-x)\}$ $1 \leq s \leq 2$. Let f_s and f_t both be tent maps having turning point periodic. Lois Kailhofer has shown that in this case (I, f_s) is homeomorphic to (I, f_t) if and only if $s = t$.

In joint work with Louis Block, Slagjana Jakimovic, and Louis Kailhofer we have given a shorter proof of this result. The proof also shows that certain homeomorphisms are isotopic to a power of the shift map on the inverse limit space $\sigma^k_{f_s} : (I, f_s) \to (I, f_s)$ for some $k \in Z$. In particular, it is shown that if $h : (I, f_s) \to (I, f_s)$ is any homeomorphism, then for some $n = 0, 1, 2, \ldots$ h^n is isotopic to some $\sigma^k_{f_s}$. It is likely, but still remains open whether every homeomorphism h is isotopic to some $\sigma^k_{f_s}$.

The general inverse limit problem remains. It is conjectured that (I, f_s) being homeomorphic to (I, f_t) implies that $s = t$ without assuming that the turning points of f_s and f_t are periodic. The techniques developed in the new proof of

Kailhofer's theorem suggest an approach to proving this general problem. We will discuss the progress being made in this direction.

Akira Koyama *Shizuoka University* Contractible polyhedra which are not embedded into the product of any graphs

abstract We have discussed several n-dimensional compacta which are not embedded into the product of any n 1-dimensional compacta. Then we represented criterions by words of cohomology groups. Thereby we did not use any geometric property and required relatively strong cohomological properties. Here we are discussing a class of manifold-like n-dimensional compacta which are not embedded into the product of any n 1-dimensional compacta. As its consequnece we show the existence of 2-dimensional contractible polyhedra which are not embedded in the product of two any graphs.

References

1. J. Dydak and A. Koyama, Compacta not embeddable into Cartesian products of curves, Bull. Acad. Polish. Sci. Math. 48(1)(2000), 51–56.
2. A. Koyama, J. Krasinkiewicz and S. Spież, On embeddings of compacta into products of curves, preprint.

F. William Lawvere *SUNY Buffalo* from bernoulli to Euler, guided by Volterra and Hurewicz

abstract A contravariant functor of structure (such as open or closed sets, continuous or smooth complex functions, etc.) is an important derived structure of categories $\mathcal{C}$ of cohesion (such as continuous, smooth, or combinatorial spaces). However, such cannot be the fundamental structure if $\mathcal{C}$ is to satisfy the elementary feature of general exponentiation, as required by Bernoulli and most later practitioners of the calculus of variations, made more explicit by Volterra and Hadamard. Bernoulli's principle that a functional $Y^X \to R$ is analytic (or continuous, or...) iff it is so when composed with any similar parameterized figure (curve, sequence, ...) permits reduction of the analysis to manageable types, namely to functions on $X \times P$ with P a parameterizer. Thus, as Hurewicz clarified with his definition of k-spaces, the basic structure of a suitable category needs to be a covariant one such as "P-shaped figures" $\mathcal{C}(\mathcal{P}, -)$ in order to achieve the needed exponential law. Of course, once geometric structure $\mathcal{C}(\mathcal{P}, -)$ has been specified for value spaces such as $R =$ Sierpinski space or $R =$ the complex plane, then derived algebraic structure can also be contravariantly defined for general spaces X in terms of P-natural maps $\mathcal{C}(\mathcal{P}, \mathcal{X}) \longrightarrow \mathcal{C}(\mathcal{P}, \mathcal{R})$. As in algebraic geometry, a small number of function-types R is often coadequate in a larger category of figure-types P which is in turn adequate for a whole exponentially-closed category. Euler's principle, that reals are ratios of infinitesimals, enables pushing this function/figure dialectic one step deeper if we explicitly exploit exponentials of infinitesimal spaces T; the spaces for which every connected component contains exactly one point include among their exponential spaces all R^n.

Fred E.J. Linton *Wesleyan University* An unnatural isomorphism for Real Banach spaces, and allied phenomena. *abstract* If we rotate the real plane about the origin by 45 degrees, and then dilate uniformly in all directions by a factor of $\sqrt{2}$, we realize a linear isometry between the plane with the l_1 norm and the plane with the sup norm. This observation, which is surely not new, seems to susceptible of virtually no generalization whatsoever: the talk will give details of an assortment of attractive-seeming generalization-candidates, and how they fail. One curious positive result comes up amidst the debris of failed candidates: yet another norm-characterization (surely also not new) of the 1-dimensional Banach space.

Luis Montejano *Instituto de Matemáticas. UNAM* Applications of topology to Discrete Geometry

abstract We shall review our work in transversal Theory and Affine configurations of flats. In particual we shall considere the role of the topological ideas in these results.

Manuel Alonso Morón *Universidad Complutense de Madrid* Upper semifinite hyperspaces: A common framework for the computational and the topological treatment of attractors in flows

Abstract In this talk we show how to use the upper semifinite topology in the hyperspace of a compact metric space in oder to describe some shape properties and some fundamentals in computational topology used to study attractors in flows. In particular we study the concept of ε-connectedness used mainly by Vanessa Robins.

Seithuti P. Moshokoa *University of South Africa* Extensions of quasi-uniformly continuous maps

abstract We discuss the problem of extending a quasi-uniformly continuous map $f:(X,d)\to(Y,||.||)$ from a quasi-pseudo metric space into a biBanach space to (X^*,e) a bicompletion of (X,d). We introduce a class of maps which preserves d^*-Cauchy sequences and present a result concerning extensions of these maps. Our result extends the Classical result concerning extensions of uniformly continuous maps between metric spaces.

Carlos Prieto *IMUNAM* Transfers for ramified coverings and equivariant homology and cohomology (jt. with M. Aguilar)

abstract We define a transfer in homology and cohomology for ramified covering maps and use it to prove some results on the homomorphisms induced by orbit maps of actions of finite groups.

Taras Radul *Universidad de los Andes, Colombia* On the transfinite extension of asymptotical inductive dimension

abstract Asymptotic dimension theory was founded by M.Gromov for studying invariants of discrete groups [1]. A.Dranishnikov has introduced the asymptotic inductive dimension $asInd$ [2]. M.Zarichnyi proposed consider the transfinite extension $trasInd$ of $asInd$ analogically to the transfinite extension of the usual inductive dimension. We prove that this extension is trivial, more exactly:

Theorem If there exists $trasIndX$ for some metric proper space X then $trasIndX<\omega$.

M.Gromov. Asymptotic Invariants of Infinite Groups, Geometric Group Theory. v.2. Cambrige Univ. Press, 199

A.Dranishnikov. On Asymptotic Inductive Dimension. JP Jour. Geometry and Topology, 2001, 1, 239–247.

Leonard R. Rubin *University of Oklahoma* Resolutions in Extension Theory

abstract The talk will deal with the theory of resolutions in extension theory. The first in this class of results was the Edwards-Walsh resolution theorem that was proved by John Walsh in 1981: If X is a metrizable compactum with $\dim_Z X \leq n$, then there exist a metrizable compactum Z with $\dim Z \leq n$ and a cell-like map π of Z onto X. This became an important step in A. Dranishnikov's affirmative answer to the Alexandroff question of whether a metrizable compactum simultaneously could be of infinite dimension and finite integral cohomological dimension.

After Walsh's publication, many other authors considered aspects of the question of resolutions, either in different classes of spaces, with respect to cohomological dimension for groups different from Z, or finally with respect to extension theory. Our presentation will attempt to trace these steps and at the end to indicate some of the most recent advances in this area.

Francisco R. Ruiz del Portal *Universidad Complutense de Madrid* A Poincaré formula for the fixed point index of homeomorphisms of surfaces

abstract Let $U \subset \mathbb{R}^2$ be an open subset and let $f : U \to \mathbb{R}^2$ be an arbitrary local homeomorphism such that $Fix(f^n) = \{p\}$ for every $n \in \mathbb{N}$. We compute geometrically the fixed point index of f^n at p, $i(f^n, p)$, in terms of the stable/unstable manifolds and the Leau-Fatou petals around p. We obtain in this way a sort of Poincaré formula without differentiability assumptions.

Jose M. R. Sanjurjo *Universidad Complutense (Madrid)* The Hopf bifurcation and shape theory

abstract The subject of the Hopf bifurcation had its origins in the work of Poincaré and since then it has been extensively studied by many authors, including Andronov. Hopf's fundamental contributions appeared in 1942. The Hopf bifurcation is originally related to the development of periodic orbits from a stable fixed point of a flow defined in the plane or in the Euclidean space. There is a richness of topological features in this theory making it specially suited to be studied with the techniques of geometric topology. We use, in particular, shape theory to study bifurcations of flows in manifolds and the global properties of some stable subsets which appear naturally in this context.

E.D.Tymchatyn *University of Saskatchewan* Simultaneous Extensions of Metrics

abstract by E.D.Tymchatyn and A.Zagorodnyuk We consider the problem of continuous simultaneous extension of partial (pseudo-)metrics on a metric space X. If X is also compact then such extensions exist (Tymchatyn-Zarichnyi,2004).

Theorem Let X be a metric space. There exists a continuous extension operator from the metric space of all Lipschitz equivalent partial pseudo-metrics on X to the space of all pseudo-metrics on X.

Alberto Verjovski *IMUNAM* On the moduli space of certain smooth codimension one foliations of the 5-sphere by complex surfaces

abstract In this talk, I will talk about recent joint work with Laurent Meersseman (Université de Rennes I).

I will first describe the set of all possible integrable CR-structures on the smooth foliation of $\mathbb{S}^{\ntrianglelefteq}$ constructed in [1]. I will give a specific concrete model of each of these structures. I wll show that this set can be naturally identified with $\mathbb{C} \times \mathbb{C} \times \mathbb{C}$.

Adapting the classical notions of coarse and fine moduli space to the case of a foliation by complex manifolds, I will indicate the prooof that the previous set, identified with $\mathbb{C}^{\#}$, defines a coarse moduli space for the foliation of [1], but that it does not have a fine moduli space. Finally, using the same ideas I will also indicate why the standard Lawson foliation on the 5-sphere can be endowed with CR-structures but none of these is integrable.

[1] L. Meersseman and A. Verjovsky. A smooth foliation of the 5-sphere by complex surfaces. Ann. of Math. 156 (2002), 915–930.

Tatsuhiko Yagasaki *Kyoto Institute of Technology* Homotopy types of spaces of embeddings of compact polyhedra into 2-manifolds

abstract The homotopy type of connected component of homeomorphism groups of connected 2-manifolds have been classified by M. E. Hamstrom, G. P. Scott et al. in the compact case and by the author in the noncompact case. In this talk we consider the problem of classifying the homotopy type of connected components of spaces of embeddings of compact connected polyhedra into 2-manifolds. Suppose M is a connected 2-manifold and X is a compact connected subpolyhedron of M with respect to some triangulation of M. Let $\mathcal{E}(X, M)$ denote the space of topological embeddings of X into M with the compact-open topology and let $\mathcal{E}(X, M)_0$ denote the connected component of the inclusion $i_X : X \subset M$ in $\mathcal{E}(X, M)$. We will describe the homotopy type of $\mathcal{E}(X, M)_0$ in terms of the subgroup $i_{X*}\pi_1(X) = \mathrm{Im}[i_{X*} : \pi_1(X) \to \pi_1(M)]$. If X is a point of M then $\mathcal{E}(X, M) \cong M$, and if X is a closed 2-manifold then $X = M$ and $\mathcal{E}(X, M)_0$ coincides with the identity component of homeomorphism groups of M. Below we assume that X *is neither a point nor a closed 2-manifold.*

Suppose $i_{X*}\pi_1(X)$ is not a cyclic subgroup of $\pi_1(M)$.

(1) $\mathcal{E}(X, M)_0 \simeq *$ if $M \not\cong \mathbb{T}^2, \mathbb{K}^2$.
(2) $\mathcal{E}(X, M)_0 \simeq \mathbb{T}^2$ if $M \cong \mathbb{T}^2$.
(3) $\mathcal{E}(X, M)_0 \simeq \mathbb{S}^1$ if $M \cong \mathbb{K}^2$.

Suppose $i_{X*}\pi_1(X)$ is a nontrivial cyclic subgroup of $\pi_1(M)$.

(1) $\mathcal{E}(X, M)_0 \simeq \mathbb{S}^1$ if $M \not\cong \mathbb{P}^2, \mathbb{T}^2, \mathbb{K}^2$.
(2) $\mathcal{E}(X, M)_0 \simeq \mathbb{T}^2$ if $M \cong \mathbb{T}^2$.
(3) Suppose $M \cong \mathbb{K}^2$.
  (i) $\mathcal{E}(X, M)_0 \simeq \mathbb{T}^2$ if X is contained in an annulus which does not separate M.
  (ii) $\mathcal{E}(X, M)_0 \simeq \mathbb{S}^1$ otherwise.
(4) Suppose $M \cong \mathbb{P}^2$.
  (i) $\mathcal{E}(X, M)_0 \simeq SO(3)/\mathbb{Z}_2$ if X is an orientation reversing circle in M.
  (ii) $\mathcal{E}(X, M)_0 \simeq SO(3)$ otherwise.

Here $\mathbb{S}^1$ is the circle, $\mathbb{T}^2$ is the torus, $\mathbb{P}^2$ is the projective plane and $\mathbb{K}^2$ is the Klein bottle. Finally consider the case where X is null homotopic in M. We choose a Riemannian manifold structure on M and denote by $S(TM)$ the unit circle bundle of the tangent bundle TM. When M is nonorientable, $\tilde{M}$ denotes the orientable double cover of M. *Suppose $i_{X*}\pi_1(X) = 1$ (i.e., $X \simeq *$ in M).*

(1) $\mathcal{E}(X, M)_0 \simeq S(TM)$ if X is an arc or M is orientable.
(2) $\mathcal{E}(X, M)_0 \simeq S(T\tilde{M})$ if X is not an arc and M is nonorientable.

Since $\mathcal{E}(X, M)$ is a topological ℓ^2-manifold, the topological type of $\mathcal{E}(X, M)_0$ is determined by the homotopy type of $\mathcal{E}(X, M)_0$.