微分トポロジー便り　第1号

1989年7月

1986年から1988年の3年間に「Topology of symplectic manifold」の研究集会（科研費総合Aトポロジーによる）を開催しました。この間，いろんな方々からこの分野の研究の大切さを示唆されましたが，研究者間の連絡等がまだうまくいっているように思えません。それで，情報伝達のひとつにとこのようなものを作ることにしました。みなさまの協力をお願いします。微分トポロジー関係のプレプリント等をもっている方はそのリストをお知らせ下さい。随想，独断・偏見等ものせたいと思っておりますのでお知らせ下さい。

シンポジウムの予告

「古典力学・量子力学とトポロジー」研究集会
（分担責任者　佐藤肇　）

日時；11月はじめから12月はじめまでの都合のよいとき
場所；名古屋近辺

この会に参加を希望する人，講演者の自薦・他薦等々は佐藤肇氏（名大・教養部）に連絡して下さい。

プレプリント

以下はバークレーのMSRIに滞在中の小沢哲也氏(名大・理)より送られてきたものです。

Y. Eliashberg : Existence and non-existence of a Stein complex structure on differentiable manifolds.

―――――― : On symplectic manifolds which are bounded by standard contact spheres and exotic contact structures on spheres of dimension > 3

C. Viterbo : A new obstruction to embedding Lagrangian Torii.

A. Weinstein : Blowing up realizations of Heisenberg-Poisson manifolds.

J. Huebschmann : Poisson cohomology and quantization.

H.W. Hofer and E. Zehnder : A new capacity for symplectic manifolds.

C. Viterbo : Capacites symplectiques et applications

小沢哲也氏（名大・理，1989年7月1日バークレーより帰国）からバークレーでのセミナーの様子を書いたものがとどきました。（1989年2月～6月の様子）

⋮

Eliashberg（2月6日）：symplectic manifold上のStein構造の存在とcontact typeのboundaryをもつsymplectic manifoldについての話。symplectic manifold X 上のalmost complex structure J に関し，X 上のproperな関数で，J-pluri subharmonicなもののlevel surfaceの性質（pseudo convexity等）を使い両者を同時進行的に扱う。2つのStein構造がいつ同値になるか。Stein symplectic manifold内のsubset Ω がpseudo convex boundaryをもつとき Ω はstrongly contact typeか．等を論じた。

Sikorav（2月17日）：次を示した。（$\approx$ はsymplectomorphic）

<u>定理</u>　$U, V \subset \mathbb{R}^n$ に対し

$$T^n \times U \approx T^n \times V \iff \exists A \in GL(n, \mathbb{Z}),\ b \in \mathbb{R}^n \quad \text{s.t.}\ V = AU + b$$

（symplectic structuresはすべてstandard）。

<u>Conj.</u>　$B^n \times U \approx B^n \times V \overset{?}{\iff} \exists A \in O(n),\ b \in \mathbb{R}^n$

（$B^n \subset \mathbb{R}^n$ はball）　　s.t. $V = AU + b$

<u>Question.</u>　$\exists ?$　∞-dimensional family $\{U \subset \mathbb{R}^n\}$

s.t. all U's are not $\approx$.

<u>Conj.</u>　Σ : Riemann surface genus > 1,

g : metric on Σ with $K_g < 0$

$U(g)$: open unit disc bundle

$U(g) \approx U(g') \overset{?}{\iff} g \simeq g'$ isom.

Giveutal（4月24日）：classicalなMaslov indexは有限次元のLagrange Grassmanianの1^{st} cohomologyに関連していたが"non-linear" Maslov indexを定義するため，$\mathbb{C}P^n$内でreal section $\mathbb{R}P^n$とHamiltonian conjugateなLagrange submanifolds全体の空間を考え，その1^{st} cohomologyの1つのgeneratorを幾何的に構成した。

Arnold（5月1日）：$\mathbb{R}$上のμ次多項式全体からA_k以上のsingularityをもつものを除いた空間を$X(\mu, k)$とするとき$X(\mu, k)$のPoincaré polynomial $\xrightarrow[\mu\to\infty]{} \dfrac{1}{1-t^{k-1}}$。

その他，wildなsingularityをもつ関数のなす空間のtopologyについての話。

Marle（5月19日）：KirillovとLichnerowiczにより別々に導入された"Jacobi manifold"（関数空間上にLie bracketがdiff. operatorで定義されていて，必ずしもderivationになっていないもの）についての解説。 更にJacobi bundle（bundleのsection全体の上のbracket structure）とhomogeneous Poisson manifoldとの関係，更に特別な場合としてWeinsteinのHeisenberg Poisson manifoldのblowing upが扱えることを述べた。

Tuynman (with Gotay)（5月26日）：$(\mathbb{R}^{2n}, \omega_0)$（$\omega_0$はstandard symplectic form）は，reductionを通して，次の意味でuniversalであることを示した。 $(\mathbb{R}^{2n}, \omega_0)$のsubmanifold Xで，$\omega_0|_X$のcharacteristic foliationがconstant rankなら，$X/_{\text{char. fol.}(\omega_0|_X)}$はsymplectic manifoldになるが，ほとんどすべてのsymplectic manifold (X,ω) はこのようにして得られる。ここで、"ほとんど"の意味は $[\omega] \in H^2_{deR}(X)$ が $H^2(X;\mathbb{Z})$ の有限個の元の線形結合で書けることを要求している。

Patissier (6月2日): symplectic vector bundle に対して定義される Maslov class $\in H^2_{\check{C}ech}$ の復習と geometric quantization への応用に関する Maslov の仕事の紹介。(Russian Math. Survey vol. 39 (1984) no. 6)

Fathi (6月7日): Teichmuller space 上の symplectic geometry についての Wolpert の仕事の紹介。
6月9日にも Riemann 面上の measured foliation に関する Thurston の仕事の紹介をした。

Fomenko (6月15日): 4次元 symplectic manifold 上の integrable な Hamiltonian 系の topology に関する仕事 (Hamiltonian の level surface の topology) の紹介。(Funct. Analy. '88, Uspech Nauch '89).

バークレーにおけるシュド・ロダニアン・セミナーと
ハミルトン系幾何学研究集会に出席して

北大・理学部　　鈴　木　治　夫

表題の２つの研究集会はバークレーＭＳＲＩ（数理科学研究所）１９８８－８９、シンプレクテイク幾何学研究計画の行事として行なわれたものである。双方互いに関連する問題が少なくなかったが、前者はシンプレクテイク構造、後者はハミルトン系を主題としており、参加者にも相異があったので別々にその様子を述べる。

シュド・ロダニアン・セミナーは主としてフランスの幾何学者によって構成されるセミナーで毎年定期的に行なわれている伝統的な研究集会であるが、本年はＭＳＲＩと共同で５月２２日から６月２日までの間バークレーで開催された。参加者は約７５名であった。主な内容として（１）ポアソン多様体の積分、（２）ハイゼンバーグ亜群による量子論から古典極限への移行過程の構成、（３）特異葉をもつ葉層のホロノミー亜群と C^*-環、（４）完全可積分系の幾何学、（５）シンプレクテイク多様体のマスロフ量子化、（６）ラグランジュはめ込み写像に対する特性類等があげられる。私は（３）の部分を担当した。なんらかの理由で亜群に関係する講演が半数近くを占めた。講演者は正規シュド・ロダニアン研究者とＭＳＲＩ所属研究者から成り、それにハミルトン系の研究者も加わっていた。

１日に３つか４つの講演があり、講演の合間はコーヒーを飲みながら討論したり、時には論文作成のためワープロ室に入って仕事をした。S.S.Chern 先生は研究所創設者として永久研究室を持っておられ休憩時間にお話することができた。５月３１日、私と小沢氏はマンダリン・ガーデンという中華レストランで Chern 先生から書食のおもてなしを受けた。このとき幾何学とは何かという話が出た。そういう論説を書いておられるとのことである。なお Complex manifolds without potential theory の改定版がでる予定で Appendix にはゲージ理論、弦理論等最近の話題が追加されるそうである。ほかに外微分形式についての６００頁程の大著の原稿が出来上がったということである。

私のホテルには殆どのシュド・ロダニアン研究者が宿泊していて、２週間朝食時毎回誰かと顔を合わせていたので終わりの頃はだいぶん親しくなった。一方研究所の同室者はハミルトン系幾何学に来ていた数理物理学者で、講演の内容の物理学に関係する部分についての知識を得るのに有益であった。日本からの参加者は私の他上記小沢哲也氏（名古屋大学）、竹井義次氏（京都大学）であった。

参考までに講演者名と、題目のリストを添えておく。

Séminaire Sud Rhodanien de Géometrie à Berkeley
Mathematical Sciences Research Institute
May 22-June 2, 1989

List of Speakers

· C. Albert (Montpellier): *Symplectic groupoids*

· M. Boucetta and P. Molino (Montpellier): *Geometry of completely integrable systems*
· M. Boyom (Montpellier): *Invariant affine structures on Lie groups and symplectic geometry*
· A. Coste and D. Sondaz (Lyon): *Lie algebroids and affine Poisson structures on groups*
· P. Dazord (Lyon): *Obstructions to the integration of Poisson manifolds*
· N. Desolnux-Moulis (Lyon): *Lagrangian foliations*
· Y. Eliashberg (MSRI, Stanford): *Towards a definition of symplectic boundary*
· Z. Ge (MSRI, Beijing): *Symplectic groupoids and Hamilton-Jacobi theory*
· M. Gotay (MSRI, USNA) and G. Tuynman (MSRI, Marseille): $\mathbf{R}^{2n}$ *is a universal symplectic manifold for reduction*
· G. Hector (Lyon): *Symplectic realizations*
· R. Lashof (Berkeley): *Equivariant prequantization*
· J.H. Lu (Berkeley): *Symplectic double groupoids and Poisson Lie groups*
· A. Medina (Montpellier): *Poisson structures on Lie groups*
· R. Montgomery (MSRI, Berleley): *Optimization with fixed holonomy*
· J.M. Morvan (Lyon) and L. Niglio (Avignon): *Characteristic classes of a lagrangian immersion*
· Y.G. Oh (MSRI, NYU): *Stability of minimal lagrangian submanifolds*
· G. Patissier (Lyon): *Quantization of a symplectic manifold according to Malsov*
· T. Ratiu (MSRI, Santa Cruz): *The compact Toda lattice*
· A. Sheu (MSRI, Kansas): *The C^* algebra of a singular foliation*
· H. Suzuki (MSRI, Hokkaido): *Holonomy groupoids of generalized foliations*
· A. Weinstein (MSRI, Berkeley): *Heisenberg groupoids*
· P. Xu (Berkeley): *Morita equivalence of Poisson manifolds*
· Y. Kerbrat (Lyon): *Berry's Phase*

ハミルトン系幾何学研究集会はＭＳＲＩシンプレクテイク幾何学研究計画の最終行事とみられる集会で、シュド・ロダニアン・セミナーに引続き、６月５日から６月１６日までの間開催された。参加者は１１６名で内容は幾何学的なものの他にハミルトン系方程式の解の挙動、近似に関するもの、コンピューターによる図示等があり、さらに日によっては予定プログラム終了後、セミナー形式による３０～４０分講演が２～３件追加された。私の関心を引いた講演として１）ドレシング変換、２）ハミルトン系エネルギー曲面の幾何学、３）剛体対の力学と幾何学、４）ニュートン系における非衝突特異点、５）タイヒミュラー空間のシンプレクテイク構造等をあげておく。他にも力学系の優れた講演があり、正規講演者数は２２であった。
１）は従来のドレシング変換について、その存在が必ずしも言えないので、２重亜群の方法により理論の構成をはかるもの (Prof.Weinstein)。２）はコンパクト４次元多様体上のハミルトン系に対応するエネルギー曲面をグラフ理論によって完全に分類したもので、その対応は、化学分子式表示の類似を想定している (Prof.Fomenko)。３）はベリ接続の理論に基づいて剛体対の力学を幾何学的に構成するもので、この理論が、量子化問題だけでなく、古典力学でも威力を発揮することを力説したものである (Prof.Marsden)。
日本からの参加者は私の他、吉田春男氏（東京天文台）伊藤秀一氏（東北大学）中村佳正氏（岐阜大学）小沢哲也氏（名古屋大学）武井義次氏（京都大学）であった。私のホテルには

Prof.Fomenko が宿泊していて、研究所の往復途中一緒になることがあり、講演内容などについて質問する機会にめぐまれた。

手許にある最近の PREPRINTS

鈴木　治夫

L. A. Cordero, M. Fernández and A. Gray, *The Frölicher spectral sequence for compact nilmanifolds.*

L. A. Cordero, M. Fernández and A. Gray, *Compact symplectic manifolds not admitting positive definite Kähler metrics.*

J. Eckeland and H. Hopfer, *Symplectic topology and Hamiltonian dynamics.*

J. Hanad and S. Shnider, *Supersymmetric Yang-Mills theory in ten dimensions and the super twistor correspondence.*

N. Salinas, A. Shue and H. Upmeier, *Toeplitz operators on pseudo-convex domains and foliation C^*-algebras.*

J. Stasheff, *Homological reduction of constrained Poisson algebras.*

A. Weinstein, *Cohomology of symplectomorphism groups and critical values of Hamiltonians.*

A. Floer の論文リスト【小野薫（東北大・理）】

- Proof of the Arnold conjecture for surfaces and generalizations to certain Kähler manifolds,
  Duke Math. J. 53 1〜32 (1986)
- (with E. Zehnder) Fixed point results for symplectic maps related to the Arnold conjecture,
  Lect. Notes in Math. 1125 Dynamical systems and Bifurcations, Proceedings, Göttingen 1984, Ed. by Braaksma, Broer, Takens, 47-63
- A refinement of the Conley index and an application to the stability of hyperbolic invariant sets,
  Ergodic Theory and Dynamical Systems, 7, 93-103 (1987)
- (with E. Zehnder) The equivariant Conley index and bifurcations of periodic solutions of Hamiltonian systems,
  Ergodic Theory and Dynamical Systems, 8 (C. Conley memorial volume) 87-97 (1988)
- A relative Morse index for the symplectic action
  Comm. Pure and Appl. Math XLI 393-407 (1988)
- The Unregularized gradient flow of the symplectic action
  Comm. Pure and Appl. Math XLI 775-813 (1988)
- Morse theory for Lagrangian intersections,
  J. D. G. 28 513-547 (1988)

- An instanton-invariant for 3-manifolds,
  Comm. Math. Phys 118 215 – 240 (1988)
- Symplectic fixed points and holomorphic spheres.
  Comm. Math. Phys. 120 575 – 611 (1989)

以下は preprint です.

- Cup-length estimates for Lagrangian intersections
- Witten's complex for arbitrary coefficients and an application to Lagrangian intersections
- Construction of monopoles on asymptotically flat manifolds
- Self dual conformal structures on $l\mathbb{CP}^2$
- The configuration space of Yang-Mills-Higgs theory on asymptotically flat manifolds
- (with H. Hofer, C. Viterbo) The Weinstein conjecture in $P \times \mathbb{C}^l$, (MSRI preprint 00824-89)

- Monopoles on asymptotically Euclidean 3-manifolds, Bull. AMS. 16 (1987) 125 – 127
- Morse theory for fixed points of symplectic diffeomorphisms, Bull. AMS. 16 (1987) 279 – 281

Holomorphic vector fieldsに関する文献 [伊藤敏和（龍大・経）]

この部門は教祖 C. Camacho の一族 A. L. Neto, P. Sad（ブラジルのIMPA）とフランスの J.F. Mattei（Toulouse大学）, R. Moussu, D. Cérveau, R. Roussarie（Dijon大学）, A. Haefliger（Genève大学）, そして, idea, 馬力ともにすぐれているメキシコ大学の X. Gómez-Mont の小さな集団のようです。日本でこの部門を研究する人がでてきてほしいと願って, 文献表を作りました。

（ブラジルのグループ）

① C. Camacho, N.H. Kuiper and J. Palis : The topology of holomorphic flows with singularity, Publ. Math. I.H.E.S., 48(1978) 5−38.

② C. Camacho and P. Sad : Invariant varieties through singularities of holomorphic vector fields, Ann. of Math. 115 (1982) 579−595.

③ C. Camacho, A.L. Neto and P. Sad : Topological invariants and equidesingularization for holomorphic vector fields, J. Diff. Geometry 20 (1984) 143−174.

④ A.L. Neto : Construction of singular holomorphic vector fields and foliations in dimension two, J. Diff. Geometry 26 (1987) 1−31.

（フランスのグループ）

⑤ J.F. Mattei and R. Moussu : Holonomie et intégrales premières, Ann. Sci. École Norm. Sup. 13 (1980) 469−523.

⑥ A. Haefliger : Deformations of transversely holomorphic flows on spheres and deformations of Hopf manifolds, Compositio Math. 55 (1985) 241−251.

（メキシコ）
⑦ X. Gómez-Mont : Transverse deformations of holomorphic foliations, Contem. Math. 58 (1985) 127-139.
⑧ ――――― : The transverse dynamics of a holomorphic flows, Ann. of Math. 127 (1988) 49-92.
⑨ ――――― : Holomorphic foliations in ruled surfaces, Transactions A.M.S. 312 (1989) 179-202.
⑩ Mexicoで1986年の夏にあった国際的な研究集会の報告集（X. Gómez-Montが編集者になっている）がSpringerのLecture Notes No. 1345「Holomorphic Dynamics」に出ている。

編集後記

足立先生主催の"微分トポロジーセミナー"のメンバーが中心になってこのようなものを作りました。多数の方々の協力と助言のもとに第1号ができあがりました。この便りへの御意見・御批判等がいただけるとありがたいです。

プレプリント，研究集会等の情報がありましたら御連絡ください。

第1号の編集責任は伊藤敏和です。

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Hassler Whitney

Hassler Whitney, Professor Emeritus at the Institute for Advanced Study in Princeton at the time of his death, died in Princeton on Wednesday, May 10 at the age of 82 of a massive stroke suffered two weeks earlier.

Hassler Whitney was a leading world figure in mathematics of this century, and the influence of his ideas has been pervasive and profound. In over 75 mathematical papers and 2 graduate-level texts, he made major contributions to graph theory, differential topology, vector bundles and characteristic classes, cohomology, analytic varieties, geometric measure theory, and singularity theory. For the past 20 years, Whitney has intensively pursued an interest in mathematics education, and he became widely known as a prophet on educational issues, and was President of the International Commission on Mathematics Education from 1979 to 1982.

Throughout his life, Whitney was avidly involved in music and in climbing. Whitney earned two Baccalaureate degrees from Yale in physics in 1928, and in music in 1929. He earned a Ph.D. in mathematics from Harvard in 1932, where he taught until 1952, when he was appointed Professor at the Institute for Advanced Study in Princeton. He played the violin, viola, and piano; he was concert master of the Princeton Community Orchestra, and played regularly with the Princeton Society of Musical Amateurs. Hassler Whitney went on many mountaineering trips until the end of his life, and he was especially fond of climbing the high peaks in the Swiss Alps. He was a member of the Swiss Alpine Club and the American Alpine Club. With his cousin, Bradley Gilman, he established the Whitney-Gilman Route on Cannon Mountain in New Hampshire. He was an active man until the end, running between six and twelve miles every other day.

Whitney was a pioneer in topology, an important field of modern mathematics. Topology is the theory of geometric figures in any number of dimensions, and the analysis of continous deformations of them and continuous maps between them.

The four-color map conjecture is an example of a question in topology which is easy to visualize. Given a map of the earth, divided arbitrarily into countries, is it possible to color the countries with only four colors so that any two countries which share a border have different colors? This question is topological because it does not depend on the exact shape of the countries, but only on their arrangement. It was finally solved in 1977, by W. Haken and K. Appel using massive computer assistance, after about 100 years of attention from many mathematicians. Some of Whitney's earliest work, in graph theory around 1931-33, was inspired by this question. Among other things, Whitney showed that, with very mild assumptions, it is possible to design a tour of the earth which visits each country once and only once (a

Hamiltonian cycle).

This was a period when topology was rapidly maturing, and Whitney soon moved on to more general kinds of topology, the topology of multi-dimensional surfaces or manifolds in multi-dimensional spaces. Such surfaces may be defined by mathematical equations, but in dealing with them, a mathematician does not try to enumerate all solutions any more than an artist tries to represent every single hair on a head: mathematicians seek to elucidate the qualitative properties of manifolds.

The Whitney embedding theorem was an important conceptual advance in the understanding of manifolds, tying together the intrinsic and the extrinsic definitions of a manifold. The intrinsic mathematical definition of a manifold does not actually depend on having the manifold in ordinary m-space, any more than the definition of a zebra depends on its being in a certain cage in the zoo. However, Whitney proved that every possible n-dimensional manifold actually occurs as a surface in m-dimensional space, if m is sufficiently high. Whitney eventually showed that every n-dimensional manifold can be embedded in $2n$-space. The Whitney trick which he introduced in this proof is still a standard tool of topologists.

Whitney was one of the founders and early proponents of the theory of cohomology. He, along with the E. Čech, invented the first clear and correct definitions of the cup product in cohomology. Whitney was a pioneer in the introduction of vector bundles and sphere bundles as a tool in the solution of topological problems. Stiefel-Whitney classes, which are important invariants of vector bundles, were discovered by Whitney and E. Stiefel around 1935.

Whitney was interested in properties of differentiable functions through most of his career, and his ideas were instrumental in the development of the field of differential topology. This interest led into his work on the theory of analytic varieties. Along with the French mathematician Renè Thom, Whitney pioneered the theory of singularities, another important area of modern mathematics. Whitney established that the generic singularities of maps from the plane to the plane are folds and cusps. Whitney introduced many ideas and techniques which had an important influence on the work of J. Mather and V. Arnold in this field, and continue in importance today.

Hassler Whitney was born on March 23, 1907, in New York City. Professor Whitney was the winner of many awards, including the National Medal of Science in 1976, the Wolf Prize in 1982, and the Steele Prize in 1985. He was a member of the National Academy of Sciences, as well as the American Mathematical Society, the National Council of Teachers of Mathematics, the American Philosophical Society, and the Swiss Mathematical Society (honorary).

Education

Professor Whitney was intensely concerned with the failure of our educational system in mathematics, and during the past 20 years he pursued this concern intensively, particularly on the elementary school level. A great deal of public attention has lately been focused on failures in the mathematical education system; Whitney felt the problem cannot be remedied just by increasing the amount of time students spend on mathematics. In fact, this only increases their mathematics anxiety. He also believed that requiring higher scores on narrow standardized tests does not motivate students to perform better.

Whitney attributed the failure largely to a system which excludes the student. Whitney pointed out that young children have an amazing natural intelligence, and a very active curiosity. Their natural and intuitive ways of thinking are akin to the ways that mathematicians work. However, throughout school mathematics they are confronted with a series of numerous and narrow 'objectives' presented in language that has no meaning to the children, teachers, parents, or even to mathematicians.

He was concerned that children are given many problems in fixed patterns, which they learn to do by following an example rather than by thinking it out for themselves. The result is that by the end of their schooling, most students have learned not to think when they see a mathematics problem. When they see a statement about mathematics, they immediately react to it either by freezing up from math anxiety, or treating it as if it were one more rule-based homework problem, 'when you see this, you do that', rather than as something to think about, no calculation necessary.

Rather than telling the children how to do things, Whitney would listen to how the children think about problems based on their experience. For instance, children who have failed to catch on to subtraction in school are nevertheless good at making change out of a dollar. Whitney would help them observe what they did in making change to gain confidence and understand what they are doing when they subtract two numbers.

Whitney saw the system of testing, and the external standards imposed by state and local boards, as one of the main causes of failure. He felt that teachers do not have the freedom to teach mathematics in a natural way, because they are under intense pressure to raise scores on very narrowly defined and misconceived tests.

Family

Hassler Whitney's contributions to world knowledge were in the tradition of his family. He was the grandson of Simon Newcomb, the famous astronomer, and the great great grandson of Ferdinand Hassler who was commissioned by Thomas Jefferson to survey the Atlantic coastline. Under Hassler's direction, a safe entrance to New York Harbor was discovered. Whitney was the the great nephew of Josiah Dwight Whitney, who first surveyed Mount Whitney and grandson of William Dwight Whitney, a prominent linguist and scholar of sanscrit. His father Edward Baldwin Whitney was Justice of the Supreme Court of New York, and his mother Josepha Whitney was an artist and active in politics.

He is survived by his wife Barbara Osterman of Princeton New Jersey, a well-known artist, and five children, James Newcomb Whitney of Wellesley Massachusetts and Paris France, Carol Whitney of Victoria B.C., Marian Whitney Melhuish of Wellington New Zealand, Sarah Whitney Thurston of Ithaca New York, and Emily Baldwin Whitney of Eureka California, as well as six grandchildren.

# # #