【RIMS 合宿型セミナー】

① 代表者	所属：	東京女子大学　現代教養学部	副代表者	東北大学　情報科学研究科
	職名：	准教授		准教授
	氏名：	山内　博		島倉　裕樹

② 題　目：ムーンシャインを超えて

(英 文 名：Beyond the Moonshine　　　　　　　　　　　　　　　　　　　　　　　　　)

③ 実施期間：　平成 25 年　　7 月　　8 日〜平成 25 年　　7 月　　12 日（　　5 日間）

④ 参加者数：　　　　　　　26 名　　（内、外国人　　　11 名）

⑤ 講 演 数：　　　　　　19 コマ (内、英語で行なわれたもの　　　19 コマ)

⑥ 合宿型セミナーの概要 (開催目的、成果など)：

　保型形式と散在型有限単純群の間の不思議な関係を定式化したムーンシャイン予想は 1979 年にコンウェイ・ノートンにより提出され、1992 年にボーチャーズにより肯定的に解決された。ムーンシャイン予想の解決から 20 年が経ち、ムーンシャイン予想に関係する共形場理論、無限次元代数の表現論、ベクトル型保型形式、モジュラー圏など種々の理論は互いに影響を与えながら大きく発展した。本研究会はムーンシャイン予想の数学に関係する専門家を集め、最新の研究結果を報告しあうとともに、今後の発展について議論する場を設けることを趣旨として、合宿形式にて開催された。仙台市郊外の山間のホテルを会場とし、期間中はほぼ丸一日このホテルに滞在した。参加者は外国人研究者１１名、日本人研究者１５名（うち４名は学生）であり、講演等はすべて英語で行われ、国際的な研究集会であった。講演中はもとより、朝食時や夕食後のロビーにおいても国内外の参加者が談笑を交えながら数学研究について語り合っており、現存する課題や今後の研究方針などについて活発な議論が行われた。本集会をきっかけとして、いくつかの共同研究も開始されている。合宿形式のメリットを生かすことができ、とてもよい集会だったと参加者からも好評を頂いた。

研究成果の公表方法

⑦　講究録を　　　□ 発行する　　　☑ 発行しない
　　　　※発行する場合：原稿完成予定時期　　　平成　　　　年　　　　月　　　　日頃

⑧　講究録以外の方法で報告集を発行する場合：
　　　　タイトル：
　　　　出 版 社：　　　　　　　　　　　　出版予定時期：平成　　　年　　　月　　　日頃

⑨　専門誌等による場合：
　　　　主要な論文リスト (掲載予定、プレプリントを含む。準備中も可)

　　今回は講究録や専門誌等による研究成果公表はしないが、各講演の題目、概要および集会の詳細は以下のサイト（すべて英文）に公開してある。
　　https://sites.google.com/a/lab.twcu.ac.jp/akiu2013/home
　　今後、本研究集会で得られた知見や研究成果は参加者が個々の論文として発表することとなる。論文中の謝辞等で本研究集会の研究成果への貢献が確認できることと思う。

※２〜３ページ目に合宿型セミナー実施プログラム添付 (Ａ４版)

RIMS Camp-Style Seminar
"Beyond the Moonshine"

This program is supported by RIMS Camp Style Seminar, University of Tsukuba, JPSP Challenging Exploratory Research No. 23654006 and JSPS Grant-in-Aids for Young Researchers (B) No. 24740027.

Organizers: Scott Carnahan (University of Tsukuba)
Ching Hung Lam (Academia Sinica)
Hiroki Shimakura (Tohoku University)
Hiroshi Yamauchi (Tokyo Woman's Christian University)

Date: July 8–12, 2013

Location: Hotel Hananoyu, Sendai 982–0241   TEL:+81–022(397)3141

Program

July 8 (Mon)

9:00 – 10:00   Ching Hung Lam (Academia Sinica)
Weyl groups and VOA generated by Ising vectors

10:30 – 11:30   Hiromichi Yamada (Hitotsubashi University)
A characterization of parafermion vertex operator algebras

(Lunch break)

13:30 – 14:30   Scott Carnahan (University of Tsukuba)
Monstrous Lie Algebras

14:45 – 15:45   Robert L. Griess (University of Michigan)
Thought about finite group theory, VOA theory and moonshine theory

16:00 – 17:00   Free Discussion

July 9 (Tue)

9:00 – 10:00   Hisanori Ohashi (Tokyo University of Science)
Integral points of some elliptic curve via the binary Golay code

10:30 – 11:30   Nils Scheithauer (Technische Universität Darmstadt)
On the classification of automorphic products

(Lunch break)

13:30 – 14:30   John Duncan (Case Western Reserve University)
Umbral Moonshine and the Niemeier Lattices

14:45 – 15:45   Tomoyuki Arakawa (RIMS, Kyoto University)
W-algebras of type A

16:00 – 17:00   Cuipo Jiang (Shanghai Jiao Tong University)
Coset construction of vertex operator algebras

July 10 (Wed)

9:00 – 10:00	Yusuke Arike (University of Tsukuba)
	Fusion products for symplectic fermionnic VOSA
10:30 – 11:30	Terry Gannon (University of Alberta)
	Postcards from the edge
	(Lunch break)
13:30 – 17:00	Free Discussion

July 11 (Thu)

9:00 – 10:00	Masahiko Miyamoto (University of Tsukuba)
	C_2-cofiniteness of cyclic orbifold model
10:30 – 11:30	Dražen Adamović (University of Zagreb)
	On the representation theory of triplet vertex algebras and their orbifold subalgebras
	(Lunch break)
13:30 – 14:30	Geoffrey Mason (University of California, Santa Cruz)
	Modular-invariance, vector-valued modular forms, and hypergeometric series
14:45 – 15:45	Hiroki Shimakura (Tohoku University)
	$\mathbb{Z}_3$-orbifold construction and holomorphic vertex operator algebras of central charge 24
16:00 – 17:00	Chongying Dong (University of California, Santa Cruz)
	Modular vertex operator algebras

July 12 (Fri)

9:00 – 10:00	Kazuya Kawasetsu (The University of Tokyo)
	The intermediate vertex subalgebras of the lattice vertex operator algebras
10:30 – 11:30	Ozren Perše (University of Zagreb)
	Fusion rules and complete reducibility of certain modules for affine Lie algebras
	(Lunch break)
13:00 – 14:00	Hiroshi Yamauchi (Tokyo Woman's Christian University)
	(2A,3A)-generated subalgebras and 3-transposition subgroups on a vertex operator algebra
14:15 – 17:00	Free Discussion

Dražen Adamović (University of Zagreb)

Title: On the representation theory of triplet vertex algebras and their orbifold subalgebras

Abstract: In the first part of this talk I will present our results and constructions on the representation theory of triplet vertex algebras (obtained jointly with A. Milas). Then we shall study orbifold subalgebras of triplet vertex algebras of types A and D. We shall present our results on classification of irreducible modules, C_2–cofiniteness, and the structure of associated Zhu's algebras (obtained jointly with X. Lin and A. Milas). We shall discuss twisted representations needed for studying orbifold subalgebras. Some generalizations will be also presented.

Tomoyuki Arakawa (RIMS, Kyoto University)

Title: W-algebras of type A

Abstract:

Yusuke Arike (University of Tsukuba)

Title: Fusion products for symplectic fermionnic VOSA

Abstract: In this talk we first explain fusion products in the representation category for a VOSA. Then we determine the fusion products of certain modules in the category of (twisted) modules for the symplectic fermionic VOSA.

Scott Carnahan (University of Tsukuba)

Title: Monstrous Lie Algebras

Abstract:

Chongying Dong (University of California, Santa Cruz)

Title: Modular vertex operator algebras

Abstract: This talk will present my joint work with Li Ren on vertex operator algebras associated to the highest weight modules for the Virasoro algebra over any field F whose characteristic is different from 2. The main results consist of two parts:

(1) $L(1/2, 0)$ is a rational vertex operator algebra with three irreducible modules $L(1/2, 0)$, $L(1/2, 1/2)$, $L(1/2, 1/16)$ up to isomorphism if the characteristic is not 7,

(2) $L(1/2, 0)$ has two irreducible modules $L(1/2, 0)$ and $L(1/2, 1/2)$ if the characteristic is 7.

John Duncan (Case Western Reserve Univeristy)

Title: Umbral Moonshine and the Niemeier Lattices

Abstract: In 2010 Eguchi–Ooguri–Tachikawa observed a relationship between the dimensions of representations of the largest Mathieu group and the elliptic genus of a K3 surface. We will explain how this may be regarded as one of a family of observations, each instance corresponding to the root system of a Niemeier lattice.

Terry Gannon (University of Alberta)

Title: Postcards from the edge

Abstract: In my talk I'll sketch some recent theorems and conjectures for VOAs, suggested by work in vector-valued modular forms, subfactors, and modular tensor categories.

Robert L. Griess (University of Michigan)

Title: Thought about finite group theory, VOA theory and moonshine theory

Abstract:

Cuipo Jiang (Shanghai Jiao Tong University)

Title: Coset construction of vertex operator algebras

Abstract: We study a class of vertex operator algebras which come from coset construction. It turns out that these vertex operator algebras are rational. This is a joint work with Zongzhu Lin.

Kazuya Kawasetsu (The University of Tokyo)

Title: The intermediate vertex subalgebras of the lattice vertex operator algebras

Abstract: In this talk, we introduce a notion of intermediate vertex subalgebras of lattice vertex operator algebras, as a generalization of the notion of principal subspaces. We give bases and the graded dimensions of such subalgebras. As an application, we will show that the characters of some modules of an intermediate vertex subalgebra between E_7 and E_8 lattice vertex operator algebras satisfy some modular differential equations. This result is an analogue of the result concerning the "hole" of the Deligne dimension formulas and the intermediate Lie algebra between the simple Lie algebras E_7 and E_8.

Ching Hung Lam (Academia Sinica)

Title: Weyl groups and VOA generated by Ising vectors

Abstract: We construct explicitly some VOA generated by Ising vectors such that the subgroups generated by the corresponding Miyamoto involutions are isomorphic to the Weyl groups of the root system of type A, D and E.

Geoffrey Mason (University of California, Santa Cruz)

Title: Modular-invariance, vector-valued modular forms, and hypergeometric series

Abstract: We consider the role that vector-valued modular forms and differential equations might play in a purely arithmetic proof of the modular-invariance of rational vertex operator algebras. This approach is successful in low dimensions.

Masahiko Miyamoto (University of Tsukuba)

Title: C_2-cofiniteness of cyclic orbifold model

Abstract: We prove the orbifold conjecture on C_2-cofiniteness for a finite solvable automorphism group. Namely, if V is a simple C_2-cofinite VOA and G is a finite solvable automorphism group of V, then a fixed point subVOA V^G is also C_2-cofinite.

Hisanori Ohashi (Tokyo University of Science)

Title: Integral points of some elliptic curve via the binary Golay code

Abstract: Elliptic curves over a function field of one variable can be regarded as an algebraic surface equipped with an elliptic fibration. By this correspondence, the height pairing on the Mordell-Weil group can be made explicit for such curves and it is called the Mordell-Weil lattice (Elkies, Shioda). In the talk, we introduce a special elliptic curve over $k(t)$, $\mathrm{char}(k) = 11$, and study the Mordell-Weil lattice of the curve. We show that it is deeply related to the Niemeier lattice of type A_1 and the Mathieu group M_{24}. As an application, we can compute the number of integral points of the curve. We also explain the connection of our results to the theory of automorphisms of $K3$ surfaces, the surface model of our curve.

Ozren Perše (University of Zagreb)

Title: Fusion rules and complete reducibility of certain modules for affine Lie algebras

Abstract: In this talk we present a new method for obtaining branching rules for affine Lie algebras at negative integer levels. This method uses fusion rules for vertex operator algebras of affine type. We show that an infinite family of ordinary modules for affine vertex algebra of type A is closed under fusion. Then we apply these fusion rules on explicit bosonic realization of level -1 modules for the affine Lie algebra of type $A_{\ell-1}^{(1)}$, obtain a new proof of complete reducibility for these representations, and the corresponding decomposition for $\ell \geq 3$. We also obtain the complete reducibility of the associated level -1 modules for affine Lie algebra of type $C_{\ell}^{(1)}$. Next we notice that the category of $D_{2\ell-1}^{(1)}$ modules at level $-2\ell+3$ has isomorphic fusion algebra. This enables us to decompose certain $E_6^{(1)}$ and $F_4^{(1)}$–modules at negative levels.
The talk is based on joint work with Dražen Adamović.

Nils Scheithauer (Technische Universität Darmstadt)

Title: On the classification of automorphic products

Abstract: We present some new classification results for automorphic products of singular weight.

Hiroki Shimakura (Tohoku University)

Title: $\mathbb{Z}_3$-orbifold construction and holomorphic vertex operator algebras of central charge 24

Abstract: The classification of holomorphic vertex operator algebras (VOAs) is a fundamental problem in the VOA theory. By Zhu's theory, their central charges are positive integers divisible by 8. By Dong and Mason, a holomorphic VOA of central charge 8 or 16 is isomorphic to a lattice VOA. Thus the most interesting problem is to classify holomorphic VOAs of central charge 24. Schellekens gave a list of possible 71 Lie algebra structures of the weight one spaces of holomorphc VOAs of central charge 24. So first step is to construct holomorphic VOAs of central charge 24 based on his list. Recently, Miyamoto established a $\mathbb{Z}_3$-orbifold construction for lattice VOAs. I will talk about an application of $\mathbb{Z}_3$-orbifold construction to Niemeier lattice VOAs and automorphisms of order 3, which is a joint work with M. Ishii and D. Sagaki.

Hiromichi Yamada (Hitotsubashi University)

Title: A characterization of parafermion vertex operator algebras

Abstract: A parafermion vertex operator algebra is the commutant of the Heisenberg algebra in the integrable highest weight module for an affine Kac-Moody algebra. In the sl_2 case, we show that a vertex operator algebra which satisfies certain properties of the parafermion vertex operator algebra can be embedded in the integrable highest weight module for $\widehat{sl}_2$ and it is in fact isomorphic to the parafermion vertex operator algebra.

Hiroshi Yamauchi (Tokyo Woman's Christian University)

Title: (2A,3A)-generated subalgebras and 3-transposition subgroups on a vertex operator algebra

Abstract: In this talk I will consider a series of subalgebras of a vertex operator algebra generated by simple $c = 1/2$ Virasoro vectors (Ising vectors) satisfying the (2A,3A)-generated configuration. Then I will show that the corresponding commutant subalgebras afford actions of 3-transposition subgroups where transposition automorphisms are realized by several Virasoro vectors of unitary series. As an application, I will explain how the second largest Fischer 3-transposition group arises as an automorphism group of a vertex operator algebra. This is the joint work with Ching Hung Lam.