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Numeration and Substitution 2012

edited by Shigeki Akiyama, Valérie Berthé, Hul Rao
and Takao Komatsu

June, 2014

Research Institute for Mathematical Sciences
Kyoto University

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Numeration and Substitution 2012

June 4 ~8, 2012

*edited by Shigeki Akiyama, Valérie Berthé, Hui Rao
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Kyoto University, Kyoto, Japan

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This volume collects 4 invited surveys and 8 contributed papers submitted to the international conference “Numeration and Substitution” held at RIMS Kyoto on June 4-June 8, 2012. The meeting was a great success by more than a hundred participants including 28 from oversea. Many developing new areas, some of them are not well-known in Japan and in Asia and some are only locally known, are nicely mixed and gave a cozy place for research discussion.

The organization of the meeting was done by three groups: organizing, scientific and editorial committees. Organizing committee helped making web pages, preparation of the meeting room, residences, VISA, welcome party and all administrative jobs related to the conference. Scientific committee selected invited speakers. Editorial committee was in charge of this proceedings volume. I would like to express my deepest gratitude for their help. Committee members are found in the end of the program, I also would like to thank RIMS for travel supports as well as local helps and giving a chance for publication of this volume.

Let me explain briefly the history of the series of meetings to which this conference intends to belong. In the first stage, they were mainly organized in CIRM, Luminy, Marseilles and LIAFA, Paris, France and gradually developed in Europe-wide, including the one in Grenoble, Aussois, in France and Graz (Austria), Pragues (Czech), Leiden (Netherland). The last one before this conference was held in Liege (Bergium) on 2011. This conference was the 1-st one held outside Europe.

Numeration (Numeration system) is a general system to represent numbers, such as, decimal/binary representations or continued fraction expansion but also includes many codings of general arithmetic algorithm. Substitution stands for a monoid homomorphism on letters, which gives the simplest model of self-inducing structures appears in dynamical systems. These two objects are intimately related in describing the structure of periods and play an important role in making a bridge between number theory and dynamical system. Therefore they appear and reappear in many places in the history of mathematics, sometimes by different subject names, by researchers in different fields. Nowadays they are also applied to cryptography, symbolic coding, computer science, construction of wavelets and fractal geometry. The idea to give a unified name of this research field and accelerate systematic joint research is due to the French group.

In this volume, we collect 4 surveys of the fast developing topics: Shift radix system, Interval exchange transform, S-adic system, and algebraic dual tilings. I believe those are still growing areas but having no textbooks yet. Therefore this volume serves a good starting point of the research. This volume also includes 8 refereed papers by

researchers in different branches of mathematics. Under the keywords 'Numeration and Substitution', we hope the research grows in many directions and produce fruitful consequences, and this volume would give an easier access to this fascinating fields.

The Research Proposer to RIMS

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この数理研講究録別冊は、2012年6月4日から6月8日まで京都大学数理解析研究所で行われた国際研究集会「数系と置換規則 (Numeration and Substitution) 2012」の講義とサーベイの記録集である。集会は百名を越す参加 (内28名が国外より) で大きく成功した。日本ではあまり知られていない分野の研究が紹介され、また、若手研究者の貢献もあって日本国内の関連研究を世界に知らしめる機会ともなった。

集会開催には組織委員会と科学委員会および本別冊の編集委員会を設けて対応した。組織委員会は、Webの整備、会場準備、宿泊の問い合わせ、Visaの対応、懇親会など集会にまつわる様々な仕事、科学委員会は Invited Speaker の選定、編集委員会は本別冊の編集のための原稿依頼、査読依頼、掲載決定の事項を担当した。この場を借りて様々なご苦勞を頂いた各委員会のメンバーに深く感謝を申し上げたい。委員会名簿がプログラムの後ろにあるのでご参照いただければと思う。また数理研には招待講演者等の旅費のサポート、およびきめ細かい対応をいただきこの集会が円滑に運営できたことを感謝したい。

あまり知られていないが、この集会にはかなりの伝統と歴史がある。最初は数系共同研究という名称でフランスのマルセイユ、パリを中心に1999年より開催されていたが、徐々に規模を拡大しヨーロッパに活動範囲を広げてきた。フランスではグルノーブル、オーソワ、またグラーツ (オーストリア)、プラハ (チェコ)、ライデン (オランダ) さらに直近では2011年にリエージュ (ベルギー) でも開催された。詳しい情報は <http://www.liafa.jussieu.fr/~cf/num/> にまとめられている。本集会はヨーロッパ外で初めて行った数系シリーズの国際集会である。

本集会のテーマの数系とは、数を digit を用いて表す方法の総称である。十進法、二進法やベータ展開、連分数なども数系と考えられ、一般の数論的アルゴリズムも研究の対象に含まれる。置換規則とは Substitution の和訳で、与えられた自己誘導的な力学系のコード化に現れる文字列の置換 (モノイド準同型) を表す。自己誘導構造は周期点の構造を記述するのに本質的役割を果たす。この数系と置換規則の二つの概念は数論と力学系をつなぐ役割をもっている。そのため関連する問題は長い数学の歴史の中で、繰り返し様々な形で現れ、世界の研究者により時に別称を与えられ、同等または類似の現象の発見・再発見が繰り返されてきた。その問題意識は数論、力学系の枠組みを超えて暗号、コード化、計算機科学、ウェーブレット構成、フラクタル解析などにも応用がある。このような重要であるが漠然とした研究対象に名称を与えることにより、組織的に研究を進めるアイデアが定着してきたのには上記のフランスの研究者グループの努力が大きい。

本別冊では、数系と置換規則に関する4つの話題 (シフト基数系、区間交換、S-adic システム、代数的双対タイル) に関し専門家にサーベイをお願いした。この4つの話題は、最近進展が著しく日進月歩の様相を示しているが、教科書ができるほどには完成してはいない。そのため、この別冊は関連研究者に格別に役立つものと思われる。また集会の参加者の方々から寄せられた多方面の論文も査読の上掲載した。この数系と置換規則は分野横

断的に様々な数学研究の中で現れる諸現象であり、これからも様々な方向に発達していくものと思われる。この講究録別冊が直接関連する研究者のみならず、関心を持った他分野の研究者にも将来役立つものになることを期待したいと思う。

研究代表者 筑波大学数理物質系 秋山 茂樹

編集委員会

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Shigeki Akiyama (Univ. Tsukuba, Japan)

Numeration and Substitution 2012

Dates: Monday, June 4th – Friday, June 8th, 2012

Place: Research Institute for Mathematical Sciences (RIMS), Kyoto, Japan

Room: Room 111

PROGRAM

Monday 4 June

- 13:00–13:10 Opening
- 13:10–14:00 Hui Rao (HuaZhong Normal Univ, China)
Dual systems of algebraic IFS and its applications.
- 14:10–15:00 Fabien Durand (Univ Jules Verne, France)
Relations between periodicity and block complexity for tilings.
- 15:10–15:30 Hajime Kaneko (JSPS Nihon Univ)
Applications of numerical systems to transcendental number theory.
- 15:30–15:50 Masamichi Yoshida (Osaka City Univ)
Numeration systems arising from Denjoy dynamical systems.
- 15:50–16:10 Martine Queffélec (Univ. Lille 1, France)
Diophantine approximation and expansions of real numbers.
- 16:20–16:40 Uijin Jung (Korea Institute for Advanced Study)
Fiber-mixing codes and factors of Gibbs measures for subshifts of finite type.
- 16:40–17:00 Yohei Tachiya (Hirosaki Univ.)
Algebraic independence results related to
pattern sequences in $\langle q, r \rangle$ -numeration systems.

Tuesday 5 June

- 9:30–10:20 Dong Han Kim (Dongguk Univ, Korea)
Diophantine type of interval exchange maps.
- 10:30–11:20 Peter Kirschenhofer (Univ. Leoben, Austria)
On Finiteness and Periodicity Properties of Shift Radix Systems (SRS).
- 11:30–12:00 Mari Yokohama & Takao Komatsu (Hirosaki Univ)
Sums of products of Cauchy numbers, including poly-Cauchy numbers.
Hypergeometric Cauchy numbers.
- 14:20–14:40 Cor Kraaikamp (TU Delft, Netherlands)
Properties of N-expansions.
- 14:40–15:00 Robbert Fokkink (TU Delft, Netherlands)
Equivariant substitution sequences.
- 15:10–15:30 Attila Pethő (University of Debrecen, Hungary)
On the distribution of polynomials with integer coefficients.
- 15:30–15:50 Yu-Mei Xue (Beihang University, Beijing, China.)
Maximal pattern complexity, dual system and pattern recognition.
- 15:50–16:10 Sébastien Ferenczi (IML - CNRS, Marseille, France)
Word combinatorics of interval exchanges for every permutation.
- 16:20-17:00 Poster Session

Wednesday 6 June

- 9:30–10:20 Vincent Delecroix (Univ Paris 7, France)
Global complexity of S-adic systems.
- 10:30–11:20 De-Jun Feng (Chinese Univ HongKong, China)
On the topology of polynomials with bounded integer coefficients.
- 11:30–12:00 Jun'ichi Tamura & Shin'ichi Yasutomi (Toho Univ)
Norm equations of certain biquadratic number fields,
and simultaneous approximation of three quadratic irrationalities.
A new multidimensional slow continued fraction algorithm and its application.

Thursday 7 June

- 9:30–10:20 Kentaro Nakaishi (Tokyo Univ.)
Pisot substitutions and Rauzy fractals.
- 10:30–11:20 Taizo Sadahiro (Tsuda College)
Carries and Markov chains.
- 11:30–12:00 Attila Kovács & Péter Burcsi (Eötvös Loránd Univ, Hungary)
Number system constructions in lattices with block diagonal bases.
Towards simultaneous shift radix systems.
- 14:00–14:20 Anne Siegel (CNRS / IRISA, France)
Rauzy fractals associated with cubic real number fields.
- 14:20–14:40 Damien Jamet (Loria, Nancy, France)
On the topology of discrete hyperplanes.
- 14:40–15:00 Tarek Sellami (IML, Marseille, France)
Common dynamics of two Pisot substitutions with the same incidence matrix.
- 15:10–15:30 Daniel Krenn (TU Graz, Austria)
Analysis of the Width- w Non-Adjacent Form
in Conjunction with Hyperelliptic Curve Cryptography.
- 15:30–15:50 Christiane Frougny (LIAFA, Paris, France)
Minimal digit sets for parallel addition in non-standard numeration systems.
- 15:50–16:10 Wolfgang Steiner (CNRS, Macquarie University, France/Austraria)
On the $(-\beta)$ -expansion of $\frac{-\beta}{1+\beta}$.
- 16:20–16:40 DoYong Kwon (Chonnam National Univ, Korea)
Moments of discrete measures with dense jumps induced by β -expansions.
- 16:40–17:00 Jean-Louis Verger-Gaugry (Institute Fourier, Univ Grenoble I, France)
On the geometry of the beta-conjugates of a real algebraic number
for the Rényi-Parry numeration system.

Friday 8 June

- 9:30–10:20 Valérie Berthé (LIAFA, Paris 7, France)
Beyond Pisot substitutions.
- 10:30–11:20 Benoit Loridant (MU Leoben, Austria)
Topology of a class of cubic Rauzy fractals.
- 11:30–11:50 Teturo Kamae (Osaka City Univ, Emeritus)
Super-stationary structure of dynamical systems.

Scientific Committee:

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Conference Web Page:

<https://sites.google.com/site/numeration2012/home>

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