The 19th Midrasha Mathematicae

8th Young Set Theory Workshop

Compactness, Incompactness and Canonical Structures

Israel Institute for Advanced Studies
Jerusalem, October 25-30, 2015
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1 Mini Courses

An up-to-date schedule may be found in here:


1.1 Péter Komjáth

THE CHROMATIC NUMBER OF INFINITE GRAPHS

We overview the various properties of the chromatic number of infinite graphs. We will be specially interested in the coloring number, a variant, which is much easier to handle.

1.2 Menachem Magidor

COMPACTNESS AND INCOMPACTNESS AT SMALL CARDINALS

In this tutorial we shall study reflection and compactness cardinals for a variety of properties of mathematical structures. The properties we shall consider are typically second order. Examples: A family of sets has a transversal (one to one choice function), An Abelian group is a free Abelian group, A graph has a countable chromatic number, The structure has a definable well ordering which is a regular cardinal etc.

Definition. 1. Given a property of mathematical structure, we say that a cardinal \( \kappa \) is a reflection cardinal for this property if every structure of cardinality \( \kappa \) has a substructure of cardinality less than \( \kappa \) having the given property.

2. \( \kappa \) is a strong reflection cardinal if every structure (no restriction on the cardinality) having this property has a substructure of cardinality less than \( \kappa \) having the given property.

3. A cardinal \( \kappa \) is a (weakly) compact for the given property if a structure of cardinality \( \kappa \) has the given property, given that every substructure of cardinality less than \( \kappa \) has the property.

4. \( \kappa \) is a strongly compact cardinal for the property if every structure (no restriction on the cardinality) has the property given that every substructure of cardinality less than \( \kappa \) has the property.

Reflection and compactness are dual properties: \( \kappa \) is a reflection cardinal for a certain property iff it is a compactness cardinal for the negation of the property.

Usually compactness properties are associated with the cardinal being a large cardinal. For example, the first supercompact cardinal is the minimal cardinal which is a strongly compact for every second order property.

In this series of talks we shall discuss the possibility of small cardinals, typically less than the first inaccessible, being compact for a given property. We shall study cases in which relatively small cardinals, like \( \aleph_n \) or \( \aleph_{\omega+1} \) are provably incompact for certain natural properties. On the other hand, we shall see cases in which it is consistent that relatively small cardinal is compact for interesting property.

This mini-course attempts to expose the listeners to a variety of set theoretic tools from straightforward combinatorial set theory, applications of PCF theory, forcing techniques for large cardinals, etc’. Because of time constrains, we shall not always be able to provide full proofs but hopefully the central ideas will come through. We expect familiarity with basic concepts of combinatorial set theory and basic forcing, though we try to give the definition of every concept we shall use.

1.3 W. Hugh Woodin

In these 4 lectures I will survey some of the basic issues which arise in the attempt to extend the Inner Model Program to the level of a supercompact cardinal.

1. THE HOD DICHTOTOMY, WEAK EXTENDER MODELS, AND UNIVERSALITY
The starting point is the HOD Dichotomy Theorem which is an abstract version of Jensen’s Covering Theorem with $L$ replaced by HOD. This theorem naturally leads to the prediction that inner models with a supercompact cardinal must be close to $V$ if that supercompact cardinal in the inner model is connected in a very weak sense to supercompa...
2 Plenary Talks by Young Researchers

An up-to-date schedule may be found in here:


2.1 Laura Fontanella

Reflection and Anti-reflection at the Successor of a Singular Cardinal

This is a joint work with Yair Hayut. One of the most fruitful research areas in set theory is the study of the so-called reflection principles. These are statements establishing, roughly, that for a given structure (a stationary set, a tree etc.) and a given property, one can find a substructure of smaller cardinality satisfying the same property. Reflection principles are typical properties of large cardinals but can consistently hold even at small cardinals. Square principles are on the contrary anti-reflection principles as they imply the failure of several reflection principles and are false in the presence of certain large cardinals. For instance the square principle of Todorcevic [4] implies that any stationary subset of $\kappa$ may be partitioned into $\kappa$ many pairwise disjoint stationary sets such that any two such sets do not reflect simultaneously [3]. We present a technique for building models where a reflection principle and a square principle hold simultaneously at the successor of a singular cardinal. We discuss two particular principles: the so-called Delta reflection which is due to Magidor and Shelah [2], and a version of the square due to Todorcevic [4]. More precisely, we show that, starting from a suitable large cardinal assumption, one can force a model where both the Delta reflection and Todorcevic’s square hold at $\aleph_{\omega+1}$.


2.2 Andrew Marks

Baire Measurable Paradoxical decompositions via matchings

The Banach-Tarski paradox states that the unit ball in $\mathbb{R}^3$ is equidecomposable with two unit balls in $\mathbb{R}^3$ by rigid motions. In 1930, Marczewski asked whether there is such an equidecomposition where each piece has the Baire property. In the 90s, Dougherty and Foreman gave a positive answer to this question.

We generalize Dougherty and Foreman’s result to completely characterize which Borel group actions have Baire measurable paradoxical decompositions. We show that if a group acting by Borel automorphisms on a Polish space has a paradoxical decomposition, then it admits a paradoxical decomposition using pieces having the Baire property. We also obtain a Baire category solution to the dynamical von Neumann-Day problem, in the spirit of Whyte and Gaboriau-Lyons: if $a$ is a nonamenable action of a group on a Polish space $X$ by Borel automorphisms, then there is a free Baire measurable action of $\mathbb{F}_2$ on $X$ which is Lipschitz with respect to $a$. The main tool we use to prove these theorems is a version of Hall’s matching theorem for Borel graphs.

This is joint work with Spencer Unger at UCLA.
2.3 Diego A. Mejía

**Many different values in Cichon’s diagram**

I present some examples of models, constructed with finite support iteration techniques, where many cardinals in Cichon’s diagram assume different values. For example, I present models where three cardinals of the right side of the diagram are separated and a model where all cardinals of the left side are separated, the latter constructed in a joint work with M. Goldstern and S. Shelah.

2.4 Diana Ojeda-Aristizabal

**Topological partition relations for ordinals below** $\omega^\omega$

For $X, Y$ topological spaces and natural numbers $l, m, n$ we write $X \rightarrow^{(Y)}_{l,m} (n)$ if for every $l$-coloring of $[X]^n$, the unordered $n$-tuples of elements of $X$, there exists $Z \subseteq X$ homeomorphic to $Y$ such that $c \upharpoonright [Z]^n$ takes at most $m$ colors. An example of such an arrow relation is $Q \rightarrow (\omega^k + 1)^2_{l,2k}$ where $l, k$ are natural numbers and both $Q$ and $\omega^k + 1$ are endowed with the order topology. This relation follows after identifying $Q$ with $\text{FIN}$, the collection of finite non empty subsets of $\mathbb{N}$ with the topology of pointwise convergence, and applying Hindman’s Theorem and its higher dimensional versions. Baumgartner found that in fact for every natural number $k$ there exists a countable ordinal $\gamma_k$ such that $\gamma_k \rightarrow (\omega^k + 1)^2_{l,2k}$. Recently C. Pina obtained an optimal value for $\gamma_2$, namely she proved that $\omega^\omega$ is the least ordinal $\gamma$ that satisfies $\gamma \rightarrow (\omega^2 + 1)^2_{l,4}$ for every $l$. When working in a countable ordinal instead of $Q$, a finer analysis is needed and Hindman’s Theorem is no longer useful. The key of Pina’s result is the use of certain families of finite sets to represent countable ordinals.

Using families of finite sets to represent countable ordinals, we begin our study with ordinals of the form $\omega \cdot k + 1$ with $k \geq 2$, and find that for every countable ordinal $\gamma$ there exists a 3-coloring of $[\gamma]^2$ that can’t be reduced in a copy of $\omega \cdot 2 + 1$. We set out to find for each $m \geq 3$ the least ordinal $\gamma$ such that for every $l$ we have that $\gamma \rightarrow (\omega \cdot 2 + 1)^2_{l,m}$. It turns out that if $\gamma \rightarrow (\omega \cdot 2 + 1)^2_{l,4}$ for every $l$, then already $\gamma \geq \omega^\omega$. We carry out a similar analysis for ordinals of the form $\omega \cdot k + 1$ with $k > 2$.

This is joint work with William Weiss from the University of Toronto.

2.5 Yizheng Zhu

**The higher sharp**

We establish the descriptive set theoretic representation of the mouse $M_n^\#$, which is called $0^{(n+1)}#$. At even levels, $0^{(2n+1)}#$ is the higher level analog of Kleene’s $O$; at odd levels, $0^{(2n+1)}#$ is the unique iterable remarkable level-$(2n+1)$ blueprint.

3 Plenary Talks by Local Researchers

An up-to-date schedule may be found in here:


3.1 Ari M. Brodsky

**Reduced powers of Souslin trees**

We study the relationship between a $\kappa$-Souslin tree $T$ and its reduced powers $T^\theta/\mathcal{U}$.

Previous works addressed this problem from the viewpoint of a single power $\theta$, whereas here, tools are developed for controlling different powers simultaneously. As a sample corollary, we obtain the consistency of an $\aleph_0$-Souslin tree $T$ and a sequence of uniform ultrafilters $\langle \mathcal{U}_n \mid n < \aleph_0 \rangle$ such that $T^\aleph_0/\mathcal{U}_n$ is $\aleph_0$-Aronszajn iff $n < 6$ is not a prime number.

This is joint work with Assaf Rinot at Bar-Ilan University.
3.2 Menachem Kojman

**THE ARITHMETIC OF DENSITY**

The density function on infinite cardinals behaves well asymptotically. A few of its properties and uses will be sketched.

3.3 Saharon Shelah

**ITERATED FORCINGS FOR INACCESSIBLE CARDINALS**

We deal with the theory of iterated forcing for inaccessible $\lambda$, not adding $\lambda$-Cohens. Our starting point is the paper [1].


3.4 Boaz Tsaban

**APPLICATIONS OF PCF THEORY AND FORCING THEORY TO FREE TOPOLOGICAL GROUPS**

This lecture will be an elementary exposition to the paper [1].

For simplicity, we consider only Abelian groups. An abelian topological group is an abelian group equipped with a topology, such that addition and negation are continuous. Since topological groups are homogenous, their topology is to a large extent determined by the topology around a single point, say, the neutral element of the group. Consequently, the most important cardinal invariant of a topological group, its ”character”, is the minimal cardinality of a local base at the neutral element. In particular, a topological group is metrizable if and only if it has countable character.

Let $X$ be a topological space. The space $X$ generates the Abelian group $A(X)$ of all linear combinations of elements of $X$ with integer coefficients, and with no additional relations. The topology on $A(X)$ is determined by the request that every continuous map on $X$ (into an abelian topological group) extends to a homomorphism on $A(X)$. It turns out that computing the character of this simply defined group requires most sophisticated set theoretic methods. We will show why this is the case (by introducing the so-called Pontryagin van-Kampen duality and modifying it to our needs), demonstrate the usefulness of set theory in this context, and propose purely set theoretic open problems that must be addressed in order to make progress in some natural directions concerning this mostly open problem.

4 Practical Information

4.1 Daylight Saving
Daylight saving ends on 24 October 2015, and winter time starts on 25 October 2015. This means you have one more hour to sleep just before the conference commences.

4.2 Jerusalem
Jerusalem is about 800 meters (2640 feet) above sea level; at geographic latitude 31°47'N and longitude 35°13'E. More information and weather updates may be found on the following websites:

- Israel: http://www.israelweather.co.il/forecast/index_english.html
- Jerusalem specifically: http://www.02ws.co.il/?&lang=0

Up-to-date information on current events and attractions in Jerusalem may be found on the following websites:

- www.jerusalem.muni.il
- www.jerusalemite.net
- www.jerusalem.com

4.3 Transportation from Ben-Gurion Airport
You will be arriving at Ben-Gurion Airport, which is located about 15 minutes from Tel Aviv and 40 minutes from Jerusalem. Private taxis to Jerusalem can be found as you exit the arrivals terminal, and cost about 70USD. You could also take the 'Nesher' Taxi, a shared door-to-door shuttle, for the set price of 64 Shekels (about 18USD). It operates 24 hours a day and can be easily found to your right as you exit the arrivals terminal. Either way, please ask the driver to drop you off at your designated hotel. It is advisable that you carry a copy of the conference invitation letter with you.

4.4 Conference Webpage
http://www.as.huji.ac.il/schools/math19

4.5 Conference Venue
The Conference will take place at the Israel Institute for Advanced Studies (IIAS) located at The Hebrew University, the Edmond J. Safra Campus, Givat Ram (The Hebrew University has several campuses). A map of The Hebrew University, Givat Ram Campus appears on the following website:

http://www.huji.ac.il/huji/maps/givatramCampus.htm

Walking from the main pedestrian gate, the Institute is the third building (Feldman building) on the right. Lectures will be held at room (#130), on the first floor.

Note: you may be required to show your passport or other I.D. when entering the campus through the main gate, and bags may be checked. This is common practice in many public places in Israel.
4.6 Registration
Sunday, 08:30-09:30, in the IIAS lobby on the ground floor.

4.7 Reception
Sunday, 18:00-20:00, in the IIAS lobby on the ground floor.

4.8 Excursion
Tuesday, 14:00-18:00.

4.9 Meals
• Breakfast will be available at the hotel.
• Lunch will be provided at the mensa of the Sherman Administration building (in between the university entrance and the IIAS — see at the above map). Your name tag is your lunch coupon!
• Coffee, tea and cookies will be provided during the breaks, in the IIAS lobby.

4.10 Computer Connections and Working Space
Please bring your laptop with you, if you wish to use a computer during the conference for your personal needs. There is free access to wireless Internet (WiFi) at the Givat Ram campus. Participants, who have laptop computers with wireless capabilities, can gain basic Internet access: The network name is (SSID) “HUJI-guest”

4.11 IIAS Contact Information
Mrs. Shani Frieman (Senior Secretary)
shani@prism.as.huji.ac.il
Tel: +972-2-6584735, +972-2-6586932
Fax: +972-2-6523429
4.12 Reimbursement Procedure

In the acceptance letter to the workshop, some of you were offered a financial assistance to partially cover your fare airline tickets up to a certain maximum amount.

Please scan and e-mail the following documents so that we may begin the reimbursement process:

<table>
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<tr>
<th>Please Check (√)</th>
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<tbody>
<tr>
<td>1. Airline ticket.</td>
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<tr>
<td>2. Boarding pass or border control card.</td>
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<tr>
<td>3. Flight ticket receipt or any other proof of payment.</td>
</tr>
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<td>4. Reimbursement Form below (Please fill out clearly!)</td>
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</tbody>
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**Reimbursement Form:**

- Name of workshop: The 19th Midrasha Mathematicae
- Speaker/Guest name:
- Name of Bank:
- Beneficiary name:¹
- Bank Account Number:
- Swift Code:
- Routing:
- IBAN(only for payment in EURO or GBP):²
- Total sum:
- Currency:

Please email all the necessary documents mentioned above only when you have them all to Mr. Nir Fosh (IIAS Budget Assistant) at nir@prism.as.huji.ac.il.

Mr. Nir Fosh is also available to answer questions over phone at +972-2-6584493.

¹The bank account holder.
²International Bank Account Number.
5 Registered Participants

5.1 Giorgio Audrito (Torino)

I am a fourth year PhD student at the University of Torino, working under the supervision of Prof. Matteo Viale.

In the wake of early Gödel’s Incompleteness Theorems, the development of modern pure set theory revolved around undecidability results for statements coming from various area of mathematics, on the negative side; and around the study of candidates for new axioms of mathematics and their consequences in settling those statements, on the positive side. My research concentrates on the search for strong axioms able to entail a certain degree of completeness, i.e. decide broad classes of mathematical problems at once. In order to obtain strong results on the “positive side” it is necessary to study the main tools used in proving undecidability results, the most important of which is forcing. This technique allows to define from a model of set theory $V$ a larger model $V[G]$ in which a certain generic object $G$ has been added, crafted so as to realize or disprove a certain statement.

When this technique (applied to some forcing notions of interest) fails to produce an undecidability result, we encounter the phenomena of generic absoluteness. We say that a certain class of statements $\Theta$ has generic absoluteness with respect to a certain class of forcing posets $\Gamma$, whenever it is not possible to change the truth value of a statement in $\Theta$ by means of a forcing in $\Gamma$. Forcing is the most efficient tool to prove undecidability results. Consequently, the generic absoluteness phenomena provide an effective way to achieve an high degree of completeness. Almost all known undecidability results are obtained by means of forcing, thus an axiom granting generic absoluteness in most cases leads to definite proofs of the existence of a given solution for large classes of problems. The pioneering modern generic absoluteness results are Woodin’s proofs of the invariance under set forcings of the first order theory of $L(\text{ON}^\omega)$ with real parameters in $\text{ZFC}+$ class many Woodin cardinals which are limit of Woodin cardinals [4, Thm. 3.1.2] and of the invariance under set forcings of the family of $\Sigma_2^1$-properties with real parameters in the theory $\text{ZFC} + \text{CH}+$ class many measurable Woodin cardinals [4, Thm. 3.2.1].

Since now, my main research interest has been the development of the iterated resurrection axioms $\text{RA}_\alpha(\Gamma)$. These principles show that strong generic absoluteness (and hence high degrees of completeness) can be achieved from axioms of low consistency strength, and are built on the resurrection axioms recently introduced in [3]. In particular, in [1] we showed that $\text{RA}_\alpha(\Gamma)$ implies generic absoluteness for the whole theory of $H_\alpha$ with parameters with respect to forcings in $\Gamma$, and that the consistency strength of $\text{RA}_\alpha(\Gamma)$ is lower than a Mahlo cardinal in most cases (for iterable forcing classes) and below a stationary limit of supercompact cardinals for $\Gamma = \text{SSP}$.

Another topic I have been recently working on is generic large cardinals. Generic large cardinals can be presented as elementary embeddings with small critical point and large cardinal properties which can be defined in certain forcing extensions. These type of elementary embeddings are useful tools to analyze the combinatorics of small cardinals [2]. Most of the generic embeddings one encounters in the literature are given by (direct-limit) ultrapowers obtained by means of “generic” ultrafilters. This naturally raises the question of whether any generic large cardinal embedding can be approximated by a generic ultrapower, so to preserve the relevant large cardinal properties of the embedding. This question aims to reflect to the setting of generic embeddings the long-time known counterpart that holds in the non-generic context: it is known that standard large cardinal embeddings can be approximated by extender ultrapowers with the desired amount of precision. In an upcoming work with Sivia Steila and Matteo Viale, we are able to show that several generic large cardinal properties are not equivalent, and that the desired approximation of an arbitrary generic embedding by generic extenders or by towers of ultrafilters works to some extent, but not as well as it occurs in the classical case.

Other topics I have been working on during the PhD are well-founded boolean ultrapowers and relations with generic large cardinal embeddings, characterizations of large cardinals axioms by combinatoric properties of infinite trees, iterations of proper and semiproper posets and consistency strength of forcing axioms. Furthermore, in my Master’s thesis I studied the relations tying properties of forcing posets with certain combinatorial properties existing between the ground model and the generic extension ($\kappa$-approximation, $\kappa$-covering, $\kappa$-decomposition).
5.2 Gianluca Basso (Pisa)

I am a second year graduate student at the Università di Pisa and I expect to graduate in September. My thesis supervisor is Prof. R. Camerlo, whom I work with since September 2014.

In my work with professor R. Camerlo we study the topological structures that are obtained as quotients of projective Fraïssé limits of finite discrete topological structures. The concept of projective Fraïssé limit was introduced in [1] and dualizes the notion of Fraïssé limit, developed by Fraïssé as a mean of obtaining $\omega$-categorical structures. Key results in this area where obtained by T.Irwin and S.Solecki in [1] and by R.Camerlo, who characterized the quotients of the projective Fraïssé limits of finite graphs in [2]. More recent developments include [3] and [4] by A.Kwiatkowska, in which the projective Fraïssé limits are used to study the class of homeomorphisms of the Cantor Set. An important role is played by Continuum theory since the quotient of the projective Fraïssé limit of the class of finite linear graphs is the Pseudo-Arc, which is the unique hereditarily indecomposable chainable continuum. The goal of the thesis is to investigate the results that have been obtained to the case of arbitrary languages containing a binary relation symbol that is interpreted as a graph-like relation.

References


basso@mail.dm.unipi.it

5.3 Ur Ben-Ari-Tishler (Jerusalem)

I am a second year Master’s student at the Hebrew University of Jerusalem, working under the supervision of Prof. Menachem Magidor. During the fall semester of 2014-2015 I’ve been on student exchange at the Institute for Logic, Language and Computation (ILLC) at the University of Amsterdam, where I began learning about the modal logic of forcing under guidance of Prof. Benedikt Löwe.

Given a collection of models for ZFC, we may think of forcing as defining a relation between these models, where two models are related if one is a forcing extension of the other. This structure suggests a connection to modal logic, which is strongly affiliated with relational structures via what is known as Kripke semantics (see [1]). And indeed, we can give a forcing interpretation to modal logic in the
following way. Given a statement $\phi$ in the language of set-theory, we say that $\phi$ is possible if it holds in some forcing extension (of $V$), and necessary if it holds in all forcing extensions. These are the modal operators, which are marked by $\square \phi$ and $\Box \phi$ respectively. This interpretation of modal logic, introduced by Hamkins in [2], is compatible with the standard Kripke semantics, and allows us to use the theoretical tools of modal logic to analyze forcing. This was done in [3] and [4], where it was shown, for example, that if ZFC is consistent, then the ZFC-provable principles of forcing, i.e. modal statements $\psi(q_0, ..., q_n)$ such that for every set-theoretic statements $\phi_0, ..., \phi_n$, ZFC $\vdash \psi(\phi_0, ..., \phi_n)$, are exactly the modal theory known as $S4$. These papers also provide a set of general tools that may be applied to more specific classes of forcing, e.g. c.c.c-forcing, or to forcing over a specific model.

This rather new area has many open questions. I am currently focusing on studying the modal logic c.c.c-forcing, to which certain lower and upper bounds have been established, but none of them is exact yet.

References

ur.benari-tish@mail.huji.ac.il

5.4 Tom Benhamou (Tel Aviv)
I am a first year M.Sc student at Tel Aviv University, working under the supervision of Prof. Moti Gitik.

During the last year I have focused mainly on violations of SCH (specifically Prikry-type forcing) and large cardinals such as: measurable, weakly and strongly compact, indescribable, strongly compact, super compact, strong cardinal and various others..
motjunod@gmail.com

5.5 Mariam Beriashvili (Tbilisi)
I am Ph. Doctor Of Mathematics since 06.05.2015, in 2011-2015 years was PhD student at the Tbilisi State University. I have been in collaboration with Prof. Dr. Roland Omanadze. He was a Supervisor of my Bachelor Thesis "Effectively Simple Sets and Strange Effectively Simple Sets" at Tbilisi State University. I am working since 2014 at I. Vekua Institute of Applied Mathematics of TSU as a junior scientific member, since 2013 I am working at Georgian Technical University as a member of scientific staff of Grant No. 31/25 of Shota Rustaveli National Science Foundation.

It is well known, that set theory plays a fundamental role in all of mathematics branches. In particular, set-theoretical methods are successfully applied in various topics of real analysis and measure theory. Our research work is devoted to some applications of additional set-theoretical axioms in point set theory and in measure theory. We consider certain types of interesting and important point sets on the real line, such as Vitali sets, Bernstein sets, Hamel bases, Luzin sets, and Sierpinski sets. These point sets are pathological in the sense of measure theory or Baire property. We study the above-mentioned sets from the point of view of measure extension problem.

Vitali, Bernstein and Hamel constructions are based on uncountable forms of the Axiom of Choice, while Luzin and Sierpinski constructions rely on the Continuum Hypothesis.

In the present work various combinations of such subsets are considered. In particular:
(1) There exists a subset $X$ of $R$ which is simultaneously a Vitali set and a Bernstein set.
(2) There exists a Hamel basis of $R$ which simultaneously is a Bernstein set.
(3) There exists no Hamel basis in $\mathbb{R}$ which simultaneously is a Vitali set.

(4) There exists no Luzin (Sierpinski) subset (generalized Luzin-Sierpinski subset) of $\mathbb{R}$ which simultaneously is a Vitali set.

(5) There exists no Luzin (Sierpinski) subset (generalized Luzin-Sierpinski subset) of $\mathbb{R}$ which simultaneously is a Bernstein set.

(6) Under the Continuum Hypothesis (Martin Axiom) there exists Luzin (Sierpinski) subset (generalized Luzin-Sierpinski subset) of $\mathbb{R}$ which simultaneously is a Hamel bases.

We investigate a modified version of the concept of measurability of sets and functions, and analyze this version from the point of view of additional set-theoretical axioms. The main feature of such an approach is that the measurability is treated not only with respect to a concrete given measure, but also with respect to various classes of measures. So, for a class $M$ of measures, the measurability of sets and functions has the following three aspects:

(a) absolute measurability with respect to $M$;
(b) relative measurability with respect to $M$;
(c) absolute non-measurability with respect to $M$.

With the aid of additional set theoretical axioms, we specify the above-mentioned aspects of measurability and use Marczewski method of extending measures for some pathological subsets of the real line.

References


marian_beriashvili@yahoo.com

5.6 Jeffrey Bergfalk (Cornell)

I'm a third year Ph.D. student at Cornell University, working under the supervision of Professor Justin Moore.

If Shelah's solution to the Whitehead problem remains the most prominent application of set theory to homological algebra (and a touchstone for the workshop's theme of compactness and incompactness [4]), it was hardly the last. In [6], the additivity of strong homology was shown to depend in part on the vanishing of $\lim^k A$ (where $A$ is the pro-group of $A_f = \bigoplus_{i \in \omega} Z^i(f) (f \in \omega^\omega)$); as [1], [2], and [4] show, that vanishing, for $k = 1$, is equivalent to a statement of the type every coherent family of functions is trivial true under the Open Coloring Axiom, and false if $\mathfrak{d} = \aleph_1$.

[6] and [7] pursue applications in the other direction, giving cohomological treatments of gaps and Aronszajn trees. Here as above, though, the analysis does not reach beyond the first “dimension” or derived functor. I'm interested in the higher $\lim^k A$, values also independent of the axioms of ZFC. These articulate more elaborate coherence relations and, as results like Goblot's Vanishing Theorem (see [3], [5]) suggest, bear some relation to the combinatorics of $\aleph_k$. I'm interested, in particular, in the set-theoretic content of their simultaneous vanishing, and in its implications for those original, motivating questions in strong homology.
References


jsb442@cornell.edu

5.7 Eilon Bilinsky (Tel Aviv)

I am a PhD student at TAU, working under the supervision of Prof. Moti Gitik.

I am interested in models of ZF without choice. Currently I am working to construct a model of ZF with an uncountable $\aleph_1$-amorphic set of reals.

eilonbil@post.tau.ac.il

5.8 Douglas W. Blue (Harvard)

I am a first year PhD student at Harvard University broadly interested in large cardinals, inner models, and forcing axioms. I am under the supervision of Peter Koellner.

Presently, I am learning basic fine structure and inner model theory, concurrently focusing on Devlin’s [1], Jensen’s [2], and Mitchell-Steel’s [3]. I continue to familiarize myself with the various large cardinal notions as I prepare to research Choiceless Cardinals. While cardinals stronger than rank-into-rank cardinals (Reinhardt, super Reinhardt...) are inconsistent in the presence of Choice, it is an open question whether the same holds in ZF. I am obviously at the beginning stages of research, but I find the possibility of Choiceless Cardinals particularly intriguing.

On the more philosophical side, I am deeply engaged in the independence phenomena and the analysis of candidate axioms. Before coming to Harvard, I completed an M.A. thesis at the Munich Center for Mathematical Philosophy analyzing forcing axioms versus V = Ultimate L as candidate axioms for reducing incompleteness in ZFC. I have thus become familiar with Woodin’s suitable extender models [6] and forcing axioms.[5]

Prior to Munich, I was at UC Berkeley. My route to set theory was circuitous – I became interested via philosophy of mathematics and logic. I subsequently started working through Schindler’s [4]. Now I find no subject as invigorating.

References


blue@g.harvard.edu

5.9 Hazel Brickhill (Bristol)

I am a second year PhD student at the University of Bristol, working under the supervision of Prof. Welch.

Stationary set reflection is a property which has been long explored. In $L$, a cardinal $\kappa$ reflects down every stationary set if and only if it is weakly compact (or equivalently $\Pi^1_1$-indescribable) (see [1]). However the property of being stationary reflecting is much weaker than weak compactness, as shown by Mekler and Shelah in [2]. In [3] Bagaria, Magidor and Sakai introduced a new notion of $n$-stationarity, which generalises stationarity and stationary reflection. They showed that in $L$, $n$-stationary reflection is equivalent to $\Pi^1_n$ indescribability.

In my research I have introduced a generalised notion of closed unbounded (club) set, so that $n$-stationary sets can be characterised as those intersecting every $n-1$-club. I have been looking at what standard properties of stationary sets generalise, and when extra assumptions, such some degree of indescribability or $V=L$, are needed. For instance to generalise the splitting property of stationary sets we have:

**Theorem**

If $\kappa$ is $\Pi^1_{n-1}$ indescribable, then any $n$-stationary subset of $\kappa$ is the union of $\kappa$ many pairwise-disjoint $n$-stationary sets.

Recently I have also been looking at a generalised notion of ineffable cardinals and various ♠ principles, which we can obtain in $L$. I would also like to look more at what we can force relating to these concepts - for instance when a forcing will preserve $n$-stationary sets.

**References**


hazel.brickhill@bristol.ac.uk

5.10 Ari M. Brodsky (Ramat-Gan)

I am a post-doctoral fellow at Bar-Ilan University, working under the supervision of Prof. Assaf Rinot since November 2014. Prior to arriving at Bar-Ilan, I completed my PhD at the University of Toronto under the supervision of Prof. Stevo Todorcević.

For any uncountable cardinal $\kappa$, a $\kappa$-Souslin tree is a tree of cardinality $\kappa$ that has no chains or antichains of size $\kappa$. It has long been known that the existence of an $\aleph_1$-Souslin tree is independent of the usual axioms of set theory (ZFC), and $\kappa$-Souslin trees for higher values of $\kappa$ have been constructed from various axioms. In my recent and ongoing work with Assaf Rinot, we have developed a new uniform method for construction of $\kappa$-Souslin trees that is indifferent to the identity of $\kappa$, and furthermore allows us to construct $\kappa$-Souslin trees with various combinations of desirable properties.
One of the keys to this uniform approach is the new proxy principle $P(\kappa, \mu, R, \theta, S, \nu, \sigma, E)$ introduced in [1]. Starting from this principle, we develop tools in [2] to control the reduced powers $T^\theta/U$ of a constructed Souslin tree $T$ simultaneously for different values of $\theta$. In our ongoing work we construct Souslin trees with properties such as completeness, rigidity, homogeneity, coherence, specializability, and freeness.

In my thesis work (see [3], [4]), I explored balanced partition relations on stationary trees, and developed a version for trees of the balanced Baumgartner-Hajnal-Todorcevic theorem, asserting the existence of chains of specified order-type that are homogeneous for a given partition.

References

brodska@macs.biu.ac.il

5.11 Marta Burczyk (Gdańsk)
I am a master’s degree student at the University of Gdańsk. My research interests lie in the intersection of set theory, combinatorics and number theory. Currently, I am working on my master’s thesis: ”Selected problems in additive combinatorics”. My advisor is Prof. Andrzej Nowik.

martafka@vp.pl

5.12 Filippo Calderoni (Torino)
I am a first year PhD student at the University of Turin and the Politechnic of Turin, working under the supervision of Prof. Luca Motto Ros.

In 2014, I got a Master in Pure and Applied Logic at the University of Barcelona. There, I worked under the supervision of Joan Bagaria studying some classical application of Set Theory to infinite groups.

Since I came to Turin, my efforts have been focused on studying the theory of Borel reducibility among analytic equivalence relations.

filippo.calderoni@unito.it

5.13 Miguel Antonio Cardona Montoya (Colombia)
I am a master student at National University of Colombia. Under the supervision of Diego A. Mejía, I am studying applications of forcing to set theory of the reals and cardinal invariants. In particular, for my master thesis, I want to consistency results about the cardinal invariants $\text{add}(I)$, $\text{cov}(I)$, $\text{non}(I)$ and $\text{cof}(I)$ associated to the ideal $I$ (see [2]) using results about properties preserved in finite support iterations of c.c.c. forcing (see [1] and [3]). In particular, I am studying the cardinal invariants associated to an ideal of Yorioka $I_f$ (see [4]). For example, Kamo and Osuga [5] proved that $\text{add}(I_f) \leq \mathfrak{b}$ and $\mathfrak{d} \leq \text{cof}(I_f)$ and found models where $\text{add}(I_f) < \text{cov}(I_f) < \text{non}(I_f) < \text{cof}(I_f)$ are separated in two sections for all possible cases. My research focuses on applying methods of forcing to separate simultaneously the cardinal invariants associated to the ideals of Yorioka. For instance, to answer the following question:

Is there a model of ZFC that satisfies $\text{add}(I_f) < \text{cov}(I_f) < \text{non}(I_f) < \text{cof}(I_f)$?

The corresponding result for the ideal of null sets has been proven by Mejía [3].
References


matematicasudea@hotmail.com

5.14 Fabiana Castiblanco (Münster)

I am a second year PhD student at the Westfälisches Wilhelms Universität Münster working under the supervision of Prof. Ralf Schindler.

Set-theoretical Topology was the focus of my research during my Master studies; I was exploring different constructions of countably compact group topologies without non-trivial convergent sequences.

Currently my research interests lie in Inner Model Theory, especially in the interaction between this area and Descriptive Set Theory. One example of this connection could be depicted when considering thin equivalence relations over the set of real numbers.

We say that $E \subseteq \mathbb{R} \times \mathbb{R}$ is thin if there is no a perfect subset of $E$-inequivalent reals. In [2, Theorem 4.1.16.], Schlicht characterizes the inner models which have representatives in all equivalence classes of thin equivalence relations in the projective pointclasses of the form $\Pi^1_n$. Looking for generalizations of these results, we hope to make some progress on the following questions:

- Under certain determinacy assumptions, which forcings can add, in the generic extension, new equivalence classes to thin $\Pi^{1}_{n+2}$ equivalence relations?
- In [1, Corollary 2.17.] Hjorth describes the inner models which have representatives for all $\Sigma^1_1$ equivalence relations. Is it possible to find a similar characterization for equivalence relations of the form $\Sigma^1_{2n+1}$?
- Schlicht [2, Lemma 2.2.2.] has proved that assuming the existence of $M_{\alpha}^n(x)$ for every $x \in \mathbb{R}$, if $P$ is a probably $\Sigma^1_2(a)$ c.c.c. forcing $(a \in \mathbb{R})$ then every $P$ generic extension preserves this kind of sharps. Can we extend this result when considering a proper forcing instead of a c.c.c. forcing?
- Related to the question above, which forcings preserve or destroy sharps for reals? Furthermore, which forcings do preserve or destroy $\Pi_{n}^1$-determinacy?

References


fabi.cast@uni-muenster.de

5.15 David Chodounsky (Prague)

I am a postdoc at the Institute of Mathematics of the Czech Academy of Sciences (Prague). I obtained my PhD in 2011 at the Charles University in Prague.

My research interests are forcing, set theory of the reals and infinitary combinatorics, cardinal invariants of the continuum, and ultrafilters on countable sets.

Recently, my main focus were certain new classes of forcing notions, examples of which are quite common among the usual posets. This is joint work with J. Zapletal [1].
Definition. Let $M$ be a countable elementary submodel of $H(\theta)$ and $P \in M$ be a poset. A condition $q \in P$ is a $Y$-master condition if for each $r \leq q$ there is a filter $F \in M$ on the Boolean completion $\operatorname{RO}(P)$ such that $\forall X \in F$ for each $X \subset P$ such that $X \in M$ and $r \in X$.

The poset $P$ is $Y$-c.c. if every $p \in P$ is $Y$-master (for each suitable model $M$). The poset $P$ is $Y$-proper if there is a $Y$-master condition below each $p \in P \cap M$.

$Y$-c.c. forcings form a class intermediate between $\sigma$-centered and c.c.c., and $Y$-proper is between strongly proper and proper. These new classes have nice and interesting properties, they are closed with respect to subforcings, factors and iterations. $Y$-proper forcings add unbounded reals, do not add random reals, do not add uncountable anticliques in open graphs, have the $\omega_1$-approximation property, ...

Moreover, these concepts are quite flexible, in the definition of a $Y$-master condition the requirement that $F$ is a filter can be modified. This gives rise to a whole portfolio of various well behaved forcing properties.

Here are some problems related to $Y$-c.c. forcings:

- Is every $Y$-proper c.c.c. forcing $Y$-c.c.?
- (ZFC) Is there a $Y$-c.c. poset not adding a Cohen real?
- Suppose that $P, Q$ are $Y$-c.c. posets such that $P \times Q$ is c.c.c. Is $P \times Q$ $Y$-c.c.?

References


chodounsky@math.cas.cz

5.16 Giovanni Cogliandro (Vienna)

My background is mainly philosophical, although since 2011 I work in Set theory within a team lead by Caludio Ternullo from the Kurt Goedel Institute in Wien. I hold a PhD in Philosophy (University of Perugia), a PhD in Law (University of Rome TRE), and a DEA in Philosophy (University of Genève).

Since 2011 I started to study the intersection of Metaphysics and Mathematics, investigating contemporary Set theory and comparing it with the emerging results coming from the new Homotopy type theory (HoTT) with a peculiar focus on the mathematical results arising in proper forcing and inner models and the different interpretation and uses of reflection principles. I am interested in the platonic background of the constructible universe of Goedel and I started working on the Metaphysics of set theory, in particular on competing views on very large cardinals (Woodin, Kentaro Sato, Friedman, Shelah, Hamkins) and different hierarchies of large large cardinals and and theories of the Universe in ST and HoTT. I am working today on very large cardinals, cardinal arithmetic and the possibility of a philosophical understanding of the different ordinal hierarchies, and of the results of Shelah (proper forcing(s)) vs/with Woodin extenders and the effort of Gitik to construct a Singular cardinals model with a countable set which pcf has cardinality $\aleph_1$.

cogliandro@gmail.com

5.17 Shani Cohen (Jerusalem)

I am a second year Masters student at the Hebrew University of Jerusalem, working under the supervision of Prof. Saharon Shelah.

In his paper [1] Shelah found a generalization of the null ideal for the case of $\lambda$-reals, rather then $\aleph_0$-reals (i.e. the usual reals). It was done in the first part of [1]; the paper presented a forcing generalizing the random real forcing first for inaccessible $\lambda$ adding a $\eta \in \lambda^+$ and later for a weakly compact $\lambda$ adding a sequence from $\prod_{\alpha < \lambda} \theta\alpha$ (for $\theta\alpha < \lambda$ and more). It means having a forcing that is $\lambda^+$-c.c., $< \lambda$-strategically complete, $\lambda$-bounding and more. In the second part of that paper, a similar forcing was presented that adds $\mu > \lambda$ new reals.
Continuing that, Shelah found similar proofs to the case of $\prod_{\gamma < \lambda} \theta_\gamma$ when $\lambda$ is smaller—first for Mahlo cardinals and later for successor of regular cardinals (that work is not yet published). My purpose is to continue that work, first by finding a forcing that adds $\mu > \lambda \lambda$-reals for those cases and continue with the attempt to generalize more results of the weakly compact case.

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shani.cn@gmail.com

5.18 Tal Cohen (Rehovot)

I am at the end of my first year as an M.Sc. student under the supervision of Tsachik Gelander in the Weizmann Institute of Science.

In [1], Gascütz proved that if $G$ is a finite group and $f : G \to H$ is an epimorphism, then every generating set in $H$ with at least $d(G)$ elements can be lifted to a generating set in $G$ (where $d(G)$ denotes the minimal number $n$ such that $G$ can be generated by $n$ elements).

This result can be generalised to totally disconnected compact groups, which are inverse limits of finite groups, if one takes generation to mean generation in the category of topological groups, i.e. closure of abstract generation.

The goal of my thesis is to prove this result for more classes of topological groups. One can find counter-examples of the lemma for general compact groups, even if they are connected, but we have already proved it for first-countable connected compact groups, which are inverse limits of connected compact Lie groups, which are in turn finitely covered by a direct product of a semisimple Lie group and an abelian Lie group.

We now hope to generalise this to groups which are somewhere between being connected and totally disconnected. Then we plan to go on to non-compact connected Lie groups (real and possibly $p$-adic) and connected locally compact groups, which are inverse limits of connected Lie groups.

References


tal.cohen@weizmann.ac.il

5.19 Klaudiusz Czudek (Gdańsk)

I am a third year undergraduate student at the University of Gdańsk. I study under the supervision of dr. Nikodem Mrózek.

Last year, I started to collaborate with Kwela and Mrózek on microscopic sets on the real line (the $\sigma$-ideal of microscopic sets is smaller than the $\sigma$-ideal of Lebesgue null sets and larger than the $\sigma$-ideal of strongly null sets). Recently, I also started to consider some problems connected with ideals of subsets of natural numbers (it is a popular topic in Gdańsk started by late professor Reclaw).

I am interested in forcing and, in particular, I would like to use it in functional analysis (which is also my favorite subject). Last semester, I attended the courses in set theory, combinatorial and descriptive set theory and the basics of forcing.

klaudiusz.czudek@gmail.com

5.20 Vincenzo Dimonte (Vienna)

My research always focused on rank-into-rank hypotheses, a special kind of large cardinals, and in particular I0.

Rank-into-rank hypotheses are large cardinal axioms that sits on the top of the large cardinal hierarchy, therefore implying the consistency of any large cardinal ever conceived. They stem from a negative result by Kunen: he proved in 1971 that there are no elementary embeddings from $V$ to $V$, where $V$
is the set theoretic universe. After this result, many new large cardinal hypotheses were created to investigate this edge of inconsistency, trying to understand if it were possible to find other apparently weaker inconsistency results. The most important are, from the weakest to the strongest:

- **I3**: there exist $\lambda$ limit and $j$ elementary embedding from $V_\lambda$ to itself;
- **I1**: there exist $\lambda$ limit and $j$ elementary embedding from $V_{\lambda+1}$ to itself;
- **I0**: there exist $\lambda$ limit and $j$ elementary embedding from $L(V_{\lambda+1})$ to itself such that for some $\kappa < \lambda$, $j(\kappa) > \kappa$, where $L(V_{\lambda+1})$ is the class of the sets constructible using elements of $V_{\lambda+1}$ as urelements.

These hypotheses gained popularity for different reasons: I3 has very interesting implications in free algebra, and from them a new branch of studies arose (LD-systems and braid groups); under I0, on the other hand, $L(V_{\lambda+1})$ has compelling similarities with $L(\mathbb{R})$ under the Axiom of Determinacy.

In my research career I investigated many facets of I0:

- there are hypotheses even above I0 that are rich and complex, and involve elementary embeddings between models of the form $L(N)$, with $V_{\lambda+1} \subset N \subset V_{\lambda+2}$. Such embeddings can be very different between each other, and there is a whole zoology to explore;
- in the construction of the large cardinal hierarchy, there has always been an attention about whether they entail some combinatorial properties or not, or in other words, how much resistant are to forcing. It turns out that they handle classical Easton forcing as well as expected (so they are consistent with GCH and many behaviours of the power function), but thanks to a Generic Absoluteness Theorem for I0, Prikry forcings will also yield new results;
- generic large cardinals are an important branch of Set Theory. A generic I0 can be defined, and it has powerful consequences.

vincenzo.dimonte@gmail.com

5.21 Stamatis Dimopoulos (Bristol)

I am a first year PhD student at the University of Bristol in the U.K., working under the supervision of Dr. Andrew Brooke-Taylor.

Vopěnka’s Principle (VP) is the assertion that for any proper class of structures for the same language $L$, there are two distinct members of the class with an elementary embedding between them. Even though it is not a large cardinal axiom of the standard form, VP implies the existence of extendible cardinals and follows from the existence of an almost huge cardinal. Thus, it has found its place in the large cardinal hierarchy and we can inquire whether we can extend the usual results for large cardinals to VP. For instance, Brooke-Taylor in [4] showed that using the standard forcing notions, VP is preserved in the generic extension.

Recently, Bagaria provided a stratification of VP in [2], with respect to the complexity of the formula defining the class of structures under consideration. More specifically, $\text{VP}(\Pi_n)$ is the statement:

For every $\Pi_n$-proper class of $L$-structures $C$, there are distinct $A, B \in C$ such that one is elementarily embeddable into the other.

Bagaria showed that $\text{VP}(\Pi_{n+1})$ follows from the existence of a $C^{(n)}$-extendible cardinal (a notion defined in the same paper) and in particular, $\text{VP}(\Pi_1)$ follows from the existence of a supercompact cardinal.

Even though VP has been found to be equivalent to important categorical statements (see [1] for more details), there is still more work to be done to find the full extent of its consequences in Set Theory. I would like to focus my research on investigating the set theoretic applications of VP and possibly find equivalent characterisations in the set theoretic context. I have already found that VP is equivalent to the universe being super-Woodin, a notion defined in [5] to construct inner models that satisfy global domination. Moreover, it is interesting to check when we can extend the previous stratification to implications of VP. An example can be found in [3] and I am currently looking at the possibility of stratifying...
the result of [5].

References


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stamatis.dimopoulos@bristol.ac.uk

5.22 Ohad Drucker (Jerusalem)

I am a fourth year PhD student at the Hebrew University, working under the supervision of Prof. Menachem Magidor.

Investigating equivalence relations have been part of descriptive set theory for many years already, the main task being classifying equivalence relations in terms of “how complicated they are”. Recently, mainly in light of works of Kanovei, Sabok and Zapletal (see [1]), a different direction of research was initiated, with questions such as: “Assume an equivalence relation is complicated. Can we make it simple on a large collection of numbers?”. For example, can a $G_δ$ equivalence relation become a closed one on an uncountable set, or on a positive measure set? Numerous problems of similar nature can then be raised.

We say that an analytic equivalence relation $E$ on the reals has Borel canonization with respect to measure zero sets if there is a Borel set $B$ of positive measure such that $E$ restricted to $B \times B$ is Borel. In [1], Kanovei, Sabok and Zapletal ask whether all analytic equivalence relations with Borel classes have Borel canonization with respect to measure zero sets (or more generally, with respect to any proper $σ$-ideal). They give positive answers for Polish orbit equivalence relations and countable equivalence relations.

Our research has been focused on the problem of Borel canonization and variations of it. Both the original problem and its variations have positive answers under large cardinal assumptions, and probably have negative answers in $L$, which we are trying to find. It turns out the problem is strongly connected with issues of generic absoluteness (see [3] and [4]).

A related issue is the existence of a perfect set of pairwise inequivalent elements when all classes of a given equivalence relation are Borel measure zero sets. We have shown that such a set exists when $E$ is analytic or coanalytic. When $E$ is $Σ^1_2$, existence of such a perfect set is independent of $ZFC$ with a counterexample in $L$. We are trying to find the weakest large cardinal axiom preventing such a counterexample.

References


5.23 Piotr Drygier (Wrocław)

I am a fourth year PhD student at the Wrocław University, working under the supervision of Prof. Grzegorz Plebanek.

My research is focused on the topology in Banach spaces especially in spaces of real-valued continuous functions on compact set (denoted by $C(K)$ for some compact set $K$).

In order to express the notions of my research we need to introduce the following two concepts.

- We say that the closed subspace $F$ of $E$ is complemented in the Banach space $E$ if there exists a projection form $E$ onto $F$ i.e. the bounded linear operator $P: E \to F$ such that $P^2 = Id$ and $P[E] = F$.

- For any Boolean algebra $A \subseteq P(\omega)$ we can consider the Stone space $K_A$ i.e. the space of all ultrafilter on $A$ equipped with the special topology. If $A$ contains all finite subsets of $\omega$, the space $K_A$ can be seen as the compactification of integers.

At present I am involved in the compactifications $\gamma \omega$ of integers and relations between the topological properties of those and the complementability of $c_0$ in some Banach spaces. For example the interesting question seems to be the connection between the separability of the growth $\gamma \omega \setminus \omega$ of compactification $\gamma \omega$ and the complementability of $c_0$ in the space $C(\gamma \omega)$.

Since some of the questions raised in this subject cannot be decided in the ZFC theory, we need to exploit extended set of axioms to obtain new results.

References

5.24 Jin Du (Chicago)

I am a third year PhD student at the University of Illinois at Chicago, working under the supervision of Prof. Dima Sinapova.

I am interested in forcing, large cardinals, and combinatorial set theory. More specifically, my research focuses on principles like diamond and square, and also on Prikry type forcings. In 2008, Gitik and Sharon [1] settled an open problem of Woodin by finding a model of \( \neg \text{SCH} + \neg \square_\kappa \) with \( \kappa = \aleph_\omega \). My current research is trying to extend these results to include a failure of \( \diamond \) using work by Gitik and Rinot [2].

References


jdu8@uic.edu

5.25 Laura Fontanella (Jerusalem)

I am a postdoc researcher at the Hebrew University of Jerusalem. My main research interests lie in large cardinals and forcing. More specifically, I have been exploring some properties of large cardinals that can consistently hold at small cardinals and I mainly focused on reflection principles. By “reflection principles” I mean statements of the following form: for a given structure (a stationary set, a tree etc.) and a given property, one can find a substructure of smaller cardinality satisfying the same property. Reflection principles are typical properties of large cardinals but can consistently hold even at small cardinals. My results concern the following reflection and anti-reflection principles.

**The tree properties**

One of the most fruitful research area is the study of the so-called *tree property*. This is the generalization of König’s Lemma to uncountable cardinals, namely we say that a cardinal \( \kappa \) has the tree property if for every tree of height \( \kappa \) with levels all of size less than \( \kappa \) there exists a cofinal branch. The tree property is a principle of reflection for the property of “not having a cofinal branch” and it provides a nice characterisation of weakly compact cardinals: an inaccessible cardinal is weakly compact if and only if it has the tree property. Despite its strength, even small cardinals can have the tree property: for instance, Mitchell proved that, assuming the consistency of a weakly compact cardinal, it is possible to force a model where \( \aleph_\omega \) has the tree property. There is a huge literature on models of the tree property at small cardinals; these lines of inquiry aim to determine whether or not it is possible to build a model where every regular cardinal has the tree property. Stronger large cardinal notions admit analogous combinatorial characterisations: an inaccessible cardinal is strongly compact if and only if it satisfies the *strong tree property*; an inaccessible cardinal is supercompact if and only if it satisfies the *super tree property*. Weiss proved that even these stronger principles can hold at small cardinals such as \( \aleph_2 \). My results in this field show that several intervals of small cardinals can simultaneously satisfy the tree property, the strong tree property or even the super tree property.

**Reflection of stationary sets and related principles**

A classical reflection principle is the *reflection of stationary sets*. For a regular cardinal \( \kappa \) this principle establishes that for every stationary subset \( S \subseteq \kappa \) there exists an ordinal \( \alpha < \kappa \) of uncountable cofinality such that \( S \cap \alpha \) is stationary in \( \alpha \). It was an open problem whether the reflection of stationary sets and the tree property could hold simultaneously at small successors of singular cardinals; Magidor and I answered this question in the affirmative: assuming the consistency of large cardinals, we forced a model where both the tree property and the reflection of stationary sets hold at \( \aleph_{\omega_2+1} \). In this model, \( \aleph_{\omega_2+1} \) satisfies an even stronger reflection principle called *Delta-reflection*. The Delta-reflection implies several nice properties for structures of various kind such as abelian groups, graphs, topological spaces and others: for instance if a regular cardinal \( \kappa \) has the Delta-reflection, then every almost free group of size \( \kappa \) is free. Considering the large variety of applications of the Delta-reflection we wondered if this...
principle would imply also the tree property and we answered this question in the negative: assuming the consistency of large cardinals, it is possible to force a model where \( \aleph_{\omega^2+1} \) satisfies the Delta-reflection but not the tree property.

**Square principles**

Square principles are anti-reflection principles as they imply the failure of several reflection principles and are false in the presence of certain large cardinals. In collaboration with Hayut, I recently investigated a version of the square, denoted \( \Box(\kappa) \), which is due to Todorcevic. This principle is defined as follows. For a regular cardinal \( \kappa \), \( \Box(\kappa) \) holds if there is a sequence \( \langle C_\alpha \rangle_{\alpha < \kappa} \) such that:

1. For every \( \alpha < \kappa \), \( C_\alpha \subseteq \alpha \) is closed and unbounded.
2. For every \( \beta \in \text{acc}(C_\alpha) \), \( C_\alpha \cap \beta = C_\beta \).
3. There is no thread, i.e. there is no club \( D \subseteq \kappa \) such that for every \( \alpha \in \text{acc}(D) \), \( D \cap \alpha = C_\alpha \).

Hayut and I proved that under some large cardinals assumptions, it is possible to build a model where both \( \Box(\aleph_{\omega^2+1}) \) holds and \( \aleph_{\omega^2+1} \) has the Delta-reflection. This means that \( \aleph_{\omega^2+1} \) can simultaneously satisfy a strong reflection principle and a strong anti-reflection principle.

**References**

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laura.fontanella@gmail.com

5.26 Kevin Fournier (Lausanne)

I am PhD student between the University of Lausanne, Switzerland and the University Paris VII, France, working under the supervision of Prof. Jacques Duparc and Prof. Boban Velicković.

I work in Descriptive Set Theory, and my research centers around reductions by continuous functions. Assuming adequate determinacy hypotheses, I work on generalizations of the results obtained on the Wadge hierarchy of Borel subsets of the Baire space to larger topological classes, beginning with the differences of co-analytic sets, Selivanovski’s \( C \)-sets and Kolmogorov’s \( R \)-sets, and aiming to the description of the whole hierarchy of the \( \Delta_3^1 \) subsets of the Baire space. Moreover, I consider applications of Descriptive Set Theory tools to automata theory, and in particular languages of labeled infinite binary trees recognized by tree automata.

kevin.fournier@uni1.ch
5.27  Shimon Garti (Jerusalem)  
shimon.garty@mail.huji.ac.il

5.28  Michel F. Gaspar (Sao Paulo)  
I am a last year undergraduate student at the Institute of Mathematics and Statistics of the University of Sao Paulo, working under the supervision of Prof. Rogerio Augusto dos Santos Fajardo.  

Since the successful application of the Forcing technique by Robert Solovay to the Measure Problem (see [1]), many questions concerning Baire-categorial and measure-theoretic aspects of the real line have been settled under different extensions of ZFC (e.g. see [2]), and this important segment on the descriptive set theory succeeded (see: [3] and [4]). Also, some developments on the field are intimately related to large cardinal assumptions (see [6]).  

During the master program my efforts will be focused on the independence phenomena in the real line, giving special attention to measure and Baire-categorial problems. Real Forcing has shown itself to be an indispensable tool, specially the idealized approach (see [7]).

References

gaspar@ime.usp.br

5.29  Fiorella Guichardaz (Torino)  
As a Master student at the University of Torino I become interested in set theory and wrote my master thesis under the supervision of Prof. Matteo Viale with an approach to forcing with Boolean algebras and Boolean valued models.  

I am now a second year PhD student at the University of Freiburg im Breisgau, working under the supervision of Prof. Heike Mildenberger. After studying a few applications of the iterated forcing, such as the consistency of BC and dBC [3], learning some set theory of the real line [4] with specific attention to relations between cardinal invariants and ultrafilters properties, I am now focusing on matrix iteration forcing.

It was introduced for the first time by Blass and Shelah [1] to show the consistency of $u < d$ and used also by Brendle and Fisher [2] to prove $con(b < s)$. The idea in [1] is to work in two dimensions (and with finite support iteration of ccc posets). Let $\delta < \nu$ be two regular cardinals. The aim is to show that in the final extension $d = \delta$ and $u = \nu$. Construct for $\alpha \leq \delta$ and $\beta \leq \nu$, the object $V[\alpha, \beta]$ such that $V[0, 0]$ is the ground model, $V[\delta, 0]$ is the extension obtained adding $\delta$ Cohen reals and $V[\delta, \nu]$ is obtained from $\delta$ Cohen reals and $\nu$ Mathias reals. In the construction of the Mathias reals some particular ultrafilters must be used (and constructed through the intermediate steps $V[\alpha, \beta]$, to avoid the introduction of small families of dominating reals).

Recall that a family $D \subseteq \omega^\omega$ is called dominating family iff $\forall f \in \omega^\omega \exists g \in D(f \leq^* g)$. The dominating number $d$ is the smallest cardinality of a dominating family.
Let $\mathcal{F}$ be a filter. $B \subseteq \mathcal{F}$ is a basis for $\mathcal{F}$ iff $\forall X \in \mathcal{F} \exists B \in \mathcal{B}(B \subseteq X)$. The character of $\mathcal{F}$ is the smallest cardinality of a basis for $\mathcal{F}$. The ultrafilter number $u$ is the minimal character of an ultrafilter.

References


5.30 Gabriele Gullà (Rome)

I am a second year PhD student in Tor Vergata University of Roma (Italy) under the supervision of prof. Paolo Lipparini.

My first interests have been topics related with continuum hypothesis: I wrote on this topics for my bachelor degree (Cohen Forcing) and in my master thesys (Woodin’s $\Omega$-logic).

Currently my interests are on three sides:
1) New (precise) characterizations for some large cardinals’ notions.
2) Forcing axioms and properties of universally baire sets. These topics are, as it’s known, strictly connected with $\Omega$-logic together with determinacy and the theory of infinite games.
3) Quine’s New Foundation and philosophy of logic, in particular truth theories by Tarski and Kripke.

For the first point:
References 1


For the second:
References 2


And for the third:
References 3

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gulla@mat.uniroma2.it
5.31 Elliot Glazer (New Jersey)

I am an undergraduate at Rutgers University going into my third year. My advisor is Professor Grigor Sargsyan, who has supervised my study in logic, forcing, descriptive set theory, and inner model theory. This summer Prof. Sargsyan is supervising my REU project, which is a lecture note on coarse inner model theory based on his introductory course, meant to make this subject somewhat more accessible to early set theory students. These notes will cover the classic determinacy results, including Borel determinacy in ZFC, analytic determinacy from a measurable cardinal, projective determinacy from infinitely many Woodin cardinals, and that AD holds in $L(R)$ if there are infinitely many Woodin cardinals, with a measurable cardinal above them all. They will also cover mice and the Mouse Set Conjecture. I hope to begin researching these topics in the fall after I complete these lecture notes.

References


glaze240@gmail.com

5.32 Ishay Golinsky (Tel Aviv)

I am a first year master student at the University of Tel Aviv, working under the supervision of Prof. Moti Gitik.

Being at a relatively early stage of my academic life, I have no research statement yet to present. Over the past year, my efforts have been dedicated mostly to the study of various large cardinal axioms and their implications.

ishayg@mail.tau.ac.il

5.33 Jan Grebik (Prague)

I am a first year master’s student at the Charles University in Prague. I am working on problems in Set theory under the supervision of Bohuslav Balcar, Wieslaw Kubis and David Chodounsky.

One of our interests is the Boolean algebra $P(\omega)/\text{fin}$, namely its cardinal characteristics $\mathfrak{i}, \mathfrak{u}, \mathfrak{r}, \mathfrak{f}$. The cardinal invariant $\mathfrak{f}$ defined by D. Monk in [4] is defined as the minimal cardinality of a maximal free sequence. Let us recall that a free sequence in a Boolean algebra $B$ is a sequence $A = (a_\alpha)_{\alpha < \kappa}$ of its elements such that for every $\beta < \kappa$ the family

$$\{a_\gamma\}_{\gamma < \beta} \cup \{\overline{a}_\delta\}_{\beta < \delta < \kappa}$$

has the finite intersection property (\overline{a} denotes the complement of $a \in B$). We say that a sequence $A$ is maximal iff we cannot append an element to its end. For more information about free sequences in the context of general Boolean algebras see [3],[4].

For $P(\omega)/\text{fin}$ ZFC proves that $\mathfrak{r} \leq \mathfrak{u}$ and $\mathfrak{r} \leq \mathfrak{i}$. However, it is consistent that $\mathfrak{i} < \mathfrak{u}, \mathfrak{r} < \mathfrak{u}$ (see [1],[2]), and $\mathfrak{u} < \mathfrak{i}$. Our aim is to prove inequalities and consistency results featuring $\mathfrak{f}$. Our starting point is the following claim. If $\mathfrak{r} = \mathfrak{u}$, then $\mathfrak{f} = \mathfrak{u} = \mathfrak{r}$. We would like to know consistency of $\mathfrak{f} > \mathfrak{r}, \mathfrak{f} > \mathfrak{i}, \mathfrak{u} > \mathfrak{f}$, or $\mathfrak{f} > \mathfrak{u}$. What value does $\mathfrak{f}$ take in the model for $\mathfrak{i} < \mathfrak{u}$ in [2]? Note that to get $\mathfrak{u} < \mathfrak{f}$ we need to have $\mathfrak{r} < \mathfrak{u} < \mathfrak{f}$ which cannot be achieved by the countable support iteration. The hope is that resolving this problem could also help answering the following questions. Is it consistent that every maximal free sequence generates an ultrafilter? What are the order and cofinal types of maximal free sequences? Is there any connection between independent families and free sequences, i.e., can an independent family be ordered and become a maximal free sequence? What if we assume CH.

References


greboshrabos@seznam.cz

5.34 Miha E. Habic (New York)

I am a third year PhD student at the Graduate Center of the City University of New York, working under the supervision of Prof. Joel David Hamkins.

Laver functions, introduced in [3], have become a ubiquitous tool in all manner of forcing constructions related to large cardinals. Recall that, if \(\kappa\) is supercompact, a Laver function for \(\kappa\) is a function \(\ell: \kappa \to V_\kappa\) such that for any \(\theta\) and any \(x \in H_\theta\) there is a \(\theta\)-supercompactness embedding \(j: V \to M\) with critical point \(\kappa\) satisfying \(j(\ell)(\kappa) = x\). The notion was later extended to other large cardinals by Gitik and Shelah (see [1]), Hamkins (see [2]) and others.

In my research I have investigated joint Laver functions, introduced by Joel David Hamkins and myself. As with Laver functions themselves, this concept can be applied to various large cardinal notions, but in the simplest case of a measurable cardinal \(\kappa\), a sequence of functions \(\ell_\alpha: \kappa \to V_\kappa\) for \(\alpha < \lambda\) is jointly Laver if for any sequence of elements \(x_\alpha \in H_\kappa\) for \(\alpha < \lambda\) there is a measurability embedding \(j: V \to M\) such that \(j(\ell_\alpha)(\kappa) = x_\alpha\) for all \(\alpha < \lambda\). One can force the existence of a joint Laver sequence of length \(2^\kappa\) starting from a measurable \(\kappa\). On the other hand, it turns out that there are no nontrivial implications between the existence of joint Laver sequences of different lengths above \(\kappa\), that is, it is consistent to have a joint Laver sequence of length \(\kappa\) but no sequence of length \(\kappa^+\), and similarly for any length between \(\kappa\) and \(2^\kappa\). With some modifications, similar statements can also be shown to hold for \(\theta\)-supercompact cardinals and a large class of \(\theta\)-strong cardinals. Interesting phenomena arise when considering \(\theta\)-strong cardinals when \(\theta\) is a limit ordinal of small cofinality; in these cases even the existence of short joint Laver sequences has consistency strength strictly above the large cardinal in question.

I am also interested in applying the jointness idea to other guessing principles. For example, a Laver function for a measurable \(\kappa\) is, after unravelling the ultrapower representation, simply a \(\lozenge_\kappa\) sequence which guesses not only on a stationary set but on a set of normal measure 1. If we now allow \(\kappa\) to be any uncountable regular cardinal, a joint \(\lozenge_\kappa\) sequence is a sequence \(\langle A_\alpha^\kappa; \xi < \kappa; \alpha < \lambda \rangle\) of \(\lozenge_\kappa\) sequences such that for any sequence of sets \(A^\alpha \subseteq \kappa\) there is a normal uniform filter on \(\kappa\) containing the sets \(S^\alpha = \{\xi; A^\alpha \cap \xi = A_\alpha^\xi\}\). Again, the largest possible length of a joint \(\lozenge_\kappa\) sequence is \(2^\kappa\) and recently I have managed to show that the existence of such a sequence is simply equivalent to \(\lozenge_\kappa\), in stark contrast to the large cardinal case.

References


mhabic@gradcenter.cuny.edu
5.35  Yair Hayut (Jerusalem)

I am a second year PhD student at the Hebrew University of Jerusalem, working under the supervision of Prof. Menachem Magidor. I finished my Master thesis in 2013. My Master thesis dealt with the connection between stationary reflection and the approachability property at successor of singulars and was done also under the supervision of Prof. Magidor.

My research is focused in the tension between reflection and anti-reflection principle, especially at successors of singular cardinals and inaccessible cardinals.

The first square principle was defined by Jensen in [1]. In this paper Jensen showed that this principle holds at $L$. The square principle is a prototype for non-compactness phenomenon. For example, Jensen’s square at $\kappa$ implies (among many consequences) that there are many non-reflecting stationary sets at $\kappa^+$. A weaker notation was defined by Todorčević, [3]. In some senses we can think of the square of Todorčević as a second order version of Jensen’s square. For example while it doesn’t imply the existence of stationary sets it does imply the existence of pair of stationary subsets of $\kappa$ that don’t reflect simultaneously.

I’m interested in possible formalizations of the above intuitive statement. A possible direction is:

**Conjecture:** Let $\varphi$ be a statement in the language $\langle \in, A, S \rangle$ of set theory with two additional unary predicate symbols and let $\kappa$ be a definable regular cardinal.

If it is consistent (relative of some large cardinals) that:

$$\forall S \subseteq \kappa \text{ stationary } \forall A \subseteq \kappa (H(\kappa), \in, A, S) \models \varphi$$

then also it is consistent (relative to some large cardinals) that:

There is a square at $\kappa$ and $\forall S \subseteq \kappa$ stationary $\forall A \subseteq \kappa (H(\kappa), \in, A, S) \models \varphi$

For example, the statements "every stationary subset of $S_\omega^{\omega_2}$ reflects", "every stationary subset $\aleph_{\omega_2}$ reflects" are of this form while the statement "every two stationary subsets of $S_\omega^{\omega_2}$ have a common reflection point" is not of this form.

The conjecture is true if $\varphi$ can be made indestructible by $\kappa$-directed closed forcing notions. In a joint work with Laura Fontanella, we showed that the strong reflection principle $\Delta_{\aleph_\omega, \aleph_{\omega_2}}$ (defined in [2]) is consistent together with square of $\aleph_{\omega_2}+1$. Since it is not known how to force the $\Delta$-principle at $\aleph_{\omega_2}$ to be indestructible, this result suggests that the above conjecture is true for wider range of statements.

**References**


yair.hayut@mail.huji.ac.il

5.36  Jacob Hilton (Leeds)

I am a third year PhD student at the University of Leeds, working under the supervision of Prof. John K. Truss. Since May 2014, I have also been in collaboration with Prof. Andrés E. Caicedo from Boise State University.

My research focuses on ordinal topologies. Ordinals are endowed with the order topology (the topology generated by open intervals).

Primarily I have been looking at topological partition relations between ordinals. Recall the usual Erdős–Rado partition relation $\mu \to (\lambda)^r_k$ between cardinals $\lambda$ and $\mu$, which means that whenever the $r$-subsets of $\mu$ are coloured with $k$ colours, then there is a homogeneous set of size $\lambda$; thus $\aleph_0 \to (\aleph_0)^r_k$ ($r, k \in \omega$) is Ramsey’s theorem. In the topological version $Y \to (topX)^r_k$ between topological spaces
X and Y, the homogeneous set must be homeomorphic to X, not merely the same size. For example, 
ω^2 + 1 → (top ω + 1) \_1^1 (exercise). See [6] for further background.

I solved what remained of the case r = 1, the “topological pigeonhole principle for ordinals” [1]. For 
countable ordinals, the solution is related to the order-theoretic pigeonhole principle of Milner and Rado [2]. For 
uncountable ordinals, I used a model of Shelah to show that certain cases are independent of ZFC.

With Prof. Caicedo I have been looking at the case r = 2. An old argument due to Sierpiński [4, Theorem 2] shows that \( \alpha \not\rightarrow (top\alpha + 1,\alpha)^2 \) for all \( \alpha \in \omega_1 \). Therefore we have been studying the 
topological ordinal Ramsey number \( R^{top}(\alpha,n) \) (\( \alpha \in \omega_1, n \in \omega \)), which is defined to be the least ordinal \( \beta \) such that \( \beta \rightarrow (top\alpha,n)^3 \), i.e. whenever the edges of a complete graph on \( \beta \) are coloured red and blue, then 
there is either a red-homogeneous subspace homeomorphic to \( \alpha \) or a blue-homogeneous set of \( n \) points. 
Together we have developed several techniques and proved among other things that 
\( R^{top}(\omega + 1, n + 1) = \omega^n + 1, R^{top}(\omega^2, n) \leq \omega^n \) and \( R^{top}(\omega^n, n + 1) \leq \omega^{\alpha n} \).

It appears to be difficult to say anything non-trivial about the case \( r \geq 3 \). I conjecture that \( \omega_1 \rightarrow (top\omega + 1)^k \) \( \langle r,k \in \omega \rangle \) but have only managed to prove that \( \omega_1 \rightarrow (top\omega + 1,4)^3 \). This was done using the pressing down argument introduced by Erdős and Rado in their proof of \( \omega_1 \rightarrow (top\omega + 1)^2 \) [5, p. 3].

Outside of partition relations, I have studied the group of autohomeomorphisms of \( \omega^n \cdot m + 1 \) \( (m, n \in \omega) \) and classified the normal subgroups contained in the pointwise stabilizer of the limit points. I have also 
studied the relationship between countable subspaces of ordinals and countable scattered linear orders 
(defined in [3]).

References
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1215, 2010.
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mmjhh@leeds.ac.uk

5.37 Stefan Hoffelner (Vienna)

My research is concerned with the interplay of inner models for large cardinals, forcing iterations, and 
definable wellorders. A lot of effort has been made in the past to construct models of set theory, which on 
the one hand contain some (not too) large cardinals, while on the other additionally admit a projective 
wellorder on the reals.

In my thesis, which is still work in progress and written under the supervision of Sy-David Friedman, 
I investigate the possibility of a universe where the nonstationary ideal on \( \omega_1 \), NS\( \omega_1 \) is \( \mathfrak{N}_2 \)-saturated, yet 
it allows a \( \Sigma^1_2 \)-wellorder on the reals.

A rough outline how to construct such a model is to start with the canonical inner model \( M_1 \) which 
has one Woodin cardinal \( \delta \), and try to seal off all long antichains in a \( \delta \)-long RCS iteration, following 
Shelah’s original argument, that a Woodin cardinal suffices to get NS\( \omega_1 \) \( \mathfrak{N}_2 \)-saturated. In this iteration 
there is plenty of room left to include forcings which create a pattern of canonically over \( M_1 \)-definable 
trees, which do or do not have a cofinal branch. This gives us the possibility to code information, such 
as a wellorder on the reals, into the sequence of the trees, while still preserving the saturation of NS\( \omega_1 \). 
The final step is to try to localize the so created patterns of cofinal or bounded \( M_1 \)-trees, that already
suitably definable, countable transitive models are able to identify the patterns. This involves a variant of the so called trick of René David, together with comparison arguments of mice.

stefan.hoffelner@gmx.at

5.38 Haim Horowitz (Jerusalem)

I am a third year PhD student at the Hebrew University of Jerusalem, working under the supervision of Prof. Saharon Shelah.

My research revolves around the following themes:
1. Forcing theory and its connections with descriptive set theory and the the set theory of the reals.
2. Higher analogs of the above (e.g. they study of iterations with large support, the study of the generalized Baire space $\kappa^\omega$, etc).

Other topics that I find extremely interesting are determinacy, generic absoluteness, algorithmic randomness and the various interactions between set theory and recursion theory.

Below I describe our recent results:

1. Regularity properties: Given a Suslin ccc forcing notion $Q$, there is a natural ideal $I_Q = I_{Q,\aleph_0}$ associated with $Q$, generalizing the null and meagre ideals (which are obtained when $Q$ is random real forcing and Cohen forcing, respectively). We also define the ideal $I_{Q,\aleph_1}$, as the closure of $I_{Q,\aleph_0}$ under unions of size $\leq \aleph_1$. A set of reals $X$ is called "$I_{Q,\kappa}$-measurable" if there exists a Borel set $B$ such that $X \Delta B \in I_{Q,\kappa}$. We would like to classify the Suslin ccc forcing notions according to the consistency strength of $T + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and $T \notin \{ZF, ZF + AC_\omega, ZF + DC, ZF + DC_\omega\}$. By Solovay’s result, the existence of an inaccessible cardinal implies the consistency of $ZF + DC + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and of reals are Lebesgue measurable and have the Baire property”. By a result of Shelah, $ZF + DC + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and of reals have the Baire property” is equiconsistent with $ZFC$. A main ingredient in Shelah’s proof is a strong version of ccc called "sweetness", which is preserved under amalgamation.

A natural question then arises: Can we get similar results for non-sweet ccc forcing notions without using an inaccessible cardinal? In [4] we give a positive result for an ideal of the form $I_{Q,\aleph_1}$ by constructing a suitable family of ccc creature forcings and iterating along a non-wellfounded linear order. Although the resulting model doesn’t satisfy $AC_\omega$, we show in a subsequent work [5] that starting with a model of $ZF + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and $T \notin \{ZF, ZF + AC_\omega, ZF + DC, ZF + DC_\omega\}$, By Solovay’s result, the existence of an inaccessible cardinal implies the consistency of $ZF + DC + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and of reals are Lebesgue measurable and have the Baire property”. By a result of Shelah, $ZF + DC + \forall \kappa \in \{\aleph_0, \aleph_1\}$ and of reals have the Baire property” is equiconsistent with $ZFC$. A main ingredient in Shelah’s proof is a strong version of ccc called "sweetness", which is preserved under amalgamation.

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2. Iterated forcing: We’ve also done some work on the general theory of iterated forcing. In [2] we introduce the concept of “corrected iteration”, which allows us to extend the theory of finite-support iterations of Suslin forcing [6] to include $(<\kappa)$-support iterations for $\kappa > \aleph_0$, as well as partial memory iterations of "absolute enough" forcing notions which are not necessarily $\Sigma^1_1$. Corrected iterations seem to play an important role in the proof of the main result of [5]. We also apply them to prove new consistency results on the simultaneous separation of cardinal invariants of the continuum.

References


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haim.horowitz@mail.huji.ac.il

5.39 Manuel Inselmann (Münster)

I am a second year PhD student at the University of Münster, working under the supervision of Prof. Benjamin Miller. Beginning in September 2015 I will be continuing my PhD project at the Kurt Gödel Research Center in Vienna.

Over the last decades, countable Borel equivalence relations became objects of great interest in descriptive set theory (e.g., see [1],[2],[4]). Several notions of reducibility, most prominently Borel reducibility and measure reducibility, have been the focus of research. The presence of a measure often allows one to gain much more insight than one is able to get in a purely Borel context. A well-known example of this comes from the notion of the $\mu$-cost of an $E$-invariant Borel probability measure $\mu$ (e.g., see [3],[5],[6]), which provides a plethora of theorems, including a positive answer to a weak version of a dynamic analogue of the von Neumann conjecture (see [5]). One goal of my PhD project is to find generalizations of the cost notion to quasi-invariant Borel probability measures.

It has been known for some time that there are continuum-many pairwise incomparable countable Borel equivalence relations under Borel reducibility (see [1]). Nevertheless, there remain a lot of open questions regarding the structure of this quasi-order. Another direction of my PhD project is to tackle some of these questions, e.g., do successors of $E_0$ under measure-reducibility exist?

References


Manuel.Inselmann@uni-muenster.de

5.40 Joanna Jureczko (Warsaw)

I am a faculty member at the Institute of Mathematics, Cardinal Stefan Wyszynski University in Warsaw, Poland.

The strong sequences method was introduced by B. A. Efimov in [1], as a useful method for proving famous theorems in dyadic spaces: Marczewski theorem on cellularity [2], Shanin theorem on a calibre [3], Esenin-Volpin theorem [5] and Erdős-Rado theorem, [4].

My research efforts have been focused on looking for applications of the strong sequences method and the cardinal number connected with it in different structures like: independent families, Cichoń Diagram and inequalities among other well known invariants. I have also proven the equivalence between this method and others: Bolzano-Weierstrass method, Erdős-Rado theorem.

References


5.41 Asaf Karagila (Jerusalem)

I am a third year PhD student at the Hebrew University of Jerusalem, my supervisor is Prof. Menachem Magidor.

My work is related to the axiom of choice in modern set theory and models in which it fails. More specifically, I’m working on the development of new methods to construct models in which the axiom of choice fails, and applying these methods in order to obtain new independence results, or clarify old results.

karagila@math.huji.ac.il

5.42 Burak Kaya (New Jersey)

I am currently a fifth year PhD student at Rutgers University, under the supervision of Simon Thomas. My research interests are mainly in descriptive set theory, more specifically in the theory of Borel equivalence relations.

Under appropriate coding and identification, various collections of structures can be regarded as standard Borel spaces, i.e., measurable spaces \((X, \mathcal{B})\) such that \(\mathcal{B}\) is the collection of Borel sets of some Polish topology on \(X\). Then, various classification problems on these structures can be seen as the study of the corresponding equivalence relations on \(X\). Given two analytic equivalence relations \(E\) and \(F\) on the standard Borel spaces \(X\) and \(Y\), we say \(E\) is \(\text{Borel reducible}\) to \(F\), written \(E \leq_B F\), if there exists a Borel map \(f : X \to Y\) such that \(xEy \iff f(x)Ff(y)\). \(E\) and \(F\) are \(\text{Borel bireducible}\) if \(E \leq_B F\) and \(F \leq_B E\). If \(E\) is Borel reducible to \(F\), then the classification problem with respect to \(E\) is, intuitively speaking, no harder than the classification problem with respect to \(F\).

My research has been focusing on the classification problem for various topological dynamical systems. A topological dynamical system (or, a flow) is a pair \((X, \varphi)\) where \(X\) is a compact metric space and \(\varphi : X \to X\) is a continuous map. \((X, \varphi)\) is called \textit{minimal} if \(X\) has no proper non-empty \(\varphi\)-invariant closed subsets. Of particular interest are \textit{Cantor minimal systems}, i.e. minimal topological dynamical systems \((X, \varphi)\) where \(X\) is a Cantor set and \(\varphi : X \to X\) is a homeomorphism. Two topological dynamical systems \((X, \varphi)\) and \((Y, \psi)\) are said to be \textit{topologically conjugate} if there exists a homeomorphism \(\pi : X \to Y\) such that \(\pi \circ \varphi = \psi \circ \pi\). By attaching a point of the underlying topological space to the corresponding dynamical systems, we can define the class of pointed topological dynamical systems as the triples of the form \((X, \varphi, x)\) where \(x \in X\). Two pointed systems \((X, \varphi, x)\) and \((Y, \psi, y)\) are said to be \textit{pointed topologically conjugate} if there is a topological conjugacy \(\pi : X \to Y\) between \((X, \varphi)\) and \((Y, \psi)\) such that \(\pi(x) = y\).

My research started as a continuation of the project of analyzing the topological conjugacy relation on various subshifts studied in [1]. Considering not only subshifts but arbitrary Cantor minimal systems, I have recently proven that the pointed topological conjugacy relation \(E_{ptc}\) on pointed Cantor minimal systems is Borel bireducible with \(E_{cntbl}\) defined on \(\mathbb{R}^\mathbb{N}\) by

\[
x E_{cntbl} y \iff \{x_n : n \in \mathbb{N}\} = \{y_n : n \in \mathbb{N}\}
\]
Moreover, I showed that $E_{cntbl}$ is Borel reducible to the topological conjugacy relation $E_{tc}$ on Cantor minimal systems. Currently, my research efforts are focused on determining the Borel complexities of the pointed topological conjugacy relation on arbitrary minimal systems and the non-pointed topological conjugacy relation on Cantor minimal systems.

References


bkaya@math.rutgers.edu

5.43 Martin Köberl (New Jersey)

Beginning with Fall 2015, I am a PhD student at Rutgers University planning to work under Prof. Sargsyan. In May 2015 I finished my Master’s studies at the University of Vienna under the supervision of Prof. Friedman.

My main interest lies in determinacy. For classes of sets of reals, such as Borel sets or projective sets, determinacy has been studied for some time already. Nowadays we have a rough overview over which large cardinals are needed to guarantee that certain classes of sets are determined. The interest in determinacy of longer games (with countably many turns for some ordinal $\alpha > \omega$ or even uncountably many turns) however, is more recent and much less is known. During my master studies I got especially interested in methods introduced by Itay Neeman in [1].

Determinacy is also interesting from a conceptual perspective, because of the connections it introduces between high-level objects and low-level objects in the mathematical universe, and the regularity properties it implies (such as Lebesgue measurability or having the Baire property). Unfortunately for sets of longer sequences, the implications their determinacy has are less understood.

Through determinacy I also got interested in inner model theory. In the future I hope to better understand this field and its attempts in classifying the consistency strength of certain theories and providing canonical models for those.

References


martin.koeberl@gmail.com

5.44 Marlene Koelbing (Vienna)

I am a first year PhD student at the Kurt Gödel Research Center Vienna, working under the supervision of Prof. Friedman.

Gaps in $\omega^\omega$ have been studied for a long time. Hausdorff and Rothberger showed the existence of $(\omega_1, \omega_1)$-gaps and $(\omega, b)$-gaps. Considering forcing the question, if a gap remains a gap in extensions was studied. Kunen and Laver showed, that a gap is destructible by forcing, iff it is destructible by one special forcing.

I am interested in the question, which results about gaps can be generalised to $\kappa^\omega$ for an uncountable cardinal $\kappa$.

References


marlene.koelbing@univie.ac.at
5.45 Menachem Kojman (Be'er Sheva)

Menachem Kojman is a professor of Mathematics at Ben-Gurion University of the Negev.

kojman@math.bgu.ac.il

5.46 Péter Komjáth, (Budapest)

Péter Komjáth is a professor of Mathematics at Matematikai Intézet Eötvös Loránd Tudományegyetem.

kope@cs.elte.hu

5.47 Michal Korch (Warsaw)

I am a PhD student at the University of Warsaw, working under the supervision of Prof. Tomasz Weiss and Prof. Piotr Zakrzewski.

My main field of interest is the set theory of the real line with particular emphasis on measure and category, the aspects of which are magnificently described in [8] (see also: [3] and [1]). The whole theory is motivated by the existing duality between measure and category and abrupt decline of it in some cases. The same one can observe defining small sets in the sense of measure and in the sense of category – see the survey paper of Miller ([5]), where the author defines classes of perfectly meager sets (sets which are meager relative to any perfect set) and universal null sets (sets which are null with respect to any possible finite diffused Borel measure). Those classes of sets were considered to be analogous in some sense, though some differences were proved.

In [11] Zakrzewski proved that two other classes of small sets on the category side defined earlier by Grzegorek coincide and have some properties dual to the class of universal null sets. Therefore he called this class universally meager sets. It is obvious that universally meager set is perfectly meager, but it is consistent with ZFC that those classes are different. We define natural class of „perfectly null” sets in 2ω – the sets that have measure zero in any perfect set P ⊆ 2ω with respect to measure μP, where μP is a measure taken form 2ω by canonical homeomorphism P → 2ω. It is obvious that every universally null set is perfectly null, but it is still not known whether this class is at least consistently different from the class of universally null sets, for more see [4]. I am also interested in properties of transitive versions of this class in a sense of some additive properties as an analogue to perfectly meager in the transitive sense sets defined in [7]). More generally one can study some ideals of small sets which are invariant under different classes of Borel isomorphisms and their transitive versions. I am also interested in generalizations of the theory of special subsets to 2κ, κ > ω.

Recently I also have been working on some problems concerning generalized Egorov’s statement. Generalized Egorov’s statement is the classical theorem of Egorov without the assumption that the functions involved are measurable. This statement and its negation are consistent with ZFC, see e.g. [9]. One can also consider Egorov’s theorem for different types of ideal convergence, see e.g. [6]. My main area of interest in this topic is to study the consistency of generalized Egorov’s statement for different types of ideal convergence.

In the field of logic in computer science, I am working on applying some categorical methods (see [2]) to prove the classical results of decidability of the monadic second order logic over α < ω2 (see e.g. [10]) and some consistency results for α ≥ ω2, and also some aspects of transfinite automata theory.

References


5.48 Regula Krapf (Bonn)

I am a second year PhD student at University of Bonn. In the current semester I have been mostly working on class forcing. In a joint project with Peter Holy, Philipp Lücke and Philipp Schlicht I have studied non-pretame forcings. In particular, we have found failures of the definability and truth lemma as well as for the amenability of the forcing relation. I am also interested in descriptive set theory, especially in the context of second order arithmetic (resp. ZFC\(^+\) + \( V = \text{HC} \)) and class forcing over models of second order arithmetic.

krapf@math.uni-bonn.de

5.49 Adam Kwela (Gdańsk)

I am a faculty member at the Institute of Mathematics, University of Gdańsk, Poland.

My main research topic is combinatorics of ideals on countable sets. Another direction in my studies are small subsets of the real line.

I am mostly interested in applications of ideals to topology and real analysis such as ideal convergence of sequences of functions, descriptive complexity of ideals and some topological ways of representing ideals. These subjects are closely related to some selective properties of ideals and various orders on ideals.

I am also investigating cardinal coefficients related to certain ideals on the real line, such as the ideal of microscopic sets.

Adam.Kwela@ug.edu.pl

5.50 Chris Le Sueur (Bristol)

I am a fourth year PhD student at the University of Bristol, where my supervisor is Professor Philip Welch. My research is mainly in Determinacy.

It is a well-known result of Martin that ZFC proves the determinacy of all Borel games, but there has been much work in calculating how much one needs to prove the determinacy of larger and smaller pointclasses. Higher up, it is known that \( \Pi^1_1 \) determinacy holds if and only if \( 0^\sharp \) exists, whilst lower down the reverse mathematics of determinacy hypotheses has been largely settled, and recent work of Montalban and Shore shows that full second order arithmetic is insufficient to prove the determinacy of \( \Delta^0_4 \) games.

The method of proving determinacy in the \( \Pi^1_1 \) difference hierarchy suggests a way to transfer the low-down results higher up. In order to push the basic method, several techniques have had to be developed, including a way of applying class forcing in weak contexts through the use of fine-structure and ramified forcing, preservation results in ultrapowers over weak models, and generalised effective descriptive set theory.

The first and last of these techniques suggest an avenue for further research, and I would also like to find lower bounds on the strength required to prove the determinacy results.

c17907@bristol.ac.uk
5.51 Chris Lambie-Hanson (Jerusalem)

I am a postdoctoral researcher at the Einstein Institute of Mathematics at the Hebrew University of Jerusalem, hosted by Menachem Magidor. I received my Ph.D. in May 2014 from Carnegie Mellon University, where I worked under the supervision of James Cummings.

My work focuses mostly on the interplay between forcing, large cardinals, and combinatorial set theory. I am particularly interested in variations on Jensen’s square principle and related notions (see [2], [3], and [12] for a wealth of information about squares and related combinatorial principles). Square principles are useful for exploring the tension between compactness and incompactness in set theory. Square principles, which typically hold in canonical inner models, are instances of incompactness, and much fruitful research has come out of investigating the extent to which squares can coexist with reflection and compactness phenomena more typical of large cardinals. Much of my work has consisted of investigating connections between square principles and other combinatorial notions. I provide two examples here.

Matteo Viale, in [14] and [15], introduced the notion of a covering matrix in order to prove that the Singular Cardinals Hypothesis follows from the Proper Forcing Axiom. In [7], I investigated the interaction between square principles and the existence of certain sorts of covering matrices, focusing in particular on matrices of size $\kappa \times \kappa^+$, where $\kappa$ is a regular, uncountable cardinal. In [9], I consider covering matrices of more general dimensions and also prove that, for a regular cardinal $\kappa$, the covering principle $\text{CP}(\kappa)$, which Viale shows in [15] implies the failure of $\square(\kappa)$, is compatible with $\square(\kappa, 2)$.

In other recent work [10], I have looked at the interaction between square principles and the existence or non-existence of branchless narrow systems. Narrow systems were introduced by Magidor and Shelah [13] as a tool to analyze trees in forcing extensions but are also interesting in their own right. My work on narrow systems led me to isolate a property called the strong system property, a robust strengthening of the tree property. The strong system property is equivalent to the tree property at inaccessible cardinals but is in general strictly stronger than the tree property. I have shown [11] that the strong system property can consistently hold at $\aleph_{\omega^2+1}$. A question of considerable interest to me is whether or not it can consistently hold at $\aleph_{\omega+1}$.

I have also done some work on stationary reflection. Answering a question of Eisworth, James Cummings and I, in [4], showed that it is consistent to have a singular cardinal, $\mu$, such that every stationary subset of $\mu^+$ reflects but there is a stationary subset of $\mu^+$ that does not reflect at ordinals of arbitrarily high cofinality below $\mu$. In [8], I proved a global version of this result and several other variations.

Lastly, I have done some work in model theory in collaboration with Alexei Kolesnikov. This work has focused on the amalgamation property in abstract elementary classes. Amalgamation is an important feature of first-order logic and is frequently assumed as an additional requirement when working with abstract elementary classes, which are a generalization of first-order logic. In [6], we produce, for every infinite cardinal $\kappa$, a collection of abstract elementary classes in a language of size $\kappa$ such that the Hanf number for amalgamation for this collection is exactly $\beth_{\kappa+1}$. This gives partial progress towards a conjecture of Grossberg [5], building and significantly improving upon results of Baldwin, Kolesnikov, and Shelah [1].

References


mlevin20@uic.edu

5.52 Maxwell Levine (Chicago)

I am a fifth-year PhD student at the the University of Illinois at Chicago, and I am working under Professor Dima Sinapova in the field of Singular Cardinal Combinatorics.

When Easton used class forcing to establish that the continuum function $\kappa \mapsto 2^\kappa$ is essentially arbitrary at regular cardinals—modulo the requirements that it be increasing and that $\text{cf}(2^\kappa) > \text{cf}(\kappa)$—it was thought that the result could be extended to singular cardinals. This turned out to be false when Silver discovered that if $\{\alpha < \kappa : 2^\alpha = \alpha^+\}$ is stationary and $\kappa$ is a singular cardinal of uncountable cofinality, then it follows that $2^\kappa = \kappa^+$. Hence, the properties of singular cardinals (and, it turns out, their successors), are at least partially determined by ZFC, and Singular Cardinal Combinatorics is about investigating the scope of this impact.

In particular, I have been studying the interactions between square properties, reflection, and the existence of certain types of scales, following work of Cummings, Foreman, and Magidor. It is a fact that $\square_\kappa$ and its weakenings—$\square_{\kappa, \lambda}$ for $\lambda < \kappa$—imply the existence of what is called a very good scale, but that the presence of strong reflection properties are at odds with both squares and scales. I am looking into the extent to which squares and very good scales can be made compatible with weak reflection properties.

References


mlevin20@uic.edu

5.53 Dani Livne (Ramat-Gan)

dani.livne@yahoo.com
5.54 Menachem Magidor, (Jerusalem)

5.55 Dor Marciano (Jerusalem)

I am a second year MSc student at the Hebrew University of Jerusalem, working under the supervision of Prof. Menachem Magidor.

Consider the following argument: "There are only countably many formulas, but uncountably many reals, therefore there must be uncountably many undefinable reals". In the context of the language of ZFC, this argument is incorrect. There are known models of ZFC in which all elements are definable (henceforth "pointwise definable models"). Every model of \( V = HOD \) has a pointwise definable elementary substructure, and every model of ZFC has a pointwise definable cardinal preserving class-forcing extension (see [1] for both of these results). In models of \( V = HOD \), it is immediate that in order to find the size of the collection of definable reals, we must often look at the size of the first undefinable ordinal.

My research efforts have been focused on this question: "What is the size (internally) of the first undefinable ordinal?". As with the examples above, there might not be undefinable ordinals. If the model is not well-founded, there might not be a first one. An immediate argument shows that there are models of \( L \) where the first undefinable ordinal is countable. We have shown that in models of \( L \), this is a dichotomy, i.e. there are no undefinable ordinals, or the first undefinable ordinal is countable. We have shown that under reasonable conditions (\( \exists \alpha > \omega_1 : L_\alpha \models ZFC \) ), there exists a model of ZFC in which the first undefinable ordinal is uncountable. For this, we have developed a general method to force-extend models of ZFC with certain properties such that the desired members are defined, while any members not definable from them in the original model remain undefinable in the extension. Using this method, we have also shown that the consistency of "The first undefinable ordinal is a cardinal" is roughly that of an inaccessible cardinal, and the consistency of "The first undefinable ordinal is a regular cardinal" is roughly that of a Mahlo cardinal. These results can be generalized to larger cardinals.

Currently, my research efforts focus on investigating the consistency of "The first undefinable ordinal is uncountable + \( V = HOD \)". This immediately follows from the consistency of a measurable cardinal, but it remains an open question if a measurable cardinal is required (recall that without \( V = HOD \), we have shown that the consistency of \( \exists \alpha > \omega_1 : L_\alpha \models ZFC \) is enough).

References


doormarci@gmail.com

5.56 Andrew Marks (Los Angeles)

I am an Assistant Professor at UCLA. I received my PhD under Ted Slaman at UC Berkeley and did a postdoc with Akekos Kechris at Caltech.

A fundamental problem encountered throughout mathematics is to completely classify some type of mathematical object by invariants. Descriptive set theory gives a general framework for studying such classification problems and comparing their relative difficulties. The field has had remarkable success, proving the existence of barriers to having simple types of classifications, calibrating the difficulty of classification problems in a variety of fields of mathematics, and in understanding the structure of the space of all classification problems. This study has had particularly close connections with ergodic theory, probability, and operator algebras.

More recently we have begun to understand the existence of important combinatorial structures underlying this study of classification. Here there is a growing relationship with another program in descriptive set theory: studying problems from classical graph combinatorics such as coloring and matching, but where we put definability restrictions on both the graphs we consider and the witnesses to their combinatorial properties.

My recent research focuses on these connections between problems in descriptive graph combinatorics, and the problem of classifying countable Borel equivalence relations up to Borel reducibility.

marks@math.ucla.edu
5.57 Paul McKenney (Ohio)

I am a visiting assistant professor at Miami University of Ohio, having graduated from Carnegie Mellon University in 2013 under the supervision of Ernest Schimmerling.

My research involves connections between combinatorial set theory and operator algebras, in particular the behavior of quotients of C*-algebras and the maps between them in various models of set theory. The landmark result in this area is Farah’s proof that Todorčević’s Open Coloring Axiom implies all automorphisms of the Calkin algebra must be inner. Recent work of mine, with A. Vignati, considers automorphisms of the corona of a separable C*-algebra under the assumption of the Proper Forcing Axiom, in an attempt to show that such automorphisms must be definable. We have obtained this result in the case of a separable, nuclear C*-algebra with an approximate identity of projections.

Another recent project, with Paul Larson, is on the structure of automorphisms of the Boolean algebra $P(\lambda)/I_\kappa$, where $I_\kappa$ is the ideal of sets of cardinality less than $\kappa$. We have shown, for instance, that a weak fragment of $\mathsf{MA}_{\aleph_1}$ implies that all automorphisms of $P(2^{\aleph_0})/\text{ctble}$ must be trivial. Our results in this area are closely connected to the well-known question (sometimes called the Katowice Problem) asking whether it is consistent with ZFC that the Boolean algebras $P(\omega)/\text{fin}$ and $P(\omega_1)/\text{fin}$ are isomorphic, and we are actively pursuing these connections.

References


pmckenney@gmail.com

5.58 Nadav Meir (Be’er Sheva)

I am a first year PhD student at the Ben-Gurion University of the Negev, working under the supervision of Dr. Assaf Hasson.

The notion of indivisibility of relational first-order structures and metric spaces is well studied in Ramsey theory. ([1], [2] and [5] are just a few examples of the extensive study in this area.) Recall that a structure $M$ in a relational first-order language is indivisible, if for every coloring of its universe $M$ in two colors, there is a monochromatic substructure $M' \subseteq M$ such that $M' \cong M$.

In [3], several induced Ramsey theorems for graphs were strengthened to a “symmetrized” version, in which the induced monochromatic subgraph satisfies that all members of a prescribed set of its partial isomorphisms extend to automorphisms of the colored graph. In [4], following [3], two new strengthening of the notion of indivisibility was introduced:

We say a substructure $N \subseteq M$ is symmetrically embedded in $M$ if every automorphism of $N$ extends to an automorphism of $M$.

We say that $M$ is symmetrically indivisible if for every colouring of $M$ in two colors, there is a monochromatic $M' \subseteq M$ such that $M'$ is isomorphic to $M$ and $M'$ is symmetrically embedded in $M$.

We say that $M$ is elementarily indivisible if for every coloring of $M$ in two colors, there is a monochromatic $M' \subseteq M$ such that $M'$ is isomorphic to $M$ and $M'$ is an elementary substructure of $M$.

In [4], the following questions were asked:

- Does elementary indivisibility imply symmetric indivisibility?
- Is every elementarily indivisible structure homogeneous?
• Is there a rigid elementarily indivisible structure?

As part of my M.Sc. thesis, I gave negative answers to the first two questions. The third question is still open.

For my Ph.D. project, I will be studying Model theory of valued fields.

References


mein@math.bgu.ac.il

5.59 Diego A. Mejía (Vienna)

I am a postdoc of Jakob Kellner at TU Wien since November 2014 and at University of Vienna from April 2014 to October 2014. During my period in Vienna, I've been working in collaboration with Prof. M. Goldstern and Prof. S. Shelah. From April 2010 to March 2014, I was a PhD student of Prof. J. Brendle at Kobe University in Japan.

My main research interests are forcing theory and their applications to obtain consistency results about cardinal invariants and set theory of the reals, particularly with large continuum (that is, \(\kappa > \aleph_2\)). I have been working intensively in forcing techniques, like template iterations and constructions from creature forcing, to obtain models where some classical cardinal characteristics of the continuum assume pairwise different values.

For instance, I have obtained models using matrix iterations of ccc forcings where Cichoń’s diagram is separated in several different values [3]; recently, with M. Goldstern and S. Shelah we constructed a model with fsi of ccc forcings where we separate all the cardinals of the left side of the diagram [2]. Indeed, there are still many interesting questions about separating many values, for example, the consistency of \(\text{cov}(\mathcal{M}) < \delta < \text{non}(\mathcal{N}) < \text{cof}(\mathcal{N})\) is not known.

With V. Fischer [1] we used a template iteration to prove the consistency of \(\aleph_1 < s < b < a\) which improves [4] where the same consistency result is obtained using a measurable cardinal.

I am also interested in ultrafilters on \(\omega\) and the RK order. In a work in progress with M. Goldstern and S. Shelah, we are aiming to prove the consistency of \(u = \aleph_1\) with the non-existence of P-points by preserving a nicely constructed very non-P-point ultrafilter while killing all the P-points along a countable support iteration of proper posets.

Lately, I've been looking at creature forcing techniques to construct models where cardinal invariants associated with ideals and other simple cardinal invariants defined with real parameters can assume many different values (continuously many), for instance, for Yorioka’s ideals (relative to the strong measure zero ideal).

References

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5.60 Omer Mermelstein (Be’er Sheva)

I am a second year PhD student at Ben-Gurion University of the Negev, working under the supervision of Dr. Assaf Hasson.

In the late 80’s Hrushovski (in [1]) presented an \textit{ab initio} construction of a strongly minimal structure not interpreting a group whose geometry is not sub-modular, thereby refuting Zil’ber’s conjecture. Furthermore, in a similar fashion, Hrushovski (in [2]) presented a way of defining, from countably many strongly minimal theories, a \textit{fusion} theory, interpreting as a reduct any of the aforementioned theories. Since then, no accurate attempt to classify strongly minimal sets according to their geometries has been made, that could not be refuted using Hrushovski fusion constructions.

The Hrushovski \textit{ab initio} construction can be seen as a two staged process where first a rank $\omega$ structure (referred to as the non-collapsed structure) is constructed using the Fraïssé limit method, and then “collapsed” into a strongly minimal structure by imposing further restrictions on the amalgamation class used. My research currently focuses on finding and understanding proper reducts of Hrushovski \textit{ab initio} constructions and their possible geometries.

References


5.61 Marcin Michalski (Wrocław)

I am a first year PhD student at the Wrocław University of Technology, working under the supervision of Prof. Jacek Cichoń and PhD Szymon Żeberski.

For an $\sigma$-ideal $\mathcal{I}$ of sets of Euclidean space we call $A$ an $\mathcal{I} − \text{Luzin}$ set if $|A| > |A \cap I|$ for each $I \in \mathcal{I}$. Pursuing my Masters Degree under the supervision of PhD Szymon Żeberski I have investigated some properties of these sets, such as their (non-)measurability in the view of the ideal $\mathcal{I}$ and properties involving algebraic structure of the space we’re working with. Further research on this subject led to a joint work of mine and Szymon Żeberski (see [2]). One of the main results was that if $2^\omega$ is a regular cardinal, then the algebraic sum of a Luzin set and a Sierpiński set belongs to Marczewski ideal $\mathcal{s}_0$.

I plan to continue research on the structure of Polish spaces (in particular- the real line) and learn more about model theory and forcing in general. Recently, due to work of Ashutosh Kumar presented at the Winterschool in Abstract Analysis 2015 (see [1]), I also got interested in topics circling around problems of coloring of the plane.

References:


marcin.k.michalski@pwr.edu.pl

5.62  Kaethe Minden (New York)
I am a PhD student at the City University of New York, working under the supervision of Prof. Gunter Fuchs.

Subcomplete forcing was introduced by Ronald Jensen as a class of forcings which does not add new reals but may change cofinalities to $\omega$, unlike proper forcing (see [2]). For example, countably closed forcings, Namba forcing and Prikry forcing are all subcomplete. Jensen has shown that this class of forcings is closed under revised countable support iterations, and has used this to show that the subcomplete forcing axiom is consistent relative to the existence of a supercompact cardinal.

In my research I primarily investigate further the properties of subcomplete (and also subproper) forcings and the forcing axioms related to them. In particular, I have recently been looking at the maximality principle for subcomplete forcings. Maximality principles can be restricted to different classes of forcings. The maximality principle for subcomplete forcings says that any statement that can be forced by a subcomplete forcing to be true in such a way that it stays true in any further forcing extension of that kind, is already true. It is consistent that the maximality principle for subcomplete forcing holds. Gunter Fuchs has studied the maximality principle for closed forcings (see [1]). Since countably closed forcings are subcomplete, a natural question to ask is which consequences of the closed maximality principles can be generalized to the case of subcomplete forcing, or more interestingly, how the models of these maximality principles differ. One result I have shown is that subcomplete forcings preserve cofinal branches of $\omega_1$-trees. So exactly as in the case of countably closed forcings the necessary form of the maximality principle for subcomplete forcings, in which it is demanded the maximality principle itself continues to be true in all further forcing extensions (with the parameters reinterpreted there), is inconsistent. I do not know if there is somehow a way of combining the maximality principles for subcomplete forcings of different levels, or creating a hierarchy, as is done for the closed maximality principles.

I am interested in further developing a picture of models of the subcomplete/subproper forcing axioms, and would also like to look at the bounded forcing axiom for these classes of forcings. There are other topics I have been looking at as well. One avenue involves formulating versions of a combinatorial property which Fuchs has introduced that characterizes the negation of branch properties for various large cardinal notions.

References


kminden@gradcenter.cuny.edu

5.63  Diana Carolina Montoya (Vienna)
I am a second year PhD student at the Kurt Gödel Research Center for Mathematical Logic in the University of Vienna. I work under the supervision of O. Univ. Prof. Sy-David Friedman. I also have had interesting and fruitful discussions with Jörg Brendle (Kobe University), Andrew-Brooke Taylor (Bristol University. UK), Vera Fisher (TU Wien) and recently with Dilip Raghavan (IMS. National University of Singapore).

The interaction between cardinal invariants in the classical Baire Space $\omega^\omega$ has been deeply studied and it has contributed to the development of forcing techniques. A new developing area of interest
nowadays is to consider its natural generalizations to the Generalized Baire Spaces $\kappa^\kappa$ when $\kappa$ is an uncountable cardinal. There are currently interesting results on this matter. For example, the well known Roitman’s Problem asks whether from $d = \aleph_1$ it is possible to prove that $a = \aleph_1$. Now, it is well known that $d$ and $a$ are independent, i.e. it is possible to prove the consistency of both $a < d$ and $d < a$. The problem that is still open is the consistency of $d = \aleph_1 < a$. In the uncountable case the analog of Roitman’s Problem has already been resolved in the positive.

**Theorem 2.1 in (3.)** If $\kappa$ is uncountable, regular cardinal and $d(\kappa) = \kappa^+$ then $a(\kappa) = \kappa^+$.

Another example shows that, whereas in the countable case all these cardinal invariants are at least $\aleph_1$, in the uncountable case the splitting number at $\kappa$ may not be at least $\kappa^+$.

**Lemma 1 and 2 in (9.)** $a(\kappa) \geq \kappa^+$ if and only if $\kappa$ is weakly compact.

Our current work in progress deals with the study of the cardinal invariants in the generalization of the well known Cichoń’s Diagram. We consider just the cardinal invariants associated to the meager ideal on $\kappa$ as well as the bounding and dominating numbers. We call this generalization Icho Diagram (See Fig.1). Moreover, we have generalized classical models of set theory obtained as forcing extensions ($\kappa$-Cohen, $\kappa$-Eventually Different, $\kappa$-Hechler, etc.), and study the values that the cardinal invariants in the diagram take on them.

![Figure 2: Icho diagram (for $\kappa$ strongly inaccessble)](image.png)

**References**


dcmontoyaa@gmail.com
5.64 Nikodem Mrożek (Gdańsk)

I am an assistant professor at the University of Gdańsk. I defended my PhD thesis in 2010 under the supervision of Prof. Ireneusz Reclaw. The title was "Ideal convergence of sequences of functions". My research interest are ideals of subsets of naturals and especially ideal convergence. I collaborated in this topic with Paweł Barbarski, Rafał Filipów, Ireneusz Reclaw and Piotr Szuca. We wrote a series of articles in this area. In particular we introduced a Bolzano-Weierstrass property of ideals used it to characterize some topological and combinatorial properties of ideals.

Recently I started to collaborate with Adam Kwela and two our students Klaudiusz Czudek and Wojciech Wołoszyn on microscopic sets on the real line (the σ-ideal of microscopic sets is smaller than the σ-ideal of Lebesgue null sets and larger than the σ-ideal of strongly null sets).

nmrozek@mat.ug.edu.pl

5.65 Dan S. Nielsen (Copenhagen)

I am a second year Masters student at the University of Copenhagen, working under the supervision of Asger Tørnquist. I am interested in the interplay between inner model theory and determinacy, as well as the more structural approach to set theory via topos-theoretic methods. In this regard, I have written projects on Gödel's constructible universe, determinacy and introductory inner model theory with an emphasis on \(0^\beta\).

fgm190@alumni.ku.dk

5.66 Diana Ojeda-Aristizabal (Toronto)

I am a postdoctoral fellow in the Mathematics Department at the University of Toronto, my mentors are Bill Weiss and Stevo Todorcevic. I did my PhD at Cornell University under the supervision of Justin Moore.

In my PhD thesis I studied problems related to the interaction between Ramsey Theory and the geometry of Banach spaces. Recently I have been working on parametrized Ellentuck-type theorems for abstract topological Ramsey spaces, and in topological partition relations for countable ordinals.

dojeda@math.toronto.edu

5.67 Yann Pequignot (Lausanne)

I am finishing my PhD at the University of Lausanne (Switzerland) and University Paris Diderot–Paris VII (France) under the supervision of Jacques Duparc and Jean-Éric Pin.

Recently I have been studying a notion of reducibility for subsets of a second countable \(T_0\) topological space based on, relatively continuous relations and admissible representations. It coincides with Wadge reducibility on zero dimensional spaces. However in virtually every second countable \(T_0\) space, it yields a hierarchy on Borel sets, namely it is wellfounded and antichains are of length at most 2. It thus differs from the Wadge reducibility in many important cases, for example on the real line.

I am also working on better-quasi-order theory. Well-quasi-order (wqo) are quasi-order with no infinite descending chain nor infinite antichain. First defined by C. St. J. Nash-Williams, the better quasi-orders (bqo) are the members of the largest class of wqo closed under taking ordinal sequences. On the one hand every “natural example” of wqo is in fact bqo. On the other hand many counter examples can be shown to exist, proving that the notion of bqo is much stronger than that of wqo. The notion of bqo provides in several cases the unique tool to prove that a given quasi-order is wqo.

yann.pequignot@unil.ch

5.68 Luís Pereira (Lisbon)

I’ve completed my PhD in 2007 at the University of Paris VII under the supervision of Prof. Todorcevic. Since that date I’ve been studying physics at the University of Lisbon.

I’m interested in cardinal arithmetic and pcf theory (see [1],[2]). Particularly, pcf structures and the combinatorics of characteristic functions of internally approachable submodels.
The known axioms for pcf structures allowed Shelah to prove is celebrated result $\aleph_0^\aleph_0 < \aleph_{\omega_1}^+ (2^{\aleph_0})^+$. I’m interested in finding additional axioms for pcf structures that allow one to decide questions like when the spaces are uncountable with countable density are they necessarily Fréchet-Urysohn? Can they be hereditarily separable? In [3] it is proved that the known axioms for pcf structures do not allow one to prove that such a space is Fréchet-Urysohn. This has as a consequence that we at the moment cannot decide whether when the pcf conjecture fails at $\aleph_\theta$ there is a sequence of $\aleph_n$’s whose product has a scale of length $\aleph_{\omega_1+1}$ modulo the ideal of finite sets. Also, in [4] it is proved that it is consistent with the known axioms for a separable uncountable pcf space to be hereditarily separable.

Concrete pcf structures are obtained from the Skolem Hulls of internally approachable submodels together with the values of their characteristic function, that is, the ordinals of the form $\sup(N \cap \lambda)$. I’m interested in the possible patterns that such sets of ordinals may exhibit. For example, in [5] I defined tree-like continuous scales to study such patterns. Other possibilities are to use diamond or anti-diamond principles to obtain similar results.

Finally, I’m interested in possible applications of Set-Theory to Mathematical Physics. $C^*$-algebras might be of importance here as can infinite tensor products of Hilbert spaces.

**References**


lmpereira@fc.ul.pt

### 5.69 Assaf Rinot (Ramat-Gan)

I am a faculty member in the Department of Mathematics, Bar-Ilan University.

My research interest is mainly in infinite combinatorics of the sort that takes place in Gödel’s constructible universe: Souslin trees, negative partition relations, incompactness graphs.

Recall that a graph is composed of an underlying set of vertices $V$, and a symmetric binary relation $E \subseteq [V]^2$ that describes the set of edges between the vertices. The product of two graphs $(V_1, E_1)$ and $(V_2, E_2)$ has the Cartesian product $V_1 \times V_2$ as its set of vertices, and two vertices $(v_1, v_2)$ and $(v'_1, v'_2)$ form an edge iff $v_1 E_1 v'_1$ and $v_2 E_2 v'_2$. A 50 year old open problem in finite graph theory conjectures that to any integer $k$, there exists some large enough integer $\varphi(k)$ such that whenever the chromatic number of $(V_1, E_1)$ and $(V_2, E_2)$ is at least $\varphi(k)$, then the chromatic number of their product is at least $k$.

By replacing “integer” with “infinite cardinal” in the above, one obtains a set-theoretic conjecture of its own interest that was considered by Hajnal and others. This infinitary conjecture is consistent modulo the existence of large cardinals, and in fact, follows outright from the existence of a proper class of strongly-compact cardinals. By [2] and [3], if $\lambda$ is a singular cardinal for which $\square_\lambda$ holds and $2^\lambda = \lambda^+$, then there exist two graphs of chromatic number $> \lambda$ whose product is merely countably chromatic. Therefore, the infinitary conjecture fails in Gödel’s constructible universe (and any forcing extension of it).

Let me mention another interesting problem. It is well-known that the productivity of the countable chain condition is independent of ZFC; It follows from Martin’s axiom, while a Souslin tree is an example of a ccc poset whose square is not ccc. What about the productivity of $\kappa$-cc for $\kappa > \aleph_1$? Of course, if $\kappa$ is weakly compact, then the $\kappa$-cc is productive. A conjecture of Todorcevic asserts that the converse is also true. That is, the productivity of the $\kappa$-cc for a regular cardinal $\kappa > \aleph_1$ implies that $\kappa$ is weakly compact.
In [1], I established an equiconsistency version of Todorcevic’s conjecture, proving that the productivity of the $\kappa$-cc for a regular cardinal $\kappa > \aleph_1$ implies that $\kappa$ is weakly compact in the constructible universe.

References

rinotas@math.biu.ac.il

5.70 Shir Sivroni (Be’er Sheva)
In the coming year I will be a PhD student in Ben Gurion university in the field of Computational Neurosciences with the supervision of Maoz Shamir. I have an M.Sc from the Technion in Mathematics. Geometric group Theory. My B.Sc is in computer sciences also from the Technion.

My interest in General Topology will probably never end. Hopefully by the end of the summer I will publish the book I am writing. This is a textbook that will contain topics in set theory and general topology. It will also contain a lot of fully solved exercises. Here is a link to the latest draft of the book.
https://drive.google.com/file/d/0B2OpQR-MHNDJe1BPWUp10WhOTOE/view?pli=1

My hope is that it will help students approach to this field.
I was also hoping to add to this book a chapter from the upcoming 19th Midrasha.

Abstract of my M.Sc thesis:
In this work we proved that given a compact hyperbolic surface without a boundary $F$, there exists an $R$-tree, $T$, on which the fundamental group of $F$ is acting by isometries. We refered in this work, only to compact hyperbolic surfaces without boundary. We also referred to the covering space of $F$, as the disc model for the hyperbolic plane. A geodesic in $F$ is the image of a geodesic in the Hyperbolic plan, under the covering map. In order to build the $R$-tree, $T$, we used the theory of laminations and of measured laminations. In particular, we used stable laminations of a certain kind of automorphisms of $F$ irreducible and non-periodic. A geodesic lamination $L$ on a surface $F$, is a closed subset of $F$ which is a disjoint union of geodesics. A lamination $L'$ in the hyperbolic plane, is a disjoint union of geodesics in the hyperbolic plane, which is equivariant under the action of the fundamental group of $F$ on the hyperbolic plane. Let $L$ be a lamination in a surface $F$ which is the stable lamination of an automorphism $h$ of $F$ which is irreducible and non-periodic. Then, the preimage of $L$ in the hyperbolic plane, under the covering map $p$, is a lamination $L'$ in the hyperbolic plane with certain properties. The geodesics of $L'$, are either boundary geodesics of an ideal finite polygon in $L'$, and therefore are isolated in $L'$ from one side, or geodesics which are not isolated from any side. The points of $T$ are defined to be closed ideal polygons in the hyperbolic plane, with boundary, which is a union of geodesics from $L'$, or, geodesics from $L'$, which are not isolated. We use the theory of measured laminations, in order to define the metric on $T$, and we use the action of the fundamental group of $F$ on the hyperbolic plane, to show that the fundamental group of $F$, is acting on $T$ by isometries.

shirs@afeka.ac.il

5.71 Damian Sobota (Warsaw)
I am a third year PhD student at the Institute of Mathematics of the Polish Academy of Sciences, working under the supervision of Prof. P. Koszmider. Till June 2014, I was also in collaboration with Prof. G. Plebanek from the Institute of Mathematics of the University of Wroclaw (Poland).

During my first two years of studies, I was working on the following problem in the topological measure theory. Let $K$ be a Hausdorff compact space and by $P(K)$ denote the set of all regular probability measures on $K$ endowed with the weak* topology. By the tightness of $P(K)$ we mean the least cardinal
number $\tau$ such that for every subset $A$ of $P(K)$ and every point $x \in \text{cl}(A)$ there is a subset $B$ of $A$ such that $|B| \leq \tau$ and $x \in \text{cl}(B)$. Given a measure $\mu \in P(K)$, we say that $\mu$ is separable (or has countable Maharam type) provided that there is a countable family $B$ of Borel subsets of $K$ such that for every Borel $A \subset K$ the following equality holds: $\inf \{\mu(A \Delta B) : B \in B\} = 0$ (or equivalently: the space $L_1(\mu)$ is separable). The statement of the problem is as follows:

Assume $P(K)$ has countable tightness. Does it imply that every measure $\mu \in P(K)$ is of countable Maharam type?

Assuming Martin’s Axiom, D. Fremlin [2] answered this question in affirmative. Together with G. Plebanek [3] we proved in ZFC that if $P(K \times K)$ has countable tightness, than every measure $\mu \in P(K)$ is of countable Maharam type. This implies for example that if $K$ is Rosenthal, then every measure $\mu \in P(K)$ is separable. The theorem also yields the following equivalence: $P(K \times K)$ has countable tightness if and only if the Banach space $C(K \times K)$ of continuous functions on $K \times K$ with the supremum norm has so-called Corson’s property $(C)$ (a convex analog of the Lindelöf property).

Currently I am studying relations between Boolean algebras and their corresponding $C(K)$-spaces. I am especially interested in the following two problems. Let $\mathcal{A}$ be a Boolean algebra and by $K_\mathcal{A}$ denote its Stone space. We say that $\mathcal{A}$ has 1) the Nikodym property if every sequence of measures $(\mu_n : n \in \omega)$ which is pointwise bounded (i.e. $\sup_n |\mu_n(a)| < \infty$ for every $a \in \mathcal{A}$) is also uniformly bounded (i.e. $\sup_n \|\mu_n\| = \sup_{a \in \mathcal{A}} \sup_n |\mu_n(a)| < \infty$); 2) the Grothendieck property if every sequence of functionals $(x_n^* \in C(K_\mathcal{A})^* : n \in \omega)$ which is weak$^*$ convergent is also weakly convergent. There are two important problems concerning those properties:

1. Is it consistent that there exist uncountable Boolean algebras of cardinality less than the continuum $2^\omega$ having the Nikodym property or the Grothendieck property?

2. Is there in ZFC a Boolean algebra with the Grothendieck property but without the Nikodym property?

The first question is motivated by the fact that all known instances of algebras having the Grothendieck property or the Nikodym property had been of cardinality $2^\omega$. The question has affirmative answers. C. Brech [1] constructed a model of ZFC in which there is a Boolean algebra $\mathcal{A}$ with the Grothendieck property and such that $|\mathcal{A}| = \omega_1 < 2^\omega$. Under the assumption that the cofinality $\text{cof}(\mathcal{N})$ of the Lebesgue null ideal $\mathcal{N}$ is less than $2^\omega$ I have recently constructed [5] a Boolean algebra with the Nikodym property and of cardinality $\text{cof}(\mathcal{N})$.

The second question is motivated by the existence of an example of a Boolean algebra with the Nikodym property but without the Grothendieck property (see the example of the Jordan algebra in W. Schachermayer [4]). Also, M. Talagrand [6] under the Continuum Hypothesis proved the existence of an algebra with the Grothendieck property and without the Nikodym property. The question in ZFC is open.

References


damian.sobota@impan.pl
5.72 Jan Starý (Prague)

I am a postdoc at the Czech Technical University in Prague. My research interests lie in set-theoretic topology and Boolean algebras.

A topological space $X$ is homogenous if for every two points $x, y \in X$ there is an autohomeomorphism $h$ of $X$ with $h(x) = y$. It is known that an (infinite) extremally disconnected compact space (EDC) is never homogeneous; in large subclasses of EDC, witnesses of non-homogeneity have been found: points having a specific property that other points do not posses. In the class of ccc EDC spaces with weight $\omega(X) \leq 2^\omega$, however, no such points have been found yet in ZFC. Dually, we are looking for very specific ultrafilters on complete ccc Boolean algebras with $\pi(B) \leq 2^\omega$.

A point $x \in X$ is discretely untouched if for every countable discrete set $D \subset X$ not containing $x$ we have $x \notin \text{cl}(D)$. A point in $x \in X$ is untouched if it escapes the closure of every nowhere dense set. Does every infinite EDC contain a discretely untouchable point?

Consistently, a discretely untouched point exists in every EDC space. It is consistent with ZFC that on every complete ccc algebra $B$ with $|B| \leq 2^\omega$, every filter with character $< 2^\omega$ can be extended to a coherent $P$-ultrafilter $U$: for every partition $P$ of $B$, the ultrafilter $U/P$ is a $p$-point on $P \approx \omega$. Such an ultrafilter is an untouched point in the Stone space of $B$.

A $\sigma$-complete ccc algebra $B$ is a Maharam algebra if it carries a strictly positive continuous submeasure. Is is known that a Maharam algebra is not necessarily a measure algebra, but the distinction is not well understood. Does every Maharam algebra embed a measure algebra? If a Maharam algebra $B$ embeds a measure algebra $M$, and hence, as a forcing, is a two step iteration $B = M \ast Q$, is then $Q$ again a Maharam algebra?

For $\sigma$-complete Boolean algebra $B$, the order-sequential topology is the finest topology letting algebraically convergent sequences (lim sup $a_n = \liminf a_n$) converge. This makes $(B, \tau_\kappa)$ a sequential space with the unique limit property, which is weaker than $T_2$. Being Hausdorff is equivalent to being a Maharam algebra. When is $(B, \tau_\kappa)$ compact? As a forcing, $B$ does not add independent reals iff $(B, \tau_\kappa)$ is countably compact. The only possibility for compact Hausdorff is $P(\omega)$. Are there other compact (non-Hausdorff, hence non-Maharam) algebras? As an example, is the Suslin algebra compact?

References


jan.stary@fit.cvut.cz

5.73 Šárka Stejskalová (Prague)

I am a first year PhD student at the Charles University in Prague, working under the supervision of Radek Honzik.

It is known that many properties of large cardinals can be reasonably formulated for small cardinals, even below $\aleph_\omega$: these properties are often called “traces” of large cardinals. For instance, if one removes the property of inaccessibility from the definition of a weakly compact cardinal, one ends up with the property that every $\kappa$-tree\footnote{T is a $\kappa$-tree if it has height $\kappa$ and each level has size less than $\kappa$.} for the given regular cardinal $\kappa$ has a cofinal branch – we say that $\kappa$ has the tree property. It is known that if $2^\kappa = \kappa^+$, where $\kappa$ is an infinite cardinal, then there is a $\kappa^{++}$-tree
without a cofinal branch (so called Aronszajn tree). Thus the tree property at $\kappa^{++}$ implies the failure of GCH at $\kappa$.

I examine how the tree property limits the possible values of the continuum function. This question is difficult and has attracted many authors recently. In [1], Friedman and Halilovic introduced a new technique which – starting from a hypermeasurable-type cardinal – allows one to construct a model where $2^{\aleph_\omega} = \aleph_{\omega+2}$ and the tree property holds at $\aleph_{\omega+2}$ ($\aleph_\omega$ strong limit). Recently, they have used a variant of this method and shown in [2] that one can get a larger gap than 2 for a measurable cardinal $\kappa$: $2^\kappa = \theta$, $\theta > \kappa^{++}$ arbitrary with cofinality larger than $\kappa$, and the tree property holds at $\kappa^{++}$.

Returning to $\aleph_\omega$, in [3] Friedman and Honzik proved that one can get – from mild large cardinal assumptions – a model where $\aleph_\omega$ is a strong limit cardinal such that $2^{\aleph_\omega} = \aleph_{\omega+2}$ and, moreover, the tree property holds at every $\aleph_{2n}$ with $2^{\aleph_{2n}} = \aleph_{2n+2}$, for $n > 0$.

References


sarka@logici.cz

5.74 Silvia Steila (Torino)

I am a third year PhD student in Logic in Computer Science at the University of Torino, working under the supervision of Prof. Stefano Berardi. In July 2012 I finished my master in Mathematics with a thesis about partition relations for countable ordinals and my advisor was Prof. Alessandro Andretta. During my PhD I have also the opportunity of studying Set Theory in the Logic group of Torino.

In [1, 2] Tørnquist and Weiss proved many natural $\Sigma^1_2$ definable counterparts of classical equivalences to the Continuum Hypothesis (CH). These become equivalent to “all reals are constructible”. Following this scheme, I am working on definable counterparts for some algebraic equivalent form of CH. More specifically I focused on the $\Sigma^1_2$ counterparts of some equivalences by Erdős and Kakutani [3], Zoli [4] and Schmerl [5]. As a corollary of them, $\mathbb{R} \subseteq L$ if and only if there exists a $\Sigma^1_2$ coloring of the plane in countably many colors with no monochromatic right-angled triangle, which is the $\Sigma^1_2$ analogous of a famous result by Erdős and Komjáth [6].

Since June 2014, I am working with Giorgio Audrito and Matteo Viale on generic elementary embeddings. As in the classical case, given a generic elementary embedding $j: V \to V[G]$ we can define in $V[G]$ the derived extender $E$ and $V$-normal tower of ultrafilters $F$ while preserving the relevant large cardinal properties of $j$. However, bad behaviour may occur when we consider the corresponding ideal extender $I(E)$ and the normal tower of ideals $I(F)$.

References

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silvia.steila2@gmail.com

5.75 Jaroslaw Swaczyna (Łódź)

I am a first year PhD student. My main research topic is ideals theory, especially on \( \omega \). Another direction in my studies are connenctions between Set Theory and Real Analysis.

I am mostly interested in applications of ideals to real analysis and in combinatorial properties of ideals. I already published (together with M. Balcerzak, P. Das and M. Filipczak) paper about some generalization of classical density ideal. Currently I am working (together with M. Balcerzak and Sz. Glab) on some more combinatorial problem about ideals on \( \omega \).

In future I want to extend my researches to connections between Set Theory, Measure Theory and Topology. I also want to learn basics of forcing.

jswaczyna@wp.pl

5.76 Dorottya Sziráki (Budapest)

I am a third year PhD student at the Central European University, Budapest, Hungary and am working under the supervision of Gábor Sági. My research involves examining model theoretic classification and variants of the spectrum problem using tools from (generalized) descriptive set theory, infinitary combinatorics, algebraic logic, and the connections between these fields.

The *spectrum* of a first order theory \( T \) correlates to each cardinal \( \kappa \) the number of \( \kappa \)-sized models of \( T \) up to isomorphism. The variants I study are obtained by replacing the role of isomorphism by embeddability, elementary embeddability or similar natural notions, and by considering extensions and modifications of first order logic, such as certain infinitary logics or first order logic without equality.

Given a cardinal \( \kappa = \kappa^{<\kappa} \), the domain of the *generalized Baire space* of \( \kappa \) is \( ^\kappa \kappa \) and its topology is generated by the basic open sets \( N_p = \{ x \in ^\kappa \kappa : p \subseteq x \} \) where \( p \in \kappa^{<\kappa} \). Via a natural encoding, the set of models with domain \( \kappa \) can be viewed as a \( \kappa \)-Borel subset of \( ^\kappa \kappa \). Isomorphism and (elementary) embeddability become \( \kappa \)-analytic relations, and in some cases even ones on (the lower levels of) the \( \kappa \)-Borel hierarchy. Hence, model theoretic results can be obtained from studying such relations.

Recently, in joint work with Jouko Väänänen, we investigated the uncountable version of a dichotomy theorem [1,3] for \( \Sigma^2_2 \) binary relations on the generalized Baire space. We showed that this statement holds under the set theoretic hypothesis \( \Gamma^-(\kappa) \) when \( \kappa \) is inaccessible, and under \( \Gamma^-(\kappa) \) and \( \Diamond_k \) when \( \kappa \) is arbitrary. The hypothesis \( \Gamma^-(\kappa) \) is a modification of the hypothesis \( I(\kappa) \) found in literature and states: there exists a \( \kappa^+ \)-complete normal ideal \( I \) on \( \kappa^+ \) and a dense subset \( K \subseteq I^+ \) in which every descending sequence of length \( < \kappa \) has a lower bound. We obtain as a corollary a dichotomy related to the variants of the spectrum functions mentioned above, which can be seen as a generalization to uncountable cardinals of an earlier result of Gábor Sági’s and mine [2].

References


Sziraki_Dorottya@phd.ceu.edu
5.77 Anda-Ramona Tanasie (Vienna)

I am a second year PhD student at the University of Vienna, working under the supervision of Prof. Sy-David Friedman. I am mainly interested in combinatorial set theory and forcing.

Looking at the algebra of Borel sets modulo some ideal $I$, we have a natural projection $p : B \to B/I$, namely, the function mapping each Borel set to its equivalence class. We are interested whether a homomorphism $h : B/I \to B$ such that $(h(x/I))I = x/I$ exists, equivalently, a homomorphism $h : B \to B$ with Kernel $I$ such that $h(x) = x \mod I$. Such a homomorphism is called lift.

The existence of a lift has been studied in the classical case for the ideal $I_{mz}$ of Lebesgue measure zero sets and for the ideal $I_{fc}$ of meager sets. Up to this point, nothing is known about the existence of lifting homomorphisms with continuum greater than $\aleph_2$. Under CH, there is a lift for $B/I$ for both of these ideals (see [1] and [2]), but a lift can also exist in a model of $\neg \text{CH}$ (see [1]).

The most impressive result concerning this problem is due to Saharon Shelah ([3],[4] and [5]) and concludes that the existence of such a homomorphism is independent of ZFC. He showed the consistency of ZFC+ “there is no lift for $B/I_{mz}$”. He presented the proof for the ideal of Lebesgue measure zero sets, but the same proof (as Shelah himself pointed out) works for the ideal of meager sets as well.

In my PhD thesis I will investigate the existence of lifting homomorphisms of the Borel algebra modulo the ideal of meager sets on the generalized Baire space $\omega_1^{\omega_1}$.

To obtain a model without liftings, Shelah defined oracle-cc iterations of forcing notions. The main goal of my thesis is to find an appropriate generalization of this notion and the corresponding iteration result.

References


tanasia8@univie.ac.at

5.78 Fabio E. Tonti (Vienna)

I am a first year PhD student at the Vienna University of Technology, working under the supervision of Prof. Jakob Kellner. Since the beginning of my PhD studies, I have also been in collaboration with Prof. Ben Miller at the University of Vienna and Prof. Asger Törnquist at the University of Copenhagen.

In recent years, the concept of Borel reducibility among Borel equivalence relations has seen a large number of applications to different fields of mathematics, in particular classification problems in the context of C*-algebras (see e.g. [5] or [1]) or the classification problem for torsion-free abelian groups of finite rank (see [6] and [7]). It is known that the relation of unitary equivalence on the space of irreducible unitary representations of a discrete countable group on a fixed separable infinite-dimensional Hilbert space is a Borel equivalence relation (this holds true even for the space of all representations; see [3]). I am particularly concerned with the problem of finding a way to distinguish the complexity for the relation of unitary equivalence among different groups. From the work of E. Thoma and subsequent work by G. Hjorth it is known that if a group is abelian-by-finite, then the associate equivalence relation is smooth; else it is not even classifiable by countable structures. For a current state of affairs see [8].
Furthermore, I am interested in cardinal characteristics. The consistency of many inequalities between cardinal characteristics of the continuum is known, but often only for \( c = \aleph_2 \). The obvious question to ask here is whether these inequalities are still consistent with large continuum; or, whether three or more cardinal characteristics can be pairwise different. In order to achieve this, I am interested in further developing the creature forcing technique from [2] (see also [4]).

References


5.79 Jacek Tryba (Gdansk)

I am a first year PhD student at the University of Gdansk, working under the supervision of Dr Rafał Filipów.

The concept of \( I \)-convergence of sequences, an extended notion of normal convergence, was introduced in [3]. My research efforts have been focused on Bolzano-Weierstrass property of ideals (see [2]), that is, that every sequence has an \( I \)-convergent subsequence on a large set of indexes. More specifically, we investigated two particular ideals connected with well known theorems in combinatorics, namely van der Waerden’s theorem and Hindman’s theorem, and showed that for those ideals the Bolzano-Weierstrass property is equivalent to its hereditary version.

I have also researched \( I \)-convergence of series, where the sequence of its finite sums is \( I \)-convergent. Especially interesting was the notion of property \( (T) \) (see [1]), when for every \( I \)-convergent series \( \sum_{n \in \omega} x_n \) there exists \( A \in I \) such that \( \sum_{n \in \omega \setminus A} x_n \) is convergent in the usual sense. I managed to show that many classes of ideals, like summability ideals or density ideals, do not have it. We still investigate whether there are any analytical ideals with that property.

References


jacek.tryba@mat.ug.edu.pl
5.80  Milette Tseelon-Riis (Leeds)

I am a first year PhD student at the University of Leeds, working under the supervision of Prof. John Truss.

In my Master’s thesis, I looked at a variety of different large cardinals, including inaccessible and Mahlo cardinals, measurable cardinals, and Ramsey cardinals. I investigated the relationship between different large cardinal axioms, and the various implications between them ([1],[2],[3]).

I was motivated by independence results in set theory, in particular by Chris Freiling’s controversial argument in favour of ¬ CH [4]. I was also fascinated by a number of various paradoxes related to the axiom of choice. I have written a philosophy essay on the Löwenheim-Skolem paradox, in which I followed the debate between Skolem and various philosophers on the interpretations of his theorem ([5],[6]).

At the moment I am investigating Ramsey Theory and variants thereof ([7],[8]).

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mm11mr@leeds.ac.uk

5.81  Spencer Unger (Los Angeles)

I received my PhD at Carnegie Mellon in 2013 under the supervision of James Cummings. For the past two years, I have been a postdoc at UCLA.

My main research interests are in combinatorial set theory. In particular, I am interested in an old question about trees: “In ZFC, can you construct a $\kappa$-Aronszajn tree for some $\kappa > \aleph_1$?” . It has long been thought that the answer should be “no” assuming that large enough cardinals are consistent. Even partial progress towards this answer requires complex forcing constructions and has interactions cardinal arithmetic at singular cardinals.

sunger@math.ucla.edu

5.82  Andrea Vaccaro (Pisa)

I am a second year Master student at the University of Pisa, and I am working to my Master thesis with Prof. Matteo Viale, from University of Torino, since February 2015.

In recent years set theory fruitfully approached functional analysis, and in particular the theory of $C^*$–algebras (see [1] and [2]).
In my thesis I try to outline some analogies between these two theories, working with $C^*$-algebras and boolean valued extensions of the complex field. In fact, some specific $C^*$-algebras can be studied in the context of boolean valued models appealing to Gelfand Transform: given a commutative unital $C^*$-algebra $A$ with extremely disconnected spectrum, there is an isomorphism (which can be defined using the Gelfand Transform) of the $C^*$-algebras $A$ and $C(St(B))$ (which can be thought as a boolean valued extension of the complex field), where $B$ is the boolean algebra given by clopen sets in the weak* topology on the spectrum of $A$. By means of this isomorphism $A$ can be therefore embedded in the set of $B$-names for complex numbers in the boolean model $V^B$.

This embedding might be an interesting tool to translate ideas and results arising in set theory to ideas and results arising in the study of commutative $C^*$-algebras and conversely.

An interesting development of this might follow using the Shoenfield absoluteness theorem in order to carry properties from the theory of $C^*$-algebras, seen as boolean valued models, to the first order theory of complex numbers and vice versa.

References


5.83 Jonathan L. Verner (Prague)

I am an assistant professor at the Department of Logic, Faculty of Arts, Charles University in Prague, Most of my research interests center around filters and ultrafilters, typically on $\omega$. One line of research I've been looking into recently is motivated by the $p = t$ result of Malliaris and Shelah [4]

**Question:** If $F$ is a centered system of infinite subsets of $\omega$ with no infinite pseudointersection does it contain a tower (a $\subseteq^*$-chain with no pseudointersection)?

The answer to this particular question is no (see [3] under $\Diamond$; in [1] an example where $F$ is a $P$-point is given). However, it raises other interesting questions, e.g. the following:

**Question:** Is it consistent that there is an ultrafilter with character $< \aleph_1$ which does not contain a tower?

Or a more general one

**Question:** If a centered system has no infinite pseudointersection does it contain a subsystem of size $\aleph_1$ with no infinite pseudointersection?

Recently, motivated by the cardinal invariant non of the ideal of monotone subsets of a metric space (see [2]), I’ve been intrigued by the following Ramsey-theoretic problem. Is there a metric space $X$ of size $\aleph_1$ (or $2^\omega$, for that matter) such that for all finite metric spaces $K$ with rational distances and all partitions of $X$ into countably many pieces, one of the pieces contains an isometric copy of $K$. The answer is yes, if we only require the pieces to contain isometric copies of finite ultrametric spaces. The general case is still open (and might just be waiting for a clever simple counterexample).


jonathan.verner@ff.cuni.cz

5.84 Alessandro Vignati (Toronto)

I am currently a third year PhD student at the York University in Toronto, Ontario, working under the supervision of Prof. Ilijas Farah.

My work is primarily focused in applications of logic to operator algebra, focusing of application of both model theory and set theory.

Given a non-unital C*-algebra $A$ it is possible to construct, similarly to the Stone-Cech compactification, an universal unital C*-algebra $M(A)$ in which $A$ is embedded canonically as an ideal.

In my research I study the structure of automorphisms of the so called corona algebra $M(A)/A$, essentially trying to use forcing axioms to prove that every such automorphism admits a suitable lifting (as in the case of $P(\omega)/\text{Fin}$, see [6] and [7]). The work of Farah (see [2]) established that every automorphism of the Calkin algebra is inner under the assumption of the Open Coloring Axioms, in contrast with the behavior obtained under CH (see [1]). Further developments were obtained in [4], where it was proved that every isomorphism of quotient algebras of the form $\prod A_n/\bigoplus A_n$, where $A_n$ are UHF algebras, has a Borel lifting, [3], where it is showed that is consistent that every isomorphisms of reduced product of matrix algebras is trivial in a very strong sense, and the forthcoming [5].

References


ale.vignati@gmail.com

5.85 Thilo V. Weinert (Be’er Sheva)

I am a postdoctoral fellow at the Ben-Gurion University of the Negev, working under the supervision of Prof. Menachem Kojman.

In my diploma thesis, written under the supervision of Prof. Ralf-Dieter Schindler, I showed that the Bounded Axiom A Forcing Axiom does not imply the Bounded Proper Forcing Axiom (see [1]). This direction of research has later been taken up by Aspero, Friedman, Mota and Sabok in [2].

In my PhD thesis ([3]) I analysed the homogeneity numbers, a sequence of cardinal characteristics of the continuum, (see [4]). I could prove that the reaping number is at most the homogeneity number for triple-colourings. Some other questions remain open, though.

Moreover I got interested in Partition Relations and was able to calculate some Ramsey numbers directly, (see [5]). More precisely I was able to prove $r(\omega^22,3) = \omega^210$, $r(\kappa\lambda2,3) = \kappa\lambda6$ and $r(\kappa\lambda3,3) = \kappa\lambda15$ for $\kappa$ weakly compact and $\lambda < \kappa$ a cardinal or, alternatively, for $\kappa = \omega_1$ and $\lambda = \omega$ under MA$(\aleph_1)$. In this context, $r(\alpha, \beta)$ is the least ordinal $\gamma$ such that $\gamma \to (\alpha, \beta)$. The two last results are new while the first was announced without a proof already in [6].
In my PhD thesis ([5]) I started an analysis of Partition Relations for linear orders in contexts where the axiom of choice fails. I continued this analysis together with Philipp Schlicht and Philipp Lücke in [7]. It turns out that there are surprisingly strict limitations on certain kinds of partition relations and it is an open problem whether

$$\langle \omega^1_2, \leq_{\text{lex}} \rangle \to (\omega^* + \omega + \omega^*, 6)^4$$

is consistent with ZF or possibly even provable in ZF + AD.

From September 2014 until September 2015 I was a postdoctoral fellow at the Einstein Institute of Mathematics under the supervision of Prof. Saharon Shelah and I am currently working with him about cardinal characteristics of the continuum.

References


5.86 Gabriel Zanetti Nunes Fernandes (Münster)

I am a third year PhD student at the University of Münster, working under the supervision of Prof. Dr. Ralf Schindler.

Variations of \(\neg\text{SCH}\) has been investigated since 1970s (eg. see [1] [2]). It has inspired forcing theory, pcf theory and core model theory ([3],[4],[5]). The core model, \(K\), refers to a specific class model of \(ZFC\) of the form \(L[E]\) that can be built under some large cardinal assumption, for example there is no inner model with a Woodin cardinal. Given an ordinal \(\kappa\), we define \(o(\kappa) = \sup\{\alpha \mid \text{crit}(E_\alpha) = \kappa\}\). The results in [6],[7] give a good understanding, under the large cardinal hypothesis \(\neg 0^\dagger\), of how cardinal arithmetic influences \(o(\kappa)\).

I am interested in extending the results from [6] and [7] for more general large cardinal hypothesis.

In [8] it is shown that ‘for every \(n \in \omega\) there is a inner model with \(n\) Woodin cardinals’ is a lower bound for the consistency strength of the statement

\[ \kappa \text{ is a singular cardinal of uncountable cofinality and } \{ \mu < \kappa \mid 2^\mu = \mu^+ \} \text{ is stationary and co-stationary} \]

From recent discussions with Ralf Schindler emerged a scenario where one could obtain the consistency of ‘\(\text{cf}(\kappa)\) many Woodin cardinals’ from (1), which I am now investigating.

References


5.87 Wolfgang Wohofsky (Vienna)

I got my PhD at the Vienna University of Technology, with Martin Goldstern as my advisor. Currently, I am a Postdoc at the University of Hamburg, working in the Mathematical Logic Group of Prof. Benedikt Löwe.

My research area is (iterated) forcing and its applications to set theory of the reals; in particular, I study questions about small (or: “special”) sets of real numbers (and variants of the Borel Conjecture).

A prominent example is the class of strong measure zero (smz) sets (a set $X$ is smz if for any sequence of $\varepsilon_n$'s, $X$ can be covered by intervals $I_n$ of length $\varepsilon_n$). The Galvin-Mycielski-Solovay theorem states that $X$ is smz if and only if it is meager-shiftable (i.e., if it can be translated away from each meager set).

The notions of smz and meager-shiftable coincide not just for the real line and $2^\omega$, but for all locally compact Polish groups. In my PhD thesis, I show that this is not true for the Baer-Specker group $\mathbb{Z}^\omega$ (answering a question of Kysiak). Several more results about smz and meager-shiftable sets and their cardinal invariants can be found in my paper [2] joint with Michael Hrušák and Ondřej Zindulka.

The Borel Conjecture (BC) is the statement that there are no uncountable smz sets; the dual Borel Conjecture (dBC) is the analogous statement about strongly meager sets (the sets which are null-shiftable). Both BC and dBC fail under CH. In 1976, Laver showed that BC is consistent; Carlson showed that dBC is consistent (actually it holds in the Cohen model).

Together with my advisor Martin Goldstern, Jakob Kellner and Saharon Shelah, I worked on the following theorem (see [1]):

There is a model of ZFC in which both the Borel Conjecture and the dual Borel Conjecture hold, i.e., $\text{Con}$(BC $+$ dBC).

In my thesis, I also introduced the notion of Sacks dense ideal (being a translation-invariant $\sigma$-ideal $\mathcal{I} \subseteq \mathcal{P}(2^\omega)$ which is “dense in Sacks forcing”, i.e., each perfect set contains a perfect subset which belongs to $\mathcal{I}$) to investigate another variant of the Borel Conjecture, which I call the Marczewski Borel Conjecture (MBC). It is the assertion that there is no uncountable $s_0$-shiftable set (the Marczewski ideal $s_0$ is related to Sacks forcing: a set $Z$ is in $s_0$ if each perfect set contains a perfect subset disjoint from $Z$). Quite recently, I started working with Jörg Brendle to attack questions related to the Marczewski Borel Conjecture.

It is known for a long time that the cofinality of the Marczewski ideal $s_0$ is strictly above the continuum (in ZFC). In a joint project with Jörg Brendle and Yurii Khomskii we investigate the analogous question for ideals such as $v_0$, $r_0$, $l_0$, $m_0$ (connected to the tree forcing notions Silver forcing, Mathias forcing, Laver forcing, Miller forcing, respectively). For the above ideals, the cofinality turns out to be above the continuum as well. The respective question for other tree forcing notions (e.g., full-splitting Miller forcing considered by Khomskii and Laguzzi, see [3]) is still open.

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theoretic characterization of all the cardinals below $\sup_{n<\omega} \delta_n$, in AD (by Jackson, such cardinals have order type $\sup_{n<\omega} E(n)$, where $E(0) = 0$, $E(n + 1) = \omega^{E(n)}$ in ordinal arithmetic).

This is only the starting point of the new exploration. Open questions concerning the bone theory include the characterization of $\omega_2$ in HOD under AD; the inner model theoretic characterization of the largest countable $\Pi^1_3$ set; the structure of the minimum admissible set over $T_2$; etc. Aside from these concrete results and questions, the concept of a Woodin cardinal remains a mystery to us. Concerning applications to other areas, a question I am aware of is the classification of projective thin equivalence relations on $\mathbb{R}$. I hope my work will bring more people working in descriptive set theory or higher recursion theory up to the projective levels.

References


zhuyizheng@gmail.com

5.91 Tomasz Żuchowski (*Wrocław*)

I have done Master Studies at the University of Wrocław under the supervision of Prof. Grzegorz Plebanek and since October 2015 I will begin PhD Studies at the University of Wrocław, also under the supervision of Prof. Plebanek.

My Master Thesis topic was Tukey reduction between partially ordered sets. Tukey reduction was introduced in 1940 by John Tukey in order to illustrate the notion of subnet in the Moore-Smith theory of net convergence. In 1980’s there was found connection between the Cichoń’s Diagram and the existence of Tukey reduction between the order $\mathcal{M}$ of the first category subsets of $2^\omega$ and the order $\mathcal{N}$ of Lebesgue measure zero subsets of $2^\omega$ (see [2]). Later the structure of Tukey reductions was thoroughly studied between various partial orders appearing in measure theory, analysis and set theory, including results in some extensions of ZFC (e.g. see: [3], [6]). Over the last years the study of Tukey classification has been still continued in various classes of orders: analytic ideals of subsets of $\omega$, orders of compact subsets of separable metric spaces or of weakly compact subsets of separable Banach spaces (e.g. see [1], [4], [5]).

In my thesis I worked on simplifying proofs of some Tukey reductions which appeared in [3]. The second topic was Tukey structure of orthogonal families of subsets of $\omega$: for $\mathcal{A} \subseteq \mathcal{P}(\omega)$ we define a family orthogonal to $\mathcal{A}$ as $\mathcal{A}^\perp = \{ B \subseteq \omega : B \cap A \text{ is finite for all } A \in \mathcal{A} \}$. We say that two orders have the same Tukey type if they are Tukey reducible to each other. I have proved that there exist $2^{2^{\omega}}$ pairwise different Tukey types of $\mathcal{A}^\perp$ for some $\mathcal{A} \subseteq \mathcal{P}(\omega)$, in contrast to theorem from [1] saying that under assumption of Axiom of Analytic Determinacy if $\mathcal{A}$ is analytic then $\mathcal{A}^\perp$ can have only five Tukey types. I constructed also families with special properties realizing some of this five types.

I plan to study in my PhD research the isomorphic structure of Banach spaces of continuous functions.

References

1. Antonio Avilés, Grzegorz Plebanek and Jose Rodríguez. Tukey classification of some ideals on $\omega$ and the lattices of weakly compact sets in Banach spaces, preprint.


I am also interested in generalizations of the concepts strong measure zero, Borel Conjecture etc. to the space $2^\kappa$ (for $\kappa$ being larger than $\omega$, especially a large cardinal). In particular, I proved that the Galvin-Mycielski-Solovay theorem connecting smz with meager-shiftable generalizes to weakly compact $\kappa$ (with the generalized notion of smz from Halko and Shelah’s paper).

References


2. Michael Hrušák, Wolfgang Wohofsky, and Ondřej Zindulka. Strong measure zero in separable metric spaces and Polish groups. Accepted for publication by the Archive for Mathematical Logic.


wolfgang.wohofsky@gmx.at

5.88 W. Hugh Woodin (Harvard)

woodin@math.harvard.edu

5.89 Martin Zeman (UCI)

mzeman@math.uci.edu

5.90 Yizheng Zhu (Münster)

I am a postdoc at the University of Münster.

My recent work has been focusing on analysis of mice with finitely many Woodin cardinals using tools from descriptive set theory. This area reveals a deep connection between inner model theory and descriptive set theory at projective levels. The story line starts from the theorem by Martin-Steel-Woodin [1, 2] that “Projective Determinacy is consistent” is equivalent to “for every $n < \omega$, the theory \"ZFC+there are $n$ Woodin cardinals\" is consistent”.

On the inner model theory side, mice with finitely many Woodin cardinals have been extensively studied. The mouse $M_n^\#$ is isolated, being the minimum mouse having $n$ Woodin cardinals and a measure on top. The complexity of iterations of mice is closed tied to the number of Woodin cardinals in the mice. On the descriptive set theory side, a lot of concrete structural implications of PD has been established. For instance, the prewellordering property and the scale property of the pointclasses $\Pi^1_{2n+1}$ and $\Sigma^1_{2n+2}$, the existence of largest countable $\Pi^1_{2n+1}$ and $\Sigma^1_{2n+2}$ subset of reals. A fundamental connection between these two viewpoints is established by Steel [3], showing that $L[T_3]$ is an initial segment of the direct limit of all countable iterates of $M_2^\#$, where $T_3$ is the tree of a $\Pi^1_3$-scale on a universal $\Pi^1_3$ set.

My work has been unveiling even more fascinating results in this direction. My central result is the descriptive set theoretic representation of the mouse $M_n^\#$, which is called $0^{(n+1)}\#$. At the even levels, I have defined a canonical tree $T_{2n}$, which generalizes the Martin-Solovay tree $T_2$ obtained from sharps for reals. $0^{(2n)}\#$ is the higher level of Kleene’s $\mathcal{O}$. It codes the truth values of the minimum admissible set over $T_{2n}$ for a class of formulas slightly bigger than $\Sigma_1$. This formulation adds a fundamental recursion theoretic flavor to the Q-theory [4], originally developed by Kechris-Martin-Solovay. It will serve as a template for solving potential higher level recursion theoretic questions. At the odd levels, $0^{(2n+1)}\#$ is the unique iterable remarkable level-$(2n+1)$ EM blueprint. It generalizes the EM blueprint formulation of $0^\#$. In many situations, the EM blueprint formulation of $0^\#$ (instead of the mouse formulation) is unavoidable, so the EM blueprint formulation of $0^{(2n+1)}\#$ will serve as a tool for generalizing many theorems from the $\Sigma^1_1$ or $\Pi^1_1$ level to all the projective levels.

Some immediate applications of my work include: “$M_{2n+1}^\#$ exists” is equivalent to the determinacy of $\Pi^1_{2n}$ and $\Pi^1_{2n+1}$ sets; an inner model theoretic statement and proof of the higher Kechris-Martin theorem; an inner model theoretic proof of the strong partition property on $\delta^1_{2n+1}$; an inner model


Tomasz.Zuchowski@math.uni.wroc.pl
6 Past Midrasha Mathematicae in Set Theory

6.1 Jerusalem (2004)

- **Mini Courses**: Matt Foreman, Stefan Geschke, Moti Gitik, Greg Hjorth, Istvan Juhasz, Menachem Kojman, Bill Mitchell, Saharon Shelah, W. Hugh Woodin, Jindra Zapletal;

7 Past Young Set Theory Workshops

7.1 Bonn (2008)

- **Mini Courses**: Alessandro Andretta, Martin Goldstern, Jouko Väänänen;
- **Plenary Talks**: David Asperó, Natasha Dobrinen, Gunter Fuchs, Alex Hellsten, John Krueger, Heike Mildenberger, Assaf Rinot, Matteo Viale;
7.2 Bellaterra (2009)

- **Mini Courses:** Mirna Džamonja, Moti Gitik, Ernest Schimmerling, Boban Velickovic;
- **Plenary Talks:** Andrew Brooke-Taylor, Bernhard König, Jordi Lopez-Abad, Luis Pereira, Hiroshi Sakai, Dima Sinapova, Asger Törnquist;

7.3 Raach (2010)

- **Mini Courses:** Ralf Schindler, Greg Hjorth, Justin Moore, Uri Abraham;
- **Plenary Talks:** Philipp Schlicht, Lyubomyr Zdomskyy, Bart Kastermans, Wiesław Kubiś, Inessa Epstein, Thomas Johnstone;
7.4 Königswinter (2011)
- Mini Courses: Ali Enayat, Joel David Hamkins, Juris Steprans, Slawomir Solecki;
- Plenary Talks: Assaf Rinot, David Schrittesser, Dilip Raghavan, Grigor Sargsyan, Katie Thomp-son, Sam Coskey;

7.5 Luminy (2012)
- Mini Courses: Ilijas Farah, Alain Louveau, Itay Neeman, Stevo Todorcevic;
- Plenary Talks: Christina Brech, Sean Cox, Vera Fischer, Daisuke Ikegami, Carlos Martinez-Ranero, David Milovich, Farmer Schlutzenberg;

7.6 Oropa (2013)
- Mini Courses: James Cummings, Sy David Friedman, Su Gao, John Steel;
- Plenary Talks: Tristan Bice, Scott Cramer, Luca Motto Ros, Victor Torres Perez, Trevor Wilson;
7.7 Będlewo (2014)

- **Mini Courses**: Piotr Koszmider, Lajos Soukup, Simon Thomas, Jindrich Zapletal;

- **Plenary Talks**: David Chodounsky, Aleksandra Kwiatkowska, Philipp Lücke, Nam Trang, Konstantinos Tyros.