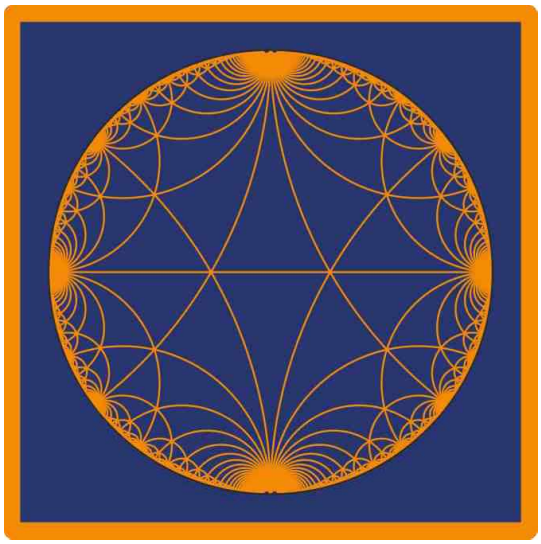

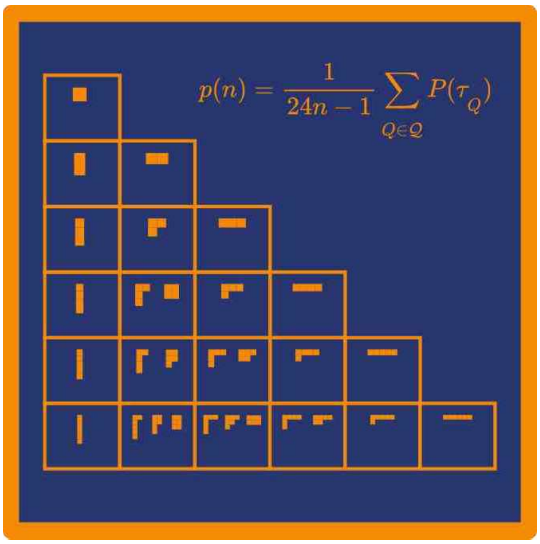

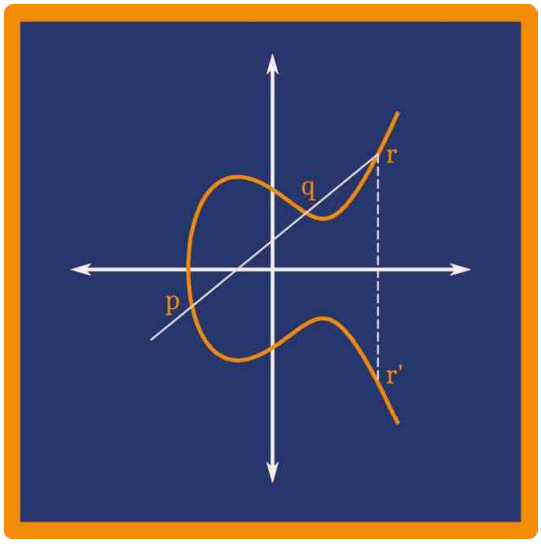

Early Number Theory Researchers Workshop 2023

August 23 – 25, 2023
Bielefeld University

Supported and funded by

TRR 358

UNIVERSITÄT BIELEFELD

Contents

About

ENTR Workshop

This workshop is meant as an opportunity for community building and fostering collaborations between early career researchers in the field of number theory.

Format

The workshop will take three days. There will be research and introductory talks by young researchers about their current research. Additionally, there will be three talks by invited speakers and a plenary discussion about career in math.

There will be plenty of time to discuss in between sessions and become acquainted over a casual cup of coffee for potential collaborations.

Organizing committee

- Bieker, Patrick (Bielefeld University)
- Burmester, Annika (Bielefeld University)
- Kiefer, Paul (Bielefeld University)
- Krah, Johannes (Bielefeld University)
- Metzler, Ingmar (TU Darmstadt)
- Rajeev, Karthika (Bielefeld University)
- Strathausen, Rebekka (Bielefeld University)

Timetable

Wednesday

	X-E0-226	X-E0-228
9:00–9:45	**Welcome (X-E0-222)**	
9:45–10:30	**Luca Marannino** Triple product p-adic L-functions: a generalization and some applications	**Nico Lorenz** Pythagoras number and number of square classes of fields with a supreme torsion form
10:30–11:00	**Coffee (X-E0-222)**	
11:00–12:00	**Yajnaseni Dutta (X-E0-234)** A Family of curves	
12:00–13:30	**Lunch**	
13:30–14:15	**Risan** Finite multiple zeta values and modular forms	**Mohamed Tawfik** Brauer-Manin obstructions on Kummer surfaces of products of elliptic curves
14:15–15:00	**Benjamin Brindle** Multiple q-zeta values, a conjecture about their structure and recent results	**Himanshu Shukla** Cassels-Tate pairing on the curves of the form $y^2 = x(x^2 - p^2)(x^2 - 4p^2)$
15:00–15:30	**Coffee (X-E0-222)**	
15:30–16:15	**Zhang Xiaoyu** Theta lifting modulo p for unitary groups	**Sonam Garg** On Arithmetic Nature of a q-Euler-Double Zeta Values
16:30–17:30	**Walk to the Sparrenburg**	

Thursday

	X-E0-226	X-E0-228
9:00–9:45	**Manuel Müller** The basis problem for modular forms for the Weil representation	**Margherita Piccolo** Representation growth of p-adic analytic groups
9:45–10:30	**Zhang Mingkuan** Eisenstein series for SL_2 and CM values of Borcherds forms	**Bianca Marchionna** Suborbit zeta functions for groups acting on trees
10:30–11:00	**Coffee (X-E0-222)**	
11:00–12:00	**Markus Schwagenscheidt (X-E0-234)** Special values of automorphic Green functions on hyperbolic n-space	
12:00–13:45	**Lunch**	
13:45–14:45	**Panel Discussion (X-E0-234)** with Claudia Alfes-Neumann and Christopher Voll	
14:45–15:30	**Coffee (X-E0-222)**	
15:30–16:15	**Colby Brown** The Markoff Equation and Solutions Modulo p	**Thomas Karam** Ranges control degree ranks of multivariate polynomials over finite prime fields
19:00	**Conference Dinner**	

Friday

	X-E0-226	X-E0-228
9:45–10:30	**Matthias Storzer** Tails of the colored Jones polynomial and their modularity	**Kajtaz Bllaca** Explicit formulas and their applications
10:30–11:00	**Coffee (X-E0-222)**	
11:00–12:00	**Joshua Maglione (X-E0-234)** Local Igusa zeta functions and hyperplane arrangements	
12:00–13:30	**Lunch**	
13:30–14:15	**David Angdinata** Twisted elliptic L-values	**Cesar Hilario** Fibrations by singular curves in positive characteristic
14:15–15:00	**Rajat Gupta** Summation formulas attached to Hecke's functional equation	**Rina Roxana Paucar Rojas** A result on the zero cycles of surfaces
15:00–15:30	**Coffee (X-E0-222)**	

List of Abstracts – Talks

Wednesday

Triple product p-adic L-functions: a generalization and some applications

Luca Marannino

Universität Duisburg-Essen

In recent years, several authors have constructed and studied p-adic L-functions attached to a triple of p-adic families of modular forms. Applications of these works address, for instance, certain cases of the Birch and Swinnerton-Dyer conjecture. I will give a brief survey on this subject and then describe parts of my PhD project. In the latter, I try to adapt this machinery and to derive applications in a setting where the p-adic properties of the objects involved are *less nice* than what usually happens in the literature.

Pythagoras number and number of square classes of fields with a supreme torsion form

Nico Lorenz

Ruhr-Universität Bochum, Germany

The Pythagoras number of a field F is defined as the least integer m such that each sum of square in F is a sum of at most m squares or ∞ if no such integer exists. This invariant has connections to other invariants such as the number of square classes and the height of the Witt Ring $W(F)$. In this talk we study these invariants of real fields that have a *supreme torsion form*, i.e. a quadratic form whose signature with respect to all orderings is 0 that contains every quadratic form whose signatures are all 0 as a subform. We show how such fields can be used to construct examples for fields with certain prescribed invariants.

A family of curves

Yajnaseni Dutta

University of Bonn

I will report on an on-going discussion with D. Huybrechts about a family of genus 4 curves over a smooth cubic 4-fold. The family is closely related to hyperkaehler geometry. I will present some geometric properties of this family and look at how far its 8-dimensional relative compactified Jacobian is from being a Lagrangian fibration of a HK manifold.

Finite multiple zeta values and modular forms

Risan

Nagoya University

In this talk, we introduce the space of formal finite multiple zeta values and discuss its relationship to modular forms. Finite multiple zeta values, recently introduced by Kaneko and Zagier, are variations of the classical multiple zeta values. We start by briefly introducing the theory of multiple zeta values, then discuss finite multiple zeta values and present the conjecture of Kaneko-Zagier which connects these two worlds. Motivated by this conjecture, we introduce the space of formal finite multiple zeta values (in depth ≤ 4). This space can be seen as a finite analogue of the formal double zeta space introduced by Gangl, Kaneko, and Zagier, for which various connections to modular forms are known. Finally, we will explain the connections of finite multiple zeta values and modular forms through numerical results and conjectures.

Brauer-Manin obstructions on Kummer surfaces of products of elliptic curves

Mohamed Tawfik

King's College London, United Kingdom

We discuss Brauer-Manin obstructions to weak approximation on Kummer surfaces of products of CM elliptic curves. In particular, we are interested in the Kummer surfaces $\mathrm{Kum}(E^c \times E^d)$ where E^c and E^d are elliptic curves with CM by $\mathbb{Z}[\zeta_3]$, and ζ_3 is a primitive cubic root of unity. First, we use a theorem by Skorobogatov and Zarhin to show that the transcendental Brauer group is finite. Then, we show that the possibly non-trivial p-primary parts of the transcendental Brauer group of the $\mathrm{Kum}(E^c \times E^d)$ are for p one of the primes 2,3,5, or 7. Then, we put necessary and sufficient conditions on c and d such that the transcendental Brauer group of $\mathrm{Kum}(E^c \times E^d)$ is non-trivial. Moreover, we find generators to the transcendental Brauer groups of orders 5 and 7. And finally, we calculate the Manin pairing and prove that a transcendental element of the Brauer group of the Kummer surface gives rise to Brauer-Manin obstruction to weak approximation on the Kummer surface.

Multiple q-zeta values, a conjecture about their structure and recent results

Benjamin Brindle

University of Cologne

q-Analogs of multiple zeta values (qMZVs) are objects that give back multiple zeta values under the limit $q \to 1$ (after some minor modification). They were studied in the last years intensively and are of interest since quasi-modular forms are just special qMZVs. Moreover, their algebraic structure is fascinating but has not been completely discovered. We focus in this talk on a conjecture originally by Bachmann. For presenting some small new results and ideas on his conjecture, we will use Burmester's balanced q-multiple zeta values.

Cassels-Tate pairing on the curves of the form $y^2 = x(x^2 - p^2)(x^2 - 4p^2)$

Himanshu Shukla

Universitaet Bayreuth

In this talk I will talk about a work in progress with Tim Evink on how to explicitly compute the Cassels-Tate pairing on the 2-Selmer groups of the Jacobians of the hyperelliptic curves of the form $y^2 = x(x^2 - p^2)(x^2 - 4p^2)$ where p is prime. Furthermore, comparing the result with rank bounds obtained by Evink, van-der Heiden, Top we show that the Cassels-Tate pairing is as effective as the technique of "visualization" for this family. Moreover, computing the pairing over the quadratic extension $\mathbb{Q}(\sqrt{p})$, we improve the bound on the rank for many curves.

Theta lifting modulo p for unitary groups

Zhang Xiaoyu

Universität Duisburg-Essen

Theta series are one of the earliest and most important examples of modular forms. A.Weil gave a representation-theoretic interpretation of these series and thanks to the work of many mathematicians, the generalization of theta series, theta lifting/correspondence between classical groups, becomes nowadays an important tool in Langlands program, Gan-Gross-Prasad conjectures, etc. Theta lifting gives an explicit transfer of automorphic forms from one group to another. In this talk, we would like to consider the arithmetic properties of theta liftings between two unitary groups: for a p-integral/p-primitive automorphic form on a unitary group, when is its theta lifting again p-integral/p-primitive? These properties can be applied to prove new cases of p-part of Bloch-Kato conjectures.

On Arithmetic Nature of a q-Euler-Double Zeta Values

Sonam Garg

Indian Institute of Technology Ropar

Kurokawa and Wakayama (2003) introduced a q-analogue of the Euler constant and studied the irrationality of certain numbers that involve q-Euler constant. Building upon their work, our recent paper [1] extends their results and explores linear independence properties for certain numbers involving a q-analogue of the Euler constant. Moreover, we obtain the closed-form expression for a q-analogue of the k-th Stieltjes constant, $\gamma_k(q)$. Further, using Nesterenko's result, we discuss a question which Erdós mentioned in 1948 and using an answer to Erdós's question, we discuss the arithmetic nature of some infinite series involving $\gamma_1(2)$.
In this talk, we aim to further expand on our research and focus on a q-analogue of the double zeta function [2]. Specifically, we discuss a closed-form expression for a q-analogues of Euler's constant of height 2 $(\gamma_{0,0}(q))$, which is the constant term in the Laurent series expansion of a q-analogue of the double zeta function around $s_1 = 1$ and $s_2 = 1$.
Furthermore, we explore the limiting values of $\zeta_q(s_1, s_2)$ as $s_1 \to 0$ and $s_2 \to 0$, and compare these limits to those of the classical double-zeta function. We also discuss identities involving different versions of a q-analogue of the Riemann zeta function and the double-zeta function [3]. Additionally, we examine the linear independence of a set of numbers involving the constant $\gamma_0'^*(q^i)$, where $1 \leq i \leq r$ for any integer $r \geq 1$, that appears in the Laurent series expansion of a q-double zeta function. Finally, we discuss the irrationality of certain numbers involving a 2-double Euler-Stieltjes constant $(\gamma_{0,0}(2))$.

[1] T. Chatterjee and S. Garg, *On q-analogue of Euler-Stieltjes Constant*, Proc. Amer. Math. Soc., 151 (2023), 2011–2022.
[2] T. Chatterjee and S. Garg, *On Arithmetic Nature of a q-Euler-Double Zeta Values*, submitted.
[3] T. Chatterjee and S. Garg, *Algebraic identities among q-analogue of Euler double zeta values*, submitted.

Thursday

The basis problem for modular forms for the Weil representation

Manuel Müller

TU Darmstadt

Let L be an even positive-definite lattice of even rank $m \in 2\mathbb{N}$ and let L' be its dual lattice. Let $k \in \mathbb{N}$ with $k \geq m/2$ and let P be a harmonic polynomial of degree $k - m/2$. Then the vector-valued theta function $\theta_{L,P}$ associated to L and weighted with P is a modular form for $\mathrm{SL}_2(\mathbb{Z})$ of weight k with respect to the Weil representation $\rho_{L'/L}$, where L'/L is called the discriminant form associated to L. Two positive-definite lattices are in the same genus if they have equal ranks and isomorphic discriminant forms. We show that if the rank m of L is large enough compared to the rank of L'/L, then the cusp forms of weight k for the Weil representation $\rho_{L'/L}$ are generated by the vector-valued theta functions in the genus of L weighted with harmonic polynomials of degree $k - m/2$.

Representation growth of p-adic analytic groups

Margherita Piccolo

Heinrich-Heine-Universität Düsseldorf

The representation growth of a group G measures the asymptotic distribution of its irreducible representations. Whenever the growth is polynomial, a suitable vehicle for studying it is a Dirichlet generating series called the representation zeta function of G. One of the key invariants in this context is the abscissa of convergence of the representation zeta function. The spectrum of all abscissae arising across a given class of groups is of considerable interest and has been studied in some cases.
In the realm of p-adic analytic groups (with perfect Lie algebra), the abscissae of convergence are explicitly known only for groups of small dimensions. But there are interesting asymptotic results for 'simple' p-adic analytic groups of increasing dimension. In this talk, I will give an overview of the main tools and ingredients in this area and I will report on recent work joint with Moritz Petschick to enlarge the class of groups.

Eisenstein series for SL_2 and CM values of Borcherds forms

Zhang Mingkuan

TU Darmstadt

We will talk about (in)coherent Eisenstein series for SL_2 over totally real number fields. By means of the Siegel-Weil formula, which relates the integral of theta functions to Eisenstein series, the CM values of Borcherds forms can be expressed via coefficients of Eisenstein series. When the harmonic Maass form is not weakly holomorphic, there will be an additional term of special values of derivative of L-functions. We realized the (in)coherent Eisenstein series over real quadratic fields as the theta lift of elliptic Eisenstein series. If time permits, we will sketch its proof and show how it can be used to calculate the special values of derivative of L-functions.

Suborbit zeta functions for groups acting on trees

Bianca Marchionna

Bielefeld University

For a group G acting transitively on a set X, it is a common problem to look at the suborbits, i.e. the orbits in X of a prescribed stabilizer subgroup G_x, and how their size grows, provided they are all finite. A way to study such growth is to encode it into a Dirichlet series $D_{G,G_x}(s)$.
The talk aims at introducing $D_{G,G_x}(s)$ - and how it relates to invariants or structural properties of G - in case X is described in terms of a tree. This favourable setting allows us to reformulate the problem into a more accessible one only involving the geometry and the combinatorics carried by X.

Special values of automorphic Green functions on hyperbolic n-space

Markus Schwagenscheidt

ETH Zurich

In their seminal paper on Heegner points and derivatives of L-series, Gross and Zagier studied the special values of automorphic Green functions for $\mathrm{SL}_2(\mathbb{Z})$ at CM points on the complex upper half-plane, and showed that certain linear combinations of these values are given by logarithms of rational numbers. They also made some remarkable conjectures about the individual special values of these automorphic Green functions, which were recently proved by Bruinier, Li, and Yang.

In the talk we discuss an analogous problem for special values of automorphic Green functions on hyperbolic n-space. It turns out that in the case of the hyperbolic 3-space we still get logarithms of algebraic numbers, but for $n > 3$ this is no longer true. If time permits, we will discuss the modularity and integrality of traces of special values of Niebur Poincaré series on hyperbolic 3-space, which is an analog of a famous result of Zagier about the generating function of traces of singular moduli. This is joint work with Sebastián Herrero, Özlem Imamoglu, and Anna von Pippich.

The Markoff Equation and Solutions Modulo p

Colby Brown

University of California

The Markoff equation is the Diophantine equation $x^2 + y^2 + z^2 - 3xyz = 0$. It's solutions can be enumerated as the elements of a tree rooted at $(1, 1, 1)$, with edges given by the Vieta involutions. Less understood are the solutions to the Markoff equation modulo a prime p. Modulo p, the solutions form the graph $X^*(p)$, and the shape of these graphs is the subject of several open questions. It is conjectured that $X^*(p)$ is connected for every prime p. If true, the conjecture would have implications for number-theoretic approaches to characterizing the Markoff solutions with prime coordinates. In this talk, we discuss the current approaches to deciding connectivity, especially those by Bourgain, Gamburd, and Sarnack, and discuss possible computational solutions.

Ranges control degree ranks of multivariate polynomials over finite prime fields

Thomas Karam

University of Oxford

Let p be a prime. It has been known since work of Green and Tao (2007) that if a polynomial $P : \mathbb{F}_p^n \mapsto \mathbb{F}_p$ with degree $2 \leq d \leq p - 1$ is not approximately equidistributed, then it can be expressed as a function of a bounded number of polynomials each with degree at most $d - 1$. Since then, this result has been refined in several directions. We will explain how this kind of statement may be used to deduce an analogue where both the assumption and the conclusion are strengthened: if for some $1 \leq t < d$ the image $P(\mathbb{F}_p^n)$ does not contain the image of a non-constant one-variable polynomial with degree at most t, then we can obtain a decomposition of P in terms of a bounded number of polynomials each with degree at most $\lfloor d/(t + 1) \rfloor$. We will also discuss the case where we replace the image $P(\mathbb{F}_p^n)$ by for instance $P(\{0, 1\}^n)$ in the assumption.

Friday

Tails of the colored Jones polynomial and their modularity

Matthias Storzer

Max Planck Institute for Mathematics

The N-colored Jones Polynomials for a knot are known to stabilize to a q-series as $N \to \infty$, the so-called tail of the colored Jones Polynomial. Garoufalidis, Le and Zagier conjectured that the tail of the colored Jones polynomial can be written as a product of partial theta functions for almost all knots with up to 8 crossings. This result was generalized by Beirne, Keilthy, and Osburn to knots with up to 10 crossings - still with missing identities.
In this talk we will give a general formula for the tail in terms of theta functions for a certain class of arborescent knots. This result also provides an explanation for the missing identities. We will end with some results and questions about the (non)modularity of the tail for general knots.
This is joint work in progress with Robert Osburn.

Explicit formulas and their applications

Kajtaz Bllaca

University of Prishtina

Assuming generalised Riemann hypothesis (GRH), we give an upper bound for the multiplicity of eventual zero at central point $1/2$ and location of the first zero with positive imaginary part of function in a certain subclass of the extended Selberg class. The crucial tool for deriving our results is the explicit formula for functions in the Selberg class and its generalizations, applied to suitably constructed test functions. Then we formulate an explicit formula for the zeta function for a function field K of genus g over a finite field $\mathbb{F}_q$, analogous to the Weil explicit formula and we give an upper bound for the multiplicity of the eventual zero of the zeta function at central point $s = 1/2$ of the zeta function ζ_K for a function field K of genus g over a finite field $\mathbb{F}_q$.

Local Igusa zeta functions and hyperplane arrangements

Joshua Maglione

Otto von Guericke University Magdeburg

We define a class of multivariate rational functions associated with hyperplane arrangements called flag Hilbert–Poincaré series. We show how these rational functions are connected to local Igusa zeta functions and class counting zeta functions for certain graphical group schemes studied by Rossmann and Voll. We report on general self-reciprocity and nonnegativity results and explore other connections within algebraic combinatorics.

Twisted elliptic L-values

David Angdinata

London School of Geometry and Number Theory

Given an elliptic curve, its L-function over an extension factorises into a product of L-functions twisted by Artin representations. Analogous to the Birch and Swinnerton-Dyer conjecture for an ordinary elliptic L-function, a twisted elliptic L-function has a conjectural order of vanishing at 1, but there seems to be a barrier to formulating its leading term at 1 in terms of arithmetic invariants. In this talk, I will describe some patterns in the leading term at 1 of elliptic L-functions twisted by primitive Dirichlet characters.

Fibrations by singular curves in positive characteristic

Cesar Hilario

Heinrich-Heine Universität Düsseldorf, Germany

By the Bertini-Sard theorem, in characteristic zero almost every fiber of a dominant morphism between two smooth algebraic varieties is smooth. This no longer holds in positive characteristic, as in this case there exist fibrations with smooth total space and every fiber singular. Perhaps the first example of such a fibration was given by Zariski in the 1940s. In this talk I will present a general framework to study this phenomenon in the specific situation where the general fiber has dimension one, i.e., each fiber is a singular curve. In particular, I will outline an unexpected connection between these fibrations and the theory of algebraic function fields.

Summation formulas attached to Hecke's functional equation

Rajat Gupta

University of Texas at Tyler

In this talk, we first review several work on the summation formulas of various kind, such as Voronoi summation formula, Poisson summation formula, and Abel-Plana summation formula. Then we will see summation formula in the setting of Hecke's functional equation. As an application, I will discuss these summation formulas in the case of cusp forms of weight $2k$ attached to the fundamental group $\mathrm{SL}(2,\mathbb{Z})$. Indeed, if time permits, I will discuss other special cases involving the function $r_k(n)$, counting the number of ways we can write n as a sum of k squares, and the ideal counting function $F(n)$ which counts the number of ideals with norm n in the arbitrary imaginary quadratic field. This is a joint work with Professor Madeline Dawsey.

A result on the zero cycles of surfaces

Rina Roxana Paucar Rojas

Universidad Nacional de Ingeneria, Peru

In this talk I will present a result of my PhD thesis, more precisely, let S be a connected smooth projective surface over C. We prove that for C_t a smooth hyperplane section of S the kernel G_t of the Gysin homomorphism r_{t*} from $\mathrm{CH}_0(C_t)_{deg=0}$ to $\mathrm{CH}_0(S)_{deg=0}$ induced by r_t, the closed embedding of C_t into S, is a countable union of translates of an abelian subvariety A_t inside the Jacobian J_t of the curve C_t. We also prove that there is a c-open subset U_0 in U such that $A_t = 0$ for all $t \in U_0$ or $A_t = B_t$ for all $t \in U_0$, where B_t is an abelian subvariety of J_t.

Useful Information

Directions, Location and Lecture Hall

The conference will take place in building X. The talks of the invited speakers and the panel discussion will be in room X-E0-234, while the rest of the talks will be in the rooms X-E0-226 and X-E0-228. The coffee breaks will take place in room X-E0-222.

From Bielefeld Hauptbahnhof, one can take the subway line 4 (Lohmannshof). Get off at the stop "Universität."

Walk to the Sparrenburg

On Wednesday afternoon, we will walk together to the Sparrenburg from the lecture hall at 4:30 pm. It takes approximately 45 minutes, so the group will arrive at the Sparrenburg at 17:15 pm in case you want to join us there.

Conference Dinner

The conference dinner takes place at Numa on Thursday at 7 pm.

Food & Beverage

There is a number of restaurants and bars to choose from.

- Brauhaus and Hofbräu: Typical german beergarden.
- Bernstein: A good restaurant with a nice view over the city. They also offer breakfast.
- 3ck and Plan B: Burger, wraps etc. You can also get cocktails here.
- Peppers: Mexican-American kitchen and cocktails.
- S'j Ramen: You can get ramen here.
- Moccaklatsch: Vegan and vegetarian kitchen.
- Irish Pub: An irish pub. They also offer pizza and they have Karaoke every Thursday.

List of Participants

Surname, First name	Affiliation
Angdinata, David Kurniadi	London School of Geometry and Number Theory
Alfes-Neumann, Claudia	Bielefeld University
Baric, Martin	Universität Paderborn
Bieker, Patrick	Bielefeld University
Bllaca, Kajtaz	University of Prishtina
Brindle, Benjamin	University of Cologne
Brown, Colby	University of California
Burmester, Annika	Bielefeld University
Choudhary, Aakash	Indian Institute of Technology Delhi
Garg, Sonam	Indian Institute of Technology Ropar
Guntermann, Anna	Bielefeld University
Gupta, Rajat	Institute of Mathematics, Academia Sinica
Hilario, Cesar	Heinrich-Heine-Universität Düsseldorf
Karam, Thomas	University of Oxford
Kiefer, Paul	Bielefeld University
Krah, Johannes	Bielefeld University
Lorenz, Nico	Ruhr-Universität Bochum
Maglione, Joshua	Otto von Guericke University Magdeburg
Maity, Saikat	Pondicherry University
Marannino, Luca	Universität Duisburg-Essen
Marchionna, Bianca	Bielefeld University
Meier, Sarah Diana	Bielefeld University
Metzler, Ingmar	TU Darmstadt
Moerman, Boaz	Utrecht University
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Vukadin, Christian	Bielefeld Universität

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Zhang, Xiaoyu	University of Duisburg-Essen

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