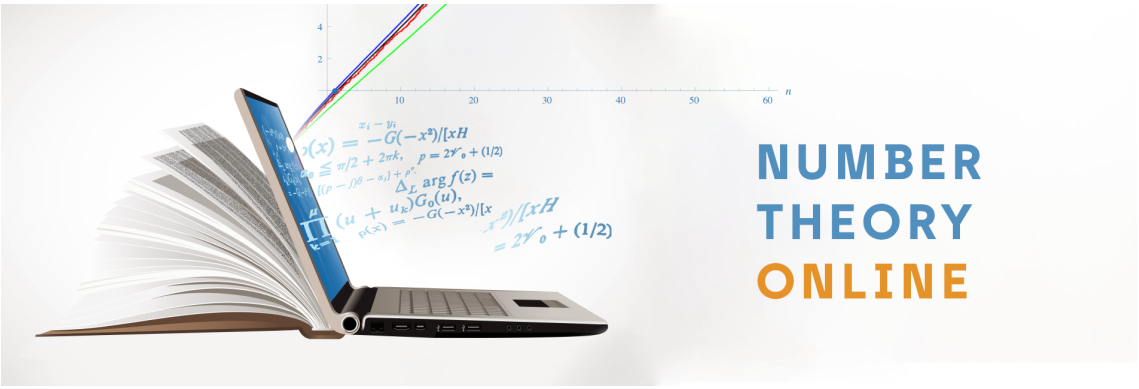

Number Theory Online 2021

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Titles and abstracts

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PLENARY SPEAKERS

Recent results on Greenberg transform

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ABSTRACT: Greenberg transform (or Greenberg realization) was firstly introduced by S. Lang in his thesis and later studied by his student M.J. Greenberg in [4]. It is an useful tool when studying polynomial equations over an artinian local ring; indeed the Greenberg transform allows to work with associated polynomial equations over the residue field without losing important information. In this talk, after recalling the classical construction and applications, I will present some new results obtained in recent papers [3, 2] (joint with T. Suzuki, E. Previato and A. Saha).

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Semi-abelian analogues of Schanuel Conjecture and applications

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ABSTRACT: In this talk we state Semi-abelian analogues of Schanuel conjecture and then we study their consequences. In particular we will see that a Relative Semi-abelian conjecture implies the algebraic independence of the values of the iterated semi-abelian exponential and the values of an iterated generalized semi-abelian logarithm.

p-adic deformations and the Birch and Swinnerton-Dyer conjecture

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ABSTRACT: I plan to report on recent results on the Birch and Swinnerton-Dyer conjecture for modular elliptic curves over certain finite extensions of the rational numbers. The central values of the relevant L-functions are related to rational points on elliptic curves via p-adic families of cohomology classes arising from geometry.

Modularity and distribution of quantum knots invariants

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ABSTRACT: We consider Zagier's modularity conjecture for the colored Jones polynomials of hyperbolic knots. We prove this conjecture in some cases and show that, in the case of the 4_1 knot, one can also deduce a law of large for the values of the colored Jones polynomial at roots of unity. This is joint work with Sary Drappeau.

On property (N) and local degrees

Sara Checcoli, Arno Fehm*

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ABSTRACT: A field of algebraic numbers has the Northcott property (N) if it contains only finitely many elements of bounded absolute logarithmic Weil height. While for number fields property (N) follows immediately by Northcott's theorem, to decide property (N) for an infinite extension of the rationals is, in general, a difficult problem. This property was introduced in 2001 by Bombieri and Zannier, who raised the question of whether it holds for fields with uniformly bounded local degrees. They also remarked that, for a (possibly infinite) Galois extension of the rationals whose local degrees are bounded at at least one prime, property (N) is implied by the divergence of a certain sum, but suggested that this phenomenon might occur only for number fields. In 2011 Widmer gave a criterion for an infinite extension of the rationals to have property (N) under some condition on the growth of the discriminants of certain finite subextensions of the field. In this talk we show the existence of infinite Galois extensions of the rationals for which the sum considered by Bombieri and Zannier is divergent and to which Widmer's criterion does not apply. We also show the existence of fields without property (N) and having (non-uniformly) bounded local degrees at all primes. This is joint work with Arno Fehm.

On the Galois module structure of field extensions: the classical and the Hopf-Galois structures.

Ilaria Del Corso
(with E.Campedell, A.Caranti, F.Ferri, D.Lombardo)

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ABSTRACT: Let L/K be a Galois extension with Galois group G. The Normal Basis Theorem shows that L is a free $K[G]$-module of rank 1. When L/K is a number field or a local field extension, it is natural to consider the question of determining the structure of the ring of integers $\mathcal{O}_L$ as $\mathcal{O}_K[G]$-module, and this question has long been studied.
In this talk I will present an overview of the main classical results and some recent research directions on this subject. We will make a focus on results and important questions concerning both the "classical" Galois structure, and the Hopf-Galois context, whose importance has been growing in the last years.

Calcolo efficiente della costante di Euler-Kronecker per campi ciclotomici (e problemi collegati)

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ABSTRACT: Viene presentato un algoritmo di calcolo efficiente per la costante di Euler-Kronecker per campi ciclotomici che ha portato a permetterne il calcolo per ogni primo dispari $q \leq 10^7$ (in precedenza erano note per $q \leq 50\,000$) e a trovare nuovi controesempi alla congettura di Ihara dell'ordine da 10 a 50 volte più grandi dei precedenti. Nel contempo si è potuto studiare, per q nel medesimo intervallo, l'ordine di grandezza di $\min_{\chi\neq\chi_0} |L'/L(1,\chi)|$ e $\max_{\chi\neq\chi_0} |L'/L(1,\chi)|$, dove con $L(s,\chi)$ si denotano le funzioni L di Dirichlet e con χ_0 il carattere principale di Dirichlet. Con idee analoghe si è studiato l'ordine di grandezza di $|L(1,\chi)|$ e del Kummer ratio per campi ciclotomici. Infine, algoritmi veloci per il calcolo di funzioni speciali aventi proprietà analoghe alla Γ di Euler sono stati sviluppati. Altre conseguenze e applicazioni sono in via di studio.

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On the Equivariant Tamagawa Number Conjecture for motives of modular forms

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ABSTRACT: The Equivariant Tamagawa Number Conjecture was formulated by Bloch and Kato in 1990, and can be seen as a generalisation to motives of the Birch and Swinnerton-Dyer Conjecture for elliptic curves. In the latter case, the validity of the p-part of the Birch and Swinnerton-Dyer Conjecture for ordinary primes p is known when the analytic rank of the rational elliptic curve $E/\mathbb{Q}$ is equal to 1. We prove a similar result for the p-part of the Bloch-Kato conjecture for motives attached to newforms. For this, we prove a version of Kolyvagin's Conjecture for modular forms, from which we deduce the p-part of the Tamagawa Number Conjecture. This is a work in collaboration with Stefano Vigni.

Classificazione delle funzioni L

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ABSTRACT: Parlerò del problema della classificazione delle funzioni L nell'ambito assiomatico della classe di Selberg, presentando i risultati noti in letteratura relativi ai gradi $0 \leq d < 2$; alla fine presenterò un nuovo risultato relativo al grado $d = 2$. Lavoro in collaborazione con J. Kaczorowski.

p-adic deformations and Stark-Heegner point constructions

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ABSTRACT:
ITALIAN
Sia E una curva ellittica definita sul campo dei numeri razionali e sia p un primo di buona riduzione. I punti di Stark-Heegner sono dei punti locali in p di E che, congetturalmente, sono globali e giocano un ruolo analogo a quello dei punti di Heegner quando il campo quadratico immaginario è rimpiazzato da un campo quadratico reale. In questo seminario descriverò recenti risultati che esibiscono un legame tra questi punti e deformazioni p-adiche di classi di coomologia globali e, se ci sarà tempo, generalizzazioni di questo tipo di costruzioni che si applicano anche al caso in cui p sia un primo di buona riduzione per E. Si tratta di un lavoro in collaborazione con Massimo Bertolini e Rodolfo Venerucci.
ENGLISH
Suppose that E is an elliptic curve defined over the field of rational numbers and that p is a prime of semistable reduction. The Stark-Heegner points are local points of E at p that are conjetured to be global and to play a role analogous to that played by Heegner points when the imaginary field is replaced by a real quadratic field. I plan to report on recent results relating them to p-adic deformation of global cohomology classes and, time permitting, describe generalizations of this kind of constructions to the case where the prime p is allowed to be of good reduction for E. This is a joint work with Massimo Bertolini and Rodolfo Venerucci.

CONTRIBUTED TALKS

Ranks of elliptic curves over $\mathbb{Q}(T)$ with small degree in T

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ABSTRACT: We consider elliptic curves $E/\mathbb{Q}(T)$ with coefficients of their Weierstrass equation being polynomials $\alpha_i(T) \in \mathbb{Q}[T]$ of degree at most 2. The goal of this seminar is to present an explicit expression for the rank of E depending only on the coefficients $\alpha_i(T)$: the computations rely on Nagao's conjecture for rational elliptic surfaces, which is proven for the considered curves, and on the use of prime densities in order to evaluate sums of Legendre symbols. We also give sharp estimates for the ranks of these curves, lists of rational points and examples of curves with maximal rank. This is a joint work with Sandro Bettin (Università di Genova), Chantal David (Concordia University) and Christophe Delaunay (Université de Franche-Comté).

Cesàro averages of counting functions

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ABSTRACT: The study of behavior of average of arithmetical functions is classical in number theory. A way to attack these type of problems is to insert a weight with suitable hypotheses into the average, with the aim of making the involved functions "more regular". In this talk we will analyze the Cesàro average, that is, averages of the form

$$\frac{1}{\Gamma(k+1)} \sum_{n \leq N} f(n) \left(\frac{N-n}{N}\right)^k, \; k \in \mathbb{R}_0^+, \; N \in \mathbb{N}^+.$$

We will show how this approach has proved, in a series of works developed in recent years up to the present day, to be a versatile tool for the study of these kind of problems for functions $f(n)$ that count the number of representations of an integer as a sum of elements that belong to some subsets of $\mathbb{N}$ (for example, powers of prime numbers).

Multiplicative and linear dependence in finite fields and on elliptic curves modulo primes

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ABSTRACT: In 2008 Maurin proved that given n multiplicatively independent rational functions $\varphi_1(x), \dots, \varphi_n(x) \in \mathbb{Q}(x)$, there are at most finitely many $\alpha \in \overline{\mathbb{Q}}$ such that $\varphi_1(\alpha), \dots, \varphi_n(\alpha)$ satisfy two independent multiplicative relations. This statement is an instance of more general conjectures of *unlikely intersections* over tori made by Bombieri, Masser and Zannier and independently by Zilber. We consider a positive characteristic variant of this problem, proving that, for sufficiently large primes, the cardinality of the set of $\alpha \in \overline{\mathbb{F}}_p$ such that $\varphi_1(\alpha), \dots, \varphi_n(\alpha)$ satisfy two independent multiplicative relations with exponents bounded by a certain constant K is bounded independently of K and p. We prove analogous results for products of elliptic curves and for split semiabelian varieties $E^n \times \mathbb{G}_m^k$.

Sul volume nodale di onde aritmetiche aleatorie

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ABSTRACT: Sul toro d-dimensionale $\mathbb{R}^d/\mathbb{Z}^d$ studiamo combinazioni lineari di onde di base (seni e coseni a frequenze intere) con coefficienti che sono variabili aleatorie Gaussiane (*onde aritmetiche aleatorie*). Gli insiemi di livello zero di tali onde, e in particolare il loro volume, sono legati allo studio delle correlazioni lineari di punti interi sulla sfera di raggio $\sqrt{n}$ in $\mathbb{R}^d$. Il problema è stato risolto in dimensione $d = 2, 3$ utilizzando risultati di teoria dei numeri e di teoria dei grafi. Al crescere della dimensione queste tecniche lasciano il posto all'analisi. Discutiamo in questo seminario ciò che è noto in dimensione $d \geq 4$ e le applicazioni al volume degli insiemi di livello zero delle onde aritmetiche aleatorie. Lavoro in collaborazione con N. Laaksonen.

On reduction steps for Leopoldt's conjecture

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ABSTRACT: Let p be a rational prime and let L/K be a Galois extension of number fields with Galois group G. Under some hypotheses, we show that Leopoldt's conjecture at p for certain proper intermediate fields of L/K implies Leopoldt's conjecture at p for L; a crucial tool will be the theory of norm relations in $\mathbb{Q}[G]$. We also consider relations between the Leopoldt defects at p for intermediate extensions of L/K, noting that Leopoldt kernels form a cohomological Mackey functor. We finally show that our results combined with some techniques introduced by Buchmann and Sands allow us to find infinite families of nonabelian totally real Galois extension of $\mathbb{Q}$ satisfying Leopoldt's conjecture for certain primes. This is joint work with Henri Johnston.

Some weighted analyses of the Riemann zeta function

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ABSTRACT: We investigate some weighted aspects regarding the value distribution of the Riemann zeta function on the critical line and the linear statistics of its nontrivial zeros, with the aim of studying the large values of zeta. The prototypical example is a weighted analogue of Selberg's central limit theorem, showing that $\log|\zeta(1/2+it)|$ has an approximately normal distribution also with respect to the tilted measure $|\zeta(1/2+it)|^{2k}dt$, for $k \in \mathbb{N}$, as $t \in [T, 2T]$ and $T \to \infty$, assuming the Riemann Hypothesis and the asymptotic formula for the twisted and shifted integral moments of zeta.

Generalized Heegner cycles over Shimura curves and p-adic L-functions

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ABSTRACT: In [3], Castella and Hsieh proved significant results about Selmer groups associated with Galois representations attached to newforms twisted by Hecke characters of an imaginary quadratic field. These results lead also to prove other instances of the rank 0 case of the Bloch–Kato Conjecture for L-functions of modular forms. The key point of the work of Castella and Hsieh is a remarkable link between certain arithmetic objects called *generalized Heegner cycles* that were introduced by Bertolini, Darmon and Prasanna in [1] and suitably defined p-adic L-functions, which are instead objects of p-adic analytic nature, interpolating special values of complex L-series. All these results are obtained under the so-called *Heegner hypothesis* that the imaginary quadratic field must satisfy with respect to the level of the modular form. But what happens if we want to weaken the Heegner hypothesis, considering more quadratic fields? In this talk, we see that several of the results of Castella–Hsieh can be extended to a quaternionic setting, that is the setting that arises when one works under a "relaxed" Heegner hypothesis. This can be done working with *generalized Heegner cycles* over Shimura curves (instead of modular curves) introduced by Brooks in [2]. For all the details, see [4].

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On maximal product sets of random sets

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ABSTRACT: For every positive integer N and every $\alpha \in [0,1)$, let $B(N,\alpha)$ denote the probabilistic model in which a random set $A \subset \{1,\dots,N\}$ is constructed by choosing independently every element of $\{1,\dots,N\}$ with probability α. We prove that, as $N \longrightarrow +\infty$, for every A in $B(N,\alpha)$ we have $|AA| \sim |A|^2/2$ with probability $1-o(1)$, if and only if

$$\frac{\log(\alpha^2(\log N)^{\log 4-1})}{\sqrt{\log\log N}} \longrightarrow -\infty.$$

This improves on a theorem of Cilleruelo, Ramana and Ramaré, who proved the above asymptotic between $|AA|$ and $|A|^2/2$ when $\alpha = o(1/\sqrt{\log N})$, and supplies a complete characterization of maximal product sets of random sets.

Random behavior of deterministic sequences: from global scale to local scale

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ABSTRACT: The uniform distribution modulo 1 of a sequence $\{x_n\}_{n\geq 1}$ measures the pseudo-random behavior at a global scale and can be characterized using exponential sums. At a more localized scale, we can study the pair correlation for sequences in the unit interval. Pseudo-random behavior with respect to this statistic is called Poissonian behavior. The metric theory of pair correlations of sequences of the form $(a_n\alpha)_{n\geq 1}$ has been pioneered by Rudnick, Sarnak and Zaharescu. Recently, a general framework was developed which gives a criterion for Poissonian pair correlation of such sequences for almost $\alpha \in (0,1)$, in terms of the additive energy of the integer sequence $\{a_n\}_{n\geq 1}$. In the present talk we will discuss a similar framework in the more delicate case where $\{a_n\}_{n\geq 1}$ is a sequence of reals. We give several concrete applications of our method and present some open problems. This is a joint work with Christoph Aistleitner and Daniel El-Baz.

On the $\mathcal{L}$-invariant for Hilbert modular forms

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ABSTRACT: Let $\mathbf{f} \in S_{\underline{k},w}(\Gamma_0(\mathfrak{n}))$ be a primitive Hilbert modular cuspform and p a rational prime. The p-adic analytic L-function $L_p(\mathbf{f}, s)$ attached to $\mathbf{f}$ contains extra interpolation factors that can possibly vanish at the central critical point of $\mathbf{f}$. In this event, the discrepancy between $L_p(\mathbf{f}, s)$ at the central point and the special value of the complex L-function is accounted by the so-called $\mathcal{L}$-*invariant* of $\mathbf{f}$. It has several a priori different definitions, all conjecturally equivalent.
We give a definition of the $\mathcal{L}$-invariant of $\mathbf{f}$ by lifting $\mathbf{f}$ to a modular form on a quaternionic Shimura variety and by studying the cohomology of such variety with coefficients in a suitable space of polynomials. We prove that our $\mathcal{L}$-invariant is equal to the Fontaine-Mazur $\mathcal{L}$-invariant.

Universal norms of p-adic Galois representations and the Fargues-Fontaine curve

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ABSTRACT: In 1996, Coates and Greenberg computed the module of universal norms associated with an abelian variety in a perfectoid field extension. A precise description of this module is essential in Iwasawa theory, notably to study Selmer groups over infinite algebraic fields extensions. Coates and Greenberg then asked if their result could be generalised to other motives. In this talk, I will present a new approach to this question relying on the classification of vector bundles over the Fargues-Fontaine curve, which enables to answer it affirmatively in new cases.

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Least Common Multiples of Integer Sequences: Old and New Results

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ABSTRACT: A consequence of the Prime Number Theorem is the asymptotic formula

$$\log \operatorname{lcm}(1, 2, \ldots, n) \sim n, \qquad \text{as } n \to +\infty,$$

where log is the natural logarithm and lcm denotes the least common multiple. Motivated by that, many authors have considered asymptotic formulas regarding $\operatorname{lcm}(a_1, a_2, \ldots, a_n)$, where $(a_n)_{n \geq 1}$ is an integer sequence of a particular kind; for example, a polynomial sequence or a linear recurrence. This talk will illustrate several results on this topic, including variations on random sequences and q-analogs.

Group cohomology and elliptic curves

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ABSTRACT: In this talk I will present a recent – or rather, still in progress – joint work with Davide Lombardo. Rather than presenting the main result of the paper, I will try to make a self-contained and detailed presentation of one particular result about a certain cohomology group associated with elliptic curves.
More precisely, let E be an elliptic curve defined over $\mathbb{Q}$ and let $\mathbb{Q}_\infty$ be the number field generated by the coordinates of all torsion points of E. Denoting by G the Galois group of $\mathbb{Q}_\infty$ over $\mathbb{Q}$ and by E_t the group of all torsion points of E (with coordinates in an algebraic closure of $\mathbb{Q}$), we proved that the exponent of $H^1(G, E_t)$ divides a universal constant C, and we were able to provide an explicit value for C.

GCD results on semiabelian varieties and a conjecture of Silverman

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ABSTRACT: A divisibility sequence is a sequence of integers d_n such that whenever m divides n one has that d_m divides d_n. Results of Bugeaud, Corvaja, Zannier, among others, have shown that pairs of divisibility sequences corresponding to subgroups of the multiplicative group have only limited common factors. Silverman conjectured that a similar behaviour should appear in (a large class of) all algebraic groups. We show, extending work of Ghioca-Hsia-Tucker and Silverman on elliptic curves, how to prove the analogue of Silverman's conjecture over function fields for abelian and split semi-abelian varieties and some generalizations.

Atkin-Lehner theory for Drinfeld Modular forms

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ABSTRACT: Let $S_k(N)$ be the space of cusp forms of level $\Gamma_0(N)$ with $N \in \mathbb{Z}$. Atkin-Lehner theory deals with the notion of oldforms, namely those coming from a lower level $M|N$, and newforms, i.e. the orthogonal complement of the space of oldforms with respect to the Petersson inner product. Moreover, it is also concerned with the construction of a basis for $S_k(N)$ made up by eigenfunctions for the Hecke operators $\mathbf{T}_n$ with n prime to N. In this talk we shall present some recent advances on the theory for Drinfeld modular forms, which are the analogue over $\mathbb{F}_q[T]$ of classical modular forms.

Participants

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Francesco Baldassarri, University of Padova
Andrea Bandini, Università di Pisa
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