

**Cycles and Special  
Values of  $L$ -series**

**Centre de Recerca Matemàtica  
Bellaterra**

**December 14 to 18, 2009**



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## 1. PRACTICAL INFORMATION

### **Lecture room:**

The Workshop will take place in the CRM “Auditori” located in the Sciences Building (Edifici de Ciències), Universitat Autònoma de Barcelona in Bellaterra. The Workshop lecture room is equipped with a multimedia projector connected to a computer. An overhead projector and blackboards are also available.

### **Administration:**

The CRM Administration will be available to the participants from Monday to Friday from 9:00 am to 5:00 pm.

### **Computer facilities:**

The computer space of the CRM will be available for the participants of the Course with the following login information:

username	crmactivities
password	Crm2009

The CRM premises as well as most of the UAB campus have wireless access. The CRM wireless login information is: `crmwifikey`

### **Printing and photocopying policy:**

Printing and photocopying at the CRM is only permitted to research visitors and staff.

Participants to CRM activities can use the OCE\* for printing and photocopying.

The OCE is located at floor -1 (one level below the CRM) and next to the front desk (looking at it, on the left hand side). They offer black and white and color printing and photocopying and from paper or pen-drive sources. Prices are 0,045 euro/page for black and white, and 0,33 euro/page for color copies. Their opening hours are Monday to Friday from 8:30 to 14:00 and from 15:00 to 20:00.

\*OCE is the Faculty printing and photocopying service

### **Breaks:**

Coffee and cookies will be served during the morning breaks to all participants.

### **Questionnaire:**

Following the directions of the CRM Governing Board, we give a questionnaire to all the people participating in activities at the CRM in order to assess their level of satisfaction. The questionnaire is anonymous and not mandatory, but we would greatly appreciate it if you could answer the questions and return it to us. Thank you for your cooperation.

**Local emergency numbers:**

Medical emergency campus number	1800 / 1900 during office hours 2525 at other times
UAB's Science Faculty reception office	1055
General emergency (police, fire-fighters, ambulances)	112

## 2. SCHEDULE

<b>Monday, December 14</b>	
09:45 – 10:00	REGISTRATION
10:00 – 11:00	Karl Rubin <i>Refined class number formulas and Kolyvagin systems.</i>
11:00 – 11:15	Coffee Break
11:15 – 12:15	Tim Dokchitser <i>On the parity conjecture for elliptic curves.</i>
12:30 – 13:30	Jan Nekovar <i>Level raising and Selmer groups of Hilbert modular forms over ring class fields.</i>
13:45 – 15:00	Lunch
15:00 – 16:00	Robert Pollack <i>Fitting ideals of Selmer groups of non-ordinary modular forms.</i>
16:15 – 17:15	Anton Mellit <i>Higher Green's functions at CM points.</i>

<b>Tuesday, December 15</b>	
10:00 – 11:00	Eric Urban <i><math>p</math>-adic Euler systems and <math>p</math>-adic modular forms.</i>
11:00 – 11:15	Coffee Break
11:15 – 12:15	François Brunault <i>Some explicit results on special values of <math>p</math>-adic <math>L</math>-functions of elliptic curves.</i>
12:30 – 13:30	Glenn Stevens <i>On <math>p</math>-adic <math>L</math>-functions over the eigencurve.</i>
13:45 – 15:00	Lunch
15:00 – 16:00	Michael Spiess <i>Special zeros of <math>p</math>-adic <math>L</math>-functions of Hilbert modular forms.</i>
16:15 – 17:15	JeeHoon Park <i>Plus/minus <math>p</math>-adic <math>L</math>-functions for Hilbert modular forms.</i>

<b>Wednesday, December 16</b>	
10:00 – 11:00	Jan Bruinier <i>Gross-Zagier formula and Borcherds products.</i>
11:00 – 11:15	Coffee Break
11:15 – 12:15	Stefan Müller-Stach <i><math>L^2</math>-cohomology of orthogonal Shimura varieties.</i>
12:30 – 13:30	Wei Zhang <i>Relative trace formula and Gross-Zagier formula.</i>
13:45 – 15:00	Lunch
15:00 – 16:00	Mladen Dimitrov <i>Automorphic symbols and <math>p</math>-adic <math>L</math>-functions for Hida families of Hilbert modular forms.</i>
16:15 – 17:15	Christophe Cornut <i>Special cycles related to <math>U(n-1, 1)</math> in <math>SO(2n-1, 2)</math>.</i>

<b>Thursday, December 17</b>	
10:00 – 11:00	Victor Rotger <i><math>p</math>-adic periods of Jacobians of Shimura curves and Stark-Heegner points.</i>
11:00 – 11:15	Coffee Break
11:15 – 12:15	Matthew Greenberg <i><math>p</math>-adic interpolation of cycles on Shimura curves.</i>
12:30 – 13:30	Marco Seveso <i>Stark-Heegner cycles and <math>L</math>-invariants attached to higher weight modular forms.</i>
13:45 – 15:00	Lunch
15:00 – 16:00	Pierre Charollois <i>Cycles and cocycles for the Hilbert modular group.</i>
16:15 – 17:15	Samit Dasgupta <i>On the <math>p</math>-adic Gross-Stark conjecture.</i>

<b>Friday, December 18</b>	
09:15–09:30	Coffee Break
09:30 – 10:30	Jose I. Burgos <i>Heights of toric varieties.</i>
10:40 – 11:40	Tonghai Yang <i>An arithmetic intersection formula and a conjecture of Colmez.</i>
11:50 – 12:50	Benjamin Howard <i>Arithmetic intersection theory on Hilbert modular surfaces.</i>



## 3. ABSTRACTS OF SPEAKERS

**Jan H. Bruinier**

*Gross-Zagier formula and the Borcherds products.*

**Abstract:** We report on joint work with T. Yang in which we consider the Faltings height pairing of arithmetic special divisors and CM cycles on Shimura varieties associated to orthogonal groups. Using Borcherds products and automorphic Green functions, we compute the archimedean contribution to the height pairing and derive a conjecture relating the total pairing to the central derivative of a Rankin  $L$ -function. We prove the conjecture in certain low dimensional cases and thereby obtain a new proof of the Gross-Zagier formula.

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**François Brunault**

*Some explicit results on special values of  $p$ -adic  $L$ -functions of elliptic curves.*

**Abstract:** In this talk I will explain how to use Perrin-Riou's very general theory of  $p$ -adic  $L$ -functions, combined with Kato's Euler system, to get an explicit formula for a  $p$ -adic regulator on  $K_2$  of the modular curve  $X(N)$ . As an example, I will give a relation between the  $p$ -adic regulator and the value of the  $p$ -adic  $L$ -function at  $s = 0$ , in the case of the strong Weil curve of conductor 20.

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**Jose I. Burgos**

*Heights of toric varieties.*

**Abstract:** The height of algebraic cycles is one of the main ingredients to understand values of  $L$  functions. In general it is very difficult to compute explicitly the height of a cycle with respect to a hermitian line bundle. In algebraic geometry, toric varieties are a fertile ground to make explicit computations. In this talk we will give a formula that expresses the height of a toric variety with respect to an ample equivariant line bundle provided with a positive metric that is invariant under the action of the compact torus in terms of the integral over the a polytope of the Legendre dual of the logarithm of the norm of a section. We will see that this formula can be explicitated in many cases obtaining known and new examples of explicit heights.

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**Pierre Charollois**

*Cycles and cocycles for the Hilbert modular group.*

**Abstract:** We will present some numerical computations of algebraic quantities (units and Stark-Heegner points) by analytical means involving periods of Hilbert modular forms.

Parts of this is joint work with Matthew Greenberg, and Mladen Dimitrov.

Contact address: charollois@math.jussieu.fr

**Christophe Cornut**

*Special cycles related to  $U(n-1, 1)$  in  $SO(2n-1, 2)$ .*

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**Samit Dasgupta**

*On the  $p$ -adic Gross-Stark conjecture.*

**Abstract:** Let  $F$  be a totally real field, and let  $\chi$  be a totally odd character of  $F$ . Gross stated a conjecture on the order of vanishing and leading term of the  $p$ -adic  $L$ -function  $L_p(\chi * \omega, s)$ . In this talk we will discuss what is known about this conjecture in the case where  $F$  is a real quadratic field.

Contact address: sdasgup2@ucsc.edu

**Mladen Dimitrov**

*Automorphic symbols and  $p$ -adic  $L$ -functions for Hida families of Hilbert modular forms.*

**Abstract:** We establish an exact control theorem for the  $p$ -ordinary cohomology groups of Hilbert modular varieties with integral coefficients and their freeness over suitable local components of the universal ordinary Hecke algebra. Combined with a new construction of the  $p$ -adic  $L$ -function of a Hilbert modular form using automorphic symbols, this yields  $p$ -adic  $L$ -functions for Hida families of Hilbert modular forms.

Contact address: dimitrov@math.jussieu.fr

**Tim Dokchitser**

*Parity conjecture for elliptic curves.*

**Abstract:** For an elliptic curve  $E$  over a number field  $K$ , the Parity Conjecture asserts that the Mordell-Weil rank of an elliptic curve  $E$  over a number field  $K$  has the same parity as its analytic rank, as given by the root number. This is the ‘modulo 2’ version of the Birch-Swinnerton-Dyer conjecture. I will explain why this conjecture follows from finiteness of the Tate-Shafarevich group, for all  $E/K$ . (This has been known in many cases, thanks to earlier work by Birch-Stephens, Greenberg, Guo, Monsky, Nekovar and Kim.) I will also explain how the proof gives an explicit formula for the local and global root numbers of elliptic curves.

This is joint work with Vladimir Dokchitser.

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**Matthew Greenberg**

*Shimura curves,  $p$ -adic  $L$ -functions and rational points on elliptic curves.*

**Abstract:** In this talk on joint work with Shahab Shahabi, I would like to describe how algebraic parts of periods of cycles on Shimura curves are interpolated by certain  $p$ -adic  $L$ -functions. In appropriate situations, derivatives of these  $p$ -adic  $L$ -functions are related to Heegner and Stark-Heegner points on elliptic curves. This generalizes results of Bertolini-Darmon and Shahabi concerning the analogous situations for classical modular curves.

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**Benjamin V. Howard**

*Special cycles on Hilbert modular surfaces and derivatives of Eisenstein.*

**Abstract:** The integral model of a Hilbert modular surface has two distinct types of special cycles on it: the codimension one Hirzebruch-Zagier divisors, and the codimension two cycle of points with complex multiplication by a fixed quartic CM field. We relate the intersection multiplicities of these cycles with the Fourier coefficients of the central derivative of an Eisenstein series.

This is joint work with Tonghai Yang.

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**Anton Mellit**

*Higher Green's functions at CM points.*

**Abstract:** I will explain how Higher Green's functions are related to regulators on higher Chow groups and why their values at CM points are logarithms of algebraic numbers.

Contact address: [mellit@imath.kiev.ua](mailto:mellit@imath.kiev.ua)

**Stefan-Müller-Stach**

*Higgscohomology on Shimura Varieties.*

**Abstract:** We explain how to compute intersection cohomology of certain local systems on Shimura varieties using a Higgs-Dolbeault cohomology theory and the Simpson correspondence for variations of Hodge structures.

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**Jan Nekovar**

*Level raising and Selmer groups of Hilbert modular forms over ring class fields.*

**Abstract:** About 10 years ago, Bertolini and Darmon introduced a new method for proving upper bounds for anticyclotomic Selmer groups using level raising. We shall discuss some improvements of their method, as well as several applications

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**JeeHoon Park**

*Plus/Minus  $p$ -adic  $L$ -functions for Hilbert modular forms.*

**Abstract:** When  $p$  is an ordinary prime, then the  $p$ -adic  $L$ -function of a modular form is an Iwasawa function (coming from  $p$ -adic measure). But if  $p$  is supersingular,  $p$ -adic  $L$ -functions are no longer Iwasawa functions. R. Pollack realized when the Hecke eigen value  $a_p$  of an elliptic modular form is zero (a particular supersingular case), there exists a plus/minus  $p$ -adic  $L$ -function which comes from a  $p$ -adic measure.

The goal of this talk is generalizing his result to Hilbert modular form case.

This is joint work with Shahab Shahabi.

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**Robert Pollack**

*Fitting ideals of Selmer groups of non-ordinary modular forms.*

**Abstract:** In this talk, I will discuss some theorems on the size and structure of Selmer groups of weight 2 non-ordinary modular forms along the cyclotomic  $Z_p$ -extension. For instance, we will prove that the Mazur-Tate element is in the Fitting ideal of each of these Selmer groups. After this, I will discuss a conjectural program to generalize these results to higher weight modular forms. The key idea of this generalization is to use the  $p$ -adic local Langlands correspondence to control the local behavior at  $p$ .

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**Victor Rotger**

*$p$ -adic periods of Jacobians of Shimura curves and Stark-Heegner points.*

**Abstract:** The main goal of this lecture is to give an explicit rigid analytic uniformization of the maximal toric quotient of the Jacobian of a Shimura curve over  $\mathbb{Q}$  at a prime dividing exactly the level. This result can be viewed as complementary to the classical theorem of Cerednik and Drinfeld which provides rigid analytic uniformizations at primes dividing the discriminant. As a corollary, we offer a proof of a conjecture formulated by M. Greenberg in his paper on Stark-Heegner points on quaternionic Shimura curves, thus making Greenberg's construction of local points on elliptic curves over  $\mathbb{Q}$  unconditional.

This is work with Matteo Longo and Stefano Vigni.

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**Karl Rubin**

*Refined class number formulas and Kolyvagin systems.*

**Abstract:** In 1995, Darmon formulated a “refined class number formula” for real quadratic fields, an algebraic Stark-type conjecture inspired by work of Mazur & Tate and of Gross. This talk (which describes joint work with Barry Mazur) will discuss a proof of Darmon's conjecture using the theory of Kolyvagin systems, and a proposed substantial generalization.

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**Marco A. Seveso**

*Stark-Heegner cycles and  $L$ -invariants attached to higher weight modular forms.*

**Abstract:** We discuss  $L$ -invariants of modular forms of weight  $k > 2$  and level  $pN$  and how they can be geometrically interpreted in order to produce a  $p$ -adic Abel-Jacobi map with value in the tangent space of a suitable monodromy module. Let  $V_f$  be the  $p$ -adic representation attached to a  $p$ -new modular form  $f$ : we explain how one can produce, by means of the Bloch-Kato exponential and the  $p$ -adic Abel-Jacobi map, a supply of local cohomology classes. These classes are conjectured to come from global cohomology classes defined over the narrow ring class fields of a real quadratic field and they are an higher weight analogue of the notion of Stark-Heegner points.

We briefly discuss relations with  $p$ -adic  $L$ -functions and we present instances where the conjectures can be proved, following ideas of Bertolini-Darmon in the weight  $k = 2$  setting.

This is in part joint work with Victor Rotger.

Contact address: [seveso.marco@gmail.com](mailto:seveso.marco@gmail.com)

**Michael Spiess**

*Special zeros of  $p$ -adic  $L$ -functions of Hilbert modular forms.*

**Abstract:** Let  $E$  be a modular elliptic curve over a totally real number field  $F$ . We explain the proof of the weak exceptional zero conjecture which links a (higher) derivative of the  $p$ -adic  $L$ -function attached to  $E$  to certain  $p$ -adic periods attached to the corresponding Hilbert modular form at the places above  $p$  where  $E$  has split multiplicative reduction.

Under some mild restrictions on  $p$  and  $E$  we deduce the exceptional zero conjecture in the strong form (i.e. where the automorphic  $p$ -adic periods are replaced by the  $L$ -invariants of  $E$  defined in terms of Tate periods) from a special case proved earlier by Mok.

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**Glenn Stevens**

*On  $p$ -adic  $L$ -functions over the eigencurve.*

**Abstract:** In this talk we will explain how to associate  $p$ -adic  $L$ -functions to points of the Coleman-Mazur eigencurve and will discuss some of the curious features related to their variation along the eigencurve. Specifically we will discuss the behavior of modular symbols on the Eisenstein locus and at arithmetic points of critical slope.

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**Eric Urban**

***$p$ -adic Euler systems and  $p$ -adic modular forms.***

**Abstract:** The goal of this talk is to explain a general strategy to construct  $p$ -adic Euler systems using the theory of  $p$ -adic automorphic forms. I will first start by explaining how to recover the  $p$ -adic Euler system classically obtained as the image by the Kummer map of the cyclotomic units. Then I will show how to generalize this strategy to other examples.

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**Tonghai Yang**

***An arithmetic intersection formula and a conjecture of Colmez.***

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**Wei Zhang**

***Relative trace formula and Gross-Zagier formula.***

**Abstract:** In this talk I will present a relative trace formula approach to the Gross-Zagier formula and its high dimensional generalization (a derivative version of the global Gross-Prasad conjecture) for unitary Shimura variety. In particular, an arithmetic fundamental lemma (*AFL*) is proposed. Some results proved recently will be presented, including the *AFL* for the unitary group in three variables.

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## 4. LIST OF PARTICIPANTS

<b>Name</b>	<b>Institution</b>
Anni, Samuele	Università di Pavia, Italy
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\* \* \* You can buy the programme's T-Shirt during your visit at the CRM. For further information please check the bulletin board at the CRM.