

# Workshop on the Hanna Neumann Conjecture

Bilbao, June 28th- July 10th

## Mini-Courses

Title: Intersections of subgroups of free products

By Yago Antolín Pichel

Abstract: In this mini-course we will

- (a) Prove the Kurosh subgroup theorem via the theory of groups acting on trees.
- (b) Define the Kurosh rank of a group acting on a tree with trivial edge stabilizers.
- (c) Show that the free products of left-orderable groups is left-orderable.
- (d) Prove that if  $A$  and  $B$  subgroups of left-orderable group acting on a tree  $T$  with trivial edge stabilizers, then the Kurosh rank of the intersection of  $A$  and  $B$  is bounded by the product of the respective Kurosh ranks.

No prior knowledge of Bass-Serre theory will be assumed.

Title: A course on graph theory, sheaves on graphs, and the Hanna Neumann Conjecture

By Joel Friedman

Abstract: I will give a minicourse on (1) graph theory, (2) sheaves on graphs, and (3) a proof of the Hanna Neumann Conjecture based on sheaf theory. As time permits, I will cover (4) other sheaf invariants, and (5) how sheaves on graphs relate to broader contexts, such as classical sheaf theory and graphs of groups.

The course will assume only a bit of undergraduate linear algebra. Familiarity with graph theory and the notion of a covering space in topology will be helpful but not assumed.

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Title: Approximation by subgroups of finite index and the Hanna Neumann conjecture  
By Andrei Jaikin-Zapirain

Abstract: In this course I will present a uniform approach towards the proofs of the discrete and pro-p versions of the Strengthened Hanna Neumann conjecture. The main source is the preprint:

[http://www.uam.es/personal\\_pdi/ciencias/ajaikin/preprints/hannaneumann.pdf](http://www.uam.es/personal_pdi/ciencias/ajaikin/preprints/hannaneumann.pdf)

The plan of the course.

1. The reformulation of the conjecture in terms of modules over a (completed) group algebra of a free (pro-p) group.
2. The properties of  $\beta_1$  in the pro-p case.
3. A structural theorem for finitely presented modules over a completed group algebra of a free pro-p group.
4. The proof of the pro-p version of the Strengthened Hanna Neumann conjecture.
5. The properties of  $\beta_1$  in the discrete case in characteristic 0. The proof of Luck's Strong Approximation Conjecture for free groups.
6. Approximation in positive characteristic: motivation and conjectures.
7. Twisted group algebras. A structural theorem for admissible finitely presented modules over a twisted group algebra of a free group.
8. The proof of the discrete version of the Strengthened Hanna Neumann conjecture.