CURRICULUM VITAE

NICOLAE CIPRIAN BONCIOCAT

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Academic rank:

Senior Researcher III, Simion Stoilow Institute of Mathematics of the Romanian Academy (IMAR)

Education:

• PhD in Mathematics, Institute of Mathematics of the Romanian Academy, 2003, advisor Prof. Dr. Şerban Basarab, with the thesis *Contributions to the theory of group products*

• MSc in Algebra, Faculty of Mathematics, University of Bucharest, 1998

• BSc in Mathematics, Faculty of Mathematics, University of Bucharest, 1997

• BSc in Engineering, Faculty of Electronics and Telecommunications, Polytechnic Institute of Bucharest, 1990

Awards:

The *"Simion Stoilow"* prize of the Romanian Academy for 2008 (awarded in 2010), for results related to the factorization problem in polynomial rings

Research interests: Number Theory, Group Theory, Combinatorics

Research summary: My field of research includes the factorization problem in polynomial rings, irreducibility and separability criteria for polynomials with integer coefficients, irreducibility and separability criteria for multivariate polynomials over arbitrary fields, multiplicative convolutions of polynomials, lacunary polynomials, compositions of polynomials, linear combinations of relatively prime polynomials, root location for polynomials, orthogonal polynomials, bounds for the multiplicities of the irreducible factors of polynomials, Newton polygons, Mahler measure, zero-free regions for Dirichlet series and power series, primality tests, connections between primality and irreducibility, nonvanishing criteria for determinants, arithmetic functions, diophantine equations, finite group theory, group products, group deformations, λ - rings, combinatorics, etc. Related to these topics, we obtained:

• irreducibility criteria obtained by Newton polygon methods, that use divisibility conditions for coefficients with respect to more than a single prime number; here we will only mention the following result that provides irreducibility conditions with respect to two prime numbers, conditions that are symmetric with respect to the two primes considered, and also to the normal and reverse ordering of the coefficients:

Theorem *Let $f(X) = a_0 + a_1X + \cdots + a_nX^n \in \mathbb{Z}[X]$, $a_0a_n \neq 0$. If there exist two distinct indices $j, k \in \{1, \ldots, n-1\}$ such that $j + k \neq n$ and two distinct prime numbers p and q such that*
i) $p \mid a_i$ for $i \neq j$, $p \nmid a_j$, $p^2 \nmid a_0$ and $p^2 \nmid a_n$,
ii) $q \mid a_i$ for $i \neq k$, $q \nmid a_k$, $q^2 \nmid a_0$ and $q^2 \nmid a_n$,
then f is irreducible over $\mathbb{Q}$.

• a Capelli - type theorem for multiplicative convolutions of polynomials that extends the classical result of Capelli (1897) on the canonical decomposition of compositions of polynomials:

Theorem *Let K be a field, $f, g, h \in K[X]$, f irreducible over K, g and h relatively prime, and $f(\alpha) = 0$. If*

$$g(X) - \alpha h(X) \underset{K(\alpha)}{\overset{can}{=}} const \cdot \prod_{i=1}^{r} \phi_i(X)^{e_i},$$

then

$$h^{\deg f} \cdot f(g/h)(X) \underset{K}{\overset{can}{=}} const \cdot \prod_{i=1}^{r} N_{K(\alpha)/K}\phi_i(X)^{e_i}.$$

In particular, the degree of every irreducible factor of $h^{\deg f} \cdot f(g/h)$ must be a multiple of $\deg f$.

We recall that the class of multiplicative convolutions (polynomials of the form $h^{deg(f)}f(g/h)$ with f, g and h polynomials over a given field) contains the usual compositions of polynomials ($h = 1$) and also the linear combinations of two polynomials (when f is linear). As main applications of this result, we obtained irreducibility criteria for multiplicative convolutions of polynomials with integer coefficients, as well as for multiplicative convolutions of polynomials in an arbitrary number of indeterminates over a given field (joint work with A.I. Bonciocat);
• Irreducibility and separability criteria for univariate polynomials with integer coefficients or with coefficients in a finite field; in this respect we point out criteria for polynomials that have one large coefficient and take a prime value, criteria for polynomials that take a prime power value, criteria for lacunary polynomials with leading coefficient divisible by a large prime power, criteria for linear combinations of relatively prime polynomials, and criteria that use various forms to express prime numbers as sums of integers subject to certain inequalities; here we will only mention the following two results (joint work with A.I. Bonciocat):

Theorem *If we write a prime number as a sum of integers $a_0, \ldots, a_n$, with $a_0a_n \neq 0$ and $|a_0| > 2|a_1| + \cdots + 2^n|a_n|$, then the polynomial $a_0 + a_1X + \cdots + a_nX^n$ is irreducible over $\mathbb{Q}$.*

Theorem *If f is a Littlewood polynomial and $f(m)$ is a prime number for an integer m with $|m| \geq 3$, then f is irreducible over $\mathbb{Q}$.*

• irreducibility and separability criteria for multivariate polynomials over arbitrary fields; in this respect we obtained several methods to construct irreducible multivariate polynomials from irreducible polynomials in fewer variables, in particular from large prime numbers. A way to produce irreducible multivariate polynomials is to express an irreducible univariate polynomial f in an arbitrary (polynomial) base g via the Euclidean algorithm, and to replace then the powers of g by the corresponding powers of a new indeterminate. Another way to produce irreducible multivariate polynomials is to replace some of the monomials a_kX^k of an irreducible univariate polynomial with monomials in two variables of the form $a_kX^iY^j$ with $i + j = k$. Another method to produce irreducible multivariate polynomials is to express an irreducible univariate polynomial as a sum of polynomials $a_i(X)$ and to consider then the sum of the terms $a_i(X)Y^i$. Here we mention the following result: *Let K be a field. If we write an irreducible polynomial $f \in K[X]$ as a sum of polynomials $a_0, a_1, \ldots, a_n \in K[X]$ with $deg(a_0) > \max deg(a_1), \ldots, deg(a_n)$, then the*

polynomial $F(X,Y) = a_0(X) + a_1(X)Y + \cdots + a_n(X)Y^n$ *is irreducible over* $K(X)$. (joint work with A. Zaharescu)
• irreducibility conditions for multivariate polynomials $F(X_1, \ldots, X_r) \in K[X_1, \ldots, X_r]$ over an arbitrary field K, with $deg_{r-1}F(X_1, \ldots, X_{r-1}, f_i)$ sufficiently small for some polynomials $f_i \in K[X_1, \ldots, X_{r-1}]$ having pairwise distinct degrees with respect to X_{r-1}, that extend to multivariate polynomials the classical irreducibility conditions of Pólya; in particular we obtained irreducibility criteria for polynomials of the form $f(x)(y - f_1(x)) \cdots (y - f_n(x)) + g(x)$, with $f, f_1, \ldots, f_n, g$ univariate polynomials over an arbitrary field (joint work with Y. Bugeaud, M. Cipu and M. Mignotte);
• bounds for the multiplicities of the roots of complex polynomials (in particular separability criteria), that use information on the absolute value of the coefficients; bounds for the multiplicities of the roots of integer polynomials, that rely on information on the canonical decomposition of the coefficients (joint work with A.I. Bonciocat and A. Zaharescu);
• bounds for the multiplicities of the irreducible factors of multivariate polynomials over arbitrary fields, that use information on the degrees of the coefficients with respect to a given indeterminate (joint work with A.I. Bonciocat and A. Zaharescu);
• square-free criteria for polynomials using no derivatives, nor discriminants; here we proved the fact that in positive characteristic, the absence of repeated irreducible factors for a given polynomial may be tested by studying a certain determinant, rather than studying its derivative or its discriminant; we also obtained nonvanishing conditions for determinants of matrices with polynomial entries (that extend Ostrowski' s nonvanishing conditions for determinants of matrices with complex entries) (joint work with E. Alkan, A.I. Bonciocat and A. Zaharescu);
• upper bounds for the number of irreducible factors (counting multiplicities) of linear combinations of relatively prime univariate polynomials with rational coefficients, and of linear combinations of relatively prime multivariate polynomials over arbitrary fields;
• strips and hyperbolas defining the location of the roots of polynomials in terms of the coefficients appearing in their Hermite expansion; our results generalize some classical results of Turan (joint work with M. Cipu);
• lower bounds for the Mahler measure for some classes of nonreciprocal polynomials with integer coefficients;
• deformations of a group law by factor systems (cocycles) and actions satisfying some rigidity conditions, and conditions for the reversibility of the deformation process; a proof of the fact that non-simple groups are such deformations of direct products; invariance properties for simple groups and for the kernel of a rigid factor system, and conditions for the existence of deformations with given kernel; an arithmetic characterization of the rigid actions of cyclic groups.

Research Grants:

(1) Member of the research team *Equations diophantiennes*, grant *GDRI ECO-Math (Groupement de Recherche International en Matématiques visant l'Europe Centrale et Orientale*
(2) Member of the research team, grant *LEA Math Mode: MATHEMATIQUES & MODELISATION (2008–2011)*
(3) Member of the team, grant *PN II ID-WE-2012-4-161* for organizing the *Workshop on Algebraic and Analytic Number Theory and Their Applications*, may, 2012.
(4) Member of the research team, grant CNCSIS-UEFISCSU ID-PCE no. 443, code 1190 (2008–2011): *Irreductibility, Factorizations, Krull Dimension, and their Computational Aspects in Polynomials, Rings, Modules, Latices, and Grothendieck Categories*

(5) Member of the research team, grant CNCSIS-UEFISCSU ID-PCE no. 51, code 304 (2007–2010): *Combinatorial, homological and arithmetical methods in the study of polynomial ideals*
(6) Member of the research team, grant CEx05-D11-11 (2005–2008): *Combinatorial, algebraic, topological methods in algebra and geometry*
(7) Member of the research team, grant 2-CEx06-11-20 (2006–2008): *Invariants of algebraic, geometrical and topological structures*
(8) Director of grant CNCSIS 106 (2006–2008): *Analytic and combinatorial methods in algebraic number theory and p-adic analysis*
(9) Member of the research team, grant *Cooperare internationala in domeniul algebrei, geometriei si topologiei - CIDAGT (grant 249-Cex-M3-249-2006)*, 2006
(10) Member of the research team, grant CERES 4-147 (2004–2006), *Representations and Homology in Geometry, Algebra and Physics*
(11) Member of the research team, grant: *Contract CERES de Centru de Excelenţă*, CE-4 (2002–2004)
(12) Member of the research team, grant *European Integration of the Romanian Mathematical Research Activity EURROMMAT* (2002–2004), funding agency: European Union

Co-organizer in Conferences:

(1) *Special Session on Algebra, Geometry and Topology Dedicated to the* 150^{th} *Anniversary of the Romanian Academy, Ovidius University of Constanţa, 19–20 may 2016,* http://math.univ-ovidius.ro/Workshop/2016/WYRM/#/Special-Session
in the *Workshop for Young Researchers in Mathematics* - 6^{th} *edition, Ovidius University of Constanţa, 19–22 may 2016*, http://math.univ-ovidius.ro/Workshop/2016/WYRM/#/
(2) *Special Session on Algebra in memory of Professor Şerban Basarab* (in the *Workshop for Young Researchers in Mathematics* - 5^{th} *edition,*), Faculty of Mathematics and Computer Science, Ovidius University of Constanţa, 22 may 2015,
$http://math.univ-ovidius.ro/Workshop/2015/WYRM/Doc/Program\_SB.pdf$
(3) *A new approach in theoretical and applied methods in algebra and analysis*, Constanţa, Romania, 4-6 april 2013,
http://math.univ-ovidius.ro/default.aspx?cat=Evenimente&ItemID=122
http://amaa-2013.wikispaces.com/home
(4) *Workshop on Algebraic and Analytic Number Theory and Their Applications*, Constanţa, Romania, 23-24 may 2013,
http://math.univ-ovidius.ro/default.aspx?cat=Evenimente&ItemID=121

Conferences and lectures:

(1) *Using prime numbers in attempts to understand polynomials*, in the *Fifth Bucharest Number Theory Day*, july 10-11, 2017, IMAR, Bucharest.
(2) *Primality, Irreducibility and Separability*, in the *Workshop in Geometry and PDE's*, june 13-14, 2017, West University of Timişoara.
(3) *Prime numbers vs. irreducible polynomials*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, march 28, 2017, IMAR and FMI, Univ. Bucharest, Bucharest.
(4) *Group deformations by rigid factor systems*, may 19, 2016, in the *Workshop for Young Researchers in Mathematics* - 6^{th} *edition, Ovidius University of Constanţa, may 19–22, 2016.*

(5) *Irreducibility criteria for multivariate polynomials*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, april 12, 2016, IMAR and FMI, Univ. Bucharest, Bucharest.
(6) *On the canonical decomposition of multivariate polynomials*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, april 19, 2016, IMAR and FMI, Univ. Bucharest, Bucharest.
(7) *Some applications of the resultant to factorization problems*, in: The Eighth Congress of Romanian Mathematicians, June 26 - July 1, 2015, Iaşi, Romania.
(8) *From bicrossproducts of finite groups to primality conditions*, in: *Special Session on Algebra in memory of Professor Şerban Basarab (Workshop for Young Researchers in Mathematics - 5^{th} edition)*, Faculty of Mathematics and Computer Science, Ovidius University of Constanţa, may 22, 2015.
(9) *Some Applications of the Newton Polygon Method*, in the Workshop for Young Researchers in Mathematics (WYRM4), may 22–23, 2014, Constanţa, Romania.
(10) *On the irreducibility of the sum of two relatively prime polynomials*, in: *A new approach in theoretical and applied methods in algebra and analysis*, april 4–6, 2013, Constanţa, Romania.
(11) *Resultants, prime numbers and irreducible polynomials*, in: *Workshop for Young Researchers in Mathematics (WYRM3)*, may 9–10, 2013, Constanţa, Romania.
(12) *Prime numbers and bicrossproducts of finite groups*, in: *Workshop on Algebraic and Analytic Number Theory and Their Applications*, may 23–24, 2013, Constanţa, Romania.
(13) *Eisenstein-Schönemann-Dumas type irreducibility conditions that use arbitrarily many prime numbers*, in: *Joint International Meeting of the AMS and the RMS*, june 27–30, 2013, Alba Iulia, Romania.
(14) *Prime numbers and irreducible polynomials*, in: *Anniversary Conference; Faculty of Sciences, 150 years (Faculty of Mathematics and Computer Science)* august 29 – september 1, 2013, Bucharest, Romania.
(15) *Separability criteria*, in: *Workshop for young researchers in Mathematics*, may 10–11, 2012, Univ. Ovidius, Constanţa, Romania.
(16) *Using prime numbers to construct irreducible polynomials*, in: *The 7^{th} Congress of Romanian Mathematicians*, june 29 – july 05, 2011, Braşov, Romania.
(17) *Irreducibility results for linear combinations of relatively prime polynomials*, in *Séminaire de Théorie des Nombres*, Univ. Strasbourg, august 29, 2011.
(18) *From prime numbers to irreducible multivariate polynomials,* in: *International Conference & Humboldt Kolleg Fundamental Structures of Algebra*, april 14–18, 2010, Ovidius University, Constanţa.
(19) *On Perron's irreducibility criterion*, in *Séminaire de Théorie des Nombres*, Univ. Strasbourg, september 01, 2010.
(20) *Multiplicative convolutions of polynomials*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, april 08, 2008, IMAR and FMI, Univ. Bucharest, Bucharest.
(21) *Prime numbers and irreducible polynomials*, in The 6^{th} Congress of Romanian Mathematicians, June 28 – July 4, 2007, Bucharest, Romania.
(22) *Primality conditions obtained from a group-theoretic construction*, in: *International Conference on Theoretic and Applied Mathematics and Informatics*, 2003, Alba-Iulia, Romania.
(23) *Upper bounds for the number of factors for a class of polynomials with rational coefficients*, in The 5^{th} Congress of Romanian Mathematicians, June 23 – 28, 2003, Piteşti, Romania.

(24) *Generating functions and applications*, in *National School on Algebra, the* 10^{th} *edition: Stanley-Reisner Rings, Simplicial Complexes, Polytopes*, june 03–08, 2002, Eforie Nord, Constanţa, Romania.
(25) *Congruences for the convolution of divisor sum function*, may 15, 2002, University of Oldenburg, Germany.
(26) λ *- rings and group representations*, in: *National School on Algebra - the* 9^{th} *edition: Infinite free resolutions.* λ *- rings*, september 15–22, 2001, Eforie Nord, Constanţa, Romania.
(27) *Groups deformations by rigid factor systems*, in: *International Workshop on Algebraic Geometry, Commutative Algebra and Topology*, 2001, Piteşti, Romania.
(28) *Generating functions*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, april 2001, IMAR and FMI, Univ. Bucharest, Bucharest.
(29) *On the partition function*, in the *"Nicolae Radu" Commutative Algebra and Combinatorics* seminar, march 2001, IMAR and FMI, Univ. Bucharest, Bucharest.
(30) *Groups bicrossed product by automorphisms*, in: *Euroconference and Workshop on Algebra and Representation Theory*, august 14–18, 2000, Constanţa, Romania.
(31) *Coxeter groups*, IMAR *Combinatorics and Representations* seminar, february 2000.
(32) *Character Theory and Orthogonality Relations*, IMAR *Combinatorics and Representations* seminar, december 1999.