

Volume 19

CRM

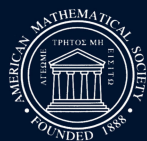
# CRM PROCEEDINGS & LECTURE NOTES

Centre de Recherches Mathématiques  
Université de Montréal

## Number Theory

Fifth Conference of the  
Canadian Number Theory Association  
August 17–22, 1996  
Carleton University,  
Ottawa, Ontario, Canada

Rajiv Gupta  
Kenneth S. Williams  
*Editors*



American Mathematical Society

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- 18 **Serge Dubuc and Gilles Deslauriers, Editors**, Spline functions and the theory of wavelets, 1999
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The Centre de Recherches Mathématiques (CRM) of the Université de Montréal was created in 1968 to promote research in pure and applied mathematics and related disciplines. Among its activities are special theme years, summer schools, workshops, postdoctoral programs, and publishing. The CRM is supported by the Université de Montréal, the Province of Québec (FCAR), and the Natural Sciences and Engineering Research Council of Canada. It is affiliated with the Institut des Sciences Mathématiques (ISM) of Montréal, whose constituent members are Concordia University, McGill University, the Université de Montréal, the Université du Québec à Montréal, and the Ecole Polytechnique. The CRM may be reached on the Web at [www.crm.umontreal.ca](http://www.crm.umontreal.ca).



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This volume is dedicated to the memory of  
Pál Erdős (1913–1996)



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## **Pál Erdős, 26 March, 1913–20 September, 1996**

Several weeks after CNTA-5, Pál Erdős passed away while attending a combinatorics conference in Warsaw. Eighty-three years young, Erdős was fond of saying that mathematicians “die” when they stop proving and conjecturing; they “leave” at the end of their lives. It was his ardent wish that he not die before he left, and it indeed turned out that way. Pál Erdős was active in many parts of mathematics, but nearly half of his phenomenal output was in number theory. Among his most important results were his elementary proof of the prime number theorem (with A. Selberg), his theorem with M. Kac on the number of prime factors of integers (which was instrumental in beginning the subject of probabilistic number theory), and his seminal papers in combinatorial number theory. It has been said that Erdős was the prince of problem solving and the uncontested king of problem posing.

A big champion of elementary methods, Erdős influenced many mathematicians, myself included, to take their heads out of the clouds of theory and ground their thoughts in specific, often numerical problems. He fervently held to a “big tent” view of mathematics—there are many approaches and styles and we should not let the whims of current fashion dictate too strongly what should be studied. He would have been quite interested in many of the different papers in this volume.

Carl Pomerance  
University of Georgia

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## Preface

The Canadian Number Theory Association (CNTA) is an informal organization of Canadian number theorists, founded in 1987 through the initiative and efforts of Richard Mollin of the University of Calgary. He also organized the first CNTA conference which took place in 1988 at the Banff Centre. Subsequent CNTA conferences were held at the University of British Columbia (Vancouver, B.C.) in 1989, at Queen's University (Kingston, Ontario) in 1991, and at Dalhousie University (Halifax, Nova Scotia) in 1994. Proceedings were published for three of these meetings and also for the International Number Theory Meeting held at Université Laval in 1987; this conference is often referred to as the 0th CNTA meeting.

The present volume contains the proceedings of the fifth CNTA conference which was held at Carleton University (Ottawa, Ontario) from August 17 to August 22, 1996. There were 180 registered participants; 60 from Canada, 81 from the United States, 29 from Europe, 7 from Asia, and 1 each from Africa, Australia and South America.

The scientific program of the conference consisted of 4 one hour plenary lectures, 27 forty minute special session talks and 71 twenty minute contributed talks. While the invited addresses focused on algebraic and computational number theory, analytic number theory, arithmetic algebraic geometry and elliptic curves, and diophantine problems, the contributed talks represented a wide variety of different areas of number theory. All abstracts of these presentations were reviewed in advance to ensure a high quality of the scientific program.

In addition to the above-mentioned talks there was a public lecture by David Boyd on "Mahler's measure and elliptic curves" and a problems session conducted by John L. Selfridge and Richard K. Guy.

The mathematical activities of the conference were arranged and overseen by the Scientific Committee consisting of H. Darmon (McGill), J. Friedlander (Toronto), R. Gupta (UBC), J.G. Huard (Canisius) (Assistant to Local Organizer), D. Roy (Ottawa), and K.S. Williams (Carleton) (Chairman and Local Organizer).

The present volume contains for the most part the written versions (often greatly enhanced) of some of the presentations. All papers were refereed. Almost all papers were prepared by the authors in some version or flavour of  $\text{\TeX}$ ; the editors wish to thank all authors for their considerable care and effort. Special thanks are also due to the referees for their important contribution to these proceedings.

I also gratefully acknowledge the help and support of faculty, staff and students of the Department of Mathematics and Statistics at Carleton University, as well as that of James G. Huard (Canisius), Diane Berezowski and Lal Alakkattussery for their valuable assistance.



The conference was supported in part by Centre de Recherches Mathématiques, Montréal; Fields Institute for Research in Mathematical Sciences, Toronto; US National Security Agency; Carleton University, and the University of Ottawa.

The sixth CNTA conference is now being organized. It will take place at the University of Manitoba; the local organizer is Hugh C. Williams. There is no doubt that it will be as successful as the previous CNTA conferences.

Ottawa, August 1997

Kenneth S. Williams  
CNTA -5 Local Organizer

## Conference Banquet in Honour of Richard K. Guy

The banquet was in honour of the 80th birthday of Richard K. Guy, Emeritus Professor of Mathematics at the University of Calgary. A number of participants including John Selfridge spoke about Professor Guy and his achievements. Duncan Buell recited a poem which he had composed in honour of the occasion and which is reproduced below.

### Richard K. Guy

He is the very model of a Master, arithmetical,  
With information quintic, quartic, cubic and quadratical.  
His treatise on the problems yet unsolved is now quite classical,  
With references aplenty to that mad Hungarian Erdős Pál .

One finds in there addition chains and asymptotic densities,  
Aliquots,  $3n + 1$ , and perfect numbers' parities.  
About binomial factors it's teeming with a lot of news,  
And many cheerful facts about the properties of residues.

The author of *Unsolved...* includes results on sums factorial  
And quirks about equations that were misattributed to Pell,  
And so in matters quintic, quartic, cubic and quadratical,  
He is the very model of a Master, arithmetical.

Originally English he's by now perhaps Canadian—  
A term whose meaning may yet be defined by Monsieur Chretien .  
He knows a thousand limericks of topics mostly prurient,  
Which he'll recite ad nauseum in sequences recurrent .

When he can tell at sight a fractal prime in the continuum;  
When he has taught us all to start our papers with 'exordium';  
When he can find a closed form for an arbitrary Gaussian sum;  
When next 239 is in *Congressus Numerantium*;

When he can tell that  $n$  less 1 by  $\phi$  of  $n$ 's divisible  
For  $n$  that isn't prime but has some factors  $p$  nontrivial  
When he's forgiven me for writing up these lines of doggerel,  
He'll be the very model of a Master, arithmetical.

Duncan Buell  
July, 1996

**The following is Richard Guy's response to the speakers.**

Thank you to the organizers for allowing Selfridge and Eggleton and my third friend to talk them into arranging this occasion.

Thank you to my parents for supplying the genes for a long and healthy life and aptitude for mathematics. They were not mathematicians but they had a love of learning and they taught elementary mathematics, along with other school subjects, with understanding, honesty and fearlessness.

Thank you to mathematics, and to number theory in particular, for providing a retreat from life's other problems. Aviezri Fraenkel told me that his aunt said, during a domestic tiff with his famous uncle, Life is not always as simple as mathematics.

Thank you to my school-teachers, Scotty Nichol, Felix Browne, J.J. Walton and notably Cyril T. Lear Caton and Kenneth Lansdell Wardle, who died only last year. Wardle was a pupil of Chevallier at Manchester Grammar School and went to Caius College, Cambridge, where I followed him, to be followed in turn by my brother-in-law, a son and a grandson.

Thank you to many famous Cambridge lecturers, A.E. Ingham, J.C. Burkill, Philip Hall and others, including Besicovitch, who would shuffle into the lecture room, draw a definite integral on the board and wheel on some unfortunate in the front row, "Does it conwaierge?" A terrified silence, so on to the next person, "Does it conwaierge?" And on to a third, until some brave soul lets out a tentative "Yes". On to the next, "Does it conwaierge?" Now it's easy; a confident "No!" On to the next, until he's collected a confusion of yesses and noes, then back to the first, "Vy does it conwaierge?" A stuttered reply and on to the next, "Vy does it not conwaierge?" It was hard not to learn mathematics from Besi .

Thank you to Harold Davenport and his remarkable London seminar, where regular attendees included Estermann, Ambrose Rogers, R.P. Bambah, G.L. Watson, Heini Halberstam and K.F. Roth who shared my interest in chess endgame studies and was in the middle of earning his Fields medal. The many visitors included de Bruijn and Erdős at the time when he and Selberg produced an elementary proof of the Prime Number Theorem.

Thank you to Singapore colleagues: Peter Lancaster, colleague for all but 4 of the 40 years I've known him, later to arrange my coming to Canada, to become a Fellow of the Royal Society of Canada and President of the Canadian Mathematical Society. A laughable example of the blind leading the sighted being his attendance at a course I once gave in Matrix Theory. To Eric Milner, now also a Fellow of the Royal Society of Canada, a colleague for all but 5 of the 45 years since we first met, through whom I met his PhD supervisor, Richard Rado. To Alexander Oppenheim, also a pupil of Chevallier at Manchester, who, in his 90's, still lives in Henley-on-Thames.

Thank you to Singapore visitors: Sammy Eilenberg, Charles Coulson (Eric Milner's Master's supervisor), Marshall Stone, but most of all to Dick and Emma Lehmer, who arranged with Oppenheim to send me to this continent in 1959, where I met Emory Starke, Baley Price (with whom I had dinner last week) and Gordon Pall and Arnold Ross who had studied with Oppenheim under L.E. Dickson. I attended the Boulder Summer Institute in Number Theory, where were half the world's most famous number theorists: Ayoub, Bateman, Birch, Alfred Brauer, Carlitz, Chowla, Paul Cohen, Davenport, Erdős, Grosswald, Kneser, Joe Lehner,

Don Lewis, Henry Mann, Ivan Niven, Gordon Pall, Rademacher, Julia and Raphael Robinson, Selberg, Straus, Olga Taussky, Vandiver, Al Whiteman and Barkley Rosser and Lowell Schoenfeld, who were already chasing those elusive zeros. I'd been in correspondence with Leo Moser, and I met him and Selfridge for the first time. Sadly, Leo died 12 years later, but I managed to overlap him for 5 memorable years in Alberta. He died on the common birthday of Donald Coxeter, of John Selfridge and of my brother-in-law.

Thank you to our children who took me back to Cambridge where I met Conway, Cassels, Swinnerton-Dyer, Alan Baker, John Coates, Andrews Wiles and Andrew Bremner, the first and last of whom have been considerable collaborators.

Thank you to thousands of students. I would especially like to remember Jack Kenyon, who died tragically a few years ago, and Roger Eggleton and Richard Nowakowski.

And thank you to someone who has experienced little of the thrill and fun of mathematics, but who has supported mathematicians and endured their eccentricities for well over a half a century: - Louise!

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Mahler's measure and elliptic curves

*David Boyd*

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- The ABC & D conjectures  
*M. Ram Murty*
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*William Galway*

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Another improvement of Ramachandra's unit index

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*Stefan Johansson*

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*Soon-Yi Kang*

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*Pierre Kaplan*

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*Omar Kihel*

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*Winfried Kohlen*

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*Joseph Lewittes*

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*Xian-Jin Li*

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*Scott C. Lindhurst*

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*Eric Liverance*

Arithmetical aspects of replicativity

*Lutz G. Lucht*

On a family of subgroups of the Teichmüller modular group of genus 2 obtained from the Jones representation

*Masanori Morishita*

Some computations concerning Lehmer's conjecture

*Michael J. Mossinghoff*

Arithmetical variations of Dirichlet's class number formula for real quadratic fields

*Toru Nakahara*

Hecke systems of ideal numbers and Kneser field extensions

*Florin Nicolae*

Uniform boundedness for rational points

*Patricia Pacelli*

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*F. Pappalardi*

Imaginary bicyclic biquadratic fields with elementary 2-class group

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Fourier coefficients of non-holomorphic cusp forms

*Yiannis Petridis*

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*Paulo Ribenboim*

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*Herman te Riele*

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*Jonathan W. Sands*

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*Chris Smyth*

Some integrals in Ramanujan's lost notebook

*Seung H. Son*

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*Lawrence Sze*

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*Francisco Thaine*

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*Jeffrey Thunder*

Arithmetic of a certain Calabi-Yau three fold

*Helena Verrill*

Diophantine approximation in Euclidean spaces

*Leonid Vulakh*

Factoring by e-mail using the Number Field Sieve

*Samuel S. Wagstaff*

Formulas for measures of indefinite quadratic forms

*Lynne Walling*

A class of simultaneous Pell equations with no solutions

*P. Gary Walsh*

Weight one cusp forms and the rank of class groups

*Siman Wong*

Cohomology groups of units in  $\mathbb{Z}_p^d$  extensions

*Mingzhi Xu*

Non-singular points on a quartic hypersurface over a finite field

*Charles Yeomans*

Elimination of the multiple from estimates for linear forms in  $p$ -adic logarithms

*Kunrui Yu*

Brauer numbers of weighted diagonal hypersurfaces over finite fields

*Noriko Yui*

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## List of Registrants

Adam, Brigitte	Université de Metz
Ahlgren, Scott	Denison University
Aikawa, Yuki	Deep River, Ontario
Akbary, Amir	University of Toronto
Alaca, Saban	Carleton University
Arsenault, Nicolas	McGill University
Astels, Stephen	University of Waterloo
Bach, Eric	University of Wisconsin
Bachman, Gennady	University of Nevada
Baragar, Arthur	University of Waterloo
Bean, Michael	University of Michigan
Bennett, Michael	University of Michigan
Berenhaut, Kenneth S.	University of Georgia
Berndt, Bruce C.	University of Illinois
Bertin, Marie José	Université de Paris VI
Beukers, Frits	Universiteit de Utrecht
Bhaduri, Ranjan	University of Hawaii
Borwein, Jonathan	Simon Fraser University
Borwein, Peter	Simon Fraser University
Boyd, David	University of British Columbia
Bradley, David	Simon Fraser University
Brownawell, W. Dale	Pennsylvania State University
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