

# Notions of Positivity and the Geometry of Polynomials

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*În noapte undeva mai e  
tot ce-a fost și nu mai e,  
ce s-a mutat, ce s-a pierdut  
din timpul viu în timpul mut.  
În Hades e – tot ce-a trecut.  
Din aheronticul ținut  
vin toate amintirile.  
În Hades e – tot ce-a trecut  
prierii și iubirile.*

**(In noapte undeva mai e,  
de Lucian Blaga)**

*Lost in the night, somewhere, there is  
all that once was and no more is,  
what got lost, what was uprooted,  
from living time to time that's muted.  
In Hades is – all that has passed. From  
Acheron, the river vast,  
all memories to us return.  
In Hades is – all that has passed  
the springtimes, and the loves we yearn.*

**(Lost in the night, somewhere,  
there is by Lucian Blaga)<sup>1</sup>**

## Introduction

This book is dedicated to the memory of Julius Borcea, visionary mathematician whose fervor and intensity left no one indifferent. Julius' restless and conquering mind could not conceal a tormented heart which burned itself out all to quickly to the consternation of all those who knew him.

His mathematical legacy consists of singular results, novel approaches to old problems and a constellation of open questions. A “symphony of conjectures”, as he liked to say.

The articles bound in the present volume were commissioned and written with the aim of exhibiting and honoring the depth of Julius' creative powers.

*Julius Bogdan Borcea* was born in Bacău, Romania, in 1968. At the age of 14 he followed his parents to Morocco then to Denmark where he completed his Baccalauréat at the Lycée Français of Copenhagen. In 1987–1989 he attended the prestigious Lycée Louis-le-Grand in Paris. He completed his mathematical studies in Lund under the supervision of Arne Meurman. After defending his PhD thesis in 1998, he embarked in postdoctoral studies at the Mittag-Leffler Institute for six months and in Strasbourg for two years. Julius was appointed Assistant

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<sup>1</sup>from *Linguistic Treason* A Romanian-English poetry translation blog

Professor at Stockholm University in 2001 and Lecturer in 2005. A year later he was granted the prestigious Swedish Mathematical Society Wallenberg Prize. Promoted Full Professor in 2008, he was awarded the most distinguished Royal Academy of Sciences Fellowship in 2009. He died on April 8, 2009.

Julius was a prominent researcher and a dedicated mentor and teacher. His scientific work ranges from vertex operator theory to zero distribution of polynomials and entire functions, via correlation inequalities and statistical mechanics. Julius' thesis already bore the mark of his originality. It consists of two seemingly independent parts: one in vertex operator theory and the other devoted to the geometry of zeros of complex polynomials in one variable. In vertex operator theory Julius generalized results of Primc and Meurman and gave a classification of annihilated fields. As concerns complex polynomials, he tackled Sendov's conjecture on zeros and critical points of complex polynomials in one variable. Using novel techniques, he proved the conjecture for polynomials of degree not exceeding 7. Earlier (1969) the conjecture had been proven for polynomials of degree not exceeding 5. At Stockholm University Julius had a steady collaboration with Bøgvad and Boris Shapiro. They worked on rational approximations of algebraic equations, piecewise harmonic functions and positive Cauchy transforms, and the geometry of zeros of polynomials in one variable.

Borcea and Brändén collaborated on a project on the geometry of zeros of polynomials and entire functions. They characterized all linear operators on polynomials preserving the property of having only real zeros, a problem that goes back to Laguerre and Pólya–Schur. These results were subsequently extended to several variables, and a connection to the Lee–Yang program on phase-transitions in statistical physics was made. Together with Tom Liggett (UCLA) they applied their methods to problems in probability theory and were able to prove an important conjecture about the preservation of negative dependence properties in the symmetric exclusion process.

Julius had a comprehensive project on the distribution of positive charges and the Hausdorff geometry of complex polynomials. One of the motivations for the project was to bring Sendov's conjecture into a larger and more natural context. He formulated several interesting conjectures, and in the summer of 2009 he was the driving force of two meetings, one at the American Institute of Mathematics in Palo Alto and the other at the Banff International Research Station together with Khavinson, Pereira, Putinar, Saff and Shimorin. These two encounters were focused on structuring and expanding Julius' program. His continuous and vivid interest in the Hausdorff geometry of polynomials was triggered by an *École Normale Supérieure* (Paris) exam he took in 1989.<sup>2</sup>

Julius had a lively interest in literature. As a young man, he wrote poetry and had dreams of becoming a writer, but in his teen years, his interest for mathematics became prevalent. Julius lived for mathematics. He had a complex personality.

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<sup>2</sup>We thank Oliver Debarre and Guy Henniart for granting us permission to reproduce below the original exam sheet.



*Julius Bogdan Borcea (1968–2009)*

Curious, passionate and turbulent, but also sensitive, caring, generous, and first and foremost intense in everything he did.

He is survived by his wife Roxana (whom he married in Prague in 1990), his mother (today retired in Romania), and his brother (settled with his family in Malmö). His father died in Malmö one year after him.

The gap left in the mathematical community by his death especially among those who were privileged to know and interact with him is incommensurable. In the wake of his incomprehensible disappearance, we carry and will strive to promote his vision and invaluable mathematical legacy.

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