

# Proceedings of Symposia in PURE MATHEMATICS

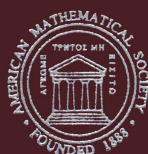
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Volume 62, Part 1

## Algebraic Geometry Santa Cruz 1995

Summer Research Institute on  
Algebraic Geometry  
July 9–29, 1995  
University of California, Santa Cruz

János Kollár  
Robert Lazarsfeld  
David R. Morrison  
Editors



American Mathematical Society

## Selected Titles in This Series

- 62 **János Kollár, Robert Lazarsfeld, and David R. Morrison, Editors**, Algebraic geometry—Santa Cruz 1995 (University of California, Santa Cruz, July 1995)
- 61 **T. N. Bailey and A. W. Knap, Editors**, Representation theory and automorphic forms (International Centre for Mathematical Sciences, Edinburgh, Scotland, March 1996)
- 60 **David Jerison, I. M. Singer, and Daniel W. Stroock, Editors**, The legacy of Norbert Wiener: A centennial symposium (Massachusetts Institute of Technology, Cambridge, October 1994)
- 59 **William Arveson, Thomas Branson, and Irving Segal, Editors**, Quantization, nonlinear partial differential equations, and operator algebra (Massachusetts Institute of Technology, Cambridge, June 1994)
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- 51 **William B. Arveson and Ronald G. Douglas, Editors**, Operator theory/operator algebras and applications (University of New Hampshire, July 1988)
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- 42 **Anil Nerode and Richard A. Shore, Editors**, Recursion theory (Cornell University, Ithaca, New York, June/July 1982)
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- 39 **Felix E. Browder, Editor**, The mathematical heritage of Henri Poincaré (Indiana University, Bloomington, April 1980)

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Algebraic Geometry  
Santa Cruz 1995

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Editors



**American Mathematical Society**  
Providence, Rhode Island

PROCEEDINGS OF A SUMMER RESEARCH INSTITUTE ON  
ALGEBRAIC GEOMETRY HELD AT THE  
UNIVERSITY OF CALIFORNIA, SANTA CRUZ  
JULY 9–29, 1995

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# Contents

## Part 1

Preface	xi
Scientific Program	xiii

### I. Geometry and Topology of Algebraic Surfaces

Homological algebra and algebraic surfaces FABRIZIO CATANESE	3
The bicanonical map for surfaces of general type CIRO CILIBERTO	57
Donaldson and Seiberg-Witten invariants of algebraic surfaces ROBERT FRIEDMAN	85
Moduli of vector-bundles on surfaces KIERAN G. O'GRADY	101
Braid groups, algebraic surfaces and fundamental groups of complements of branch curves M. TEICHER	127

### II. Higher Dimensional Algebraic Geometry

A view on contractions of higher dimensional varieties MARCO ANDREATTA AND JAROSŁAW WIŚNIEWSKI	153
Stable pairs and log flips AARON BERTRAM	185
Multiplier ideals, vanishing theorems and applications LAWRENCE EIN	203
Singularities of pairs JÁNOS KOLLÁR	221



Vanishing, singularities and effective bounds via prime characteristic local algebra	
KAREN E. SMITH	289

### III. Motives and Connections with Arithmetic

Lectures on mixed motives	
SPENCER BLOCH	329
Period domains over finite and local fields	
MICHAEL RAPOPORT	361
Hermitian vector bundles on arithmetic varieties	
CHRISTOPHE SOULÉ	383

### IV. Real Algebraic Varieties and Singularities

Invariants of generic plane curves and invariants of singularities	
S. M. GUSEIN-ZADE	423
Enumerative geometry for real varieties	
FRANK SOTTILE	435

## Part 2

Preface	xi
Scientific Program	xiii

### V. Quantum Cohomology and Connections with Physics

Seiberg-Witten integrable systems	
RON DONAGI	3
Notes on stable maps and quantum cohomology	
W. FULTON AND R. PANDHARIPANDE	45
Mapping class groups and moduli spaces of curves	
RICHARD HAIN AND EDUARD LOOIJENGA	97
Algebraic and symplectic geometry of Gromov-Witten invariants	
JUN LI AND GANG TIAN	143

**VI. Fundamental Groups and Non-Abelian Hodge Theory**

On the Shafarevich maps L. KATZARKOV	173
The Hodge filtration on nonabelian cohomology CARLOS SIMPSON	217

**VII. Complex Geometry**

Algebraic criteria for Kobayashi hyperbolic projective varieties and jet differentials JEAN-PIERRE DEMAILLY	285
Twistors for Tourists: A pocket guide for algebraic geometers CLAUDE LEBRUN	361

**VIII. Toric Geometry**

Recent developments in toric geometry DAVID A. COX	389
Equations defining toric varieties BERND STURMFELS	437

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## Preface

The 1995 AMS Summer Research Institute on Algebraic Geometry was held at the University of California, Santa Cruz, from July 9 through July 29, 1995. The organizing committee consisted of Henri Gillet, János Kollár, Robert Lazarsfeld (chairman), Robert MacPherson, David Morrison and Yum-Tong Siu. The present volumes contain write-ups of all the plenary lecture series with the exception of E. Witten's course on duality in supersymmetric gauge theories<sup>1</sup> and A. J. de Jong's lectures on alterations of singularities<sup>2</sup>. They also contain a number of survey articles growing out of seminar talks.

One of the main thrusts of the Institute was to provide an introduction to some of the exciting new areas and directions that have recently opened up in geometrically oriented algebraic geometry. At the same time, the conference provided a forum for the dissemination of important developments in the more classical branches of the field. A summary of the complete scientific program appears on the following pages. We hope that the papers in these Proceedings will give a sense of the breadth and vitality of algebraic geometry as it emerged at Santa Cruz. However the editors are well aware that, in spite of their best efforts, important areas remain under-represented in these volumes.

Finally, on behalf of the whole organizing committee, we would like to thank Chris Harkness and the AMS for their work in the day-to-day organization of the Institute, David Cox and David Perkinson for organizing the graduate student seminar, and the seminar organizers and speakers for their contributions to the scientific program. But we'd particularly like to express our gratitude to all the participants, whose good humor and enthusiasm ensured the success of the Institute.

JÁNOS KOLLÁR, ROBERT LAZARSFELD, DAVID R. MORRISON

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<sup>1</sup>A much expanded version of Witten's lecture series was delivered at the Institute for Advanced Study during 1996-97, and is being written up for publication.

<sup>2</sup>de Jong's lectures reported on A. J. de Jong, Smoothness, semi-stability and alterations. Inst. Hautes Etudes Sci. Publ. Math. No. 83 (1996), 51-93.

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# Scientific Program of the Institute

## FIRST WEEK

### PLENARY LECTURE SERIES AND MINI-COURSES

- C. LeBrun, An introduction to twistors
- C. Simpson, Hodge theory and fundamental groups
- E. Witten, Duality in supersymmetric gauge theories

### SEMINAR AND CONTRIBUTED LECTURES

- V. Alexeev, On the automorphisms of surfaces of log-general type
- J. Amorós, On nonfibered Kähler groups
- D. Arapura, Solvable Kähler groups
- P. Aspinwall, Quantum algebraic geometry and K3 surfaces
- L. Barbieri-Viale, Bloch's conjecture revisited
- V. Batyrev, Mirror symmetry and toric geometry
- T. Bauer, Higher order embeddings of abelian varieties
- F. Catanese, Images of canonical surfaces in three-space and nodal surfaces
- A. Corti, Some ideas and problems in the Mori program and the Sarkisov program
- O. Debarre, Subvarieties with minimal class on Jacobians
- A. Dickenstein, Residues in toric varieties
- I. Dolgachev, Mirror symmetry for K3 surfaces
- H. Esnault, Higher Chern classes of flat bundles in the Deligne bundle are torsion on a complex projective manifold (after A. Reznikov)
- R. Friedman, Algebraic surfaces and Seiberg–Witten invariants
- M. Green, What comes after the Abel–Jacobi map?
- M. Gross, Deforming Calabi–Yau threefolds
- Z. Guan, Classification of almost homogeneous spaces
- R. Hain, Hodge theory and mapping class group
- R. Hartshorne, Classification of space curves and Zeuthen's problem
- Y. Hu, Relative GIT and universal moduli spaces
- K. Hulek, Moduli of abelian and K3 surfaces
- A. Hwang, Examples of Kähler metrics with constant scalar curvature
- E. Izadi, Cubic hypersurfaces
- H. Kaji, On the homogeneous projective varieties with degenerate secants
- A. Kaplan, Hodge cycles at infinity
- Y. Karpiashpan, Riemann reciprocity in higher dimensions

S. Katz, Mirror symmetry and curves of higher genus  
 L. Katzarkov, On the Shafarevich maps  
 K. Konno, The slope of fibered surfaces  
 H. Lange, Quadrics containing a Prym-canonical curve  
 J. Li, Donaldson invariants and virtual moduli cycle  
 N. Mohan Kumar, Deformation of rank two vector bundles on  $\mathbb{P}^3$   
 D. Morrison, Black holes and Calabi–Yau manifolds  
 D. Morrison, Evidence for mirror symmetry from toric enumerative geometry  
 T. Napier, Covering spaces of families of curves  
 K. O’Grady, Moduli of vector bundles on surfaces: some global questions  
 J. Rabin, Supercurves and their Jacobians  
 M. Ramachandran, Subvarieties, local systems and harmonic maps  
 M. Reid, Freedom and very ampleness  
 Y. Ruan, Higher genus pseudo-holomorphic curves  
 T. Szemberg, Primitive line bundles and higher order embeddings  
 M. Teicher, Braid groups and algebraic surfaces  
 D. Toledo, Projective varieties with non-residually finite fundamental groups  
 J. Wahl, Cohomology of the square of an ideal sheaf and geometry of canonical curves  
 P.H.M. Wilson, Symplectic classes on Calabi–Yau threefolds

## SECOND WEEK

### PLENARY LECTURE SERIES AND MINI-COURSES

J.-P. Demailly, Hyperbolicity of projective algebraic varieties and jet bundles  
 W. Fulton, Enumerative geometry via quantum cohomology: an introduction to the work of Kontsevich and Manin  
 J. Kollár, Higher dimensional geometry and its applications

### SEMINAR AND CONTRIBUTED LECTURES

M. Andreatta, Extremal contractions from a 4-fold  
 C. Bartocci, Fourier–Mukai transform and moduli spaces of stable sheaves on  $K3$  surfaces  
 A. Beauville, Recent progress in moduli spaces of vector bundles on curves  
 A. Bertram, Quantum Schubert calculus  
 I. Biswas, Hodge cycles on moduli spaces of vector bundles on curves  
 R. Brussee, The canonical and the Seiberg–Witten classes of a Kähler manifold  
 L. Caporaso, Rational curves on rational ruled surfaces  
 J. Cheah, Hilbert function of the Hilbert scheme of points  
 C. Ciliberto, On the bicanonical map for surfaces of general type  
 E. Colombo, Families of abelian varieties on a complete smooth curve  
 G. Dethloff, Iitaka–Severi conjecture for complex 3-folds  
 R. Donagi, Seiberg–Witten integrable systems  
 L. Ein, Recent work on linear series  
 H. Esnault, An algebraic invariant of flat bundles  
 R. Hain,  $C - C^-$

- A. Kabanov, The second cohomology of the moduli space of algebraic curves with symplectic coefficients
- Y. Kachi, Flips from certain fibered 4-folds
- N. Katz, Informal report on rigid local systems
- Y. Kawamata, On Fujita's freeness conjecture
- S. Kleiman, Gorenstein algebras, symmetric matrices, self-linked ideals, and symbolic powers
- S. Kovács, Smooth families over rational and elliptic curves
- H. Kurke, Framed vector bundles and framed local jumps
- J. M. Landsberg, Differential-geometric characterizations of complete intersections
- R. Lazarsfeld, Local positivity of ample line bundles
- E. Looijenga, Cohomology of moduli spaces of curves
- J. McKernan, Rational curves on quasi-projective surfaces
- Y. Miyaoka, Vector fields on Calabi–Yau manifolds in characteristic  $p$
- R. Morelli, Counting lattice points in polytopes
- S. Mori, Quotients by groupoids
- S. Müller-Stach, Higher Chow groups of surfaces
- I. Nieto, The singular  $H_{2,2}$ -invariant quartic surfaces in  $\mathbb{P}_3$
- M. Ohno, On degenerate secant varieties which have the smallest contact loci with their tangent spaces
- R. Pandharipande, The canonical class of  $\overline{\mathcal{M}}_{0,n}(\mathbb{P}^r, d)$
- T. Pantev, Motivic local systems on curves
- U. Persson, Geography and moduli of surfaces: new insights
- M. Pikaart, On the stable cohomology of  $M_g$  (and  $\overline{M}_g$ )
- S. Popescu, Calabi–Yau 3-folds and moduli of abelian surfaces
- E. Previato, Poncelet's theorem in space
- M. S. Ravi, Some applications of algebraic geometry to systems and control theory
- M. Reid, Some flips
- A. Rudakov, Classification of stable vector bundles on Del Pezzo surfaces
- B. Runge, On complex Shimura varieties
- F.-O. Schreyer, Surfaces in  $\mathbb{P}^4$  with applications
- C. Schuhmann, Mapping threefolds onto three-quadrics
- K. Smith, Fujita conjecture in positive characteristic
- E. Szabó, Automorphisms of varieties of general type
- M. Thaddeus, Birational approximation of moduli spaces
- B. Totaro, The cohomology of configuration spaces, and Fulton–MacPherson's compactification
- I.-H. Tsai, Varieties dominated by compact Hermitian symmetric spaces
- E. Viehweg, Moduli of polarized manifolds and normal varieties with weak singularities
- V. Vinnikov, Commuting nonselfadjoint operators and algebraic curves
- G. Xu, On the complement of a generic curve in the projective plane
- A. Yekutieli, Adeles, Chern classes and the residue complex
- D.-Q. Zhang, Hypersurfaces on Fano 3-folds with log terminal singularities
- S. Zucker, Hodge theory and spectres on locally symmetric varieties



## THIRD WEEK

## PLENARY LECTURE SERIES AND MINI-COURSES

- S. Bloch, Motives and motivic cohomology
- J. de Jong, Dominating varieties by smooth varieties
- C. Soulé, Hermitian vector bundles on arithmetic varieties

## SEMINAR AND CONTRIBUTED LECTURES

- D. Abramovich, Uniformity of points on curves
- J.-B. Bost, Canonical polygons of hermitian vector bundles and transcendence methods
- R.-O. Buchweitz, Hodge modules of weighted homogeneous complete intersections
- J. Burgos Gil, Arithmetic  $K$ -theory and Beilinson regulator
- M.-C. Chang, Asymptotics on Hilbert schemes and moduli spaces
- W. Cherry, Non-Archimedean analytic curves in abelian varieties
- A. Collino, Torelli for the infinitesimal invariant of  $C - C^-$  and  $K$ -theory
- J.-L. Colliot-Thélène, Zero-cycles on varieties over  $p$ -adic fields
- M. Cook, Using generic initial ideals to lower the bound of degree of surfaces not of general type in  $\mathbb{P}^4$
- H. D'Souza, A complete classification theorem for a class of 3-folds
- H. Gillet, Motives and the weight filtration on  $\mathbb{Z}$ -cohomology
- M. Grinberg, Nearby cycles in linear algebra
- S. Gusein-Zade, The Arf-invariant and the Arnold invariants of plane curves
- B. Hassett, Uniformity of points on surfaces of general type
- H. Hauser, Initial ideals and resolution of surface singularities
- R. Hoobler, Étale cohomology of geometric local rings is Galois cohomology
- E. Hrushovski, Model theory and the Mordell–Lang conjecture
- T. Iarrobino, Interpolation problem at points of  $\mathbb{P}^n$  and the  $s$ -secant variety of the Veronese embedding
- S. Ishii, The canonical modifications by weighted blowing ups
- P. Jaworski, On the topological triviality along the moduli of deformations of quasi-homogeneous singularities
- M. Kapranov, Hecke operators on moduli space of vector bundles on an algebraic surface
- N. Katz, What we do and don't know about curves over finite fields
- S. Katz, Schubert: a Maple package for intersection theory
- S. Kimura, Finite dimensionality of Chow motives and Bloch's conjecture
- R. Kobayashi, Value distribution theory and algebraic geometry
- D. McLaughlin, Reciprocity
- G. Megyesi, Singularities of configurations of curves and a generalization of the Miyaoka–Yau inequality
- B. Moonen, Linearity properties of Shimura varieties
- A. Moriwaki, Bogomolov conjecture over function fields
- M. Nakamaye, A new proof of Dyson's lemma
- J. Nekovář, Syntomic cohomology,  $p$ -adic regulators and Chow groups
- A. Némethi, The mixed Hodge structure of an ICIS
- Y. Nisnevich, A generalization of Quillen's work on the Gersten conjecture and algebraic cycles onto singular varieties

- M. Nori, Torsion and divisibility of algebraic cycles
- K. Pardue, Free resolutions and deformation classes of graded modules
- T. Peternell, The role of the tangent bundle in the classification theory of algebraic varieties
- R. Pink, Compactification of the moduli space of Drinfeld modules
- M. Rapoport,  $p$ -adic period domains
- W. Raskind, Higher Abel–Jacobi maps and filtrations on Chow groups
- C. Schoen, On the  $\ell$ -adic Abel–Jacobi map
- N. Shepherd-Barron, Icosahedral Galois representations, mod 2 and 5
- V. Shokurov, A projectivity criterion
- M. Singer, Computational questions in differential Galois theory
- Y.-T. Siu, Hyperbolicity of complements of plane curves
- F. Sottile, Enumerative geometry of the real Grassmannian
- V. Srinivas, Torsion zero cycles on singular varieties
- J. Stevens, Degenerations of elliptic curves and cusp singularities
- M. Stillman, MACAULAY – The new generation
- B. Sturmfels, Defining equations of toric varieties
- P. Vojta, Roth’s theorem with moving targets
- C. Weibel, Roitman’s theorem for singular complex surfaces
- S. Zhang, Equidistributions for torsion points and small points
- S. Zhang, Heights of Heegner cycles and derivatives of  $L$ -series

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*(Continued from the front of this publication)*

- 38 **Richard V. Kadison, Editor**, Operator algebras and applications (Queens University, Kingston, Ontario, July/August 1980)
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