INFOMAT

August 2018

DET AKADEMISKE ÅRET 2018-2019 ER I GANG

Bildet er fra oppstart ved Universitetet i Sørøst-Norge, campus Bø.

INFOMAT kommer ut med 11 nummer i året og gis ut av Norsk Matematisk Forening. Deadline for neste utgave er alltid den 15. i neste måned. Stoff til INFOMAT sendes til

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Ansvarlig redaktør er Arne B. Sletsjøe, Universitetet i Oslo.

Matematisk kalender

2018:
September:
13.-14. *Nasjonalt matematikermøte*, Bergen
Desember:
6.-8. *Enumeration and Moduli*, Oslo

NASJONALT MATEMATIKERMØTE, Bergen, 13.-14. september 2018

I forbindelse med det nasjonale prosjektet *Pure mathematics in Norway*, sponset av Bergen forskningsstiftelse (BFS) og Tromsø forskningsstiftelse (TFS), og Norsk matematisk forenings 100 års-jubileum, vil det bli arrangert et nasjonalt matematikermøte i Bergen 13-14. september i år, i tillegg til et ekstra møte forbeholdt PhD-stipendiater 12. september. Møtet vil inneholde både plenumsforedrag og parallelle foredrag. For mer informasjon, inkludert liste over foredragsholdere, se hjemmesiden *http://www.uib.no/matematikermote*

ENUMERATION AND MODULI, Oslo 6.-8. desember 2018

A conference in algebraic geometry on the occasion of Geir Ellingsrud's 70th birthday. For further information, see: *http://www.mn.uio.no/math/english/research/groups/algebra/events/conferences/Enumerationandmoduli/index.html*

FIELDSMEDALJEN 2018

Caucher Birkar has made fundamental contributions to birational geometry in two particular areas: the minimal model program (MMP) and the boundedness of Fano varieties. The original MMP involves two kinds of projective varieties *Y* with so-called terminal singularities whose canonical divisors *K* have opposite properties: for a minimal model *K* is non-negative on curves on *Y*; while for a Fano fibering *Y* has a surjective morphism onto a lower dimensional projective variety with -*K* relatively ample. The MMP attempts to construct for each smooth projective variety a birational map to either a minimal model or a Fano fibering.

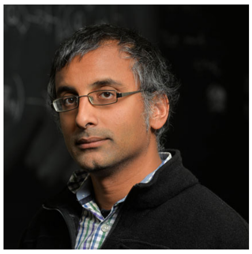
Although the MMP is not always known to work, Birkar jointly with Cascini, Hacon, and McKernan made a stunning contribution; a special version of the MMP works for complex varieties of arbitrary dimension whose canonical divisor is either big or not pseudo effective, a situation which covers many important cases. They actually established the MMP for a wider class of singularities, which was essential for the induction on dimension in the proof, and it implies many important consequences such as the finite generation of canonical rings of arbitrary smooth projective varieties. The MMP is now a fundamental tool which is used extensively.

It was Birkar who further proved that complex Fano varieties (i.e., Fano fiberings over a point) of arbitrary fixed dimension with terminal singularities are parametrized by a (possibly reducible) algebraic variety. Since these Fano varieties constitute one of the main outputs of MMP as applied to smooth projective varieties, their boundedness, previously considered unreachable, is fundamentally important. Birkar has settled the more general Borisov-Alexeev-Borisov conjecture building upon results by Hacon, McKernan, Xu, and others. Birkar's boundedness will be crucial as a paradigm for the full MMP.

Alessio Figalli has made multiple fundamental advances in the theory of optimal transport, while also applying this theory in novel ways to other areas of mathematics. Only a few of his numerous results in these areas are described here. Figalli's joint work with De Philippis on regularity for the Monge-Ampère equation is a groundbreaking result filling the gap between gradient estimates discovered by Caffarelli and full Sobolev regularity of the second derivatives of the convex solution

of the Monge-Ampère equation with merely bounded right-hand side. The result is almost optimal in view of existing counterexamples. It has direct implications on regularity of the optimal transport maps, and on regularity to semigeostrophic equations.
Figalli initiated the study of the singular set of optimal transport maps and obtained the first definite results in this direction: he showed that it has null Lebesgue measure in full generality. He has also given significant contributions to the theory of obstacles problems, introducing new methods to analyze the structure of the free boundary.
Figalli and his coauthors have also applied optimal transport methods in a striking fashion to obtain sharp quantitative stability results for several fundamental geometric inequalities, such as the isoperimetric and Brunn-Minkowski inequalities, without any additional assumptions of regularity on the objects to which these inequalities are applied; the methods are also not reliant on Euclidean symmetries, extending in particular to the Wulff inequality to yield a quantitative description of the low-energy states of crystals.

Peter Scholze has transformed arithmetic algebraic geometry over *p*-adic fields. Scholze's theory of perfectoid spaces has profoundly altered the subject of *p*-adic geometry by relating it to geometry in characteristic *p*. Making use of this theory, Peter Scholze proved Deligne's weight-monodromy conjecture for complete intersections. As a further application, he constructed Galois representations that are attached to torsion cohomology classes of locally symmetric spaces, resolving a longstanding conjecture. Scholze's version of *p*-adic Hodge theory extends to general *p*-adic rigid spaces. Together with Bhatt and Morrow, Scholze developed an integral version of *p*-adic Hodge theory that establishes a relation between the torsion in Betti and crystalline cohomologies.
On the way to the revolution that he launched in arithmetic geometry, Scholze took up a variety of topics that he reshaped, such as algebraic topology and topological Hochschild homology.
Scholze developed new cohomological methods. Beyond *p*-adic fields, Scholze's vision of a cohomology theory over the integers has become a guideline that fascinates the entire mathematical community.



Akshay Venkatesh has made profound contributions to an exceptionally broad range of subjects in mathematics, including number theory, homogeneous dynamics, representation theory and arithmetic geometry. He solved many longstanding problems by combining methods from seemingly unrelated areas, presented novel viewpoints on classical problems, and produced strikingly far-reaching conjectures.
What follows is a small sample of his major achievements:
Venkatesh introduced a general and unifying technique based on representation theory and homogeneous dynamics in the subconvexity problem for L-functions and (partly in collaboration with Michel) used these ideas to give a complete treatment of all cases of subconvexity for *GL(2)* over number fields.
He made major progress on the local-global principle for the representations of one quadratic lattice by another, in joint work with Ellenberg.
In joint work with Einsiedler, Lindenstrauss and Michel, Venkatesh proved equidistribution of the periodic torus orbits in $SL(3,\mathbf{Z})\backslash SL(3,\mathbf{R})$ that are attached to the ideal classes of totally real cubic number fields as the discriminant tends to infinity.
Venkatesh established effective equidistribution of periodic orbits of many semisimple groups both in the local and adelic settings, in joint work with Einsiedler, Margulis, and in part with Mohammadi.
With Ellenberg and Westerland, Venkatesh established significant special cases of the Cohen-Lenstra conjectures concerning class groups in the function field setting.

CHERN-MEDALJEN

Masaki Kashiwara's mark on current mathematics is exceptional. It extends from microlocal analysis, representation theory and combinatorics to homological algebra, algebraic geometry, symplectic geometry and integrable systems. Most notable are his decisive contributions to theory of *D*-modules and his creation of crystal bases, which have shaped modern representation theory.

Over a span of almost 50 years he has established the theory and applications of algebraic analysis. Introduced by Sato around 1960, algebraic analysis is a framework in which systems of linear differential equations are formulated as modules over a ring *D* of differential operators and are analysed with algebraic means such as rings, modules, sheaves and categories. Sato's idea of *D*-modules was greatly developed by Kashiwara in his 1971 thesis, and has become a fundamental tool in many branches of mathematics. With Sato and Kawai, he developed microlocal analysis, the study of partial differential equations, locally combining space and Fourier variables, and working on the cotangent bundle of the base manifold. In the 1980s with Schapira he further introduced and developed microlocal sheaf theory.

One of his early major results was his 1980 construction of the Riemann-Hilbert correspondence, a far-reaching generalization of Hilbert's 21st problem about the existence of a linear differential equation on the projective line with prescribed monodromy. Greatly generalising work of Deligne, Kashiwara (and later independently Mebkhout) established an equivalence between the derived category of regular holonomic *D*-modules on a complex algebraic variety ("systems of linear differential equations") and the derived category of constructible sheaves on the same variety ("solutions"), thereby creating a fundamental bridge between algebra and topology.

The Riemann-Hilbert correspondence found a remarkable application to a problem in representation theory: the Kazhdan-Lusztig conjecture, proved independently by Brylinski-Kashiwara and Beilinson-Bernstein. This beautiful synthesis of algebra, analysis and geometry may be viewed as a precursor to geometric representation theory in its modern form. With Tanisaki, Kashiwara generalized the conjecture yet further to infinite-dimensional Kac-Moody Lie algebras, a critical ingredient for the completion of Lusztig's program in positive characteristic.

Kashiwara's 1990 discovery of crystal bases is another landmark in representation theory. Quantum groups are deformations of the enveloping algebras of Kac-Moody Lie algebras originating from certain lattice models in statistical mechanics. Here the deformation parameter q is temperature, with $q = 0$ corresponding to absolute zero. Crystal bases are bases of representations of quantum groups at $q=0$ which encode essential information about the representations. Kashiwara proved that for all q, crystal bases lift uniquely to global bases which turned out to coincide with the canonical bases discovered earlier by Lusztig. Being a powerful combinatorial tool, crystal bases have had great impact with many applications, including solving the classical problem of decomposing tensor products of irreducible representations.

Kashiwara's work, with many different coauthors, continues to be groundbreaking. He has been at the forefront of recent developments on crystal bases, including the categorification of representations of quantized enveloping algebras. Other highlights include the solution of two well-known open problems about *D*-modules: the `codimension 3 conjecture' (2014) and the extension of the Riemann-Hilbert correspondence to the irregular case (2016). His work on sheaf quantization of Hamiltonian isotopies (2012) opened the way to applications of microlocal sheaf theory to symplectic geometry.

Kashiwara has many other results too numerous to mention. For example, he obtained major results on representations of real Lie groups, and on infinite-dimensional Lie algebras, in particular in connection with integrable systems and the KP hierarchy. Kashiwara's influence extends far beyond his published work. Many of his informal talks have initiated important subjects and his ideas have been a source of inspiration for many people. Several of his books have become essential references, his book on sheaves with Schapira being regarded as the bible of the subject.

Kashiwara's work stands out in depth, breadth, technical brilliance and extraordinary originality. It is impossible to imagine either algebraic analysis or representation theory without his contributions.