



ID de Contribution: 12

Type: Non spécifié

Algebraic geometry, theory of singularities, and convex geometry

lundi 22 juin 2015 15:15 (50 minutes)

I will review some results which relate these areas of mathematics.

Newton polyhedra connect algebraic geometry and the theory of singularities to the geometry of convex polyhedra. This connection is useful in both directions. On the one hand, explicit answers are given to problems of algebra and the theory of singularities in terms of the geometry of polyhedra. On the other hand, algebraic theorems of general character (like the Hirzebruch–Riemann–Roch theorem) give significant information about the geometry of polyhedra. In this way one obtains, for example, a multidimensional generalization of the classical one-dimensional Euler–Mclaurin formula. Combinatorics related to the Newton polyhedra theory allows to prove that in hyperbolic space of high dimension there do not exist discrete groups generated by reflections with fundamental polyhedron of finite volume (it was a longstanding conjecture). The theory of Newton–Okounkov bodies relates algebra, singularities and geometry outside the framework of toric geometry. This relationship is useful in many directions. For algebraic geometry it provides elementary proofs of intersection-theoretic analogues of the geometric Alexandrov–Fenchel inequalities and far-reaching generalizations of the Fujita approximation theorem. The local version of the theory provides a new proof of the famous Teissier’s inequalities for the multiplicities of primary ideals in a local ring. In geometry it suggests a transparent analog of Alexandrov–Fenchel inequality for coconvex bodies.

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Classification de Session: Afternoon session