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There are Significantly More Nonnegative Polynomials than Sums of Squares

Abstract for the Combinatorics Seminar 2004 February 23

It is a classical result that if a real nonnegative polynomial is either univariate or of degree 2 then it is necessarily a sum of squares of other polynomials. Hilbert showed that these are essentially the only cases when that happens; with one exception, in all the other cases there are nonnegative polynomials that are not sums of squares. Hilbert's proof was nonconstructive and the first explicit example was constructed by Motzkin only fifty years later. I will show that if the degree of the polynomial is fixed and is above 2, then as the number of variables tends to infinity there are significantly more nonnegative polynomials than sums of squares. Time permitting, I will explain the methods of the proof, which deal with the geometry of convex hulls of orbits of points under a group action, and discuss applications to other objects of the same form.

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Last update: **2020/01/29 19:03**

