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The last decade has seen a rich and growing interplay between the continuous volume of a polytope P and its discrete volume, the latter defined by the number of integer points that are contained in the polytope. Many branches of combinatorics, discrete geometry, and number theory can be unified using this interplay. Indeed, one of the main problems in encryption is to find the number of integer (or lattice) points that are contained inside a given parallelepiped whose vertices have rational coordinates.

Recently, we've succeeded in extending the theory of discrete volumes of polytopes with rational coordinates to that of polytopes with real coordinates, using Fourier Analysis. This theory deals with extensions of angles to higher dimensions, where generalized angles – called solid angles – play a role in defining new discrete volumes of polytopes. Some of the Number Theory that comes into the general analysis consists of Dedekind Sums and their many higher dimensional generalizations. Dedekind sums are finite trigonometric sums that involve Finite Fourier Analysis, and form the building blocks of integer point enumeration in polytopes.

Among the applications of the theory of discrete volumes of polytopes are the Frobenius coin exchange problem, the enumeration of doubly-stochastic matrices, new volume formulas for the Birkhoff polytopes and related transportation polytopes, and algorithms for integer flow networks.

Selected Publications

DeSario, D. and Robins, S., A solid angle theory for real polytopes*,* **to appear.**

Beck, M. and Robins, S., Computing the continuous discretely: integer point enumeration in polytopes, Springer publications in the book series "Undergraduate Texts in Mathematics", (2006), 1-226.

Beck, M., Robins, S., and Zacks, S. Higher-dimensional Dedekind sums and their bounds arising from the discrete diagonal of the n-cube, Advances in Applied Mathematics 36, no. 1 (2006), 1–29.

Beck, M. and Robins, S. Dedekind sums: a combinatorial-geometric viewpoint, Unusual Applications of Number Theory (M. Nathanson, ed.), DIMACS Series in Discrete Mathematics and Theoretical Computer Science 64 (2004), 25–35. Contemporary Mathematics 374 (2005), 15–36.

Beck, M. and Robins, S. Explicit and efficient formulas for the lattice point count inside rational polygons, Discrete & Computational Geometry 27 (2002), 443–459.

Beck, M. Diaz, R. and Robins, S. The Frobenius problem, rational polytopes, and Fourier-Dedekind sums, Journal of Number Theory 96 (2002), 1–21.

Diaz, R. and Robins, S. The Ehrhart Polynomial of a Lattice Polytope, Annals of Mathematics, 145, (1997), 503-518.