Oriented Matroids Today

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Abstract

This *dynamic survey* offers an "entry point" for current research in oriented matroids. For this, it provides updates on the 1993 monograph "Oriented Matroids" by Björner, Las Vergnas, Sturmfels, White & Ziegler [73], in three parts:

1. a sketch of a few "Frontiers of Research" in oriented matroid theory,
2. an update of corrections, comments and progress as compared to [73], and
3. an extensive, complete and up-to-date bibliography of oriented matroids, comprising and extending the bibliography of [73].

1 Introduction(s).

Oriented matroids are both important and interesting objects of study in Combinatorial Geometry, and indispensable tools of increasing importance and applicability for many other parts of Mathematics. The main parts of the theory and some applications were, in 1993, compiled in the quite comprehensive monograph by Björner, Las Vergnas, Sturmfels, White & Ziegler [73]. For other (shorter) introductions and surveys, see Bachem & Kern [29], Bokowski & Sturmfels [130], Bokowski [102], Goodman & Pollack [302], Ziegler [642, Chapters 6 and 7], and, most recently, Richter-Gebert & Ziegler [507].

This *dynamic survey* provides three parts:

1. a sketch of a few "Frontiers of Research" in oriented matroid theory,
2. an update of corrections, comments and progress as compared to [73], and
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2 What is an Oriented Matroid?

Let $V = (v_1, v_2, \ldots, v_n)$ be a finite, spanning, sequence of vectors in $\mathbb{R}^r$, that is, a finite *vector configuration*. With this vector configuration, one can associate the following sets of data, each of them encoding the *combinatorial structure* of V.

- The *chirotope* of V is the map

$$\begin{array}{rcl} \chi_V : \{1,2,\ldots,n\}^r & \longrightarrow & \{+,-,0\} \\ (i_1,i_2,\ldots,i_r) & \longmapsto & \mathrm{sign}(\det(v_{i_1},v_{i_2},\ldots,v_{i_r})) \end{array}$$

  that records for each r-tuple of the vectors whether it forms a positively oriented basis of $\mathbb{R}^r$, a basis with negative orientation, or not a basis.

- The set of *covectors* of V is

$$\mathcal{V}^*(V) \;\; := \;\; \big\{\big(\mathrm{sign}(a^t v_1),\ldots,\mathrm{sign}(a^t v_n)\big) \in \{+,-,0\}^n : a \in \mathbb{R}^n\big\},$$

  that is, the set of all partitions of V (into three parts) induced by hyperplanes through the origin.

- The collection of *cocircuits* of V is the set

$$\mathcal{C}^*(V) \;\; := \;\; \big\{\big(\mathrm{sign}(a^t v_1),\ldots,\mathrm{sign}(a^t v_n)\big) \in \{+,-,0\}^n : a \in \mathbb{R}^n \text{ is orthogonal to a hyperplane spanned by vectors in } V\big\},$$

  of all partitions by "special" hyperplanes that are spanned by vectors of the configuration V.

- The set of *vectors* of V is

$$\mathcal{V}(V) \;\; := \;\; \big\{\big(\mathrm{sign}(\lambda_1),\ldots,\mathrm{sign}(\lambda_n)\big) \in \{+,-,0\}^n : \lambda_1 v_1 + \ldots + \lambda_n v_n = 0 \text{ is a linear dependence between vectors in } V\big\}.$$

- The set of *circuits* is

$$\mathcal{C}(V) \;\; := \;\; \big\{\big(\mathrm{sign}(\lambda_1),\ldots,\mathrm{sign}(\lambda_n)\big) \in \{+,-,0\}^n : \lambda_1 v_1 + \ldots + \lambda_n v_n = 0 \text{ is a } \textit{minimal} \text{ linear dependence between vectors in } V\big\}.$$

A simple, but basic, result now states that all of these sets of data are equivalent, except for a global sign change that identifies χ with $-\chi$. Thus whenever one of the data

$$\{\chi_V, -\chi_V\}, \qquad \mathcal{V}^*(V), \qquad \mathcal{C}^*(V), \qquad \mathcal{V}(V), \qquad \text{or} \qquad \mathcal{C}(V)$$

is given, one can from this uniquely reconstruct all the others.

Furthermore, one has **axiom systems** (see [73, Chap. 3]) for *chirotopes*, *covectors*, *cocircuits*, *vectors* and *circuits* that are easily seen to be satisfied by the corresponding collections above. Thus there are combinatorial structures, called **oriented matroids**, that can equivalently be given by any of these five different sets of data, and defined/characterized in terms of any of the five corresponding axiom systems. (The proofs for the equivalences between these data sets resp. axiom systems are not simple.)

Vector configurations as discussed above give rise to oriented matroids of *rank* r on n *elements* (or: on a *ground set* of size n). Usually the ground set is identified with $E = \{1, 2, \ldots, n\}$.

Equivalent to vector configurations, one has the model of (real, linear, essential, oriented) *hyperplane arrangements*: finite collections $\mathcal{A} := (H_1, H_2, \ldots, H_n)$ of hyperplanes (linear subspaces of codimension one) in $\mathbb{R}^r$, with the extra requirement that $H_1 \cap \ldots \cap H_n = \{0\}$, and with a choice of a positive halfspace H_i^+ for each of the hyperplanes. In fact, every vector configuration gives rise to such an arrangement via $H_i^+ := \{x \in \mathbb{R}^r : v_i^t x \geq 0\}$, and from an oriented hyperplane arrangement we recover a vector configuration by taking the positive unit normals.

More specialized, one has the model of *directed graphs*: if $D = (V, A)$ is a finite directed graph (with vertex set $V = \{0, 1, 2, \ldots, r\}$ and arc set $A = \{a_1, \ldots, a_n\} \subseteq V^2$), then one has the obvious "directed circuits" in the digraph that give rise to circuits in the sense of sign vectors in $\mathcal{C}(V) \subseteq \{+, -, 0\}^n$, while directed cuts give rise to covectors, and minimal directed cuts give rise to cocircuits. Thus one obtains the oriented matroid of a digraph, which can also, equivalently, be constructed by associating with each arc (i, j) the vector $e_i - e_j \in \mathbb{R}^r$, where we take e_i to be the i-th coordinate vector in $\mathbb{R}^r$ for $i \geq 1$, and $e_0 := 0$.

Although the axiom systems of oriented matroids describe the data arising from vector configurations very well, it is not true that every oriented matroid corresponds to a real vector configuration. In other words, there are oriented matroids that are not *realizable*. This points to basic theorems and problems in Oriented Matroid Theory:

- The *Topological Representation Theorem* (see [73, Chap. 5]) shows that while real vector configurations can equivalently be represented by *oriented hyperplane arrangements*, general oriented matroids can be represented by *oriented arrangements of pseudo-hyperplanes*.
- There is no finite set of axioms that would characterize the oriented matroids that are representable by vector configurations. In fact, even for $r = 3$ there are oriented matroids on n elements that are *minimally non-realizable* for arbitrarily large n.
- The *realization problem* is a difficult algorithmic task: for a given oriented matroid, to decide whether it is realizable, and possibly find a realization. This statement is a by-product of the constructions for the Universality Theorem for oriented matroids, see below.

3 Some Frontiers of Research.

Currently there is substantial research done on a variety of aspects and questions; among them are several deep problems of oriented matroid theory that were thought to be both hard and fundamental, and are now gradually turning out to be just that.

Here I give short sketches and a few pointers to the (very recent) literature, for just a few selected topics. (By construction, the selection is very much biased. I plan to expand and update regularly. Your help and comments are essential for that.)

3.1 Realization spaces.

Mnëv's Universality Theorem of 1988 [458] states that every primary semialgebraic set defined over $\mathbb{Z}$ is "stably equivalent" to the realization space of some oriented matroid of rank 3. In other words, the semialgebraic sets of the form

$$\mathcal{R}(X) \quad := \quad \{Y \in \mathbb{R}^{3\times n} : \mathrm{sign}(\det(X_{i,j,k})) = \mathrm{sign}(\det(Y_{i,j,k})) \text{ for all } 1 \leq i < j < k \leq n\},$$

for real matrices $X \in \mathbb{R}^{3\times n}$, can be arbitrarily complicated, both in their topological and their arithmetic properties. Mnëv's even stronger Universal Partition Theorem [459] announced in 1991 says that essentially every semialgebraic family appears in the stratification given by the determinant function on the (3×3)-minors of $(3 \times n)$-matrices.

These results are fundamental and far-reaching. For example, via oriented matroid (Gale) duality they imply universality theorems for d-polytopes with $d+4$ vertices.

For some time, no complete proofs were available. This has only recently changed with the complete proof of the Universal Partition Theorem by Günzel [271] and by Richter-Gebert [502]. Richter-Gebert [501, Sect. 2.5] has also — finally! — provided a suitable notion of "stable equivalence" of semialgebraic sets that is *weak enough* to make the Universality Theorems true, and *strong enough* to imply both homotopy equivalence and arithmetic equivalence (i.e., it preserves the existence of K-rational points in the semialgebraic set for every subfield K of $\mathbb{R}$).

Further, surprising recent progress is now available with Richter-Gebert's [501, 506] Universality Theorem (and Universal Partition Theorem) for 4-dimensional polytopes, and related to this his Non-Steinitz theorem for 3-spheres. (See [272] for a second proof.)

Here are two major challenges that remain in this area:

- To construct and understand the smallest oriented matroids with non-trivial realization spaces. The smallest *known* examples are Suvorov's [577] oriented matroid of rank 3 on 14 points with a disconnected realization space (see also [73, p. 365]), and Richter-Gebert's [503] new example Ω_{14}^{+} with the same parameters, which additionally has rational realizations, and a non-realizable symmetry.
- To provide Universality Theorems for *simplicial* 4-dimensional polytopes (the Bokowski-Ewald-Kleinschmidt polytope [107] is still the only simplicial example known with a non-trivial realization space; see also Bokowski & Guedes de Oliveira [109]).

3.2 Extension spaces and MacPhersonians.

Quite diverse lines of thinking lead to the consideration of *spaces of oriented matroids* and their topological structures. Here the basic construction takes, for example,

- for the *MacPhersonian* $MP(n, r)$ the set of all oriented matroids of rank r on a fixed set of n elements,
- for the *extension space* $\mathcal{E}(\mathcal{M})$ the set of all non-trivial single element extensions of a fixed oriented matroid $\mathcal{M}$.

In each case one obtains a partially ordered set by consideration of rank-preserving weak maps [73, Section 7.7], and from this a topological space by taking the order complex (the simplicial complex given by the chains in the poset; see Björner [70]). Basic conjectures in the field are that

- the MacPhersonian $MP(n, r)$ should have the homotopy type, or at least the $\mathbb{Z}/2$-cohomology, of the Grassmannian $G_r(\mathbb{R}^n)$,
- the extension space $\mathcal{E}(\mathcal{M})$ should have the homotopy type of a sphere S^{r-1}, if $\mathcal{M}$ is realizable.

Note that if $\mathcal{M}$ is an oriented matroid of rank r on a set of n elements, then $\mathcal{E}(\mathcal{M})$ naturally appears as a subspace of $MP(n{+}1, r)$.

The first construction (and terminology) is motivated by MacPherson's [432, 278] theory of "combinatorial differential manifolds," in which oriented matroids are used as a substitute for smooth structure, and thus cohomology classes of the MacPhersonians appear as characteristic classes. Extension spaces are, for example, closely related to zonotopal tilings (via the Bohne-Dress Theorem, see below) and to oriented matroid programs; see Sturmfels & Ziegler [576].

The spaces to be considered here have a lot of interesting structure, but they are huge and hard to treat as global objects, which may account for some of the difficulty of their study. Nevertheless, there is quite some progress in recent work, in particular in the situation of low rank, by Babson [23] and Anderson [12, 13] (on MacPhersonians) and in Sturmfels & Ziegler [576] and Mnëv & Richter-Gebert [460] (on extension spaces). A brief survey is in Mnëv & Ziegler [461].

The problems arising here have close connections to a classical problem of oriented matroid theory: Las Vergnas' conjectures that every oriented matroid has at least one mutation (simplicial tope) and that the set of uniform oriented matroids of rank r on a given finite set is connected under performing mutations. In fact, if these conjectures are false, then the MacPhersonian cannot be connected! As for the Las Vergnas conjecture, Bokowski [101] and Richter-Gebert [497] have the strongest results; more work is neccessary.

Further work also remains in the understanding of weak and strong maps — currently the only comprehensive source is [73, Section 7.7]. One still has to derive structural information from the failure of Las Vergnas' strong map factorization conjecture (disproved by Richter-Gebert in [497]) and derive criteria for situations where factorization is possible.

3.3 Affine and infinite oriented matroids.

The Bohne-Dress Theorem, announced by Andreas Dress at the 1989 "Combinatorics and Geometry" Conference in Stockholm, provides a bijection between the zonotopal tilings of a fixed d-dimensional zonotope Z and the single-element liftings of the realizable oriented matroid associated with Z. This theorem turned out to be, at the same time,

- fundamental (see e. g. the connection to extension spaces of oriented matroids [576]),
- "intuitively obvious" (just draw pictures!), and
- surprisingly hard to prove; see Bohne [92] and Richter-Gebert & Ziegler [505].

This theorem leads to several new areas of study. On the one hand, the classification and enumeration of rhombic tilings of a hexagon relates to the theory of plane partitions and symmetric functions; see e.g. Elnitzky [240], Edelman & Reiner [225].

On the other hand, there is a definite need for a better understanding of zonotopal tilings of the entire plane (or of $\mathbb{R}^d$). Two different approaches have been started by Bohne [93, Kapitel 5] and by Crapo & Senechal [191], but no complete picture has emerged, yet. This is of interest, for example, in view of the mathematical problems posed by understanding quasiperiodic tilings and quasicrystals; see Senechal [536, 537].

3.4 Realization algorithms.

The realizability problem — given a "small" oriented matroid, find a realization or prove that none exists — is a key problem not only in oriented matroid theory, but also for various applications, such as the classification of "small" simplicial spheres into polytopal and non-polytopal ones (see Bokowski & Sturmfels [128, 130], Altshuler, Bokowski & Steinberg [11], Bokowski & Shemer [123]). The universality theorems mentioned above tell us that the problem is hard: in fact, in terms of Complexity Theory is just as hard as the "Existential Theory of the Reals," the problem of solving general systems of algebraic equations and inequalities over the reals. While it is not known whether the problem over $\mathbb{Q}$ is at all algorithmically solvable (see Sturmfels [567]), there are algorithms available that (at least theoretically) solve the problem over the reals. For the general problem Basu, Pollack & Roy [43] currently have the best result:

> Let $\mathcal{P} = \{P_1, \ldots, P_s\}$ be a set of polynomials in $k < s$ variables each of degree at most d and each with coefficients in a subfield $K \subseteq \mathbb{R}$.
> There is an algorithm which finds a solution in each connected component of the solution set, for each sign condition on $P_1, \ldots, P_s$, in at most $\binom{O(s)}{k} s\, d^{O(k)} = (s/k)^k s\, d^{O(k)}$ arithmetic operations in K.

However, until now this is mostly of theoretical value. What can be done for specific, explicit, small examples? Given an oriented matroid of rank 3, it seems that

- the most efficient algorithm (in practice) currently available to *find a realization* (if one exists) is the iterative "rubber band" algorithm described in Pock [481].
- the most efficient algorithm (in practice) currently available to *show that it is not realizable* (if it isn't) is the "binomial final polynomials" algorithm of Bokowski & Richter-Gebert [115] which uses solutions of an auxiliary linear program to construct final polynomials. (An explicit example of a non-realizable oriented matroid Ω_{14}^- without a final polynomial was just recently constructed by Richter-Gebert [503].)

Neither of these two parts is guaranteed to work: but still the combination of both parts was good enough for a (still unpublished) complete classification of all 312,356 (unlabeled reorientation classes of) uniform oriented matroids of rank 3 on 10 points into realizable and non-realizable ones (Bokowski, Laffaille & Richter-Gebert [113]).

A very closely related topic is that of Automatic Theorem Proving in (plane) geometry. In fact, the question of validity of a certain incidence theorem can be viewed as the realizability problem for (oriented or unoriented) matroids of the configuration. Richter-Gebert's Thesis [495] and Wu's book [622] here present two recent (distinct) views of the topic, both with many of its ramifications.

Here we are far from having reached the full scope of current possibilites. For an (impressive) demonstration I refer to the computer geometry system CINDARELLA by Crapo & Richter-Gebert [189] based on the idea of "binomial proofs" [188]. It is amazing to see how much can be achieved here by two persons in just two summers...

4 Some Additions and Corrections.

In this section, I collect some notes, additions, corrections and updates to the 1993 book by Björner, Las Vergnas, Sturmfels, White & Ziegler [73]. The list is far from complete (even in view of the points that I know about), and with your help I plan to expand it in the future.

Page 244, Exercise 5.2(c).

Hochstättler [349] has shown that quite general arrangements of wild spheres also yield oriented matroids.

Page 270, Proposition 6.5.1.

Felsner [247] has constructed a new and especially effective encoding scheme for wiring diagrams, which implies improved upper bound for the number of wiring diagrams and hence of simple pseudoline arrangements, namely

$$\log_2 s_n \; < \; 0.6988\, n^2.$$

Page 334, Exercises 7.15(b)$^{(*)}$ and 7.17.

An example of an oriented matroid that has a simple adjoint, but not a double adjoint was constructed by Hochstättler & Kromberg [351].

Also, they observed [352] that some assertions in Exercise 7.17 are not entirely correct: Jürgen Richter-Gebert's [495, p. 117] 8-point torus is realizable over an ordered *skew field*, but not over $\mathbb{R}$. Therefore the oriented matroid given by such a skew realization has an infinite sequence of adjoints, but it is not realizable in $\mathbb{R}^4$.

Page 337, Exercises 7.44*.

No one seems to remember the example: so consider this to be an open problem. (The non-existence of such an example is also discussed, as a Conjecture of Brylawski, in McNulty [448].)

Page 405 (top).

It is not true that the sphere $\mathcal{S} = M^9_{963}$ is neighborly: the edges 13 and 24 are missing (in the labeling used in [73]). Thus Shemer's Theorem 9.4.13 cannot be applied here. A proof that the sphere admits at most one matroid polytope, AB(9), was given by Bokowski [96] in 1978 (see also Altshuler, Bokowski & Steinberg [11] and Antonin [16]). It is described in detail in Bokowski & Schuchert [121]. (The oriented matroid RS(8) discussed in [73, Sect. 1.5] arises as a contraction of the oriented matroid AB(9).)

Page 413, Exercise 9.12$^{(*)}$.

Bokowski & Schuchert [121] showed that the smallest example (both in terms of its rank $r = 5$ and in terms of its number of vertices $n = 9$), is given by Altshuler's sphere M^9_{963}.

5 The Bibliography.

The purpose of the following is to keep the bibliography of the book [73] up-to-date electronically. For this, the following contains *all* the references of this book (including those which are not directly concerned with oriented matroids). Into this I have inserted all the corrections, missing references, additions and updates that I am currently aware of. Any corrections, new papers concerned with oriented matroids, and other updates that you tell me about will be entered asop. I am eager to hear about your corrections, updates and comments!

References

[1] M. Aigner: *Combinatorial Theory,* Grundlehren Series **234**, Springer 1979.

[2] M. Alfter & W. Hochstättler: *On pseudomodular matroids and adjoints,* Discrete Math. *Appl.* **60** (1995), 3-11.

[3] M. Alfter, W. Kern & A. Wanka: *On adjoints and dual matroids,* J. Combinatorial Theory, Ser. B **50** (1990), 208-213.

[4] L. Allys & M. Las Vergnas: *Minors of matroid morphisms,* J. Combinatorial Theory, Ser. B (1991), to appear (?).*

[5] N. Alon: *The number of polytopes, configurations and real matroids,* Mathematika **33** (1986), 62-71.

[6] N. Alon & E. Györy: *The number of small semispaces of a finite set of points in the plane,* J. Combinatorial Theory, Ser. A **41** (1986), 154-157.

[7] A. Altshuler: *Neighborly* 4*-polytopes and neighborly combinatorial* 3*-manifolds with ten vertices,* Canadian J. Math. **29** (1977), 400-420.

[8] A. Altshuler, J. Bokowski & P. Schuchert: *Spatial polyhedra without diagonals,* Israel J. Math. **86** (1994), 373–396.

[9] A. Altshuler, J. Bokowski & P. Schuchert: *Sphere systems and neighborly spatial polyhedra with* 10 *vertices,* in: First international conference on stochastic geometry, convex bodies and empirical measures, Palermo 1993 (M. Stoka, ed.), Circolo Matematico di Palermo, Suppl. Rend. Circ. Mat. Palermo, II. Ser. **35** (1994), 15-28.

[10] A. Altshuler, J. Bokowski & P. Schuchert: *Neighborly* 2*-manifolds with* 12 *vertices,* Preprint, TH Darmstadt; J. Combinatorial Theory, Ser. B, to appear.

[11] A. Altshuler, J. Bokowski & L. Steinberg: *The classification of simplicial* 3*-spheres with nine vertices into polytopes and nonpolytopes,* Discrete Math. **31** (1980), 115-124.

[12] L. Anderson: *Topology of Combinatorial Differential Manifolds,* Ph. D. Thesis, MIT 1994, 40 pages.

[13] L. Anderson: *All Euclidean combinatorial differential manifolds are PL-manifolds,* Preprint 1995, 29 pages.

[14] L. Anderson & R. Wenger: *Oriented matroids and hyperplane transversals,* Preprint 1994, 8 pages; Advances Applied Math., to appear.

[15] T. Ando: *Totally positive matrices,* Linear Algebra Appl. **90** (1987), 165-219.

[16] C. Antonin: *Ein Algorithmusansatz für Realisierungsfragen im E^d getestet an kombinatorischen* 3*-Sphären,* Staatsexamensarbeit, Universität Bochum 1982.

[17] V. I. Arnol'd: *The cohomology ring of the colored braid group,* Mathematical Notes **5** (1969), 138-140.

[18] S. F. Assmann & D. J. Kleitman: *Characterization of curve map graphs,* Discrete Applied Math. **8** (1984), 109-124.

*References with an asterisk do not really seem to exist.

[19] M. F. Atiyah: *Convexity and commuting Hamiltonians,* Bulletin London Math. Soc. **14** (1982), 1-15.

[20] D. Avis & K. Fukuda: *A basis enumeration algorithm for linear systems with geometric applications,* Applied Math. Letters **4** (1991), 39-42.

[21] D. Avis & K. Fukuda: *A pivoting algorithm for convex hulls and vertex enumeration of arrangements and polyhedra,* Discrete Comput. Geometry **8** (1992), 295-313.

[22] D. Avis & K. Fukuda: *Reverse search for enumeration,* Preprint 1992/93, 24 pages; Discrete Applied Math., to appear.

[23] E. K. Babson: *A Combinatorial Flag Space,* Ph.D. Thesis, MIT 1992/93, 40 pages.

[24] A. Bachem: *Convexity and optimization in discrete structures,* in: "Convexity and Its Applications" (P. M. Gruber, J. Wills, eds.), Birkhäuser, Basel 1983, pp. 9-29.

[25] A. Bachem: *Polyhedral theory in oriented matroids,* in: Mathematical Programming, (Proc. Rio de Janeiro Conf. 1981), North Holland 1984, pp. 1-12.

[26] A. Bachem, A. W. M. Dress & W. Wenzel: *Five variations on a theme by Gyula Farkas,* Advances Appl. Math. **13** (1992), 160-185.

[27] A. Bachem & W. Kern: *Adjoints of oriented matroids,* Combinatorica **6** (1986), 299-308.

[28] A. Bachem & W. Kern: *Extension equivalence of oriented matroids,* European J. Combinatorics **7** (1986), 193-197.

[29] A. Bachem & W. Kern: *A guided tour through oriented matroid axioms,* Acta Math. Appl. Sin. Engl., Ser. 9, No. 2 (1993), 125-134.

[30] A. Bachem & W. Kern: *Linear Programming Duality. An Introduction to Oriented Matroids,* Universitext, Springer-Verlag, Berlin 1992.

[31] A. Bachem & A. Reinhold: *On the complexity of the Farkas property of oriented matroids,* preprint 89.65, Universität Köln 1989.

[32] A. Bachem & A. Wanka: *On intersection properties of (oriented) matroids,* Methods of Operations Research **53** (1985), 227-229.

[33] A. Bachem & A. Wanka: *Separation theorems for oriented matroids,* Discrete Math. **70** (1988), 303-310.

[34] A. Bachem & A. Wanka: *Euclidean intersection properties,* J. Combinatorial Theory, Ser. B **47** (1989), 10-19.

[35] A. Bachem & A. Wanka: *Matroids without adjoints,* Geometriae Dedicata **29** (1989), 311-315.

[36] K. Bacławski & N. White: *Higher order independence in matroids,* J. London Math. Society **19** (1979), 193-202.

[37] M. L. Balinski: *On the graph structure of convex polyhedra in n-space,* Pacific J. Math. **11** (1961), 431-434.

[38] D. W. Barnette: *Diagrams and Schlegel diagrams,* in: Combinatorial Structures and their Applications, Gordon and Breach, New York 1970, pp. 1-4.

[39] D. W. Barnette: *A proof of the lower bound conjecture for convex polytopes,* Pacific J. Math. **46** (1973), 349-354.

[40] D. W. Barnette: *Graph theorems for manifolds,* Israel J. Math. **16** (1973), 62-72.

[41] D. W. Barnette: *Two "simple" 3-spheres,* Discrete Math. **67** (1987), 97-99.

[42] A. I. Barvinok: *On the topological properties of spaces of polytopes,* in: Topology and Geometry — Rohlin Seminar (O.Ya. Viro, ed.), Lecture Notes in Mathematics **1346**, Springer 1988, pp. 495-500.

[43] S. Basu, R. Pollack & M.-F. Roy: *A new algorithm to find a point in every cell defined by a family of polynomials,* in: "Quantifier Elimination and Cylindric Algebraic Decomposition (B. Caviness, J. Johnson, eds.), Texts and Monographs in Symbolic Computation Springer-Verlag, Wien, New-York, to appear.

[44] M. M. Bayer, C. W. Lee: *Combinatorial aspects of convex polytopes,* in: *Handbook of Convex Geometry* (P. Gruber, J. Wills, eds.), North-Holland, Amsterdam 1993, pp. 485–534.

[45] M. Bayer & B. Sturmfels: *Lawrence polytopes,* Canadian J. Math. **42** (1990), 62-79.

[46] E. Becker: *On the real spectrum of a ring and its applications to semialgebraic geometry,* Bulletin Amer. Math. Soc. **15** (1986), 19-60.

[47] R. Benedetti & J.-J. Risler: *Real Algebraic and Semi-algebraic Sets,* Hermann, Paris 1990.

[48] C. T. Benson & L. C. Grove: *Finite Reflection Groups (second edition),* Springer 1985.

[49] C. Berge & M. Las Vergnas: *Transversals of circuits and acyclic orientation in graphs and matroids,* Discrete Math. **50** (1984), 107-108.

[50] M. Bern & P. Eppstein & P. Plassmann & F. Yao: *Horizon theorems for lines and polygons,* in: Discrete and Computational Geometry: Papers from the DIMACS Special Year (ed. J. E. Goodman, R. Pollack, W. Steiger), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Vol. 6, Amer. Math. Soc. 1991, pp. 45-66.

[51] W. Bienia & R. Cordovil: *An axiomatic of non-Radon partitions of oriented matroids,* European J. Combinatorics **8** (1987), 1-4.

[52] W. Bienia & I. P. da Silva: *On the inversion of one base sign in an oriented matroid,* J. Combinatorial Theory Ser. B **90** (1990), 299-308.

[53] W. Bienia & M. Las Vergnas: *Positive dependence in oriented matroids,* preprint 1990.

[54] D. Bienstock: *Some provably hard crossing number problems,* Proc. 6th ACM Ann. Symp. on Computational Geometry (Berkeley, June 1990), ACM 1990, pp. 253-260.

[55] L. J. Billera, P. Filliman & B. Sturmfels: *Constructions and complexity of secondary polytopes,* Advances in Math. **83** (1990), 155-179.

[56] L. J. Billera, I. M. Gel'fand & B. Sturmfels: *Duality and minors of secondary polyhedra,* J. Combinatorial Theory, Ser. B **57** (1993), 258–268.

[57] L. J. Billera, M. M. Kapranov & B. Sturmfels: *Cellular strings on polytopes,* Proc. Amer. Math. Soc. **122** (1994), 549–555.

[58] L. J. Billera & C. W. Lee: *A proof of the sufficiency of McMullen's conditions for f-vectors of simplicial polytopes,* J. Combinatorial Theory Ser. A **31** (1981), 237-255.

[59] L. J. Billera & B. S. Munson: *Polarity and inner products in oriented matroids,* European J. Combinatorics **5** (1984), 293-308.

[60] L. J. Billera & B. S. Munson: *Oriented matroids and triangulations of convex polytopes,* in: Progress in Combinatorial Optimization (Proc. Waterloo Silver Jubilee Conference 1982), Academic Press, Toronto 1984, 17-37.

[61] L. J. Billera & B. S. Munson: *Triangulations of oriented matroids and convex polytopes,* SIAM J. Algebraic Discrete Methods **5** (1984), 515-525.

[62] L. J. Billera & B. Sturmfels: *Fiber polytopes,* Annals of Mathematics **135** (1992), 527–549.

[63] L. J. Billera & B. Sturmfels: *Iterated fiber polytopes,* Mathematika **41** (1994), 348-363.

[64] R H Bing: *Some aspects of the topology of 3-manifolds related to the Poincaré conjecture,* in: Lectures on Modern Mathematics, Vol. II (T.L. Saaty, ed.), Wiley 1964, pp. 93-128.

[65] A. Björner: *Shellable and Cohen-Macaulay partially ordered sets,* Transactions Amer. Math. Soc. **260** (1980), 159-183.

[66] A. Björner: *On complements in lattices of finite length,* Discrete Math. **36** (1981), 325-326.

[67] A. Björner: *Posets, regular CW complexes and Bruhat order,* Europ. J. Combinatorics **5** (1984), 7-16.

[68] A. Björner: *Orderings of Coxeter groups,* in: Combinatorics and Algebra (C. Greene, ed.), Contemporary Math. **34** (1984), 175-195.

[69] A. Björner: *Some combinatorial and algebraic properties of Coxeter complexes and Tits buildings,* Advances in Math. (1984) **52**, 173-212.

[70] A. Björner: *Topological methods,* preprint 1991; in: *Handbook of Combinatorics* (R. Graham, M. Grötschel, L. Lovász, eds.), North Holland, Amsterdam 1995, to appear.

[71] A. Björner, P. H. Edelman & G. M. Ziegler: *Hyperplane arrangements with a lattice of regions, Discrete Comput. Geometry* **5** (1990), 263-288.

[72] A. Björner & G. Kalai: *Extended Euler-Poincaré relations for cell complexes,* in: *Applied Geometry and Discrete Mathematics – The Victor Klee Festschrift* (P. Gritzmann, B. Sturmfels, eds.), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Amer. Math. Soc. **4** (1991), 81-89.

[73] A. Björner, M. Las Vergnas, B. Sturmfels, N. White & G. M. Ziegler: *Oriented Matroids, Encyclopedia of Mathematics*, Vol. 46, Cambridge University Press 1993.

[74] A. Björner & M. Wachs: *On lexicographically shellable posets, Transactions Amer. Math. Soc.* **277** (1983), 323-341.

[75] A. Björner & G. M. Ziegler: *Shellability of oriented matroids,* Abstract, Workshop on *Simplicial Complexes*, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, March 1988; and Abstract, Conf. on *Ordered Sets*, Oberwolfach, April 1988.

[76] A. Björner & G. M. Ziegler: *Combinatorial stratification of complex arrangements, J. Amer. Math. Soc.* **5** (1992), 105-149.

[77] A. Björner & G. M. Ziegler: *Reflections in oriented matroids and finite Coxeter groups,* in preparation.*

[78] R. G. Bland: *Complementary orthogonal subspaces of $\mathbb{R}^n$ and orientability of matroids,* Ph.D. Thesis, Cornell University 1974, 80 pages.

[79] R. G. Bland: *A combinatorial abstraction of linear programming, J. Combinatorial Theory* Ser. B **23** (1977), 33-57.

[80] R. G. Bland: *New finite pivoting rules for the simplex method, Math. Operations Research* **2** (1977), 103-107.

[81] R. G. Bland: *Linear programming duality and Minty's lemma,* preprint, Cornell University 1980, 43 pages.

[82] R. G. Bland & D. E. Cho, *Balancing configurations in $\mathbb{R}^d$ by reflection of points,* preprint, Cornell University 1987, 60 pages.

[83] R. G. Bland & B. L. Dietrich: *A unified interpretation of several combinatorial dualities,* preprint, Cornell University 1987, 41 pages.

[84] R. G. Bland & B. L. Dietrich: *An abstract duality, Discrete Math.* **70** (1988), 203-208.

[85] R. G. Bland & D. L. Jensen: *Weakly oriented matroids,* preprint, Cornell University 1987, 40 pages.

[86] R. G. Bland & M. Las Vergnas: *Orientability of matroids, J. Combinatorial Theory* Ser. B **24** (1978), 94-123.

[87] R. G. Bland & M. Las Vergnas: *Minty colorings and orientations of matroids, Annals of the New York Acadademy of Sciences* **319** (1979), 86-92.

[88] A. Blass & B. E. Sagan: *Bijective proofs of two broken circuit theorems, J. Graph Theory* **10** (1986), 15-21.

[89] G. Blind & R. Blind: *Convex polytopes without triangular faces, Israel J. Math.* **71** (1990), 129-134.

[90] R. Blind & P. Mani: *On puzzles and polytope isomorphism, Aequationes Math.* **34** (1987), 287-297.

[91] L. M. Blumenthal: *Theory and Applications of Distance Geometry,* Oxford University Press (Clarendon Press) 1953; reprinted by Chelsea, New York 1970.

[92] J. Bohne: *A characterization of oriented matroids in terms of conformal sequences, Bayreuther Math. Schriften* **40** (1992), 1-5.

[93] J. Bohne: *Eine kombinatorische Analyse zonotopaler Raumaufteilungen,* Dissertation, Bielefeld 1992; Preprint 92-041, SFB 343, Universität Bielefeld 1992, 100 pages.

[94] J. Bohne & A. W. M. Dress: *Penrose tilings and oriented matroids,* in preparation.*

[95] J. Bohne & A. W. M. Dress & S. Fischer: *A simple proof for De Bruijn's dualization principle,* in: *Some elementary proofs for some elementary facts in algebra and geometry*, preprint 89-027, SFB 343, Bielefeld 1989, 8 pages; in: *Proceedings of the Raj Chandra Bose Memorial Conference on Combinatorial Mathematics and Applications*, Calcutta, India, *Sankhya*, Ser. A, **54**, ??.

[96] J. Bokowski: *A non-polytopal sphere,* preprint 1978, 4 pages.

[97] J. Bokowski: *Geometrische Realisierbarkeitsfragen – Chirotope und orientierte Matroide,* in: Proc. 3. Kolloq. *Discrete Geometrie* (Salzburg 1985), 53-57.

[98] J. Bokowski: *Aspects of computational synthetic geometry; II. Combinatorial complexes and their geometric realization – an algorithmic approach,* in: *Computer-aided geometric reasoning* (H.H. Crapo, ed.), INRIA Rocquencourt, France, June 1987.

[99] J. Bokowski: *A geometric realization without self-intersections does exist for Dyck's regular map, Discrete Comput. Geometry* **4** (1989), 583-589.

[100] J. Bokowski: *On the generation of oriented matroids with prescribed topes,* preprint 1291, TH Darmstadt 1990, 11 pages.

[101] J. Bokowski: *On the Las Vergnas conjecture concerning simplicial cells in pseudo-plane arrangements,* preprint, 5 pages, 1991.

[102] J. Bokowski: *Oriented matroids,* Chapter 2.5 in: *Handbook of Convex Geometry* (eds. P. Gruber, J. Wills), North-Holland, Amsterdam, 1993, 555-602.

[103] J. Bokowski: *On recent progress in computational synthetic geometry,* in: *Polytopes: Abstract, Convex and Computational* (T. Bisztriczky, P. McMullen, and A. Weiss, eds.), Proc. NATO Advanced Study Institute, Toronto 1993, Kluwer Academic Publishers 1994, pp. 335-358.

[104] J. Bokowski: *On the construction of equifacetted* 3*-spheres,* preprint 1704, TH Darmstadt 1994, 12 pages.

[105] J. Bokowski & U. Brehm: *A new polyhedron of genus* 3 *with* 10 *vertices,* in: Papers Int. Conf. *Intuitive Geometry* (K. Böröczky, G. Fejes Tóth, eds.), Siófok/Hungary 1985, *Colloquia Math. Soc. János Bolyai* **48** (1985), 105-116.

[106] J. Bokowski & A. Eggert: *All realization of Möbius' torus with* 7 *vertices, Structural Topology* **17** (1991), 59-78.

[107] J. Bokowski, G. Ewald & P. Kleinschmidt: *On combinatorial and affine automorphisms of polytopes, Israel J. Math.* **47** (1984), 123-130.

[108] J. Bokowski & K. Garms: *Altshuler's sphere M^{10}_{425} is not polytopal, European J. Combinatorics* **8** (1987), 227-229.

[109] J. Bokowski & A. Guedes de Oliveira: *Simplicial convex* 4*-polytopes do not have the isotopy property, Portugaliae Mathematica* **47** (1990), 309-318.

[110] J. Bokowski & A. Guedes de Oliveira: *Invariant theory-like theorems for matroids and oriented matroids, Advances Math.* **109** (1994), 34-44.

[111] J. Bokowski, A. Guedes de Oliveira & J. Richter: *Algebraic varieties characterizing matroids and oriented matroids,* Advances in Mathematics **87** (1991), 160-185.

[112] J. Bokowski, A. Guedes de Oliveira, U. Thiemann & A. Veloso da Costa: *On the cube problem of Las Vergnas,* Preprint 1995, 15 pages.

[113] J. Bokowski, G. Laffaille & J. Richter-Gebert: *Classification of non-stretchable pseudoline arrangements and related properties,* in preparation, 1991.*

[114] J. Bokowski & W. Kollewe: *On representing contexts in line arrangements, Order* **8** (1992), 393-403.

[115] J. Bokowski & J. Richter: *On the finding of final polynomials,* European J. Combinatorics **11** (1990), 21-34.

[116] J. Bokowski & J. Richter-Gebert: *On the classification of non-realizable oriented matroids, Part I: Generation,* preprint 1283, TH Darmstadt 1990, 17 pages.

[117] J. Bokowski & J. Richter-Gebert: *On the classification of non-realizable oriented matroids, Part II: Properties,* preprint, TH Darmstadt 1990, 22 pages.

[118] J. Bokowski & J. Richter-Gebert: *A new Sylvester-Gallai configuration representing the 13-point projective plane in* $\mathbb{R}^4$, J. Combinatorial Theory Ser. B, **54** (1992), 161-165.

[119] J. Bokowski, J. Richter-Gebert & W. Schindler: *On the distribution of order types,* Computational Geometry: Theory and Applications **1** (1992), 127-142.

[120] J. Bokowski, J. Richter & B. Sturmfels: *Nonrealizability proofs in computational geometry,* Discrete Comput. Geometry **5** (1990), 333-350.

[121] J. Bokowski & P. Schuchert: *Altshuler's sphere* M^9_{963} *revisited,* SIAM J. Discrete Math. **8** (1995), 670-677.

[122] J. Bokowski & P. Schuchert: *Equifacetted 3-spheres as topes of nonpolytopal matroid polytopes,* in: "The László Fejes Tóth Festschrift" (I. Bárány, J Pach, eds.), Discrete Comput. Geometry **13** (1995), 347-361.

[123] J. Bokowski & I. Shemer: *Neighborly 6-polytopes with 10 vertices,* Israel J. Math. **58** (1987), 103-124.

[124] J. Bokowski & B. Sturmfels: *Problems of geometrical realizability — oriented matroids and chirotopes,* preprint 901, TH Darmstadt 1985, 20 pages.

[125] J. Bokowski & B. Sturmfels: *Programmsystem zur Realisierung orientierter Matroide,* Programmdokumentation, Preprints in Optimization 85.22, Universtät Köln 1985, 33 pages.

[126] J. Bokowski & B. Sturmfels: *On the coordinatization of oriented matroids,* Discrete Comput. Geometry **1** (1986), 293-306.

[127] J. Bokowski & B. Sturmfels: *Reell realisierbare orientierte Matroide,* Bayreuther Math. Schriften **21** (1986), 1-13.

[128] J. Bokowski & B. Sturmfels: *Polytopal and nonpolytopal spheres – an algorithmic approach,* Israel J. Math. **57** (1987), 257-271.

[129] J. Bokowski & B. Sturmfels: *An infinite family of minor-minimal nonrealizable 3-chirotopes,* Math. Zeitschrift **200** (1989), 583-589.

[130] J. Bokowski & B. Sturmfels: *Computational Synthetic Geometry,* Lecture Notes in Mathematics **1355** (1989), Springer, Heidelberg.

[131] A. V. Borovik & I. M. Gelfand: *WP-matroids and thin Schubert cells on Tits systems,* Advances Math. **103** (1994), 162-179.

[132] N. Bourbaki: *Groupes et Algèbres de Lie, Chap. 4,5, et 6,* Hermann, Paris 1968.

[133] K. S. Brown: *Buildings,* Springer, New York 1989.

[134] H. Bruggesser & P. Mani: *Shellable decompositions of cells and spheres,* Math. Scand. **29** (1971), 197-205.

[135] T. H. Brylawski & G. M. Ziegler: *Topological representation of dual pairs of oriented matroids,* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), Discrete Comput. Geometry (3) **10** (1993), 237-240.

[136] J. R. Buchi & W. E. Fenton: *Large convex sets in oriented matroids,* J. Combinatorial Theory Ser. B **45** (1988), 293-304.

[137] R. C. Buck: *Partitions of space,* Amer. Math. Monthly **50** (1943), 541-544.

[138] P. Camion: *Matrices totalement unimodulaires et problèmes combinatoires,* Thesis, Univ. Brussels 1963.

[139] P. Camion: *Modules unimodulaires,* J. Combinatorial Theory **4** (1968), 301-362.

[140] R. J. Canham: Ph.D. Thesis, Univ. of East Anglia, Norwich 1971.

[141] J. Canny: *Some algebraic and geometric computations in PSPACE, Proc. 20th ACM Symposium on Theory of Computing*, Chicago, May 1988.

[142] S. E. Cappell, J. E. Goodman, J. Pach, R. Pollack, M. Sharir & R. Wenger: *The combinatorial complexity of hyperplane transversals, Proc. 6th ACM Annual Symposium on Computational Geometry*, (Berkeley, June 1990), ACM 1990, pp. 83-91.

[143] S. E. Cappell, J. E. Goodman, J. Pach, R. Pollack, M. Sharir & R. Wenger: *Common tangents and common transversals, Advances Math.* **106** (1994), 198-215.

[144] C. Carathéodory: *Über den Variabilitätsbereich der Koeffizienten von Potenzreihen die gegebene Werte nicht annehmen, Math. Annalen* **64** (1904), 95-115.

[145] S. Chaiken: *Oriented matroid pairs, theory and and electric application,* preprint 1995, 5 pages; posters, 32 pages.

[146] G. D. Chakerian: *Sylvester's problem on collinear points and a relative, American Math. Monthly* **77** (1970), 164-167.

[147] A. L. C. Cheung: *Adjoints of a geometry, Canadian Math. Bulletin,* **17** (1974), 363-365.

[148] A. L. C. Cheung & H. H. Crapo: *A combinatorial perspective on algebraic geometry, Advances in Math.* **20** (1976), 388-414.

[149] V. Chvátal: *Linear Programming,* Freeman, New York 1983.

[150] J. Clausen: *A note on the Edmonds-Fukuda pivoting rule for simplex algorithms, European J. Operational Research* **29** (1987), 378-383.

[151] J. Clausen & T. Terlaky: *On the feasibility of the Edmonds-Fukuda pivoting rule for oriented matroid programming,* preprint 1987, 16 pages.

[152] C. Collins: *Quantifier elimination for real closed fields by cylindrical algebraic decomposition,* in: *Automata Theory and Formal Languages* (H. Brakhage, ed.), Springer Lecture Notes in Computer Science **33** (1975), 134-163.

[153] G. E. Cooke & R. L. Finney: *Homology of Cell Complexes,* Princeton University Press 1967.

[154] R. Cordovil: *Sur les orientations acycliques des géométries orientées de rang* 3*,* Actes du *Colloque International sur la Theorie des Graphes et la Combinatoire* (Marseilles 1981), *Ann. Discrete Math.* **9** (1980), 243-246.

[155] R. Cordovil: *Sur l'évaluation* $t(M;2,0)$ *du polynôme de Tutte d'un matroïde et une conjecture de B. Grünbaum relative aux arrangements de droites du plan, European J. Combinatorics* **1** (1980), 317-322.

[156] R. Cordovil: *Quelques propriétés algébriques des matroïdes,* Thèse, Université Paris VI, 1981, 167 pages.

[157] R. Cordovil: *Sur les matroïdes orientés de rang* 3 *et les arrangements de pseudodroites dans le plan projectif réel, European J. Combinatorics* **3** (1982), 307-318.

[158] R. Cordovil: *Sur un théorème de séparation des matroïdes orientés de rang* 3*, Discrete Math.* **40** (1982), 163-169.

[159] R. Cordovil: *The directions determined by n points in the plane: a matroidal generalization, Discrete Math.* **43** (1983), 131-137.

[160] R. Cordovil: *Oriented matroids of rank three and arrangements of pseudolines, Ann. Discrete Math.* **17** (1983), 219-223.

[161] R. Cordovil: *Oriented matroids and geometric sorting, Canad. Math. Bull.* **26** (1983), 351-354.

[162] R. Cordovil: *A combinatorial perspective on non-Radon partitions, J. Combinatorial Theory,* Ser. A **38** (1985), 38-47. (Erratum, ibid. **40**, 194.)

[163] R. Cordovil: *On the number of lines determined by n points,* preprint 1986, 16 pages.

[164] R. Cordovil: *Polarity and point extensions in oriented matroids, Linear Algebra and its Appl.* **90** (1987), 15-31.

[165] R. Cordovil: *On the homotopy type of the Salvetti complexes determined by simplicial arrangements,* European J. Combinatorics **15** (1994), 207-215.

[166] R. Cordovil: *On the center of the fundamental group of the complement of an arrangement of hyperplanes,* Portugaliae Math. **51** (1994), 363-373.

[167] R. Cordovil & I. P. da Silva: *A problem of McMullen on the projective equivalence of polytopes,* European J. Combinatorics **6** (1985), 157-161.

[168] R. Cordovil & I.P. da Silva: *Determining a matroid polytope by non-Radon partitions,* Linear Algebra Appl. **94** (1987), 55-60.

[169] R. Cordovil & P. Duchet: *Séparation par une droite dans les matroïdes orientés de rang* 3, Discrete Math. **62** (1986), 103-104.

[170] R. Cordovil & P. Duchet: *Cyclic polytopes and oriented matroids,* preprint 1987, 17 pages.

[171] R. Cordovil & P. Duchet: *On the sign-invariance graphs of uniform oriented matroids,* Discrete Math. **79** (1989/90), 251-257.

[172] R. Cordovil & J. L. Fachada: *Braid monodromy groups and wiring diagrams,* Bolletino U. M. I. **9-B** (1995), 399-416.

[173] R. Cordovil & K. Fukuda: *Oriented matroids and combinatorial manifolds,* European J. Combinatorics **14** (1993), 9-15.

[174] R. Cordovil, K. Fukuda & A. Guedes de Oliveira: *On the cocircuit graph of an oriented matroid,* preprint 1991, 11 pages.

[175] R. Cordovil & A. Guedes de Oliveira: *A note on the fundamental group of the Salvetti complex determined by an oriented matroid,* Europ. J. Combinatorics **13** (1992), 429-437.

[176] R. Cordovil, A. Guedes de Oliveira & M. Las Vergnas: *A generalized Desargues configuration and the pure braid group,* preprint 1992, 13 pp.

[177] R. Cordovil, A. Guedes de Oliveira & M. L. Moreira: *Parallel projection of matroid spheres,* Portugaliae Mathematica **45** (1988), 337-346.

[178] R. Cordovil, M. Las Vergnas & A. Mandel: *Euler's relation, Möbius functions and matroid identities,* Geometriae Dedicata **12** (1982), 147-162.

[179] R. Cordovil & M. L. Moreira: *A homotopy theorem on oriented matroids,* Discrete Math. **111** (1993), 131-136.

[180] M.-F. Coste-Roy, J. Heintz & P. Solerno: *On the complexity of semialgebraic sets,* preprint 1989.

[181] M.-F. Coste-Roy, J. Heintz & P. Solerno: *Description of the connected components of a semialgebraic set in single exponential time,* Discrete Comput. Geometry **11** (1994), 121-140.

[182] H. S. M. Coxeter: *The complete enumeration of finite groups of the form* $R_i^2 = (R_iR_j)^{k_{ij}} = 1$, J. London Math. Soc. **10** (1935), 21-25.

[183] H. S. M. Coxeter: *The classification of zonohedra by means of projective diagrams,* Journal de Math. Pures Appl. **41** (1962), 137-156.

[184] H. S. M. Coxeter: *Regular Polytopes (third edition),* Dover, New York 1973.

[185] H. H. Crapo: *Single-element extensions of matroids,* J. Research Nat. Bureau Standards **69B** (1965), 55-65.

[186] H. H. Crapo & J.-P. Laumond: *Hamiltonian cycles in Delaunay complexes,* in: Geometry and Robotics (J.-D. Boinsonnat et J.-P. Laumond, eds.), Lecture Notes in Computer Science, Springer 1989, 292-305.

[187] H. H. Crapo & R. Penne: *Chirality and the isotopy classification of skew lines in projective 3-space,* Advances in Math. **103** (1994), 1-106.

[188] H. Crapo & J. Richter-Gebert: *Automatic proving of geometric theorems,* in: Proc. Conference "Invariant Methods in Discrete and Computational Geometry," Williamstadt, Curacao 1994, Kluwer Academic Publishers, to appear.

[189] H. CRAPO & J. RICHTER-GEBERT: *CINDERELLA Computer Interactive Drawing Environment,* work in progress, 1992/94; contact: `richter@math.tu-berlin.de`

[190] H. H. CRAPO & G.-C. ROTA: *Combinatorial Geometries,* MIT Press 1970.

[191] H. CRAPO & M. SENECHAL: *Tilings by related zonotopes,* preprint 1995, 14 pages; Mathematical and Computer Modelling, to appear.

[192] G. M. CRIPPEN & T. F. HAVEL: *Distance Geometry and Molecular Conformation,* Research Studies Press, Taunton/England, 1988.

[193] J. CSIMA & E.T. SAWYER: *There exist* $6n/13$ *ordinary points,* Discrete Comput. Geometry **9** (1993), 187-202.

[194] G. DANARAJ & V. KLEE: *Shellings of spheres and polytopes,* Duke Math. J. **41** (1974), 443-451.

[195] G. B. DANTZIG: *Linear Programming and Extensions,* Princeton University Press 1963.

[196] I. P. DA SILVA: *Quelques propriétés des matroïdes orientés,* Dissertation, Université Paris VI, 1987, 131 pages.

[197] I. P. DA SILVA: *An axiomatic for the set of maximal vectors of an oriented matroid based on symmetry properties of the set of vectors,* preprint 1988, 18 pages.

[198] I. P. F. DA SILVA: *Axioms for maximal vectors of an oriented matroid: a combinatorial characterization of the regions determined by an arrangement of pseudohyperplanes,* European J. Combinatorics **16** (1995), 125-145.

[199] I. P. F. DA SILVA: *On fillings of* $2N$*-gons with rhombi,* Discrete Math. **111** (1993), 137-144.

[200] I. P. F. DA SILVA: *On inseparability graphs of matroids having exactly one class of orientations,* preprint 1993, 7 pages.

[201] I. P. F. DA SILVA: *An intersection property defining series-parallel networks,* preprint 1993, 18 pages; preprint 1994, 30 pages.

[202] R. J. DAVERMAN: *Decompositions of Manifolds,* Academic Press, 1986.

[203] P. DELIGNE: *Les immeubles des groupes de tresses généralisés,* Inventiones Math. **17** (1972), 273-302.

[204] J. A. DE LOERA, S. HOŞTEN, F. SANTOS, B. STURMFELS, *The polytope of all triangulations of a point configuration,* Preprint 1995, 17 pages; Documenta Mathematica, to appear.

[205] P. DELSARTE & Y. KAMP: *Low rank matrices with a given sign pattern, SIAM J. Discrete Math.* **2** (1989), 51-63.

[206] M. DEZA & K. FUKUDA: *On bouquets of matroids and orientations,* Publ. R.I.M.S. Kyoto University, Kokyuroku **587** (1986), 110-129.

[207] M. B. DILLENCOURT: *An upper bound on the shortness exponent of inscribable polytopes,* J. Combinatorial Theory, Ser. B **46** (1989), 66-83.

[208] A. DREIDING, A. W. M. DRESS & H. HAEGI: *Classification of mobile molecules by category theory,* Studies in Physical and Theoretical Chemistry **23** (1982), 39-58.

[209] A. DREIDING & K. WIRTH: *The multiplex. A classification of finite ordered point sets in oriented d-dimensional space,* Math. Chemistry **8** (1980), 341-352.

[210] A. W. M. DRESS: *Duality theory for finite and infinite matroids with coefficients,* Advances in Math. **59** (1986), 97-123.

[211] A. W. M. DRESS: *Chirotops and oriented matroids,* Bayreuther Math. Schriften **21** (1986), 14-68.

[212] A. W. M. DRESS & R. SCHARLAU: *Gated sets in metric spaces,* Aequationes Mathematicae **34** (1987), 112-200.

[213] A. W. M. DRESS & W. WENZEL: *Endliche Matroide mit Koeffizienten,* Bayreuther Math. Schriften **26** (1988), 37-98.

[214] A. W. M. DRESS & W. WENZEL: *Geometric algebra for combinatorial geometries,* Advances in Math. **77** (1989), 1-36.

[215] A. W. M. Dress & W. Wenzel: *On combinatorial and projective geometry,* Geometriae *Dedicata* **34** (1990), 161-197.

[216] A. W. M. Dress & W. Wenzel: *Grassmann-Plücker relations and matroids with coefficients, Advances in Mathematics* **86** (1991), 68-110.

[217] A. W. M. Dress & W. Wenzel: *Perfect matroids, Advances in Math.* **91** (1992), 158-208.

[218] A. W. M. Dress & W. Wenzel: *Valuated matroids, Advances in Math.* **93** (1992), 214-250.

[219] P. H. Edelman: *Meet-distributive lattices and the anti-exchange closure,* Algebra Universalis **10** (1980), 290-299.

[220] P. H. Edelman: *The lattice of convex sets of an oriented matroid,* J. Combinatorial Theory Ser. B **33** (1982), 239-244.

[221] P. H. Edelman: *The acyclic sets of an oriented matroid,* J. Combinatorial Theory Ser. B **36** (1984), 26-31.

[222] P. H. Edelman: *A partial order on the regions of $\mathbb{R}^n$ dissected by hyperplanes,* Transactions *Amer. Math. Soc.* **283** (1984), 617-631.

[223] P. H. Edelman & C. Greene: *Balanced tableaux, Advances in Math.* **63** (1987), 42-99.

[224] P. H. Edelman & R. E. Jamison: *The theory of convex geometries,* Geometriae Dedicata **19** (1985), 247-270.

[225] P. H. Edelman & V. Reiner: *Free arrangements and tilings,* preprint 1994, 31 pages.

[226] P. H. Edelman & V. Reiner: *The higher Stasheff-Tamari posets,* Preprint 1995, 28 pages; *Mathematika*, to appear.

[227] P. H. Edelman & J.W. Walker: *The homotopy type of hyperplane posets,* Proceedings Amer. *Math. Soc.* **94** (1985), 329-332.

[228] H. Edelsbrunner: *Algorithms in Computational Geometry,* Springer 1987.

[229] H. Edelsbrunner & L. J. Guibas: *Topologically sweeping an arrangement,* J. Computer and *System Sciences* **38** (1989), 165-194.

[230] H. Edelsbrunner & E. P. Mücke: *Simulation of simplicity: A technique to cope with degenerate cases in geometric algorithms,* Fourth Annual ACM Symposium on Computational *Geometry* 1988, pp. 118-133.

[231] H. Edelsbrunner, J. O'Rourke & R. Seidel: *Constructing arrangements of lines and hyperplanes with applications, SIAM J. Computing* **15** (1986), 341-363.

[232] H. Edelsbrunner & R. Seidel: *Voronoi diagrams and arrangements,* Discrete Comput. Ge*ometry* **1** (1986), 25-44.

[233] H. Edelsbrunner, R. Seidel & M. Sharir: *On the zone theorem for hyperplane arrangements, SIAM J. Computing* **22** (1993), 418-429.

[234] H. Edelsbrunner & E. Welzl: *On the number of line separations of a finite set in the plane,* J. Combinatorial Theory Ser. A **38** (1985), 15-29.

[235] J. Edmonds: *Submodular functions, matroids and certain polyhedra,* in: *Combinatorial Structures and their Applications*, (H. Hanani, N. Sauer and J. Schönheim, eds.) Gordon and Breach, New York 1970, pp. 69-87.

[236] J. Edmonds & K. Fukuda: *Oriented matroid programming,* Ph.D. Thesis of K. Fukuda, University of Waterloo 1982, 223 pages.

[237] J. Edmonds, L. Lovász & A. Mandel: *Solution, Math. Intelligencer* **2** (1980), 107.

[238] J. Edmonds & A. Mandel: *Topology of oriented matroids,* Abstract 758-05-9, *Notices Amer. Math. Soc.* **25** (1978), A-510.

[239] J. Edmonds & A. Mandel: *Topology of oriented matroids,* Ph.D. Thesis of A. Mandel, University of Waterloo 1982, 333 pages.

[240] S. Elnitzky: *Rhombic tilings of polygons and classes of reduced words in Coxeter groups,* Ph. D. Thesis, University of Michigan, 1993.

[241] P. Erdös & G. Purdy: *Some extremal problems in combinatorial geometry,* in: Handbook of Combinatorics (R. Graham, M. Grötschel, L. Lovász, eds.), North-Holland, Amsterdam 1995, to appear.

[242] P. Erdös & G. Szekeres: *A combinatorial problem in geometry,* Compositio Math. **2** (1935), 463-470.

[243] G. Ewald, P. Kleinschmidt, U. Pachner & C. Schulz: *Neuere Entwicklungen in der kombinatorischen Konvexgeometrie,* in: Contributions to Geometry (J. Tölke, J. Wills, eds.), Proc. Geometry Symposium Siegen 1978, Birkhäuser 1979, pp. 131-163.

[244] U. Faigle: *Orthogonal sets, matroids, and theorems of the alternative,* Bolletino U.M.I. **4-B** (1985), 139-153.

[245] M. J. Falk: *Geometry and topology of hyperplane arrangements,* Ph.D. Thesis, University of Wisconsin, Madison 1983, 103 pages.

[246] M. J. Falk: *On the algebra associated with a geometric lattice,* Advances in Math. **80** (1990), 152-163.

[247] S. Felsner: *On the number of arrangements of pseudolines,* Preprint, FU Berlin 1995, 10 pages.

[248] W. Fenchel: *Convexity through the ages,* in: Convexity and its applications (P. Gruber, J. Wills, eds.), Birkhäuser 1983, pp. 120-130.

[249] W. E. Fenton: *Axiomatic of convexity theory,* Ph.D. Thesis, Purdue Univ. 1982, 98 pages.

[250] W. E. Fenton: *Completeness in oriented matroids,* Discrete Math. **66** (1987), 79-89.

[251] S. M. Finashin: *Configurations of seven points in* $\mathbb{RP}^3$*,* in: Topology and Geometry — Rohlin Seminar (O.Ya. Viro, ed.), Lecture Notes in Mathematics **1346** (1988), Springer, pp. 501-526.

[252] J. Folkman & J. Lawrence: *Oriented matroids,* J. Combinatorial Theory, Ser. B **25** (1978), 199-236.

[253] K. Fukuda: *Oriented matroids and linear programming,* (in Japanese), Proceedings of the 15th Symposium of the Operations Research Society of Japan, 1986, pp. 8-14.

[254] K. Fukuda & K. Handa: *Perturbations of oriented matroids and acycloids,* preprint 1985, 18 pages.

[255] K. Fukuda & K. Handa: *Antipodal graphs and oriented matroids,* Discrete Math. **111** (1993), 245-256.

[256] K. Fukuda & T. Matsui: *On the finiteness of the crisscross method,* European Journal of Operational Research **52** (1991), 119-124.

[257] K. Fukuda & T. Matsui: *Elementary inductive proofs for linear programming,* Publ. R.I.M.S. Kyoto University, Kokyuroku 1989.

[258] K. Fukuda, S. Saito & A. Tamura: *Combinatorial face enumeration in arrangements and oriented matroids,* Discrete Appl. Math.. **31** (1991), 141-149.

[259] K. Fukuda, S. Saito, A. Tamura & T. Tokuyama: *Bounding the number of k-faces in arrangements of hyperplanes,* Discrete Appl. Math. **31** (1991), 151-165.

[260] K. Fukuda & A. Tamura: *Local deformation and orientation transformation in oriented matroids,* Ars Combinatoria **25A** (1988), 243-258.

[261] K. Fukuda & A. Tamura: *Local deformation and orientation transformation in oriented matroids II,* preprint, Research Reports on Information Sciences B-212, Tokyo Institute of Technology 1988, 22 pages.

[262] K. Fukuda & A. Tamura: *Characterizations of $*$-families,* J. Combinatorial Theory, Ser. B **47** (1989), 107-110.

[263] K. Fukuda & A. Tamura: *Dualities in signed vector spaces,* Portugaliae Mathematica **47** (1990), 151-165.

[264] K. Fukuda, A. Tamura & T. Tokuyama: *A theorem on the average number of subfaces in arrangements and oriented matroids,* Geom. Dedicata **47** (1993), 129-142.

[265] K. FUKUDA & T. TERLAKY: *A general algorithmic framework for quadratic programming and a generalization of Edmonds-Fukuda rule as a finite version of Van de Panne-Whinston method,* preprint 1989, 18 pages.

[266] K. FUKUDA & T. TERLAKY: *Linear complementarity and oriented matroids, J. Operations Research Society of Japan* **35** (1992), 45-61.

[267] D. R. FULKERSON: *Networks, frames, blocking systems,* in: Mathematics of the Decision Sciences, Part I, (G.B. Dantzig, A.F. Vienot eds.) Lectures in Applied Mathematics **2**, Amer. Math. Soc. 1968, pp. 303-334.

[268] B. GÄRTNER: *Set systems of bounded Vapnik-Chervonenkis dimension and a relation to arrangements,* Diplomarbeit, FU Berlin 1991.

[269] B. GÄRTNER & E. WELZL: *Vapnik-Chervonenkis dimension and (pseudo-)hyperplane arrangements, Discrete Comput. Geometry* **12** (1994), 399-432.

[270] H. GÜNZEL, R. HIRABAYASHI & H. T. JONGEN: *Multiparametric optimization: on stable singularities occurring in combinatorial partition codes,* preprint; *Control & Optimization* **23** (1994), 153-167.

[271] H. GÜNZEL: *On the universality theorem of configurations,* preprint, Aachen 1994, 31 pages; *Discrete Comput. Geometry*, in press.

[272] H. GÜNZEL: *On the universal partition theorem for 4-polytopes,* preprint No. 64, Aachen 1995, 26 pages.

[273] G. GONZALEZ-SPRINBERG & G. LAFFAILLE: *Sur les arrangements simples de huit droites dans* $\mathbb{R}P^2$*, C.R. Acad. Sci. Paris* **309** (1989), Ser. I, 341-344.

[274] I. M. GEL'FAND: *General theory of hypergeometric functions, Soviet Math. Doklady* **33** (1986), 573-577.

[275] I. M. GEL'FAND, R. M. GORESKY, R. D. MACPHERSON & V. SERGANOVA: *Combinatorial geometries, convex polyhedra and Schubert cells, Advances in Math.* **63** (1987), 301-316.

[276] I. M. GEL'FAND, M. M. KAPRANOV & A. V. ZELEVINSKY: *Discriminants of polynomials in several variables and triangulations of Newton polyhedra, Leningrad Math. Journal* **2** (1991), 449-505.

[277] I. M. GEL'FAND & R. D. MACPHERSON: *Geometry in Grassmannians and a generalization of the dilogarithm, Advances in Math.* **44** (1982), 279-312.

[278] I. M. GEL'FAND & R. D. MACPHERSON: *A combinatorial formula for the Pontrjagin classes, Bull. Amer. Math. Soc.* **26** (1992), 304-309.

[279] I. M. GEL'FAND & G. L. RYBNIKOV: *Algebraic and topological invariants of oriented matroids, Soviet Math. Doklady* **40** (1990), 148-152.

[280] I. M. GEL'FAND, G. L. RYBNIKOV & D. A. STONE: *Projective orientations of matroids, Advances in Math.* **113** (1995), 118-150.

[281] I. M. GEL'FAND & V. V. SERGANOVA: *On the general definition of a matroid and a greedoid, Soviet Math. Doklady* **33** (1987), 6-10.

[282] B. GERARDS & W. HOCHSTÄTTLER: *Onion skins in oriented matroids,* RUTCOR Research Report 14-93, Rutgers University 1993; Preprint 93.138, Mathematisches Institut, Universität zu Köln 1993, 3 pages.

[283] J. E. GOODMAN: *Proof of a conjecture of Burr, Grünbaum and Sloane, Discrete Math.* **32** (1980), 27-35.

[284] J. E. GOODMAN & R. POLLACK: *On the combinatorial classification of non-degenerate configurations in the plane, J. Combinatorial Theory* Ser. A **29** (1980), 220-235.

[285] J. E. GOODMAN & R. POLLACK: *Proof of Grünbaum's conjecture on the stretchability of certain arrangements of pseudolines, J. Combinatorial Theory* Ser. A **29** (1980), 385-390.

[286] J. E. GOODMAN & R. POLLACK: *A combinatorial perspective on some problems in geometry, Congressus Numerantium* **32** (1981), 383-394.

[287] J. E. GOODMAN & R. POLLACK: *Three points do not determine a (pseudo-) plane, J. Combinatorial Theory* Ser. A **31** (1981), 215-218.

[288] J. E. GOODMAN & R. POLLACK: *Helly-type theorems for pseudolines arrangements in P^2, J. Combinatorial Theory* Ser. A **32** (1982), 1-19.

[289] J. E. GOODMAN & R. POLLACK: *A theorem of ordered duality, Geometriae Dedicata* **12** (1982), 63-74.

[290] J. E. GOODMAN & R. POLLACK: *Convexity theorems for generalized planar configurations,* in: *Convexity and Related Combinatorial Geometry* (Proc. 2nd Univ. Oklahoma Conf.), Marcel Dekker 1982, pp. 73-80.

[291] J. E. GOODMAN & R. POLLACK: *Multidimensional sorting, SIAM J. Computing* **12** (1983), 484-503.

[292] J. E. GOODMAN & R. POLLACK: *On the number of k-subsets of a set of n points in the plane, J. Combinatorial Theory* Ser. A **36** (1984), 101-104.

[293] J. E. GOODMAN & R. POLLACK: *Semispaces of configurations, cell complexes of arrangements, J. Combinatorial Theory* Ser. A **37** (1984), 257-293.

[294] J. E. GOODMAN & R. POLLACK: *A combinatorial version of the isotopy conjecture,* in: Proc. Conf. "Discrete Geometry and Convexity", New York 1982, (J.E. Goodman, E. Lutwak, J. Malkevitch, R. Pollack, eds.), *Annals of the New York Academy of Sciences* **440** (1985), 12-19.

[295] J. E. GOODMAN & R. POLLACK: *Geometric sorting theory,* in: Proc. Conf. "Discrete Geometry and Convexity", New York 1982, (J.E. Goodman, E. Lutwak, J. Malkevitch, R. Pollack, eds.), *Annals of the New York Academy of Sciences* **440** (1985), 347-354.

[296] J. E. GOODMAN & R. POLLACK: *Polynomial realizations of pseudolines arrangements, Comm. Pure Applied Math.* **38** (1985), 725-732.

[297] J. E. GOODMAN & R. POLLACK: *Upper bounds for configurations and polytopes in $\mathbb{R}^d$, Discrete Comput. Geometry* **1** (1986), 219-227.

[298] J. E. GOODMAN & R. POLLACK: *There are asymptotically far fewer polytopes than we thought, Bulletin Amer. Math. Soc.* **14** (1986), 127-129.

[299] J. E. GOODMAN & R. POLLACK: *Hadwiger's transversal theorem in higher dimensions, Journal Amer. Math. Soc.* **1** (1988), 301-309.

[300] J. E. GOODMAN & R. POLLACK: *New bounds on higher dimensional configurations and polytopes,* in: Proc. Third Int. Conf. *Combinatorial Mathematics,* (G.S. Bloom, R.L. Graham, J. Malkevitch, eds.), *Annals of the New York Academy of Sciences* **555** (1989), 205-212.

[301] J. E. GOODMAN & R. POLLACK: *The complexity of point configurations, Discrete Appl. Math.* **31** (1991), 167-180.

[302] J. E. GOODMAN & R. POLLACK: *Allowable sequences and order types in discrete and computational geometry,* in: "New Trends in Discrete and Computational Geometry" (J. Pach, ed.), *Algorithms and Combinatorics* **10**, Springer-Verlag, Berlin Heidelberg 1993, 103-134

[303] J. E. GOODMAN, R. POLLACK & B. STURMFELS: *Coordinate representation of order types requires exponential storage, Proceedings of the 21st Annual ACM Symposium on Theory of Computing*, Seattle 1989, 405-410.

[304] J. E. GOODMAN, R. POLLACK & B. STURMFELS: *The intrinsic spread of a configuration in $\mathbb{R}^d$, Journal Amer. Math. Soc.* **3** (1990), 639-651.

[305] J. E. GOODMAN, R. POLLACK & R. WENGER: *Geometric transversal theory,* in: "New Trends in Discrete and Computational Geometry" (J. Pach, ed.), *Algorithms and Combinatorics* **10**, Springer-Verlag, Berlin Heidelberg 1993, 163-198.

[306] J. E. GOODMAN, R. POLLACK, R. WENGER & T. ZAMFIRESCU: *Every arrangement extends to a spread,* in *Proc. Third Annual Canadian Conference on Computational Geometry*, 1991, pp. 191-194.

[307] J. E. Goodman, R. Pollack, R. Wenger & T. Zamfirescu: *Every arrangement extends to a spread,* Combinatorica **14** (1994), 301-306.

[308] J. E. Goodman, R. Pollack, R. Wenger & T. Zamfirescu: *There is a universal topological plane,* In: *Proc. Eighth Annual ACM Symp. Computational Geometry*, Berlin, June 1992, pp. 171-176.

[309] J. E. Goodman, R. Pollack, R. Wenger & T. Zamfirescu: *Arrangements and topological planes,* American Math. Monthly **101** (1994), 866-878.

[310] C. Greene: *Acyclic orientations (Notes),* in: Higher Combinatorics (M. Aigner, ed.), Reidel, Dordrecht 1977, 65-68.

[311] C. Greene & T. Zaslavsky: *On the interpretation of Whitney numbers through arrangements of hyperplanes, zonotopes, non-Radon partitions and orientations of graphs,* Transactions Amer. Math. Soc. **280** (1983), 97-126.

[312] D.Y. Grigor'ev & N. N. Vorobjov: *Solving systems of polynomial equations in subexponential time,* J. Symbolic Computation **5** (1988), 37-64.

[313] P. Gritzmann & V. Klee: *Computational aspects of zonotopes and their polars,* in preparation.

[314] P. Gritzmann & B. Sturmfels: *Minkowski addition of polytopes: Computational complexity and applications to Gröbner bases,* SIAM J. Discrete Math. **6** (1993), 246-269.

[315] M. Grötschel, L. Lovász & A. Schrijver: *Geometric Algorithms and Combinatorial Optimization,* Algorithms and Combinatorics **2**, Springer 1988.

[316] B. Grünbaum: *Convex Polytopes,* Interscience Publ., London 1967.

[317] B. Grünbaum: *The importance of being straight,* in: Proc. 12th Biannual Intern. Seminar of the Canadian Math. Congress (Vancouver 1969), 1970, 243-254.

[318] B. Grünbaum: *Arrangements and Spreads, CBMS Regional Conference Series in Math.* **10**, Amer. Math. Soc. 1972.

[319] B. Grünbaum & V. Sreedharan: *An enumeration of simplicial 4-polytopes with 8 vertices,* J. Combinatorial Theory **2** (1967), 437-465.

[320] A. Guedes de Oliveira: *Projecção paralela em matroides orientados,* M.Sc. Thesis, University of Porto, Portugal 1988.

[321] A. Guedes de Oliveira: *Oriented matroids and projective invariant theory,* Dissertation, TH Darmstadt 1989, 112 pages.

[322] A. Guedes de Oliveira: *Oriented matroids: An essentially topological algebraic model,* in: Actas do III encontro de algebristas portugueses, (Coimbra, Portugal 1993), Coimbra: Departamento de Matematica, Universidade de Coimbra (1993), 117-129.

[323] A. Guedes de Oliveira: *On the Steinitz exchange lemma,* Discrete Math. **137** (1995), 367-370.

[324] L. Guibas, D. Salesin & J. Stolfi: *Epsilon geometry: building robust algorithms from imprecise computations, Proc. Fifth Annual ACM Symposium on Computational Geometry* 1989, pp. 208-217.

[325] L. Gutierrez Novoa: *On n-ordered sets and order completeness,* Pacific J. Math., **15** (1965), 1337-1345.

[326] E. Halsey: *Zonotopal complexes on the d-cube,* Ph.D. Thesis, Univ. Washington, Seattle 1971.

[327] Y. O. Hamidoune & M. Las Vergnas: *Jeux de commutation orientés sur les graphes et les matroïdes,* C.R. Acad. Sci. Paris, Ser. A **298** (1984), 497-499.

[328] Y. O. Hamidoune & M. Las Vergnas: *Directed switching games on graphs and matroids,* J. Combinatorial Theory, Ser. B **40** (1986), 237-269.

[329] K. Handa: *The faces of an acycloid,* preprint 1985, 12 pages.

[330] K. Handa: *The faces and coboundaries of an acycloid,* in: Topology and Computer Science (1987), pp. 535-545.

[331] K. Handa: *A characterization of oriented matroids in terms of topes,* European J. Combinatorics **11** (1990), 41-45.

[332] K. Handa: *Topes of oriented matroids and related structures,* Publ. Res. Inst. Math. Sci. **29** (1993), 235-266.

[333] K. Handa: *On conditions for an acycloid to be matroidal,* preprint 1993, 14 pages.

[334] S. Hansen: *A generalization of a theorem of Sylvester on the lines determined by a finite point set,* Math. Scand. **16** (1965), 175-180.

[335] V. L. Hansen: *Braids and Coverings: Selected Topics,* London Math. Soc. Texts, Vol. 18, Cambridge University Press 1989.

[336] W. Harbecke: *Zur algorithmischen Behandlung des Steinitz-Problems,* Diplomarbeit, Universität Bochum 1981.

[337] H. Harborth: *Two-colorings of simple arrangements,* in: Proc. 6th Hungarian Colloquium on Combinatorics (Eger 1981), North-Holland 1984, pp. 371-378.

[338] H. Harborth: *Some simple arrangements of pseudolines with a maximum number of triangles,* in: Proc. Conf. "Discrete Geometry and Convexity", New York 1982, (J.E. Goodman, E. Lutwak, J. Malkevitch, R. Pollack, eds.), Annals of the New York Academy of Sciences **440** (1985), 31-33.

[339] M. Hartmann & M. H. Schneider: *Max-balanced flows of oriented matroids,* Discrete Math. **137** (1995), 223-240.

[340] M. Henk, J. Richter-Gebert & G. M. Ziegler: *Basic properties of convex polytopes,* Preprint, TU Berlin 1995, 28 pages; CRC Handbook of "Discrete and Computational Geometry" (J. E. Goodman, J. O'Rourke, eds.), to appear.

[341] D. A. Higgs: *A lattice order for the set of all matroids on a set,* Canadian Math. Bulletin **9** (1966), 684-685.

[342] H. Hiller: *Geometry of Coxeter Groups,* Pitman, Boston 1982.

[343] W. Hochstättler: *Shellability of oriented matroids,* in: Proc. Conf. Integer programming and combinatorial optimization, (R. Karman, W.R. Pulleyblank, eds.), Univ. of Waterloo Press, Waterloo 1990, 275-281.

[344] W. Hochstättler: *A lattice theoretic characterization of oriented matroids,* Preprint 1991; European J. Combinatorics, to appear.

[345] W. Hochstättler: *Seitenflächenverbände orientierter Matroide,* Dissertation, Universität zu Köln 1992, 89 pages.

[346] W. Hochstättler: *Nested cones and onion skins,* Applied Math. Letters **6** (1993), 67-69.

[347] W. Hochstättler: *A note on the weak zone theorem,* Congressus Numerantium **98** (1993), 95-103.

[348] W. Hochstättler: *A non-visiting path, nested cones and onion skins,* Report 92-126, Mathematisches Institut, Universität zu Köln 1992, 8 pages.

[349] W. Hochstättler: *Oriented matroids from wild spheres,* Report 95.200, Mathematisches Institut, Universität zu Köln 1995, 14 pages.

[350] W. Hochstättler & S. Kromberg: *Ajoints and duals of matroids linearly representable over a skewfield,* Report 94.154, Mathematisches Institut, Universität zu Köln 1995, 7 pages.

[351] W. Hochstättler & S. Kromberg: *A pseudoconfiguration of points without adjoint,* Report 95.195, Mathematisches Institut, Universität zu Köln 1995, 17 pages.

[352] W. Hochstättler & S. Kromberg: *Oriented Matroids with an infinite sequence of adjoints,* Personal communication 1995; Preprint, Köln 1995, in preparation.

[353] W. Hochsättler & J. Nešetřil: *Linear programming duality and morphisms,* Report 95.209, Universität zu Köln 1995, 16 pages.

[354] W. V. D. Hodge & D. Pedoe: *Methods of Algebraic Geometry,* Cambridge University Press 1947.

[355] C. Hoffmann, J. Hopcroft & M. Karasick: *Towards implementing robust geometric algorithms,* Proceedings Fourth Annual ACM Symposium on Computational Geometry, Urbana, Illinois 1988.

[356] J. F. P. HUDSON: *Piecewise Linear Topology,* Benjamin, New York 1969.

[357] G. P. HUIJARI: *An optimal algorithm for the coordinatization of oriented matroids,* Discrete Comput. Geometry (1986), in press.*

[358] J. E. HUMPHREYS: *Introduction to Lie algebras and representation theory,* Graduate Texts in Mathematics **9**, Springer, 1972.

[359] J. E. HUMPHREYS: *Linear Algebraic Groups,* Graduate Texts in Mathematics **21**, Springer, 1975.

[360] J. E. HUMPHREYS: *Reflection groups and Coxeter groups,* Cambridge University Press 1990.

[361] U. HUND: *Pseudosphärenarrangements zu orientierten Matroiden,* Diplomarbeit, Universität Münster, 79 pages.

[362] U. HUND: *Every polytope with at most $d+4$ vertices is a quotient of a neighborly polytope,* Preprint 463/1995, TU Berlin 1995, 6 pages.

[363] A. W. INGLETON: *Representations of matroids,* in: Combinatorial Mathematics and its Applications (D.J.A. Welsh, ed.), Academic Press 1971, 149-167.

[364] N. JACOBSON: *Lectures in Abstract Algebra, Volume III,* van Nostrand, Princeton 1964.

[365] B. JAGGI & P. MANI-LEVITSKA: *A simple arrangement of lines without the isotopy property,* preprint, Universität Bern 1988, 28 pages.

[366] B. JAGGI, P. MANI-LEVITSKA, B. STURMFELS & N. WHITE: *Uniform oriented matroids without the isotopy property,* Discrete Comput. Geometry **4** (1989), 97-100.

[367] M. JAMBU & H. TERAO: *Free arrangements of hyperplanes and supersolvable lattices,* Advances in Math. **52** (1984), 248-258.

[368] R. E. JAMISON: *A perspective on abstract convexity: Classifying alignments by varieties,* in: Convexity and Related Combinatorial Geometry (D. C. Kay and M. Breem, eds.), Proc. Second Univ. Oklahoma Conf. 1980, Dekker, New York 1982, pp. 113-150.

[369] R. E. JAMISON: *A survey of the slope problem,* in: Proc. Conf. "Discrete Geometry and Convexity", New York 1982, (J.E. Goodman, E. Lutwak, J. Malkevitch, R. Pollack, eds.), *Annals of the New York Academy of Sciences* **440** (1985), 34-51.

[370] R. JARITZ: *Orientierung und Ordnungsfunktionen in kombinatorischen Geometrien,* Preprint Math/Inf/96/2, Universität Jena, February 1996, 15 pages.

[371] D. L. JENSEN: *Coloring and duality: combinatorial augmentation methods,* Ph.D. Thesis, Cornell University 1985, 371 pages.

[372] J. KAHN: *On lattices with Möbius function $\pm 1, 0$,* Discrete Comput. Geometry **2** (1987), 1-8.

[373] G. KALAI: *A simple way to tell a simple polytope from its graph,* J. Combinatorial Theory, Ser. A **49** (1988), 381-383.

[374] G. KALAI: *Many triangulated spheres,* Discrete Comput. Geometry **3** (1988), 1-14.

[375] M. M. KAPRANOV & V. A. VOEVODSKY: *Combinatorial-geometric aspects of polycategory theory: Pasting schemes and higher Bruhat order,* Cahiers Top. Geom. Diff. **32** (1991), 11-28.

[376] M. M. KAPRANOV & V. A. VOEVODSKY: *Free n-category generated by a cube, oriented matroids, and higher Bruhat orders,* Funct. Anal. Appl. **25**, No.1 (1991), 50-52; translation from *Funkts. Anal. Prilozh.* **25**, No.1 (1991), 62-65.

[377] J. KARLANDER: *A characterization of affine sign vector systems,* preprint, KTH Stockholm 1992; *European J. Combinatorics*, to appear.

[378] S. KARLIN: *Total Positivity,* Vol. I, Stanford University Press 1968.

[379] L. M. KELLY & W. O. J. MOSER: *On the number of ordinary lines determined by n points,* Canadian J. Math. (1958) **10**, 210-219.

[380] L. M. KELLY & R. ROTTENBERG: *Simple points in pseudoline arrangements,* Pacific J. Math. (1972) **40**, 617-622.

[381] W. Kern: *Adjoints und Polare von orientierten Matroiden,* Diplomarbeit, Universität Erlangen 1982.

[382] W. Kern: *Verbandstheoretische Dualität in kombinatorischen Geometrien und orientierten Matroiden,* Dissertation, Universität Köln 1985, 57 pages.

[383] E. Klafszky & T. Terlaky: *A new approach to the feasibility problem for oriented matroids,* (in Hungarian) *Alkalmazott Mat. Lapok* **12** (1986), 279-282.

[384] E. Klafszky & T. Terlaky: *Remarks on the feasibility problem of oriented matroids,* Annales Universitatis Scientiarum Budapestiensis de Rolando Eötvös nominatae, Sectio Computatorica, **7** (1987), 155-157.

[385] E. Klafszky & T. Terlaky: *Oriented matroids, quadratic programming and the criss-cross method,* (in Hungarian) *Alkalmazott Mat. Lapok* **14** (1989), 365-375.

[386] E. Klafszky & T. Terlaky: *Some generalizations of the criss-cross method for the linear complementarity problem of oriented matroids,* Combinatorica **9** (1989), 189-198.

[387] E. Klafszky & T. Terlaky: *Some generalizations of the criss-cross method for quadratic programming,* Optimization **24** (1992), 127-139.

[388] V. Klee & P. Kleinschmidt: *Polytopal complexes and their relatives,* in: *Handbook of Combinatorics* (R. Graham, M. Grötschel, L. Lovász, eds.), North Holland, Amsterdam 1995, to appear.

[389] S. Kleiman & D. Laksov: *Schubert calculus, Amer. Math. Monthly* **79** (1972), 1061-1082.

[390] P. Kleinschmidt: *On facets with non-arbitrary shapes, Pacific J. Math.* **65** (1976), 511-515.

[391] P. Kleinschmidt: *Sphären mit wenigen Ecken, Geometriae Dedicata* **5** (1976), 307-320.

[392] M. H. Klin, S. S. Tratch & N. S. Zefirov: *2D-configurations and clique-cyclic orientations of the graphs $L(K_p)$,* preprint, Moscow 1990, 24 pages.

[393] D. E. Knuth: *Axioms and Hulls, Lecture Notes in Computer Science* **606**, Springer 1992.

[394] W. Kollewe: *Representation of data by pseudoline arrangements,* Preprint Nr. 1505, Technische Hochschule Darmstadt 1992, 8 pages.

[395] D. Larman: *On sets projectively equivalent to the vertices of a convex polytope, Bulletin London Math. Soc.* **4** (1972), 6-12.

[396] M. Las Vergnas: *Matroïdes orientables,* preprint 1974, 80 pages.

[397] M. Las Vergnas: *Matroïdes orientables, C.R. Acad. Sci. Paris*, Ser.A **280** (1975), 61-64.

[398] M. Las Vergnas: *Coordinatizable strong maps of matroids,* preprint 1975, 123 pages.

[399] M. Las Vergnas: *Sur les extensions principales d'un matroïde, C. R. Acad. Sci. Paris*, Ser. A **280** (1975), 187-190.

[400] M. Las Vergnas: *Acyclic and totally cyclic orientations of combinatorial geometries, Discrete Math.* **20** (1977), 51-61.

[401] M. Las Vergnas: *Bases in oriented matroids, J. Combinatorial Theory*, Ser. B **25** (1978), 283-289.

[402] M. Las Vergnas: *Extensions ponctuelles d'une géométrie combinatoire orientée,* in: *Problémes combinatoires et théorie des graphes* (Actes Coll. Orsay 1976), Colloques internationaux No. 260, C.N.R.S. 1978, 265-270.

[403] M. Las Vergnas: *Sur les activités des orientations d'une géométrie combinatoire,* in: *Codes et hypergraphes* (Actes Coll. Math. Discrete Bruxelles, Cahiers Centre Et. Rech. Opér.) **20** (1978), pp. 293-300.

[404] M. Las Vergnas: *Convexity in oriented matroids, J. Combinatorial Theory*, Ser. B **29** (1980), 231-243.

[405] M. Las Vergnas: *On the Tutte polynomial of a morphism of matroids, Ann. Discrete Math.* **8** (1980), 7-20.

[406] M. Las Vergnas: *Oriented matroids as signed geometries real in corank* 2, in: *Finite and infinite sets*, (Proc. 6th Hungarian Combinatorial Conf. Eger 1981), North-Holland 1984, 555-565.

[407] M. Las Vergnas: *The Tutte polynomial of a morphism of matroids. II Activities of orientations,* in: *Progress in Graph Theory*, (Proc. Waterloo Silver Jubilee Conf. 1982), Academic Press 1984, 367-380.

[408] M. Las Vergnas: *A correspondence between spanning trees and orientations in graphs,* in: *Graph Theory and Combinatorics* (Proc. Cambridge Comb. Conf. 1983), Academic Press 1984, 233-238.

[409] M. Las Vergnas: *Order properties of lines in the plane and a conjecture of G. Ringel, J. Combinatorial Theory* Ser. B **41** (1986), 246-249.

[410] M. Las Vergnas: *Hamilton paths in tournaments and a problem of McMullen on projective transformations in* $\mathbb{R}^d$*, Bull. London Math. Soc.* **18** (1986), 571-572.

[411] M. Las Vergnas: *Acyclic reorientations of weakly oriented matroids, J. Combinatorial Theory* Ser. B **49** (1990), 195-199.

[412] M. Las Vergnas, J.-P. Roudneff & I. Salaün: *Regular polytopes and oriented matroids,* preprint 1991, 18 pages.

[413] J. Lawrence: *Oriented matroids,* Ph.D. Thesis, University of Washington, Seattle 1975, 67 pages.

[414] J. Lawrence: *Oriented matroids and multiply ordered sets, Linear Algebra Appl.* **48** (1982), 1-12.

[415] J. Lawrence: *Lopsided sets and orthant-intersection by convex sets, Pacific J. Math.* **104** (1983), 155-173.

[416] J. Lawrence: *Shellability of oriented matroid complexes,* preprint 1984, 8 pages.

[417] J. Lawrence: *Some dual pairs of simple oriented matroids by concatenation,* preprint 1984, 7 pages.

[418] J. Lawrence & L. Weinberg: *Unions of oriented matroids, Ann. Discrete Math.* **8** (1980), 29-34.

[419] J. Lawrence & L. Weinberg: *Unions of oriented matroids, Linear Alg. Appl.* **41** (1981), 183-200.

[420] C. Lee: *Regular triangulations of convex polytopes,* in: *Applied Geometry and Discrete Mathematics – The Victor Klee Festschrift* (P. Gritzmann, B. Sturmfels, eds.), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Amer. Math. Soc. **4** (1991), 443-456.

[421] J. Lee: *Subspaces with well-scaled frames,* Thesis, Cornell University 1986.

[422] J. Lee: *The incidence structure of subspaces with well-scaled frames, J. Combinatorial Theory* Ser. B **50** (1990), 265-287.

[423] F. Levi: *Die Teilung der projektiven Ebene durch Gerade oder Pseudogerade, Ber. Math.-Phys. Kl. Sächs. Akad. Wiss.,* **78** (1926), 256-267.

[424] W. B. R. Lickorish: *Unshellable triangulations of spheres, Europ. J. Combinatorics* **12** (1991), 527-530.

[425] J. Linhart: *On the total weight of arrangements of halfspaces, Geometriae Dedicata* **43** (1993), 165-172.

[426] J. Linhart: *Arrangements of oriented hyperplanes, Discrete Comput. Geometry* **10** (1993), 435-446.

[427] D. Ljubić, J.-P. Roudneff & B. Sturmfels: *Arrangements of lines and pseudolines without adjacent triangles, J. Combinatorial Theory*, Ser. A **50** (1989), 24-32.

[428] H. Lombardi: *Nullstellensatz réel effectif et variantes, C. R. Acad. Sci. Paris*, Série I **310** (1990), 635-640.

[429] L. Lovász & A. Schrijver: *Remarks on a theorem of Rédei, Stud. Sci. Math. Hung.* **16** (1981), 449-454.

[430] A. T. Lundell & S. Weingram: *The Topology of CW Complexes,* Van Nostrand, New York 1969.

[431] S. MacLane: *Some interpretations of abstract linear independence in terms of projective geometry, Amer. J. Math.,* **58** (1936), 236-241.

[432] R. D. MacPherson: *Combinatorial differential manifolds,* in: Proc. "Topological Methods in Modern Mathematics: a Symposium in Honor of John Milnor's Sixtieth Birthday, Stony Brook NY 1991 (L. R. Goldberg, A. V. Phillips, eds.), Publish or Perish, Houston TX 1993, 203-221.

[433] A. Mandel: *Decision process for representability of matroids and oriented matroids,* Research Report CORR 78-40, University of Waterloo 1978.

[434] P. Mani: *Spheres with few vertices, J. Combinatorial Theory* Ser. A **13** (1972), 346-352.

[435] D. A. Marcus: *Minimal positive* 2*-spanning sets of vectors, Proceedings Amer. Math. Soc.* **82** (1981), 165-172.

[436] D. A. Marcus: *Gale diagrams of convex polytopes and positive sets of vectors,* Discrete Appl. Math. **9** (1984), 47-67.

[437] H. Martini: *Some results and problems around zonotopes,* in: *Colloquia Mathematica Societatis János Bolyai* **48** (1985), 383-418.

[438] J. H. Mason: *Geometrical realization of combinatorial geometries, Proceedings Amer. Math. Soc.* **30** (1971), 15-21.

[439] S. Maurer: *Matroid basis graphs, I, J. Combinatorial Theory* **14** (1973), 216-240.

[440] B. Mazur: *Arithmetic on curves, Bulletin Amer. Math. Soc.* **14** (1986), 206-159.

[441] C. McDiarmid: *General percolation and oriented matroids,* in: "Random Graphs '85," Lect. 2nd International Seminar (Poznan, Poland 1985), *Annals Discrete Math.* **33** (1987), 187-197.

[442] P. McMullen: *On zonotopes, Transactions Amer. Math. Soc.* **159** (1971), 91-109.

[443] P. McMullen: *The number of faces of simplicial polytopes, Israel J. Math.* **9** (1971), 559-570.

[444] P. McMullen: *Space-tiling zonotopes, Mathematika* **22** (1975), 202-211.

[445] P. McMullen: *Transforms, diagrams and representations,* in: *Contributions to Geometry* (Proc. Geometry Symp. Siegen 1978), Birkhäuser 1979, 92-130.

[446] P. McMullen: *Volumes of projections of unit cubes, Bulletin London Math. Soc.* **15** (1984), 278-280.

[447] J. McNulty: *Ports and oriented matroids, Congressus Numerantium* **96** (1993), 11-20.

[448] J. McNulty: *Two new classes of non-orientable matroids,* Preprint 1994, 41 pages.

[449] P. S. Mei: *Axiomatic theory of linear and convex closure,* Ph.D. Thesis, Purdue University 1971, 152 pages.

[450] E. Melchior: *Über Vielseite der projektiven Ebene, Deutsche Math.* **5** (1940), 461-475.

[451] V. J. Milenkovic: *Verifiable implementations of geometric algorithms using finite precision arithmetic,* Ph.D. Dissertation, Carnegie Mellon University 1988.

[452] V. J. Milenkovic & L. R. Nackman: *Finding compact coordinate representations for polygons and polyhedra,* in: *Proc. 6th ACM Ann. Symp. on Computational Geometry*, (Berkeley, June 1990), pp. 244-252.

[453] D. A. Miller: *A class of topological oriented matroids with some applications to non-linear programming,* Ph.D. Thesis, University of California, Berkeley 1983, 105 pages.

[454] D. A. Miller: *Oriented matroids from smooth manifolds, J. Combinatorial Theory*, Ser. B **43** (1987), 173-186.

[455] G. J. Minty: *On the axiomatic foundations of the theories of directed linear graphs, electrical networks and network-programming, J. Math. and Mechanics* **15** (1966), 485-520.

[456] N. E. MNËV: *On manifolds of combinatorial types of projective configurations and convex polyhedra, Soviet Math. Doklady* **32** (1985), 335-337.

[457] N. E. MNËV: *Realizability of combinatorial types of convex polyhedra over fields, J. Soviet Mathematics* **28** (1985), 606-609.

[458] N. E. MNËV: *The universality theorems on the classification problem of configuration varieties and convex polytopes varieties,* in: Topology and Geometry — Rohlin Seminar (O.Ya. Viro, ed.), Lecture Notes in Mathematics **1346**, Springer 1988, 527-544.

[459] N. E. MNËV: *The universality theorem on the oriented matroid stratification of the space of real matrices,* in: Discrete and Computational Geometry: Papers from the DIMACS Special Year (eds. J. E. Goodman, R. Pollack, W. Steiger), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Vol. 6, Amer. Math. Soc. 1991, pp. 237-243.

[460] N. E. MNËV & J. RICHTER-GEBERT: *Two constructions of oriented matroids with disconnected extension space,* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), *Discrete Comput. Geometry* **10** (1993), 271-285.

[461] N. E. MNËV & G. M. ZIEGLER: *Combinatorial models for the finite-dimensional Grassmannians,* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), *Discrete Comput. Geometry* **10** (1993), 241-250.

[462] W. D. MORRIS JR.: *Oriented matroids and the linear complementary problem,* Ph.D. Thesis, Cornell University 1986, 111 pages.

[463] W. D. MORRIS JR.: *LCP degree theory and oriented matroids, SIAM J. Matrix Anal. Appl.* **15** (1994), 995-1006.

[464] W. D. MORRIS JR. & M. J. TODD: *Symmetry and positive definiteness in oriented matroids, European J. Combinatorics* **9** (1988), 121-129.

[465] R. T. MORRISON & R. N. BOYD: *Organic Chemistry,* 5th ed., Allyn & Bacon, Boston 1987.

[466] D. MUMFORD: *The Red Book of Varieties and Schemes,* Lecture Notes in Mathematics **1358**, Springer 1988.

[467] J. R. MUNKRES: *Elements of Algebraic Topology,* Addison-Wesley 1984.

[468] B. S. MUNSON: *Face lattices of oriented matroids,* Ph.D. Thesis, Cornell University 1981, 135 pages.

[469] K. G. MURTY: *Linear Complementarity, Linear and Nonlinear Programming,* Heldermann Verlag, Berlin 1988.

[470] T. ODA: *Convex Bodies and Algebraic Geometry: an Introduction to the Theory of Toric Varieties, Ergebnisse der Math. Grenzgebiete*, 3. Folge **15**, Springer-Verlag, Berlin Heidelberg 1988.

[471] P. ORLIK: *Introduction to Arrangements, CBMS Regional Conf. Series in Math.* **72**, Amer. Math. Soc. 1989.

[472] P. ORLIK & L. SOLOMON: *Combinatorics and topology of complements of hyperplanes, Inventiones Math.* **56** (1980), 167-189.

[473] P. ORLIK & H. TERAO: *Arrangements of Hyperplanes, Grundlehren in Mathematics* **300**, Springer 1992.

[474] J. OXLEY: *Matroid Theory,* Oxford University Press, Oxford 1992.

[475] U. PACHNER: *Konstruktionsmethoden und das kombinatorische Homöomorphieproblem für Triangulationen semilinearer Mannigfaltigkeiten, Abh. Math. Sem. Univ. Hamburg* **57** (1986), 69-86.

[476] L. PARIS: *Universal cover of Salvetti's complex and topology of simplicial arrangements of hyperplanes,* Transactions Amer. Math. Soc. **340** (1993), 149-178.

[477] R. PENNE: *Lines in 3-Space. Isotopy, Chirality and Weavings,* Ph. D. Dissertation, University of Antwerpen, 1992.

[478] R. PENNE: *Configurations of few lines in 3-Space. Isotopy, chirality and planar layouts, Geometriae Dedicata* **45** (1993), 49-82.

[479] R. PENNE: *Some nonrealizable line diagrams, J. Intell. Robot. Syst.* **11** (1994), 193-207.

[480] M. Pocchiola & G. Vegter: *Order types and visibility types of configurations of disjoint convex plane sets,* Extended abstract, Preprint LIENS-94-4, Dept. Mathématiques Informatique, École Normale Supérieure, Paris 1994, 13 pages.

[481] K. P. Pock: *Entscheidungsmethoden zur Realisierbarkeit orientierter Matroide,* Diplomarbeit, TH Darmstadt 1991, 56 pages.

[482] R. Pollack & M.-F. Roy: *On the number of cells defined by a set of polynomials,* C. R. Acad. Sci. Paris, Ser. I **316** (1993), 573-577.

[483] A. Polymeris: *Sign vectors. Polar consistency,* preprint 1984, 31 pages.

[484] F. P. Preparata & I. M. Shamos: *Computational Geometry. An Introduction,* Springer 1985.

[485] O. Pretzel: *Orientations of chain groups,* Order **12** (1995), 135-142.

[486] D. Quillen: *Homotopy properties of the poset of non-trivial p-subgroups of a group,* Advances in Math. **28** (1978), 101-128.

[487] R. Rado: *An inequality,* J. London Math. Soc. **27** (1952), 1-6.

[488] J. Rambau: *Triangulations of cyclic polytopes and higher Bruhat orders* Preprint 496/1996, TU Berlin, February 1996, 30 pages.

[489] R. Randell: *Lattice-isotopic arrangements are topologically isomorphic,* Proceedings Amer. Math. Soc. **107** (1989), 555-559.

[490] J. R. Reay: *A new proof of the Bonnice-Klee theorem,* Proceedings Amer. Math. Soc. **16** (1965), 585-587.

[491] L. Rédei: *Ein kombinatorischer Satz,* Acta Sci. Math. (Szeged) **7** (1934), 39-43.

[492] J. Renegar: *On the computational complexity and geometry of the first-order theory of the reals, Parts I-III,* J. Symbolic Comput. **13** (1992), 255-299, 301-327, 329-352.

[493] J. Richter: *Kombinatorische Realisierbarkeitskriterien für orientierte Matroide,* (in German), Diplomarbeit, TH Darmstadt 1988, 112 pages; Mitteilungen Math. Seminar Gießen **194** (1989), 1-112.

[494] J. Richter-Gebert: *Non-euclidean uniform oriented matroids have bi-quadratic final polynomials,* Combinatorica **13** (1993), 259-268.

[495] J. Richter-Gebert: *On the Realizability Problem for Combinatorial Geometries – Decision Methods,* Dissertation, Darmstadt 1991, 144 pages.

[496] J. Richter-Gebert: *Construction Methods for Oriented Matroids,* Dissertation, KTH Stockholm 1992.

[497] J. Richter-Gebert: *Oriented matroids with few mutations,* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), Discrete Comput. Geometry **10** (1993), 251-269.

[498] J. Richter-Gebert: *Combinatorial obstructions to the lifting of weaving diagrams,* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), Discrete Comput. Geometry **10** (1993), 287-312.

[499] J. Richter-Gebert: *Line arrangements and zonotopal tilings: a little printer exercise,* Hyper-Space **2** (1993), 8–17.

[500] J. Richter-Gebert: *Mechanical theorem proving in projective geometry,* Annals of Mathematics and Artificial Intelligence **13** (1995), 139-172.

[501] J. Richter-Gebert: *Realization spaces of 4-polytopes are universal,* Preprint, TU Berlin 1995, 111 pages; available at URL `http://www.math.tu-berlin.de/~richter`

[502] J. Richter-Gebert: *Mnëv's universality theorem revisited,* Séminaire Lotaringien de Combinatoire 1995, 15 pages.

[503] J. Richter-Gebert: *Two interesting oriented matroids,* Preprint, TU Berlin 1996, 11 pages; Documenta Mathematica, to appear.

[504] J. Richter & B. Sturmfels: *On the topology and geometric construction of oriented matroids and convex polytopes,* Transactions Amer. Math. Soc. **325** (1991), 389-412.

[505] J. Richter-Gebert & G. M. Ziegler: *Zonotopal tilings and the Bohne-Dress theorem,* in: Proc. *Jerusalem Combinatorics '93* (H. Barcelo, G. Kalai, eds.), *Contemporary Math.* **178**, Amer. Math. Soc. 1994, 211-232.

[506] J. Richter-Gebert & G. M. Ziegler: *Realization spaces of 4-polytopes are universal,* Preprint 431/1995, TU Berlin 1995, 9 pages; *Bulletin of the American Mathematical Society* **32** (1995), to appear.

[507] J. Richter-Gebert & G. M. Ziegler: *Oriented matroids,* Preprint, TU Berlin 1995, 23 pages; CRC Handbook of "Discrete and Comput. Geometry" (J. E. Goodman, J. O'Rourke, eds.), to appear; available per WWW from URL `http://www.math.tu-berlin.de/~ziegler`

[508] G. Ringel: *Teilungen der Ebene durch Geraden oder topologische Geraden, Math. Zeitschrift* **64** (1956), 79-102.

[509] G. Ringel: *Über Geraden in allgemeiner Lage, Elemente der Math.* **12** (1957), 75-82.

[510] R. T. Rockafellar: *The elementary vectors of a subspace of* $\mathbb{R}^n$, in: *Combinatorial Mathematics and its Applications*, (Proc. Chapel Hill Conf.), Univ. North Carolina Press 1969, 104-127.

[511] M. Ronan: *Lectures on Buildings,* Academic Press, Boston 1989.

[512] C. Roos: *Network programming with umbrellas,* preprint 84-32, Delft University of Technology, Dept. Mathematics and Informatics 1984, 68 pages.

[513] J.-P. Roudneff: *On the number of triangles in simple arrangements of pseudolines in the real projective plane, Discrete Math.* **60** (1986), 245-251.

[514] J.-P. Roudneff: *Matroïdes orientés et arrangements de pseudo-droites,* Thése, Paris 1987a, 159 pages.

[515] J.-P. Roudneff: *Quadrilaterals and pentagons in arrangements of lines, Geometriae Dedicata* **23** (1987), 221-227.

[516] J.-P. Roudneff: *Arrangements of lines with a minimal number of triangles are simple, Discrete Comput. Geometry* **3** (1988), 97-102.

[517] J.-P. Roudneff: *Tverberg-type theorems for pseudoconfigurations of points in the plane, European J. Combinatorics* **9** (1988), 189-198.

[518] J.-P. Roudneff: *Reconstruction of the orientation class of an oriented matroid, European J. Combinatorics* **9** (1988), 423-429.

[519] J.-P. Roudneff: *Inseparability graphs of oriented matroids, Combinatorica* **9** (1989), 75-84.

[520] J.-P. Roudneff: *The maximum number of triangles in arrangements of (pseudo-) lines, J. Combinatorial Theory* Ser. B, **66** (1996), 44-74.

[521] J.-P. Roudneff: *Cells with many facets in arrangements of hyperplanes, Discrete Math.* **98** (1991), 185-191.

[522] J.-P. Roudneff & B. Sturmfels: *Simplicial cells in arrangements and mutations of oriented matroids, Geometriae Dedicata* **27** (1988), 153-170.

[523] J.-P. Roudneff & M. Wagowski: *Characterizations of ternary matroids in terms of circuit signatures, J. Combinatorial Theory* Ser. B **47** (1989), 93-106.

[524] M. E. Rudin: *An unshellable triangulation of a tetrahedron, Bulletin Amer. Math. Soc.* **64** (1958), 90-91.

[525] T.B. Rushing: *Topological Embeddings,* Academic Press 1973.

[526] S. Sahni: *Computationally related problems, SIAM J. Computing* **3** (1974), 262-279.

[527] K. Saito: *On the uniformization of complements of discriminant loci,* Conference Notes, Amer. Math. Soc. Summer Institute, Williamstown 1975.

[528] M. Salvetti: *Topology of the complement of real hyperplanes in* $\mathbb{C}^N$, *Inventiones Math.* **88** (1987), 603-618.

[529] M. Salvetti: *On the homotopy theory of the complexes associated to metrical-hemisphere complexes, Discrete Math.* **113** (1993), 155-177.

[530] R. SCHNEIDER: *Tesselations generated by hyperplanes,* Discrete Comput. Geometry **2** (1987), 223-232.

[531] P. H. SCHOUTE: *Analytic treatment of the polytopes regularly derived from the regular polytopes,* Verh. Konink. Acad. Wetensch. Amsterdam **11** (1911), No. 3.

[532] A. SCHRIJVER: *Theory of Linear and Integer Programming,* Wiley-Interscience 1986.

[533] PETER SCHUCHERT: *Matroid-Polytope und Einbettungen kombinatorischer Mannigfaltigkeiten,* Dissertation, TH Darmstadt 1995; Shaker Verlag 1995.

[534] P. SCOTT: *On the sets of directions determined by n points,* Amer. Math. Monthly **77** (1970), 502-505.

[535] R. SEIDEL: *On the number of faces of higher order Voronoi diagrams,* Proc. 3rd ACM Ann. Symp. on Computational Geometry (1987), 181-187.

[536] M. SENECHAL: *Crystalline Symmetries. An Informal Mathematical Introduction,* Adam Hilger, Bristol, Philadelphia and New York 1993.

[537] M. SENECHAL: *Quasicrystals and Geometry,* Cambridge University Press 1995.

[538] R. SHAMIR: *The efficiency of the simplex method: a survey,* Management Sci. **33** (1987), 301-334.

[539] R. W. SHANNON: *Certain Extremal Problems in Arrangements of Hyperplanes,* Ph.D. Thesis, University of Washington, Seattle, 1974, 97 pages.

[540] R. W. SHANNON: *A lower bound on the number of cells in arrangements of hyperplanes,* J. Combinatorial Theory Ser. A **20** (1976), 327-335.

[541] R. W. SHANNON: *Simplicial cells in arrangements of hyperplanes,* Geometriae Dedicata **8** (1979), 179-187.

[542] I. SHEMER: *Neighborly polytopes,* Israel J. Math. **43** (1982), 291-314.

[543] G. C. SHEPHARD: *Combinatorial properties of associated zonotopes,* Canadian J. Math. **26** (1974), 302-321.

[544] P. SHOR: *Stretchability of pseudolines is NP-hard,* in: Applied Geometry and Discrete Mathematics – The Victor Klee Festschrift (P. Gritzmann, B. Sturmfels, eds.), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Amer. Math. Soc. **4** (1991), 531-554.

[545] S. SKIENA: *Counting the k-projections of a point set,* J. Combinatorial Theory Ser. A **55** (1990), 153-160.

[546] L. SOLOMON: *The orders of the finite Chevalley groups,* J. Algebra **3** (1966), 376-393.

[547] L. SOLOMON & H. TERAO: *A formula for the characteristic polynomial of an arrangement,* Advances in Math. **64** (1987), 305-325.

[548] E. H. SPANIER: *Algebraic Topology,* McGraw-Hill 1966.

[549] R. P. STANLEY: *Supersolvable lattices,* Algebra Universalis **2** (1972), 197-217.

[550] R. P. STANLEY: *Acyclic orientations of graphs,* Discrete Math. **5** (1973), 171-178.

[551] R. P. STANLEY: *The number of faces of simplicial convex polytopes,* Advances in Math. **35** (1980), 236-238.

[552] R. P. STANLEY: *Decompositions of rational convex polytopes,* Annals of Discrete Math. **6** (1980), 333-342.

[553] R. P. STANLEY: *Two combinatorial applications of the Aleksandrov-Fenchel inequalities,* J. Combinatorial Theory, Ser. A **31** (1981), 56-65.

[554] R. P. STANLEY: *On the number of reduced decompositions of elements of Coxeter groups,* European J. Combinatorics **5** (1984), 359-372.

[555] R. P. STANLEY: *T-free arrangements of hyperplanes,* in: Progress in Graph Theory (J.A. Bondy, U.S.R. Murty, eds.), Academic Press 1984, p. 539.

[556] R. P. Stanley: *A zonotope associated with graphical degree sequences,* in: *Applied Geometry and Discrete Mathematics – The Victor Klee Festschrift* (P. Gritzmann, B. Sturmfels, eds.), DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Amer. Math. Soc. **4** (1991), 555-570.

[557] J. Steiner: *Einige Sätze über die Teilung der Ebene und des Raumes, J. Reine Angew. Math.* **1** (1826), 349-364.

[558] E. Steinitz & H. Rademacher: *Vorlesungen über die Theorie der Polyeder,* Springer-Verlag, Berlin 1934; reprint, Springer 1976.

[559] B. Stevens: *Miro-Matroide — Uniabhängigkeitsstrukturen in komplexen Matroiden,* Diplomarbeit, Universität zu Köln 1993, 141 pages.

[560] T. Strommer: *Triangles in arrangements of lines, J. Combinatorial Theory* Ser. A **23** (1977), 314-320.

[561] B. Sturmfels: *Zur linearen Realisierbarkeit orientierter Matroide,* Diplomarbeit, TH Darmstadt 1985, 167 pages.

[562] B. Sturmfels: *Central and parallel projections of polytopes, Discrete Math.* **62** (1986), 315-318.

[563] B. Sturmfels: *Oriented matroids and combinatorial convex geometry,* Dissertation, TH Darmstadt 1987, 95 pages.

[564] B. Sturmfels: *Computational synthetic geometry,* Ph.D. Thesis, University of Washington, Seattle 1987, 144 pages.

[565] B. Sturmfels: *Boundary complexes of convex polytopes cannot be characterized locally, J. London Math. Soc.* **35** (1987), 314-326.

[566] B. Sturmfels: *Cyclic polytopes and d-order curves, Geometriae Dedicata* **24** (1987), 103-107.

[567] B. Sturmfels: *On the decidability of Diophantine problems in combinatorial geometry, Bulletin Amer. Math. Soc.* **17** (1987), 121-124.

[568] B. Sturmfels: *Aspects of computational synthetic geometry; I. Algorithmic coordinatization of matroids,* in: *Computer-aided geometric reasoning* (H.H. Crapo, ed.), INRIA Rocquencourt, France, June 1987, pp. 57-86.

[569] B. Sturmfels: *Some applications of affine Gale diagrams to polytopes with few vertices, SIAM J. Discrete Math.* **1** (1988), 121-133.

[570] B. Sturmfels: *Totally positive matrices and cyclic polytopes, Linear Algebra Appl.* **107** (1988), 275-281.

[571] B. Sturmfels: *Simplicial polytopes without the isotopy property,* I.M.A. preprint 410, University of Minnesota 1988, 4 pages.

[572] B. Sturmfels: *Neighborly polytopes and oriented matroids, European J. Combinatorics* **9** (1988), 537-546.

[573] B. Sturmfels: *On the matroid stratification of Grassmann varieties, specialization of coordinates, and a problem of N. White, Advances in Math.* **75** (1989), 202-211.

[574] B. Sturmfels: *Gröbner bases of toric varieties, Tôhoku Math. Journal* **43** (1991), 249-261.

[575] B. Sturmfels & N. White: *Gröbner bases and invariant theory, Advances in Math.* **76** (1989), 245-259.

[576] B. Sturmfels & G. M. Ziegler: *Extension spaces of oriented matroids, Discrete Comput. Geometry* **10** (1993), 23-45.

[577] P. Y. Suvorov: *Isotopic but not rigidly isotopic plane systems of straight lines,* in: *Topology and Geometry — Rohlin Seminar* (O.Ya. Viro, ed.), Lecture Notes in Mathematics **1346**, Springer 1988, pp. 545-556.

[578] A. Tarski: *Decision Method for Elementary Algebra and Geometry,* 2nd revised ed., University of California Press 1951.

[579] H. Terao: *Arrangements of hyperplanes and their freeness I, II, J. Fac. Science Univ. Tokyo, Sci. IA* **27** (1980), 293-320.

[580] H. Terao: *Generalized exponents of a free arrangement of hyperplanes and Shephard-Todd-Brieskorn formula,* Inventiones Math. **63** (1981), 159-179.

[581] T. Terlaky: *The criss-cross method and its applications,* (in Hungarian), Ph.D. Thesis, Hungarian Academy of Sciences, Budapest 1985.

[582] T. Terlaky: *A finite criss-cross method for oriented matroids,* J. Combinatorial Theory Ser. B **42** (1987), 319-327.

[583] J. Tits: *Le problème des mots dans les groupes de Coxeter,* Ist Naz. Alta Math. & Symposia Math. **1** (1968), 175-185.

[584] J. Tits: *Buildings of spherical type and finite BN-pairs,* Lecture Notes in Math. **386**, Springer 1974.

[585] J. Tits: *A local approach to buildings,* in: The Geometric Vein. (The Coxeter Festschrift), (C. Davis, B. Grünbaum, F.A. Sherk, eds.), Springer 1982, 519-547.

[586] M. J. Todd: *Complementarity in oriented matroids,* SIAM J. Algebraic Discrete Methods **5** (1984), 467-487.

[587] M. J. Todd: *Linear and quadratic programming in oriented matroids,* J. Combinatorial Theory Ser. B **39** (1985), 105-133.

[588] N. Tomizawa: *Theory of holometry (I) – on acycloids,* (in Japanese), Papers of the Technical Group on Circuits and Systems, Institute of Electronics and Communication Engineers of Japan, CAS 84-14 (1984).

[589] N. Tomizawa: *Theory of holometry (II) – acycloids and greedy systems,* (in Japanese), Papers of the Technical Group on Circuits and Systems, Institute of Electronics and Communication Engineers of Japan, CAS 84-65 (1984).

[590] N. Tomizawa: *Theory of acycloids and holometry,* (in Japanese), RIMS kokyuroku (Memoir of the Research Institute of Mathematical Sciences of Kyoto University) "Graph Teory and Applications" **534** (1984), 91-138.

[591] S. S. Tratch & N. S. Zefirov: *Combinatorial models and algorithms in chemistry. The ladder of combinatorial objects and its application to the formalization of structural problems of organic chemistry,* (in Russian), in: Principles of Symmetry and Systemology in Chemistry (N.F. Stepanov, ed.), Moscow State University Publ. & Moscow 1987, pp. 54-86.

[592] P. Ungar: *$2N$ noncollinear points determine at least $2N$ directions,* J. Combinatorial Theory Ser. A **33** (1982), 343-347.

[593] P. Vamos: *The missing axiom of matroid theory is lost forever,* J. London Math. Soc **18** (1978), 403-408.

[594] A. N. Varchenko: *Combinatorics and topology of the disposition of affine hyperplanes in real space,* Functional Anal. Appl. **21** (1987), 9-19.

[595] A. N. Varchenko: *On the numbers of faces of a configuration of hyperplanes,* Soviet Math. Doklady **38** (1989), 291-295.

[596] A. N. Varchenko & I. M. Gel'fand: *Heaviside functions of a configuration of hyperplanes,* Functional Anal. Appl. **21** (1988), 255-270.

[597] A. M. Vershik: *Critical points of fields of convex polytopes and the Pareto-Smale optimum with respect to a convex cone,* Soviet Math. Doklady **26** (1982), 353-356.

[598] A. M. Vershik: *Topology of the convex polytopes' manifolds, the manifold of the projective configurations of a given combinatorial type and representations of lattices,* in: Topology and Geometry — Rohlin Seminar (O.Ya. Viro, ed.), Lecture Notes in Mathematics **1346**, Springer 1988, pp. 557-581.

[599] O. Ya. Viro, ed.: *Topology and Geometry — Rohlin Seminar,* Lecture Notes in Mathematics **1346**, Springer 1988.

[600] I. A. Volodin, V. E. Kuznetsov & A. T. Fomenko: *The problem of discriminating algorithmically the standard three-dimensional sphere,* Russian Math. Surveys **29** (1974), 71-172.

[601] M. L. Wachs & J. W. Walker: *On geometric semilattices,* Order **2** (1986), 367-385.

[602] M. Wagowski: *The Tutte group of a weakly orientable matroid,* Linear Algebra Appl. **17** (1989), 21-24.

[603] M. Wagowski: *Matroid signatures coordinatizable over a semiring,* European J. Combinatorics **10** (1989), 393-398.

[604] J. W. Walker: *Homotopy type and Euler characteristic of partially ordered sets,* European J. Combinatorics **2** (1981), 373-384.

[605] Z. Wang: *A finite algorithm for feasible circuits over oriented matroids,* in: "Graph theory and its applications: East and West" (M.F. Capobianco et al., eds.), Proc. First China-USA International Conference (Jinan, China, June 1986), Annals of the New York Academy of Sciences **576** (1989), 602-605.

[606] Z. Wang: *A finite conformal-elimination free algorithm over oriented matroid programming,* Chinese Annals of Math. **8B** (1987), 120-125.

[607] Z. Wang: *A general scheme for solving linear complementarity problems in the setting of oriented matroids,* (in Chinese), Chin. Ann. Math. Ser. A **16** (1995), 94-99.

[608] A. Wanka: *Matroiderweiterungen zur Existenz endlicher LP-Algorithmen, von Hahn-Banach Sätzen und Polarität von orientierten Matroiden,* Dissertation, Universität Köln 1986, 86 pages.

[609] G. Wegner: *Kruskal-Katona's theorem in generalized complexes,* in: Finite and Infinite Sets, *vol. 2*, Coll. Math. Soc. János Bolyai **37**, North-Holland 1984, pp. 821-827.

[610] D. J. A. Welsh: *Matroid Theory,* Academic Press 1976.

[611] E. Welzl: *More on k-sets in the plane,* Discrete Computat. Geometry **1** (1986), 95-100.

[612] W. Wenzel: *Projective equivalence of matroids with coefficients,* J. Combinatorial Theory, Ser. A **57** (1991), 15-45.

[613] W. Wenzel: *Combinatorial Algebra of Δ-Matroids and Related Combinatorial Geometries,* Habilitationsschrift, Bielefield 1991, 148 Seiten; preprint 92/45, "Combinatorics and its Applications", Zentrum für interdisziplinäre Forschung, Universität Bielefeld 1992.

[614] N. White: *The bracket ring of a combinatorial geometry. I,* Transactions Amer. Math. Soc. **202** (1975), 79-103.

[615] N. White: *The basis monomial ring of a matroid,* Advances in Math. **24** (1977), 292-279.

[616] N. White, ed.: *Theory of Matroids,* Cambridge University Press 1986.

[617] N. White, ed.: *Combinatorial Geometries,* Cambridge University Press 1987.

[618] N. White: *A non-uniform oriented matroid which violates the isotopy property,* Discrete Comput. Geometry **4** (1989), 1-2.

[619] N. White, ed.: *Matroid Applications,* Cambridge University Press 1991.

[620] N. White: *Multilinear Cayley factorization,* J. Symbolic Computation **11** (1991), 421-438.

[621] R. O. Winder: *Partitions of N-space by hyperplanes,* SIAM J. Appl. Math. **14** (1966), 811-818.

[622] W. Wu: *Mechanical Theorem Proving in Geometry,* Texts and Monographs in Symbolic Computation, Vol. 2, Springer-Verlag, Vienna 1994.

[623] S. Yuzvinsky: *The first two obstructions to the freeness of arrangements,* Transactions Amer. Math. Soc. **335** (1993), 231-244.

[624] T. Zaslavsky: *Facing up to arrangements: face count formulas for partitions of space by hyperplanes,* Memoirs Amer. Math. Soc. No. 154, **1** (1975).

[625] T. Zaslavsky: *Counting the faces of cut-up spaces,* Bulletin Amer. Math. Soc. **81** (1975), 916-918.

[626] T. Zaslavsky: *Combinatorial ordered geometry, Part I: Bilateral geometry, or, Generalized affine and vector space ordering,* typewritten manuscript, 64 pp.

[627] T. Zaslavsky: *A combinatorial analysis of topological dissections,* Advances in Math. **25** (1977), 267-285.

[628] T. ZASLAVSKY: *Arrangements of hyperplanes: matroids and graphs,* in: *Proc. Tenth Southeastern Conf. Combinatorics* (F. Hoffmann et al, eds.), Vol. II, Utilitas Math. Publ. & Winnipeg, Manitoba 1979, pp. 895-911.

[629] T. ZASLAVSKY: *The slimmest arrangements of hyperplanes: I: Geometric lattices and projective arrangements,* Geometriae Dedicata **14** (1983), 243-259.

[630] T. ZASLAVSKY: *The slimmest arrangements of hyperplanes: II. Basepointed geometric lattices and Euclidean arrangements,* Mathematika, **28** (1981), 169-190.

[631] T. ZASLAVSKY: *Extremal arrangements of hyperplanes,* in: Proc. Conf. "Discrete Geometry and Convexity", New York 1982, (J.E. Goodman, E. Lutwak, J. Malkevitch, R. Pollack, eds.), *Annals of the New York Academy of Sciences* **440** (1985), pp. 69-80.

[632] T. ZASLAVSKY: *Orientation of signed graphs,* European J. Combinatorics **12** (1991), 283-291.

[633] E.-C. ZEEMAN: *Seminar on combinatorial topology,* Mimeographed notes, Inst. des Hautes Études Sci. & Paris 1963.

[634] G. M. ZIEGLER: *Algebraic combinatorics of hyperplane arrangements,* Ph.D. Thesis, MIT 1987, 168 pages.

[635] G. M. ZIEGLER: *The face lattice of hyperplane arrangements,* Discrete Math. **74** (1988), 233-238.

[636] G. M. ZIEGLER: *Combinatorial construction of logarithmic differential forms,* Advances in Math. **76** (1989), 116-154.

[637] G. M. ZIEGLER: *Multiarrangements of hyperplanes and their freeness,* Contemporary Math. **90** (1989), 345-358.

[638] G. M. ZIEGLER: *Some minimal non-orientable matroids of rank* 3*,* Geometriae Dedicata **38** (1991), 365-371.

[639] G. M. ZIEGLER: *Higher Bruhat orders and cyclic hyperplane arrangements,* Topology **32** (1993), 259-279.

[640] G. M. ZIEGLER: *"What is a complex matroid?"* Special issue on "Oriented Matroids" (eds. J. Richter-Gebert, G. M. Ziegler), *Discrete Comput. Geometry* **10** (1993), 313-348.

[641] G. M. ZIEGLER: *Combinatorial Models for Subspace Arrangements,* Habilitationsschrift, TU Berlin, April 1992.

[642] G. M. ZIEGLER: *Lectures on Polytopes,* Graduate Texts in Mathematics **152**, Springer-Verlag, New York 1995; *Updates, corrections, and more*, electronic preprint available per WWW from URL `http://www.math.tu-berlin.de/~ziegler`

[643] M. ZMYSLONY: *Orientierte Matroide und ihre Anwendung in der Netzwerktheorie,* in: *Graphen und Netzwerke – Theorie und Anwendung* (27. Intern. Wiss. Koll. TH Ilmenau) 1982, 65-68.