Susan Hermiller
Brief summaries of selected research publications

The goal of much of my research is both to use geometric, topological, asymptotic, or algebraic properties to find particularly tractable solutions of algorithmic problems for large classes of groups, and to understand what topological or algebraic conditions on a group are implied by such algorithms.

Articles:

1. S. Hermiller and Z. Šunić, *No positive cone in a free product is regular*, arXiv:1609.06288, 7pp; submitted.

We show that there exists no left order on the free product of two nontrivial, finitely generated, left-orderable groups such that the corresponding positive cone is represented by a regular language. Since there are orders on free groups of rank at least two with positive cone languages that are context-free (in fact, 1-counter languages), our result provides a bound on the language complexity of positive cones in free products that is the best possible within the Chomsky hierarchy. It also provides a strengthening of a result by Cristóbal Rivas stating that the positive cone in a free product of nontrivial, finitely generated, left-orderable groups cannot be finitely generated as a semigroup.

2. M. Brittenham, S. Hermiller and T. Susse, *Geometry of the word problem for 3-manifold groups*, arXiv:1609.06253, 30pp; submitted.

One fundamental goal in geometric group theory since its inception has been to find algorithmic and topological characteristics of the Cayley graph satisfied by all compact 3-manifold fundamental groups, to facilitate computations. This was the original motivation for the definition of automatic groups by Epstein, Cannon, Holt, Levy, Paterson, and Thurston, and its recent extension to Cayley automatic groups by Kharlampovich, Khoussainov, and Miasnikov. However, automaticity fails and Cayley automaticity is unknown for 3-manifold groups in two of the eight geometries. Autostackable groups, first introduced in paper #9, are a natural extension of both automatic groups and groups with finite convergent rewriting systems. In common with these two motivating properties, autostackability gives a solution to the word problem using a finite state automaton (FSA). In this paper (#2) we show that every finitely generated group that is hyperbolic relative to a collection of abelian subgroups is autostackable, and *every* closed 3-manifold fundamental group is autostackable.

An autostackable structure consists of a discrete dynamical system on the Cayley graph, that can be computed by an FSA. More specifically, for a group G with finite generating set A and Cayley graph Γ, a *flow function* with bound $K \geq 0$ with respect to a spanning tree T in Γ, is a function Φ mapping the set $\vec{E}$ of directed edges of Γ to the set $\vec{P}$ of directed paths in Γ, such that (1) for each $e \in \vec{E}$ the path $\Phi(e)$ has the same initial and terminal vertices as e and length at most K, (2) Φ acts as the identity on edges lying in T (ignoring direction), and (3) there is no infinite sequence $e_1, e_2, e_3, ...$ of edges with each e_i not in T and each e_{i+1} in the path $\Phi(e_i)$. Extending Φ to $\widehat{\Phi} : \vec{P} \to \vec{P}$ by $\widehat{\Phi}(e_1 \cdots e_n) := \Phi(e_1) \cdots \Phi(e_n)$, then for each $p \in \vec{P}$, there is a $n_p > 0$ such that $\widehat{\Phi}^{n_p}(p)$ is a path in the tree T; that is, when $\widehat{\Phi}$ is iterated, paths in Γ "flow" toward the tree. For each $g \in G$, let $nf(g)$ be the label of the unique nonbacktracking path in T from 1 to g, and let $e_{g,a}$ denote the directed edge starting at g labeled a. The group G is *autostackable* if there is a bounded flow function for which the set

$$graph(\Phi) := \{(nf(g), a, label(\Phi(e_{g,a})) \mid g \in G, a \in A\}$$

is recognized by a FSA (that is, $graph(\Phi)$ is a regular language).

In paper #9, we show that all automatic (and asynchronously automatic) groups (on prefix-closed normal forms) are autostackable, and all groups with a finite rewriting system are autostackable. All three of these properties also have interpretations as regular convergent prefix-rewriting systems (RCP-RS): An automatic structure (on a prefix-closed set) is an inter-reduced RCP-RS (by a result of F. Otto), a finite convergent rewriting system is a prefix-invariant bounded RCP-RS, and an autostackable structure is a bounded RCP-RS (paper#9).

The proof of autostackability of all closed 3-manifold groups relies on several closure properties of autostackable groups in paper #2 and #5, including extensions, finite index supergroups, and fundamental groups of graphs of groups in which each vertex group has an autostackable structure that is translation invariant under the action of an adjacent edge group.

In papers #3, #7, and #8 we study van Kampen diagrams and Dehn functions of groups with bounded flow functions, and in papers #3 and #5, we study their homological finiteness properties; see the descriptions for these papers for more details.

3. S. Hermiller and C. Martínez-Pérez, *HNN extensions and stackable groups*, arXiv:1605.06145, 34pp; submitted.

See the description for paper#2 for background definitions and notation. In this paper we show that there exists an autostackable group with Dehn function that is nonelementary primitive recursive (namely the Baumslag-Gersten group), and there is a group with a bounded flow function whose Dehn function is not computable (and so the word problem is not solvable). Between these, we build on work of Dison and Riley to show that the class of groups admitting a bounded flow function with computable graph includes groups with Dehn functions in each level of the Grzegorczyk hierarchy of primitive recursive functions.

We also studied autostackability of finitely generated metabelian groups. Groves and Smith showed that such a group admits a finite convergent rewriting system if and only if the metabelian group is constructible. In contrast, in paper #5 we give autostackable structures for a family of Diestel-Leader groups that are nonconstructible metabelian groups.

4. C. Bleak, T. Brough, and S. Hermiller, *Determining solubility for finitely generated groups of PL homeomorphisms*, arXiv:1507.06908, 28 pp; submitted.

The set of finitely generated subgroups of the group $PL_+(I)$ of orientation-preserving piecewise-linear homeomorphisms of the unit interval includes many important groups, most notably R. Thompson's group F. In this paper we show that every finitely generated subgroup $G < PL_+(I)$ is either soluble, or contains an embedded copy of Brin's group B, a finitely generated, non-soluble group, which verifies a conjecture of Bleak from 2009. In the case that G is soluble, we show that the derived length of G is bounded above by the number of G-orbit classes of the breakpoints of any finite set of generators. We specify a set of 'computable' subgroups of $PL_+(I)$ (which includes R. Thompson's group F) and we give an algorithm which determines in finite time whether or not any given finite subset X of such a computable group generates a soluble group. When the group is soluble, the algorithm also determines the derived length of $\langle X \rangle$. Finally, we give a solution of the membership problem for a family of finitely generated soluble subgroups of any computable subgroup of $PL_+(I)$.

5. M. Brittenham, S. Hermiller, and A. Johnson, *Homology and closure properties of autostackable groups*, J. Algebra **452** (2016), 596-617.

See the description for paper#2 for initial discussion of this paper. In addition to the closure properties for autostackable groups mentioned there, we also show that the class of autostackable groups is closed under graph products.

In considering homological finiteness conditions of autostackable groups, the two properties that motivated autostackability, namely automaticity and finite convergent rewriting systems, both imply the finiteness condition FP_∞. However, in this paper we show that the class of autostackable groups includes a group that is not of type FP_3, namely Stallings' non-FP_3 group.

6. L. Ciobanu, S. Hermiller, D. Holt, and S. Rees, *Conjugacy languages in groups*, Israel J. Math. **211** (2016), 311-347.

Building upon the concepts introduced in paper #10, we study rationality of the growth function and regularity of several languages derived from conjugacy classes in a finitely generated group G for a variety of examples including word hyperbolic, virtually abelian, Artin, and Garside groups. We also study the behavior of these languages upon changes in the generating set of the group. We prove that the conjugacy growth of a virtually cyclic group is rational over every generating set, proving one direction of a conjecture of Rivin (1997).

7. M. Brittenham and S. Hermiller, *A uniform model for almost convexity and rewriting systems*, J. Group Theory **18** (2015) 805-828.

See the description for paper#2 for background definitions and notation. Paper #7 first introduced the concept of bounded flow functions on finitely generated groups; this is also known as stackability. Stackability implies the existence of an inductive procedure for constructing van Kampen diagrams with respect to a particular finite presentation; in the case when the graph of the flow function is computable (e.g., when the group is autostackable), this procedure is an algorithm. Using results of paper #12, Thompson's group F has a bounded flow function whose graph satisfies a language theoretic restriction slightly weaker than the autostackable condition of papers #2,#9. We show that stackability gives a uniform model for two other geometric group theory properties, one (almost convexity) defined purely from the geometry, the other (finite complete rewriting systems) defined purely as an algorithmic property.

8. M. Brittenham and S. Hermiller, *Tame filling invariants for groups*, Internat. J. Algebra Comput. **25** (2015) 813-854.

A new pair of asymptotic invariants for finitely presented groups, called intrinsic and extrinsic tame filling functions, are introduced. These filling functions are quasi-isometry invariants that strengthen the notions of intrinsic diameter (or isodiametric) and extrinsic diameter functions for finitely presented groups. We show that the existence of a (finite-valued) tame filling function implies that the group is tame combable, as defined by Mihalik and Tschantz.

We demonstrate that the existence of a bounded flow function (see the definition in the description of paper #2; this is also the stackable property of paper #7) facilitates computation of asymptotic filling invariants for groups, allowing these new more refined invariants to be computed, and we apply this to many examples. We show that for groups with a finite complete rewriting system, the string growth complexity function is an upper bound for both tame filling invariants. For Thompson's group F this yields both a new proof, and a strengthening, of a result of Gersten that the isodiametric function of F is linear.

9. M. Brittenham, S. Hermiller, and D. Holt, *Algorithms and topology for Cayley graphs of groups*, J. Algebra **415** (2014), 112-136.

See the description for paper #2 for a full description of the results of this paper #9. In this paper we introduce autostackability, show that it gives a word problem solution using a finite state automaton, and show that it provides an effective inductive procedure for constructing van Kampen diagrams with respect to a canonical finite presentation. We also give the characterization of autostackability is given in terms of prefix-rewriting systems, and show that every group which admits a finite convergent rewriting system or an asynchronously automatic structure with respect to a prefix-closed set of normal forms is autostackable.

10. L. Ciobanu and S. Hermiller, *Conjugacy growth series and languages in groups*, Trans. Amer. Math. Soc. **366** (2014) 2803-2825.

Conjugacy growth has been a particularly active area of research in geometric group theory in the past few years, and in this paper we introduce a new direction for research in this area with the geodesic conjugacy language and geodesic conjugacy growth series for a finitely generated group. We study the effects of various group constructions on rationality of both the geodesic conjugacy and (spherical) conjugacy growth series, as well as on regularity of the geodesic and shortlex conjugacy languages. In particular, we show that regularity of the geodesic conjugacy language is preserved by the graph product construction, and rationality of the geodesic conjugacy growth series is preserved by both direct and free products. Although for free groups Rivin has shown that the conjugacy growth function is not rational, and we show that the shortlex normal forms for conjugacy classes are not even context-free, in contrast we show for these groups that the conjugacy geodesics are regular and so the conjugacy geodesic growth function is rational.

11. M. Brittenham, S. Hermiller, and R. Todd, *4-moves and the Dabkowski-Sahi invariant for knots*, J. Knot Theory Ramifications **22** (2013) 1350069.1-20.

In 1979 Nakanishi conjectured that the 4-move is an unknotting operation. The conjecture remains open, although it has been verified for several classes of knots, including 2-bridge knots (Przytycki). It is known that 1- and 2-moves are unknotting operations, but 3-moves and n-moves for $n > 4$ are not (Dabkowski and Przytycki), and consequently there is growing belief that the conjecture is false. Dabkowski and Sahi introduced an invariant of links under 4-moves that is a quotient of the fundamental group of the knot complement, and show that if invariant is not a (infinite) cyclic group, then the knot cannot be unknotted with 4-moves. However, this invariant has been found to be intractable; computational algorithms were unable to determine whether or not the group is $\mathbb{Z}$ for specific examples.

In this paper we introduce another group invariant which is a quotient of the Dabkowski-Sahi group (and hence also of the knot group) which has proved to be tractable in almost all cases, and which incorporates the same information, namely that if the group is not cyclic, then the knot cannot be unknotted with 4-move. We use this new invariant (and considerable time on a supercomputer) to show that both groups are cyclic for all alternating knots with up to 14 crossings, and 99.4% of all alternating knots with up to 20 crossings, have cyclic invariants; therefore, in these cases both invariants cannot detect a counterexample to the 4-move conjecture.

12. S. Cleary, S. Hermiller, M. Stein and J. Taback, *Tame combing and almost convexity conditions*, Math. Z. **269** (2011) 879-915.

We explore relationships between the family of successively weaker almost convexity conditions, and successively weaker tame combing conditions. We show that both Thompson's group F and the Baumslag-Solitar groups $BS(1,p)$ with $p \geq 3$ admit a tame combing with a linear radial tameness function. By earlier work of Belk and Bux showing that F is not minimally almost convex, and of Elder and Hermiller showing that $BS(1,p)$ with $p \geq 7$ is not minimally almost convex, in each case with respect to a standard generating set, this result provides examples of groups and generating sets satisfying a strong tame combing condition yet not even the weakest almost convexity condition on the same generating set. We also show that an inclusion on strong tame combing conditions is strict by showing that although $BS(1,p)$ with the standard generators and $p \geq 8$ does admit a tame combing with a linear radial tameness function, the linear coefficient of this function must be greater than 1.

13. S. Hermiller, S. Lindblad and J. Meakin, *Decision problems for inverse monoids presented by a single sparse relator*, Semigroup Forum **81** (2010) 128-144.

We study a class of inverse monoids of the form $M = Inv\langle X \mid w = 1\rangle$, where the single relator w has a combinatorial property that we call sparse. For a sparse word w, we prove that the word problem for M is decidable. We also show that the set of words in $(X \cup X^{-1})^*$ that represent the identity in M is a deterministic context free language, and that the set of geodesics in the Schützenberger graph of the identity of M is a regular language.

14. S. Hermiller, D. F. Holt and S. Rees, *Groups whose geodesics are locally testable*, Internat. J. Algebra Comput. **18** (2008) 911-923.

A regular set of words is (k-)locally testable if membership of a word in the set is determined by the nature of its subwords of some bounded length k. In this article we study groups for which the set of all geodesic words with respect to some generating set is (k-)locally testable, and we call such groups (k-)locally testable. We show that a group is 1-locally testable if and only if it is free abelian. We show that the class of (k-)locally testable groups is closed under taking finite direct products. We show also that a locally testable group has finitely many conjugacy classes of torsion elements.

Our work involved computer investigations of specific groups, for which purpose we implemented an algorithm in GAP to compute a finite state automaton with language equal to the set of all geodesics of a group (assuming that this language is regular), starting from a shortlex automatic structure. We provide a brief description of that algorithm.

15. R. H. Gilman, S. Hermiller, D. F. Holt, and S. Rees, *A characterization of virtually free groups*, Arch. Math. **89** (2007) 289-295.

We prove that a finitely generated group G is virtually free if and only if there exists a generating set for G and $k > 0$ such that all k-local geodesic words with respect to that generating set are geodesic. That is, this locally excluding property of the set of geodesic words determines the algebraic structure of the group.

16. S. Hermiller, D. F. Holt and S. Rees, *Star-free geodesic languages for groups*, Internat. J. Algebra Comput. **17** (2007) 329-345.

An early fundamental result about hyperbolic groups is the theorem (in Epstein et al) that the set of geodesics in a hyperbolic group is a regular language. In this paper, and continuing in papers #14 and #15, we show that further restricting the language class results in both algebraic and algorithmic consequences for the group.

In this article we show that every group with a finite presentation satisfying one or both of the small cancellation conditions $C'(1/6)$ and $C'(1/4) - T(4)$ has the property that the set of all geodesics (over the same generating set) is a star-free regular language. The class of groups whose geodesic sets are star-free with respect to some generating set is shown to be closed under taking graph (and hence free and direct) products, and includes all virtually abelian groups. We also show that star-free regularity of the geodesic set is dependent on the generating set chosen, even for free groups, and consequently disprove a conjecture of Margolis and Rhodes on the relationship between the property of admitting a star-free geodesic set and the class of hyperbolic groups.

17. S. Hermiller and Z. Šunić, *Poly-free constructions for right-angled Artin groups*, J. Group Theory **10** (2007) 117-138.

We show that every right-angled Artin group $A\Gamma$ defined by a graph Γ of finite chromatic number is poly-free with poly-free length bounded between the clique number and the chromatic number of Γ. Further, a characterization of all right-angled Artin groups of poly-free length 2 is given, namely the group $A\Gamma$ has poly-free length 2 if and only if there exists an independent set of vertices D in Γ such that every cycle in Γ meets D at least twice. Finally, it is shown that $A\Gamma$ is a semidirect product of 2 free groups of finite rank if and only if Γ is a finite tree or a finite complete bipartite graph. All of the proofs of the existence of polyfree structures are constructive.

18. S. Hermiller and J. P. McCammond, *Noncommutative Gröbner bases for the commutator ideal*, Internat. J. Algebra Comput. **16** (2006), 187-202.

Let I denote the commutator ideal in the free associative algebra on m variables over an arbitrary field. In this article we prove there are exactly $m!$ finite Gröbner bases for I, and uncountably many infinite Gröbner bases for I with respect to total division (or admissible) orderings. In addition, for $m = 3$ we give a complete description of its universal Gröbner basis.

This illustrates a strong difference between Gröbner bases for commutative and noncommutative polynomials; in the commutative case, only finitely many Gröbner bases exist for a given ideal.

19. S. Hermiller and I. Swanson, *Computations with Frobenius powers*, Experiment. Math. **14** (2005), 161-173.

Katzman showed that tight closure of ideals in polynomial rings in finitely many variables over a field commutes with localization at one element if for all ideals I and J in a polynomial ring there is a linear upper bound in q on the degree in the least variable of reduced Gröbner bases in reverse lexicographic ordering of the ideals of the form $J + I^{[q]}$. Katzman conjectured that the latter property would always be satisfied. In this paper we prove several cases of Katzman's conjecture. We also provide an experimental analysis (with proofs) of asymptotic properties of Gröbner bases connected with Katzman's conjectures.

20. M. Elder and S. Hermiller, *Minimal almost convexity*, J. Group Theory **8** (2005), 239-266.

Almost convexity is a measure of nonpositive curvature of a group, that is satisfied by many groups not covered by other more common measures (eg automaticity). Minimal almost convexity (MAC) is a weaker curvature property that includes more groups yet. In this article we show that the Baumslag-Solitar group $BS(1, 2)$ is minimally almost convex, or MAC. We also show that $BS(1, 2)$ does not satisfy Poénaru's almost convexity condition $P(2)$, and hence the condition $P(2)$ is strictly stronger than MAC. Finally, we show that the groups $BS(1, q)$ for $q \geq 7$ and Stallings' non-FP_3 group do not satisfy MAC. As a consequence, the condition MAC is not a commensurability invariant.

21. J. M. Alonso and S. Hermiller, *Homological finite derivation type*, Internat. J. Algebra Comput. **13** (2003), 341-359.

A monoid M has type left-, right-, or bi-FP_n if there is a projective resolution of $\mathbb{Z}$ by finitely generated left-, right-, or bi-$\mathbb{Z}M$-modules of length n. For groups, these three properties are the same, but D.E. Cohen showed that left- and right-FP_∞ differ for monoids. In this paper we show that left FP_n and right FP_n (not necessarily with the same resolution) together implies bi-FP_n for monoids.

In 1987 Squier defined the notion of finite derivation type for a finitely presented monoid. To do this, he associated a 2-complex to the presentation. The monoid then has finite derivation type if, modulo the action of the free monoid ring, the 1-dimensional homotopy of this complex is finitely generated. Cremanns and Otto showed that finite derivation type implies the homological finiteness condition left FP_3, and when the monoid is a group, these two properties are equivalent. In this paper we also define a new version of finite derivation type, based on homological information, together with an extension of this finite derivation type to higher dimensions, and show connections to homological type FP_n for both monoids and groups.

22. J. R. J. Groves and S. Hermiller, *Isoperimetric inequalities for soluble groups*, Geom. Dedicata **88** (2001), 239-254.

To approach the question of which solvable groups are automatic, we show that every constructible solvable group, and hence every possible candidate for a solvable automatic group, can be obtained by the following operations, in the given order: Start with a finitely generated nilpotent group, form one (ascending) HNN extension in which the base group coincides with one of the associated subgroups, form a finite number of split extensions by infinite cyclic groups, and, finally, form a finite extension. We also show that an ascending HNN extension G of a finitely generated torsion-free nilpotent group is automatic if and only if the group is virtually abelian. Moreover, if G is not virtually nilpotent, then the Dehn function for G is at least exponential, and if G is not polycyclic, the abelianized Dehn function for G is also at least exponential.

23. S. Hermiller and J. Meier, *Measuring the tameness of almost convex groups*, Trans. Amer. Math. Soc. **353** (2001), 943-962.

A 1-combing for a finitely presented group consists of a continuous family of paths based at the identity and ending at points x in the 1-skeleton of the Cayley 2-complex associated to the presentation. We define two functions, radial and ball tameness functions, that measure how efficiently a 1-combing moves away from the identity. These functions are geometric in the sense that they are quasi-isometry invariants. We show that a group is almost convex if and only if the radial tameness function is bounded by the identity function; hence almost convex groups, as well as certain generalizations of almost convex groups, are contained in the quasi-isometry class of groups admitting linear radial tameness functions.

24. S. Hermiller, X. H. Kramer and R. C. Laubenbacher, *Monomial orderings, rewriting systems, and Gröbner bases for the commutator ideal of a free algebra*, J. Symbolic Comput. **27** (1999), 133-141.

We show the existence of a monoid with uncountably many distinct minimal complete rewriting systems. (The results of this paper were strengthened in paper #18 to an uncountable family of Gröbner bases with respect to total division orderings.)

25. S. Hermiller and M. Shapiro, *Rewriting systems and geometric three-manifolds*, Geom. Dedicata **76** (1999), 211-228.

We show that the fundamental groups of all closed 3-manifolds with uniform geometries other than hyperbolic have finite complete rewriting systems. The fundamental groups of a large class of amalgams of circle bundles also have finite complete rewriting systems. (See also discussion of paper #2.)

26. S. Hermiller and J. Meier, *Artin groups, rewriting systems and three-manifolds*, J. Pure Appl. Algebra **136** (1999), 141-156.

We construct finite complete rewriting systems for two large classes of Artin groups: those of finite type, and those whose defining graphs are based on trees. The constructions in the two cases are quite different; while the construction for Artin groups of finite type uses normal forms introduced through work on complex hyperplane arrangements, the rewriting systems for Artin groups based on trees are constructed via three-manifold topology.

This construction naturally leads to the question: Which Artin groups are three-manifold groups? We show that an Artin groups whose defining graph Γ has even edge labels is a 3-manifold group if and only if every connected component of Γ is either a tree or a triangle with all edges labeled 2.

(More recently, Gordon (2004) showed that this theorem holds for all Artin groups.)

27. S. Hermiller, *Tutorial on string rewriting systems and extensions of Gröbner bases*, Proceedings of the FLoC'99 Workshop on Gröbner Bases and Rewriting Techniques, Trento, Italy, 1999, www-madlener.informatik.uni-kl.de/ag-madlener/staff/FLoC99/workshop8.html

28. S. Hermiller and J. Meier, *Tame combings, almost convexity and rewriting systems for groups*, Math. Z. **225** (1997), 263-276.

Finite complete rewriting systems have proven to be useful objects in geometric group theory; in this paper we study the geometry of groups admitting such rewriting systems. We show that a group G with a finite complete rewriting system admits a tame 1-combing. (This paper precedes Perelman's results on Thurston's Geometrization Conjecture; from our results it also follows (by work of Mihalik and Tschantz) that if G is an infinite fundamental group of a closed irreducible 3-manifold M, then the universal cover of M is $\mathbb{R}^3$.) We also establish that a group admitting a geodesic rewriting system is almost convex in the sense of Cannon, and that almost convex groups are tame 1-combable.

29. S. Hermiller and J. Meier, *Algorithms and geometry for graph products of groups*, J. Algebra **171** (1995), 230-257.

The graph product construction is widely applied; in particular, graph products of infinite cyclic groups [respectively, cyclic groups of order 2], also called right-angled Artin [respectively, Coxeter] groups, have been widely studied in geometric group theory. This paper lays the foundations for showing that the graph product construction preserves many geometric and algorithmic properties of groups, including hyperbolic groups, semihyperbolic groups, automatic groups, groups with finite complete rewriting systems, and combable groups.

30. S. Hermiller, *Rewriting systems for Coxeter groups*, J. Pure Appl. Algebra **92** (1994), 137-148.

A finite complete rewriting system for a group is a finite presentation which gives a solution to the word problem and a regular language of normal forms for the group. Constructions of finite complete rewriting systems are given for any Coxeter group G satisfying one of the following hypotheses: 1) G has three or fewer generators, or 2) G does not contain a special subgroup of the form $\langle s_i, s_j, s_k \mid s_i^2 = s_j^2 = s_k^2 = (s_i s_j)^2 = (s_i s_k)^m = (s_j s_k)^n = 1\rangle$ with m and n both finite and not both equal to two.

31. C. A. Scamehorn, S. Hermiller and R. M. Pitzer, *Electronic structure of polyhedral alkanes*, J. Chemical Physics **84** (1986), 833-837.

Three regular polyhedra have valence four and so represent polyhedral alkanes of chemical formula C_nH_n. We use the high level of symmetry to obtain a set of self-consistent field wave functions to study the bond distances and ionization potentials of these molecules.

32. J. A. Schiavone and S. Hermiller, *A regression model for forecasting microwave radio fading at Palmetto, GA*, IEEE Trans. Antennas and Propagation **AP-34** (1986), 936-942.

We use a logistic regression analysis on meteorological data and microwave signal transmission strength to develop an empirical model for forecasting signal fading.

33. H. B. Thompson and S. Hermiller, *A family of random number routines*, J. Comput. Math. Science Teaching **4** no.4 (1985), 57-60.

We develop a new random number generator to minimize biases appearing in a standard generator.

34. H. B. Thompson and S. Hermiller, *Computer managed problem drill: The program* PROBLEM, J. Comput. Math. Science Teaching **2** no.1 (1982), 25-30.

We introduce a software package for generating, administering, and grading student homeworks in mathematics, sciences, and engineering.

Conference proceedings:

35. C. Bleak, S. Hermiller, T. Jajcayova and S. Margolis, editors: Proceedings of the International Conference on Geometric and Combinatorial Methods in Group Theory and Semigroup Theory 2009, Internat. J. Algebra Comput. **21** (2011), no. 1-2.

36. S. Hermiller, J. Meakin and M. Sapir, editors: Proceedings of the International Conference on Geometric and Combinatorial Methods in Group Theory and Semigroup Theory 2000, Internat. J. Algebra Comput. **12** (2002), no. 1-2.