Sergei SINCHUK – Curriculum Vitae

Born on 21 June 1988 in Petrozavodsk, USSR, citizen of Russia, married, no children

1 Contact information

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2 Education

2005–2010	Specialist in Pure Mathematics, graduated cum laude, Saint-Petersburg State University, Russia.
2010–2013	C. Sc. degree in Algebra completed under supervision of N. Vavilov thesis title "Parabolic factorizations of reductive groups", Saint-Petersburg State University, Russia.

3 Work experience

2008–2022	researcher and developer at Jetbrains Research, Saint-Petersburg;
2013–2022	postdoctoral researcher at Chebyshev Laboratory, Faculty of Mathematics and Computer Science, Saint-Petersburg State University.

4 Research interests

My research addresses the interplay between group theory, algebraic geometry and unstable algebraic K-theory. The main project I have been working on lately is the study of Steinberg groups associated to Chevalley groups. Steinberg groups are certain series of groups presented by means of generators and relations. They are, in some sense, combinatorial approximations of the groups of points of algebraic groups. Let Φ be a spherical reduced irreducible root system and G_Φ be the simply-connected Chevalley–Demazure group scheme of type Φ. For an arbitrary commutative unital ring R we denote by $G_\Phi(R)$ the group of R-points of G_Φ. If the rank of all irreducible components of Φ is at least 2 then $G_\Phi(R)$ contains a "big" normal subgroup called *elementary subgroup*. This subgroup is denoted $\mathrm{E}(\Phi, R)$ and is generated by the so-called root-unipotents $t_\alpha(\xi)$, $\alpha \in \Phi$, $\xi \in R$. The Steinberg group $\mathrm{St}(\Phi, R)$ is the group defined

by means of generators $x_\alpha(\xi)$ modeling root unipotents $t_\alpha(\xi)$ and Chevalley commutator relations . It is an extension of the group $\mathrm{E}(\Phi, R)$. Under certain assumptions on Φ and R the group $\mathrm{St}(\Phi, R)$ is known to be centrally closed (i. e. every its central extension splits). The groups $\mathrm{K}_1(\Phi, R)$ and $\mathrm{K}_2(\Phi, R)$ are defined via the following exact sequence:

$$\mathrm{K}_2(\Phi, R) \hookrightarrow \mathrm{St}(\Phi, R) \xrightarrow{\pi} G_\Phi(R) \twoheadrightarrow \mathrm{K}_1(\Phi, R). \tag{4.1}$$

Here is the list of problems upon which I have worked on.

- *Centrality of* K_2 *conjecture.* This conjecture asserts that $\mathrm{K}_2(\Phi, R)$ is a central subgroup of $\mathrm{St}(\Phi, R)$ for an arbitrary commutative ring provided the rank of Φ is at least 3. The conjecture was formulated in the 1970s in the works of M. Stein and W. van der Kallen. In some sense, it is a central question of the theory of Steinberg groups/Chevalley groups. The linear case of the conjecture was proved already in 1978 by W. van der Kallen. Since then no progress has been made. Together with my coauthors we are able to settle the conjecture positively in [5, 6, 11].

- *Study of Steinberg groups associated to Kac–Moody groups.* Let A be a generalized Cartan matrix. One can define Steinberg groups $\mathrm{St}(A, R)$ in the setting of Kac–Moody groups. Then one can define and study the groups $\mathrm{K}_2(A, R)$ similarly to the groups $\mathrm{K}_2(\Phi, R)$. In [7] a method of computation of the group $\mathrm{K}_2(A, F)$ was proposed based on an earlier result of J. Morita and U. Rehmann.

- *Homotopy invariance of* K_2*-groups aka* K_2*-analogue of Bass–Quillen conjecture.* Denote by $\mathrm{VB}_n(R)$ the set of constant rank n projective modules over R. Recall that the classical Quillen–Suslin theorem asserts that for any field F there are no nonfree projective modules over the polynomial ring $F[t_1, \dots t_n]$, i. e. that $\mathrm{VB}_n(R) = \{*\}$ for any n. Recall also that the stronger Lindel–Popescu theorem (which itself is a solution to a particular case of Bass–Quillen conjecture) asserts that $\mathrm{VB}_n(R[t]) = \mathrm{VB}_n(R)$ provided R is a regular ring containing a field. Analogues of Lindel–Popescu theorem have been long studied for K_1-functors in the works of E. Abe, F. Grunewald, J. Mennicke, L. Vaserstein and recently A. Stavrova. However until recently this problem has not been studied on the level of K_2. In [10, 12] I together with my coauthors have shown that a direct analogue of Lindel–Popescu theorem holds for linear and even orthogonal K_2-functors, i. e. that under certain assumptions on R and Φ one has $\mathrm{K}_2(\Phi, R[t]) = \mathrm{K}_2(\Phi, R)$. As a corollary we show that the groups $\mathrm{K}_2(\Phi, R)$ can be reinterpreted as fundamental groups of the scheme G_Φ in the unstable $\mathbb{A}^1$-homotopy category $\mathcal{H}(k)$ of F. Morel and V. Voevodsky, see [12, Corollary 1.2].

The Mathematical Subject Classification codes for my research interests are as follows:

- Primary: 20G, 19B, 19C;

- Secondary: 11E70; 19G05; 19G12; 19G38.

5 Work experience at Jetbrains

My first project at JetBrains was the development of an operational transformation model for a collaborative groupware editor verified in Coq proof assistant. More information can be found in this paper.

The most recent project at JetBrains which I have been working on was the development of *Arend*, a language with dependent types based on V. Voevodsky's Homotopy Type Theory. A short talk about

Arend aimed at wider audiences can be found here (in Russian). The idea of the project was to develop a dependently typed language together with a smart integrated development environment (IDE) which would be more convenient to use as compared to the existing systems of formalized mathematics. My responsibilities within the project included learning mathematical logic, learning about the existing systems of formalized mathematics (like Mizar or Coq), actual language and IDE development using Kotlin (see my commits here), implementing various algorithms (e.g. I have implemented Arend's termination checker) and developing automatic tests.

6 List of some of my talks

- Decompositions of Dennis–Vaserstein type, *Algebraic Groups and Related Structures, a conference dedicated to N. Vavilov on occasion of his 60th birthday*, September 2012, Saint-Petersburg, Russia;
- Steinberg groups of Chevalley groups, *ATM Workshop on Classical and Non-stable Algebraic K-Theory*, July 2013, Mumbai, India;
- Parabolic factorizations of Steinberg groups, *Ischia Group Theory*, April 2014, Ischia, Italy;
- Coq-verified operational transformation for trees *Agda Implementors Meeting*, May 2014, Paris, France.
- On centrality of K_2 of Chevalley groups, *Linear algebraic groups, vector bundle classification and division rings*, June 2015, Lens, France;
- —, *Lie algebras, algebraic groups and invariant theory*, February 2017, Moscow, Russia.
- On the K_2-analogue of Serre problem for Chevalley groups, *Lie algebras, algebraic groups and invariant theory*, August 2018, Samara, Russia.
- What is a building? *Chebyshev laboratory colloquim for students*, 28th February 2019, Saint-Petersburg, Russia.
- An analogue of Horrocks' theorem for orthogonal Steinerg groups *Lie algebras, algebraic groups and invariant theory* , January 2020, Moscow, Russia.
- Presenting Chevalley groups over rings of polynomials by generators and relations, *Lie algebras, algebraic groups and invariant theory*, August 2021, Samara, Russia.
- On the $\mathbb{A}^1$-homotopy groups of Chevalley groups, *Saint-Petersburg online seminar on $\mathbb{A}^1$-topology, motives and K-theory*, September 2021;
- —, *Online conference "Linear algebraic groups and related structures" on the occasion of N. Gordeev's 70th Anniversary*, November 2021

7 Other math schools and conferences that I have attended

- *Galois cohomology, motives and cubic Jordan algebras*, May 2012, Lens, France;
- *International Conference on Representations of Algebras*, August 2012, Bielefeld, Germany;

- *Thematic trimester "Semantics of proofs and certified mathematics"*, May 2014, Paris, France;
- *Thematic program "Algebraic Groups and Representations"*, June 2014, Lyon, France.
- *Yaroslavl summer school "Algebra and Geometry"* in Yaroslavl, Russia, I attended the event in 2014, 2015 and 2016.

8 Scholarships, prizes and grants

- Rokhlin prize scholarship, December 2016 (first prize);
- Native Towns scholarship from GazpromNeft (in the postdoc category), October 2017;
- I won RSCF grant 22-21-00257 as a grant leader, October 2021.

9 Language skills

- Russian (native);
- English (advanced, IELTS 7.0 in 2012);
- French (intermediate, studied for several years);
- German (intermediate, studied for several years).

10 Service to math community

I did reviewing work for Zentralblatt and Mathscinet online databases. Also I have written referee reports for the following journals:

- Journal of Pure and Applied Algebra
- Journal of Algebra
- Communications in Algebra
- Mathematical Notes
- St. Petersburg Math. Journal.

11 Math-related technologies I am familiar with

- Document preparation: LaTeX (15+ years of experience)
- Systems of formalized mathematics: Coq (2+ years of experience).
- Computer algebra systems: Maple, gap, Macaulay2

12 List of selected papers and preprints

[1] N. Vavilov, S. Sinchuk Parabolic factorizations of split classical groups. *St. Petersburg Math. J.* **23**:4 (2012), 637–657;

[2] A. Ananyevskiy, N. Vavilov, S. Sinchuk On the overgroups of $E(m, R) \otimes E(m, R)$. I - Levels and normalizers. St. Petersburg Math. J. **23**:5 (2012), 819–849;

[3] S. Sinchuk Injective stability for unitary K_1, revisited. *J.* K-*Theory*, **11** (2013), 233–242;

[4] S. Sinchuk Improved Stability for odd-dimensional orthogonal group. *J. Math. Sci.*, **199**:3 (2014), 343–349;

[5] S. Sinchuk On centrality of K_2 for Chevalley groups of type E_ℓ. *J. Pure Appl. Alg.* **220** (2016), 857–875;

[6] A. Lavrenov, S. Sinchuk On centrality of even orthogonal K_2. *J. Pure Appl. Alg.*, **221** (2017), 1134–1145;

[7] S. Sinchuk A note on K_2 of Kac–Moody groups over fields, 2017, *Lin. Alg. Appl.*, **534C**, (2017), 174–180;

[8] S. Sinchuk, A. Smolensky Decompositions of congruence subgroups of Chevalley groups. *Int. J. Alg. Comput.*, **28**:6 (2018), 935–958;

[9] S. Sinchuk Parametrized symmetric groups and the second homology of a group, *Algebra i Analiz*, **32**:6 (2020), 147–164;

[10] A. Lavrenov, S. Sinchuk A Horrocks-type theorem for even orthogonal K_2, *Doc. Math.* **25**, 767–809 (2020)

[11] A. Lavrenov, S. Sinchuk, E. Voronetsky Centrality of K_2 for Chevalley groups: a pro-group approach, *Israel J. Math*, to appear, (2022).

[12] A. Lavrenov, S. Sinchuk, E. Voronetsky On the $\mathbb{A}^1$-invariance of K_2 modeled on linear and even orthogonal groups, (preprint) (2021).

13 Papers on formalized mathematics and verified software

- S. Sinchuk, P. Chuprikov, K. Solomatov Verified operational transformation for trees. *Int. Conf. Interactive Theorem Proving* (2016), 358–373, Springer;
- S. Sinchuk Arend – a language with dependent types based on HoTT (in Russian, part 1)
- S. Sinchuk Arend – a language with dependent types based on HoTT (in Russian, part 2)