STATEMENT OF RESEARCH INTERESTS
by Z.A.Lykova

PURE MATHEMATICS

My **pure mathematical research** is in Noncommutative Geometry and Complex Analysis. In **Complex Analysis** I have been working jointly with Prof. J. Agler (UCSD, USA) and Prof. N.J. Young (Newcastle and Leeds Univ.) on hyperbolic geometry in the sense of Kobayashi, which comprises a study of the complex geometry of domains Ω through the analytic maps from the complex disc $\mathbf{D}$ into Ω. Recently we have been studying the hyperbolic geometry of the *open symmetrised bidisc* $\mathcal{G} \stackrel{\text{def}}{=} \{(z+w, zw) : |z| < 1, |w| < 1\}$. Study of the domain $\mathcal{G}$ began because of its connection with control engineering in 1999. However, it has turned out that the geometry of $\mathcal{G}$ is also significant for the general theory of invariant distances.

In **Noncommutative Geometry** I have studied a number of questions on the structure and properties of topological algebras from the viewpoint of homological algebra. The theory has applications in many branches of mathematics, including spectral theory, the theory of de Rham homology in differential geometry, automatic continuity theory and K-theory. I am particularly interested in the cohomological problems that arise in noncommutative geometry. I am in the course of developing an extensive theory for this purpose and have made significant progress during the last few years.

Geodesics, retracts, and the norm-preserving extension property in the symmetrized bidisc

A set V in a domain U in $\mathbb{C}^n$ has the *norm-preserving extension property* if every bounded holomorphic function on V has a holomorphic extension to U with the same supremum norm. In [2] we prove that an algebraic subset of the *symmetrized bidisc*

$$G = \{(z+w, zw) : |z| < 1, \ |w| < 1\}$$

has the norm-preserving extension property if and only if it is either a singleton, G itself, a complex geodesic of G, or the union of the set $\{(2z, z^2) : |z| < 1\}$ and a complex geodesic of degree 1 in G. We also prove that the complex geodesics in G coincide with the nontrivial holomorphic retracts in G. Thus, in contrast to the case of the ball or the bidisc, there are sets in G which have the norm-preserving extension property but are not holomorphic retracts of G. In the course of the proof we obtain a detailed classification of the complex geodesics in G modulo automorphisms of G. We give applications to von Neumann-type inequalities for Γ-contractions (that is, commuting pairs of operators for which the closure of G is a spectral set) and for symmetric functions of commuting pairs of contractive operators. We find three other domains that contain sets with the norm-preserving extension property which are not retracts: they are the spectral ball of 2×2 matrices, the tetrablock and the pentablock. We also identify the subsets of the bidisc which have the norm-preserving extension property for symmetric functions. The paper is joint with Prof. J. Agler (UCSD, USA) and Prof. N.J. Young (Newcastle/Leeds Univ.).

Extremal holomorphic maps and the symmetrised bidisc

In [40] we introduce the class of n-extremal holomorphic maps, a class that generalises both finite Blaschke products and complex geodesics, and apply the notion to the finite interpolation problem for analytic functions from the open unit disc into the symmetrised bidisc $\mathcal{G}$. We show that a well-known necessary condition for the solvability of such an interpolation problem is not sufficient whenever the number of interpolation nodes is 3 or greater. We introduce a classification of rational $\mathcal{G}$-inner functions, that is, analytic functions from the disc into $\mathcal{G}$ whose radial limits at almost all points on the unit circle lie in the distinguished boundary of $\mathcal{G}$. The classes are related to n-extremality and the conditions $\mathcal{C}_\nu$; we prove numerous strict inclusions between the classes. The referee wrote: "this article may well become a classic..." The papers are joint with Prof. J. Agler and Prof. N.J. Young.

The boundary Carathéodory-Fejér interpolation problem

In [36] we prove a solvability criterion for the *boundary Carathéodory-Fejér problem*: given a point $x \in \mathbb{R}$ and, a finite set of target values, to construct a function f in the Pick class such that the first few derivatives of f take on the prescribed target values at x. We also derive a linear fractional parametrization of the set of solutions of the interpolation problem. In [37] we give a new solvability criterion for the *weak boundary Carathéodory-Fejér problem*: given a point $x \in \mathbb{R}$ and, a finite set of target values $a^0, a^1, \ldots, a^n \in \mathbb{R}$, to construct a function f in the Pick class such that the limit of $f^{(k)}(z)/k!$ as $z \to x$ nontangentially in the upper half plane is a^k for $k = 0, 1, \ldots, n$. The criteria are in terms of positivity of an associated Hankel matrix. The paper is joint with Prof. J. Agler and Prof. N.J. Young.

The higher-dimensional amenability of tensor products of Banach algebras

In [38] I investigate the higher-dimensional amenability of tensor products $\mathcal{A} \widehat{\otimes} \mathcal{B}$ of Banach algebras $\mathcal{A}$ and $\mathcal{B}$. I prove that the weak bidimension db_w of the tensor product $\mathcal{A}\hat{\otimes}\mathcal{B}$ of Banach algebras $\mathcal{A}$ and $\mathcal{B}$ with bounded approximate identities satisfies $db_w\mathcal{A}\hat{\otimes}\mathcal{B} = db_w\mathcal{A} + db_w\mathcal{B}$. I show that it cannot be extended to arbitrary Banach algebras. For example, for a biflat Banach algebra $\mathcal{A}$ which has a left or right, but not two-sided, bounded approximate identity, we have $db_w\mathcal{A}\hat{\otimes}\mathcal{A} \le 1$ and $db_w\mathcal{A} = 1$. I describe explicitly the continuous Hochschild cohomology $\mathcal{H}^n(\mathcal{A} \widehat{\otimes} \mathcal{B}, (\mathcal{X} \widehat{\otimes} \mathcal{Y})^*)$ and the cyclic cohomology $\mathcal{HC}^n(\mathcal{A} \widehat{\otimes} \mathcal{B})$ of certain tensor products $\mathcal{A} \widehat{\otimes} \mathcal{B}$ of Banach algebras $\mathcal{A}$ and $\mathcal{B}$ with bounded approximate identities; here $(X \widehat{\otimes} Y)^*$ is the dual bimodule of the tensor product of essential Banach bimodules X and Y over $\mathcal{A}$ and $\mathcal{B}$ respectively.

Hochschild cohomology of certain nuclear Fréchet and DF algebras

There is much current interest in the computation of cyclic (co)homology groups. Most of the literature has been devoted to the purely algebraic context, but there have also been papers addressing the calculation of the continuous version of these groups for topological algebras. However, it remains the case that these groups can only be calculated for a restricted range of algebras.

In [34] I describe explicitly continuous Hochschild and cyclic cohomology groups of simplicially trivial nuclear Fréchet and DF algebras. In [35] I show the existence of a topological isomorphism in the Künneth formula for the cohomology groups of complete nuclear DF-complexes such that all their boundary maps have closed range. This allows me to prove the existence of a topological isomorphism in the Künneth formula for continuous Hochschild cohomology groups of nuclear Fréchet algebras. In [35] I describe explicitly the continuous Hochschild and cyclic-type homology and cohomology of certain tensor products of topological algebras which are Fréchet or nuclear Fréchet or nuclear DF-spaces.

Cyclic-type cohomology of locally convex topological algebras

My work [32] describes techniques for the calculation of the cyclic type cohomology groups of projective limits of locally convex algebras and applies them to some natural classes of algebras. Let $(A_\alpha, T_{\alpha,\beta})_{(\Lambda,\leq)}$ be a reduced projective system of complete Hausdorff locally convex algebras with jointly continuous multiplications, and let A be the projective limit algebra $A = \lim\limits_{\overleftarrow{\alpha}} A_\alpha$. I prove that, for the continuous cyclic cohomology HC^* and continuous periodic cohomology HP^* of A and $A_\alpha, \alpha \in \Lambda$, for all $n \geq 0$, $HC^n(A) = \lim\limits_{\overrightarrow{\alpha}} HC^n(A_\alpha)$, the inductive limit of $HC^n(A_\alpha)$, and, for $k = 0, 1$, $HP^k(A) = \lim\limits_{\overrightarrow{\alpha}} HP^k(A_\alpha)$. For a projective limit algebra $A = \lim\limits_{\overleftarrow{m}} A_m$ of a countable reduced projective system $(A_m, T_{m,\ell})_{\mathbf{N}}$, I also establish relations between the cyclic-type continuous homology of A and $A_m, m \in \mathbf{N}$.

In [33] I show methods for the computation of the Hochschild and cyclic-type continuous homology and cohomology of some locally convex strict inductive limits $A = \lim\limits_{\overrightarrow{m}} A_m$ of Fréchet algebras A_m.

A Künneth formula for the simplicial cohomology groups of Fréchet algebras

A Künneth formula for bounded chain complexes $\mathcal{X}$ and $\mathcal{Y}$ of Fréchet spaces and continuous boundary maps with closed ranges and, in particular, for the simplicial cohomology groups of Fréchet algebras is proved in [30, 31]. These papers are joint with Dr. F. Gourdeau (Laval Univ., Canada) and Dr. M.C. White (Newcastle Univ.). For the semigroup algebras $\ell^1(\mathbf{Z}_+^k)$ and $L^1(\mathbf{R}_+^k)$, we apply the Künneth formula to describe the simplicial cohomology and homology groups explicitly.

Excision in the Hochschild and cyclic cohomology of Fréchet and Banach algebras

The excision property for continuous Hochschild, cyclic and periodic cyclic (co)homology in the category of Fréchet and Banach algebras is proved in [25, 27] and in [28] (joint with Dr. J. Brodzki (Univ. of Southampton)). For continuous Hochschild and cyclic cohomology groups it was an open problem. This is particularly aimed at cohomological problems arising in differential geometry and K-theory.

My work [26] (joint with Dr. M.C. White) describes techniques for the calculation of continuous Hochschild (co)homology groups of Banach algebras. We prove the existence of long exact sequences associated with extensions of algebras for continuous cohomology of Banach algebras with coefficients in dual bimodules (under certain conditions on the kernel of the extension and on the bimodule). Thus we can break the calculation down by making use of extensions of Banach algebras. We also show that the existence of an associated long exact sequence of continuous homology groups with coefficients in bimodules is equivalent to the existence of one for cohomology groups with coefficients in dual bimodules. We apply these results to study of the n-amenability and the simplicial triviality of Banach algebras.

Extensions of Banach algebras and automatic continuity

A research monograph [1] joint with Prof. W.G. Bade (UC at Berkeley) and Prof. H.G. Dales (Leeds Univ.) on algebraic and strong splittings of extensions of Banach algebras is published as a Memoir of the American Mathematical Society. The book includes many examples of Banach algebras A for which it is proved that there is an extension of A which does not split algebraically or strongly. Thus we consider the generalisation of the Wedderburn decomposition problem. Another direction is automatic continuity theory. For example, we show that, for many classes of Banach algebras, including C^*-algebras, every extension of these algebras which splits algebraically also splits strongly. There are still many open questions in this area. For example, for many classes of algebra A (in particular the class of all C^*-algebras) it is not known if there is an extension of A which does not split strongly.

Homological dimension of operator algebras

A typical concern in homological algebra is the calculation of global homological dimension. Besides being of independent interest, this question is closely connected with the continuous Hochschild cohomology, which is very useful in the study of derivations, extensions and perturbations of Banach algebras. Most progress had been made in the case of commutative Banach algebras, and in the non-commutative case Banach algebras of zero global homological dimension were fairly well understood, but there were few results otherwise. I was able to show that if a C^*-algebra is such that the images of its irreducible representations consist of compact operators then its global homological dimension is at least 2 [9, 11, 16]. The same conclusion holds for some other classes of operator algebras on Banach spaces. These results give information about the existence of non-split extensions of an algebra.

Relative homology over commutative Banach algebras

The major part of my research between 1985 and 1999 was on the development of the theory of relative homology of Banach algebras [13, 14, 15, 17, 18, 19, 20, 22]. In the algebraic context these notions were introduced by Hochschild and were further developed by Cartan and Eilenberg. The study of some central homological characteristics of Banach algebras was started by Liddell, Phillips and Raeburn. I was able to find analogues for many of the notions of relative homological theory in a Banach algebra context, and to use these analogues to prove numerous results about homological structure. For example, for a C^*-algebra A, all central cohomology groups of A for $n \geq 1$ vanish if and only if A has an identity and a continuous trace [17]. Another series of results relates the cohomology of a Banach algebra A relative to its centre to the usual cohomology of A for dual modules [18, 20]. Further results show the existence of Banach algebras with prescribed homological dimension relative to a commutative subalgebra [14, 15, 24].

Projectivity of operator algebras and their ideals

Another typical concern in homological algebra is the identification of projective algebras and their ideals. It is again true that much had been known for commutative Banach algebras. The focus of much of my research has been to investigate this homological property for a natural class of non-commutative algebras arising in functional analysis: operator algebras on Banach spaces. For example, I showed that all closed left ideals in a separable C^*-algebra are projective, but that every infinite-dimensional von Neumann algebra has a closed left ideal which is not projective [10, 11]. Results of this type were previously known for C^*-algebras only in the commutative case.

A familiar technique in operator algebras is to reduce properties of an algebra to those of its commutative subalgebras. I succeeded in doing this for certain homological properties. For example, if a C^*-algebra has the property that every closed left ideal is projective then the same is true of all its commutative subalgebras [29].

APPLIED MATHEMATICS

After getting an MSc in Mathematics I was involved in research in two areas of Applied Mathematics. The first one was the numerical solution of the differential equations for the motion of a particle in a gravitational field (1976-1979), see [3, 4, 5, 51, 52, 53, 54]. Our research group received a state prize for this work.

The second one (1982-1988) was on methods of assessing the capacity of building contractors and on planning their productivity [6, 7, 55, 56, 57, 58, 59, 60].

PUBLICATIONS of Z. A. LYKOVA

References

RESEARCH MONOGRAPH

[1] Bade, W.G., Dales, H.G. and Lykova, Z.A. Algebraic and strong splittings of extensions of Banach algebras, *Memoirs of the American Mathematical Society*, 1999, v. **137**, 113pp.

[2] Agler, J., Lykova, Z.A. and Young, N.J., Geodesics, retracts, and the norm-preserving extension property in the symmetrized bidisc, *Memoirs of the American Mathematical Society*, 2019, v. **258**, no. 1242, 108pp. https://doi.org/10.1090/memo/1242

PUBLISHED RESEARCH PAPERS

Applied Mathematics

[3] Grigorev, O.N. and Lykova, Z.A. *Nauchno-Tehnicheskii Sb., RKT*, 1978, ser. 5 vyp. 4, 55–59 (in Russian).

[4] Goikhman, I.Z., Lykova, Z.A. and Pyatnitzkaya, E.V. *Nauchno-Tehnicheskii Sb., RKT*, 1980, ser. 5, vyp. 2, 62–68 (in Russian).

[5] Goikhman, I.Z., Lykova, Z.A. and Pyatnitzkaya, E.V. *Nauchno-Tehnicheskii Sb., RKT*, 1980, ser. 5, vyp. 2, 69–74 (in Russian).

[6] Berkhin, P.E., Dukarskii, O.M., and Lykova, Z.A. Calculation of the capacity of remote work in power stations. *Energeticheskoe stroitelstvo,* 1987, **9**, 59–61 (in Russian).

[7] Berkhin, P.E., Dukarskii, O.M., Kolokoltzev, N.Ya. and Lykova, Z.A. On the planning of productivity and the number of workers for the Energy Industry by using computers. *J. Elektricheskie Stantzii*, 1987, **6**, 13–15 (in Russian).

Pure Mathematics

[8] Lykova, Z.A. On conditions for projectivity of Banach algebras of compact operators. *Vest. Mosk. Univ. ser. mat. mech.*, 1979, **4**, 8–13 (in Russian); *Moscow Univ. Math. Bull.*, 1979, 34, no. 6, 6-11.

[9] Lykova, Z.A. A lower estimate of the global homological dimension of infinite-dimensional CCR-algebras. *Uspekhi Mat. Nauk*, 1986, v. 41, vyp 1 (247), 197–198 (in Russian); *Russian Math. Surveys*, 1986, 41, no. 1, 233–234.

[10] Lykova, Z.A. On homological characteristics of operators algebras. *Vest. Mosk. Univ. ser. mat. mech.*, 1986, **1**, 8–13 (in Russian); *Moscow Univ. Math. Bull.*, 1986, 41, no. 3, 10-15.

[11] Lykova, Z.A. On homological properties of some classes of operator algebras. "Candidat" thesis, Moscow State University, Moscow, 1986, 103pp. (in Russian).

[12] Lykova, Z.A. On homological properties of some classes of operator algebras. Abstract of "Candidat" thesis, MSU publishers, Moscow, 1987, 13pp. (in Russian).

[13] Lykova, Z.A. Central bidimension of C*-algebras. Proceedings of 6th Symposium on Theory of Rings, Algebras and Modules, Lvov, U.S.S.R., 1990, p. 82 (in Russian).

[14] Lykova, Z.A. Hochschild cohomology of some Banach algebras over a commutative Banach algebras. Proceedings of the 2nd International Conference on Algebra, Barnaul, U.S.S.R., 1991, p. 73 (in Russian).

[15] Lykova, Z.A. On non-zero values of central homological dimension of C*-algebras. *Glasgow Math. J.*, 1992, 34, 369-378.

[16] Lykova, Z.A. A lower estimate of the global homological dimension of infinite-dimensional CCR-algebras. In *Operator algebras and topology.* Pitman Research Notes in Mathematics, no. 270. Longman Scientific and Technical, England, 1992, 93–129.

[17] Lykova, Z.A. Structure of Banach algebras with trivial central cohomology. *J. Operator Theory*, 1992, 28, no. 1, 147-165.

[18] Lykova, Z.A. On the amenability of Banach algebras. Proceedings of the 3rd International Conference on Algebra, Krasnoyarsk, Russia, 1993, 413–414.

[19] Lykova, Z.A. The ordinary and central amenability of C*-algebras. *Uspekhi Mat. Nauk.*, 1993, 48, vyp. 1 (289), 171–172 (in Russian); *Russian Math. Surveys*, 1993, 48, no. 1, 175–177.

[20] Lykova, Z.A. Central contractible C*-algebras. *Uspekhi Mat. Nauk.*, 1993, no. 8, vyp. 2 (290), 185–186 (in Russian); *Russian Math. Surveys*, 1993, 48, no. 2, 190-191.

[21] Helemskii, A. Ya. and Lykova, Z.A. On the normal version of simplicial cohomology of operator algebras. *Bulletin of the Australian Math. Soc.*, 1993, v. 48, no.3, 407-410.

[22] Lykova, Z.A. On the Banach relative cyclic cohomology. Proceedings of the International Conference on Algebra and Analysis, Kazan, Russia, 1994, 135-136.

[23] Lykova, Z.A. The homology of C*-algebras. Linear Complex Analysis Problem Book, Part 1, *Lecture Notes in Math.*, Springer, Berlin, 1994, no. 1573, 79-82.

[24] Lykova, Z.A. Examples of Banach algebras over commutative Banach algebras with given homological dimension, *Communications in Algebra*, 1998, v. 26, no. 6, 1779-1793.

[25] Lykova, Z.A. Excision in Banach simplicial and cyclic cohomology groups, *Proceedings of the Edinburgh Math. Soc.*, 1998, v. 41, 411–427.

[26] Lykova, Z.A. and White, M. C. Excision in cohomology of Banach algebras with coefficients in dual bimodules. In *Banach Algebras'97.* Walter de Gruyter Publishers, 1998, 341-361.

[27] Lykova, Z.A. Relative cohomology of Banach algebras, *J. Operator Theory*, 1999, v. 41, 23-53.

[28] Brodzki, J. and Lykova, Z.A. Excision in cyclic type homology of Fréchet algebras, *Bulletin of the London Mathematical Society*, 2001, v. 33, 283-291.

[29] Lykova, Z.A. Relations between the homologies of C^*-algebras and their commutative C^*–subalgebras. *Mathematical Proceedings of the Cambridge Philosophical Society*, 2002, v. 132, 155-168.

[30] Gourdeau, F., Lykova, Z.A. and White, M. C. The simplicial cohomology of $L^1(\mathbf{R}^k_+)$, American Mathematical Society, *Contemporary Mathematics*, 2004, v. 363, 95-110.

[31] Gourdeau, F., Lykova, Z.A. and White, M. C. A Künneth formula in topological homology and its applications to the simplicial cohomology of $\ell^1(\mathbf{Z}^k_+)$, *Studia Mathematica*, 2005, 166(1), 29-54.

[32] Lykova, Z.A. Cyclic cohomology of projective limits of topological algebras, *Proceedings of the Edinburgh Math. Soc.*, 2006, 49, 173-199.

[33] Lykova, Z.A. Cyclic-type cohomology of strict inductive limits of Fréchet algebras, *Journal of Pure and Applied Algebra*, 2006, 205, 471-497.

[34] Lykova, Z.A. Cyclic cohomology of certain nuclear Fréchet and DF-algebras, *Central European Journal of Math.,* 2008, 6(3), 405-421.

[35] Lykova, Z.A. Hochschild cohomology of tensor products of topological algebras, *Proceedings of the Edinburgh Math. Soc.*, 2010, 53(2), 447-470.

[36] Agler, J., Lykova, Z.A. and Young, N.J. The boundary Carathéodory-Fejér interpolation problem, *Journal of Mathematical Analysis and Applications*, 2011, 382(2), 645-662.

[37] Agler, J., Lykova, Z.A. and Young, N.J. Pseudo-Taylor expansions and the Carathéodory-Fejér problem, *Journal of Mathematical Analysis and Applications*, 2012, 386, 308-318.

[38] Lykova, Z.A. The higher-dimensional amenability of tensor products of Banach algebras, *J. Operator Theory*, 2012, 67(1), 73-100.

[39] Cushing, D. and Lykova, Z.A. Projectivity of Banach and C^*-algebras of continuous fields, *The Quarterly Journal of Mathematics*, 2013, 64(2), 341-371.

[40] Agler, J., Lykova, Z.A. and Young, N.J., Extremal holomorphic maps and the symmetrised bidisc, *Proceedings of the London Math. Soc.*, 2013, 106(4), 781-818.

[41] Agler, J., Lykova, Z.A. and Young, N.J., A case of mu-synthesis as a quadratic semidefinite program, *SIAM Journal on Control and Optimization* (Appl. Maths), 2013, 51(3), 2472-2508.

[42] Agler, J., Lykova, Z.A. and Young, N.J., 3-extremal holomorphic maps and the symmetrised bidisc, *Journal of Geometric Analysis*, 2015, 25 (3), 2060-2102.

[43] Agler, J., Lykova, Z.A. and Young, N.J., The complex geometry of a domain related to μ-synthesis, *Journal of Mathematical Analysis and Applications*, 2015, 422 (1), 508–543.

[44] Agler, J., Lykova, Z.A. and Young, N.J., Finite Blaschke products and the construction of rational Γ-inner functions, *Journal of Mathematical Analysis and Applications*, 2017, 447, 1163–1196.

[45] Brown, D.C., Lykova, Z.A., and Young, N.J., A rich structure related to the construction of holomorphic matrix functions, *Journal of Functional Analysis*, 2017, 272(4), 1704–1754.

[46] Agler, J., Lykova, Z.A. and Young, N.J., Algebraic and geometric aspects of rational Γ-inner functions, *Advances in Mathematics*, 2018, 328, 133-159; available online https://doi.org/10.1016/j.aim.2017.12.018 .

[47] Agler, J., Lykova, Z.A. and Young, N.J., Carathéodory extremal functions on the symmetrized bidisc. In: Bart H., ter Horst S., Ran A., Woerdeman H. (eds) *Operator Theory, Analysis and the State Space Approach*. Operator Theory: Advances and Applications, **271** (2018) pp.1-21, Birkhäuser, Cham. https://doi.org/10.1007/978-3-030-04269-1 .

[48] Lykova, Z.A., Young, N.J., and Ajibo, A.E., Analytic interpolation into the tetrablock and μ-synthesis problem, In: Bolotnikov V., ter Horst S., Ran A., Vinnikov V. (eds) *Interpolation and Realization Theory with Applications to Control Theory*, Operator Theory: Advances and Applications, **272** (2019) pp. 235-247, Birkhäuser, Cham. https://www.springer.com/gb/book/9783030116132#aboutBook (arXiv:1802.09067 [math.CV] 25 Febr. 2018)

[49] Agler, J., Lykova, Z.A. and Young, N.J., Characterizations of some domains via Carathéodory extremals, *Journal of Geometric Analysis*, 2019, 29, Issue 4, 3039–3054, https://doi.org/10.1007/s12220-018-0059-6, (arXiv:1802.09056 [math.CV] 25 Febr. 2018)

[50] Agler, J., Lykova, Z.A. and Young, N.J., A Geometric Characterization of the Symmetrized Bidisc, *Journal of Mathematical Analysis and Applications*, 2019, 473, Issue 2, 1377-1413; https://doi.org/10.1016/j.jmaa.2019.01.027 .

Restricted Publication: State registered Technical reports – Applied Mathematics

[51] (Aleshin, V. V., Grigoriev, O. N. & Lykova, Z.A.) Technical report, 1977, no. 41631-L, Research Institute for Automatic Control and Instrumentation, Moscow, U.S.S.R., 63pp (in Russian).

[52] (Aleshin, V. V., Goikhman, I.Z., Lykova, Z.A. etc.) Technical report, 1978, no. 43109-L, Research Institute for Automatic Control and Instrumentation, Moscow, U.S.S.R., 57pp (in Russian).

[53] (Aleshin, V. V., Goikhman, I.Z., Lykova, Z.A. etc.) Technical report, 1979, no. 45258-L, Research Institute for Automatic Control and Instrumentation, Moscow, U.S.S.R., 47pp (in Russian).

[54] (Aleshin, V. V., Goikhman, I.Z. & Lykova, Z.A.) Technical report, 1979, no. 45490-L, Research Institute for Automatic Control and Instrumentation, Moscow, U.S.S.R., 63pp (in Russian).

[55] (Berkhin, P.E., Dukarskii, O.M., Lykova, Z.A. etc.) Technical report "The elaboration of methods of assessing the capacity of building contractors", 1982, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 29pp (in Russian).

[56] (Berkhin, P.E., Dukarskii, O.M., Lykova, Z.A. etc.) Technical report "Systematisation of objective functions and limitations on methods of assessing the capacity of building contractors", 1983, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 24pp (in Russian).

[57] (Berkhin, P.E., Dukarskii, O.M. & Lykova, Z.A.) Technical report "The elaboration of methods of assessing the capacity of building contractors", 1983, State reg. no. 01830053478, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 59pp (in Russian).

[58] (Berkhin, P.E., Dukarskii, O.M., Lykova, Z.A., Persits, D.B. etc) Technical report "On the elaboration of performance indicators for planning decisions", 1984, State reg. no. 01830061648, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 242pp (in Russian).

[59] (Berkhin, P.E., Dukarskii, O.M., Levit, B. Ya., Lykova, Z.A. etc) Technical report "An introduction to the problems of assessing the effectiveness and capacity of contracting organisations for 5 years and until the year 2000", 1985, State reg. no. 01840054621, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 61pp (in Russian).

[60] (Berkhin, P.E., Dukarskii, O.M. & Lykova, Z.A.) Technical report "An investigation of connections between the principal technical and economic figures for the Energy Industry", 1986, State reg. no. 01850053944, Institute "Orgenergostroi", Planning Institute for the Energy Industry, Moscow, U.S.S.R., 32pp (in Russian).

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