CURRICULUM VITAE November 2020

Prof. Sergei I. Chernyshenko
http://www.imperial.ac.uk/people/s.chernyshenko
https://www.imperial.ac.uk/aeronautics/fluiddynamics/ChernyshenkoResearch/index.php

Degrees (all from the Moscow State University, Department of Mechanics and Mathematics):

DSc (Doktor Nauk, a Russian professorial-level degree) in Physics and Mathematics, 1995; PhD in Fluid Dynamics, 1983; Diploma in Mechanics (5-year taught course), 1977.

Past and present positions

2007 – Full Professor, Department of Aeronautics, Imperial College London, UK
2003 – 2007 Full Professor, SES, University of Southampton, UK
2000 – 2003 Professorial Research Fellow, SES, University of Southampton, UK
1980 – 2000 Leading Researcher (previous positions: Senior Researcher, Researcher, Junior Researcher, Engineer), Institute of Mechanics, Moscow State University, Russia
1998 – 2000 Research Associate (concurrent with the Leading Researcher position), Department of Mathematics, Manchester University, UK
1977 – 1980 Part-time Research Assistant (concurrent with a PhD studentship), Department of Mechanics and Mathematics, Moscow State University, Russia

Editorial work

1999 – Member of the Editorial Board of the Fluid Dynamics Journal (Russian Academy of Sciences)
2017 –2020 Associated Editor of the Applied Mechanics Reviews (ASME)

Evidence of esteem

1997 – 1999	Russian State Stipend for Outstanding Scientists, Russia
1997	Best-paper-of-the-year award from Plenum Publishing Corp. and Editorial Board of the Fluid Dynamics journal, Germany and Russia
1995	Elected to the National Committee on Theoretical and Applied Mechanics, Russia
1994 – 1996	Russian State Stipend for Outstanding Scientists, Russia
1990	State Committee for People Education Award in research (2nd rank, shared), USSR
1988	Joukowski Award in aerodynamics (1st rank, shared), USSR

Grants. Principal Investigator, EPSRC EP/J011126/1 (partners: EP/J010537/1 and EP/J010073/1), 2013-2016, £425,000 for Imperial College, £1,114,000 for all partners, "Sum-of-squares approach to global stability and control of fluid flows". Co-Investigator, Technology Strategy Board, UK, 2014-2016, £250,000 for the Department of Aeronautics, "Advanced Laminar Flow Enabling Technologies (ALFET)". Principal Investigator, The Royal Society, 2014, £6000, "Proof of concept of a new method of turbulent drag reduction". Co-investigator (PI Prof. M Leschziner), EPSRC, EP/G061556/1, 2009-2012, £342,188 (for Imperial College team). "Investigation of alternative drag-reduction strategies in turbulent boundary layers by using wall forcing". Principal Investigator, Airbus/EPSRC, EP/F004672, 2007-2008, £191,978, "Fluidic control for turbulent drag reduction". Scientific Coordinator, EC Framework 6, contract number AST4-CT-2005-012139, 2005-2008, €1,800,000, "Fundamentals of actively controlled flows with trapped vortices". Scientific Coordinator, EU Framework 6, FP6-2006-TTC-TU-Priority-4, 2006-2008, €132000, "Fundamentals of Actively Controlled Flows with Trapped Vortices, Extension". Principal Investigator, EPSRC, GR/S67029, 2004-2007, £69,071 (£138,171 with services included) "Master-mode analysis of the genesis of organised structures in turbulent flows". Principal Investigator, EPSRC, EP/D050871/1, 2006-2009, £140,540, "Numerical study of turbulent flow in eccentric annular pipes". Co-Investigator, EPSRC, GR/S82947/01 PLATFORM, "Turbulence Platform", 2004-2009, 2004-2009, £395,873. Jointly with Prof. J.C. Vassilicos (Principal Investigator), Prof. I.P. Castro, Dr. G.N. Coleman, Prof. M.A. Leschziner, Prof. J. Morrison, and Prof. N.D. Sandham (Southampton). Principal Investigator, Royal Society (International incoming short visit) grant, 2006, £3,832, on "Generalised optimal perturbation approach to predicting turbulent streaks". Principal Investigator, EPSRC, GR/R27785/01, 2001-2004, £59,894, on "Mechanism of longitudinal vortices in near-wall turbulent flow". Principal Investigator, Royal Society (Europian Science Exchange), 2002-2003, Ref no 13872, £8,175, jointly with Prof. Luca Zannetti (Politecnico di Torino, Italy), on "Active control of trapped vortices". Principal Investigator, International Science Foundation, Grant M4K000, $11,775, 1994, on "High-Reynolds-number Batchelor-model flows". Principal Investigator, International Science Foundation, Grant M4K30, $6,482, 1995, on "High-Reynolds-number Batchelor-model flows". Principal Investigator, Russian Foundation for Basic Research, Project 96-01-01290, 1996-1998 (amount in roubles made meaningless by inflation but it was substantial for Russian researchers at the time of receipt), on "Mathematical theory of rotating stall." Principal Investigator, Russian Foundation for Basic Research, Project 93-01-17622,1993-1995, (Co-PI Prof. A.A.Barmin), on "Construction of mathematical models and investigation of heat and mass transfer processes with phase transitions and chemical reactions in natural porous mediums and volcanic systems".

Research track record

I do research in theoretical fluid dynamics, with strong emphasis on mathematics and a motivation of seeking fundamental understanding of scientific problems that can eventually be beneficial to society. My research strategy is to concentrate on a challenging problem, contribute my best, and move on. I can publish a single paper on a topic and let the idea be taken over by other researchers, as for example it happened with [20] long time ago or with [17] more recently. My main research, however, went in 15-20-year-long overlapping cycles, the key publications for which are [16], [18], and [19]. Each cycle started with a fundamental research and then shifted towards applications.

In the first cycle, I solved [19] the long-standing problem of high-Re asymptotics of steady separated flow, thus closing more than a century-long chapter in the history of classical fluid dynamics, which started with the construction of small-Re asymptotics by George G. Stokes in 1851, continued with the high-Re asymptotics for attached flows, which constitutes the famous boundary-layer theory, by Ludwig Prandtl in 1904, and developed further by many researchers. With its central problem solved, the entire area went out of the mainstream, but the theoretical ideas from the solution were then applied to study control of flow separation using vortex cells.

The second cycle of my research is devoted to turbulence. Its starting problem was the origin of streaks in near-wall turbulent flows. Going against the view dominant at the time, in [18] I provided convincing arguments in favour of an emerging alternative paradigm and formulated a theoretical approach capable of quantitative predictions. Considerable effort was required to disseminate the new ideas. My work contributed to the acceptance of linearized methods in studies of developed turbulent flows. This constituted a major change in the research direction in this area. Armed with these new fundamental ideas, my attention was then shifted to turbulent skin friction drag reduction, which is a question of large practical importance, and a great challenge. In [15] the dependence of drag reduction on the frequency and wave-number of in-plane wall motion was considered. Streaks in a turbulent flow past an oscillating wall in the regime with drag reduction were studied in [14]. These papers were the first-ever quantitative theoretical predictions for these important features of turbulent flows with drag reduction, which previously could be obtained only in experiment or direct numerical simulation. The current studies [6,12] within this second cycle are devoted to the question of extrapolating the results of laboratory experiments and numerical calculations to the conditions of aircraft flight, and to the question of practically-feasible methods of drag reduction. The success of my second cycle of research is evidenced by the surge in personal invitations to give conference talks and participate in advanced schools [Inv1-Inv6]. For me, however, this is also the evidence that it might be time to move on once again.

In contrast to the previous cycles, the starting point of the third cycle of my research was not a problem but a method: a breakthrough, made around 2000 in the works of Nesterov, Parrilo, and Lasserre, in an area of mathematics seemingly unrelated to fluid dynamics. The idea [16] of how to apply this breakthrough to fluid-dynamics received a warm welcome, as it was evidenced by the personal invitations for international events [Inv5,Inv7-Inv9] and by the award of a large EPSRC grant to the project “Sum-of-squares approach to global stability and control of fluid flows”, which was coordinated by me and done by teams of Imperial College and Oxford and Southampton universities. An invited paper [11] summarises the ideas forming the basis for this current research cycle, which is quickly expanding in scope [1,5,7-9].

Papers of the last five years
(with rare exceptions I put myself after my younger co-authors in the list of paper authors)

1. Lakshmi, M.V., Fantuzzi, G., Fernández-Caballerom J.D., Hwang, Y., Chernyshenko, S.I. 2020. Finding Extremal Periodic Orbits with Polynomial Optimization, with Application to a Nine-Mode Model of Shear Flow, SIAM Journal on Applied Dynamical Systems 19 (2), 763-787
2. Iyer, A., Witherden, F., Chernyshenko, S., & Vincent, P. (2019). Identifying eigenmodes of averaged small-amplitude perturbations to turbulent channel flow. Journal of Fluid Mechanics, **875**, 758-780. doi:10.1017/jfm.2019.520
3. Chernyshenko, Sergei, Chi Zhang, Hamza Butt and Mohammad Beit-Sadi. 2019. A large-scale filter for applications of QSQH theory of scale interactions in near-wall turbulence. Fluid Dynamics Research, **51**: 011406.
4. Ghebali, S., Chernyshenko, S., & Leschziner, M.A. 2017. Can large-scale oblique undulations on a solid wall reduce the turbulent drag? Physics of Fluids, **29**, 105102.
5. D. Huang, B. Jin, D. Lasagna, S. Chernyshenko and O. Tutty, 2017. Expensive Control of Long-Time Averages Using Sum of Squares and Its Application to a Laminar Wake Flow. IEEE Transactions on Control Systems Technology, **25**, no. 6, pp. 2073-2086, doi: 10.1109/TCST.2016.2638881.

Selected earlier papers

6. Zhang C. and Chernyshenko S.I. 2016. Quasisteady quasihomogeneous description of the scale interactions in near-wall turbulence. *Phys. Rev. Fluids.* **1**, 014401.
7. Fantuzzi G., Goluskin D., Huang D., and Chernyshenko S.I. 2016. Bounds for deterministic and stochastic dynamical systems using sum-of-squares optimization. *SIAM J. App. Dyn. Sys*., **15**, 1962-1988.
8. Lasagna D., Huang D., Tutty O.R., and Chernyshenko S. 2016. Sum-of-squares approach to feedback control of laminar wake flows. *J. Fluid Mech.*, **809**, 628-663.
9. Lasagna D., Tutty O.R., and Chernyshenko S. 2016. Flow regimes in a simplified Taylor-Couette-type flow model. *Eur. J. of Mech. B-Fluids*, **57**, 176-191.
10. Huang D., Chernyshenko S., Goulart P., Lasagna D., Tutty O., and Fuentes F. 2015. Sum-of-squares of polynomials approach to nonlinear stability of fluid flows: an example of application. *Proc. R. Soc. A*, **471**, 20150622.
11. Chernyshenko S.I., Goulart P., Huang D., Papachristodoulou A., 2014. Polynomial sum of squares in fluid dynamics: a review with a look ahead. *Phil. Trans. R. Soc. A*, **372**, 20130350.
12. Mathis R., Marusic I., Chernyshenko S.I., and Hutchins N. 2013. Estimating wall-shear-stress fluctuations given an outer region input. *J. Fluid Mech.*, **715**, 163-180.
13. Vodop'yanov I.S., Nikitin N.V., and Chernyshenko S.I. 2013. Turbulent drag reduction by spanwise oscillations of a ribbed surface. *Fluid Dynamics*, **48**, 461-470.
14. Blesbois O., Chernyshenko S.I., Touber E., and Leschziner M.A. 2013. Pattern prediction by linear analysis of turbulent flow with drag reduction by wall oscillation. *J. Fluid Mech*., **724**, 607-641.
15. Duque-Daza C.A., Baig M.F., Lockerby D.A., Chernyshenko S.I., and Davies C. 2012. Modelling turbulent skin-friction control using linearized Navier–Stokes equations. *J. Fluid Mech*., **702**, 403-414.
16. Goulart P.J., Chernyshenko S., 2012. Global stability analysis of fluid flows using sum-of-squares. *Physica D - Nonlinear Phenomena*, **241**, 692-704.
17. Chernyshenko S.I. Constantin P., Robinson J.C., and Titi E.S. 2007. A posteriori regularity of the three-dimensional Navier-Stokes equations from numerical computations. *J. Math Phys.* **48**, Issue 6, 10.1063/1.2372512.
18. Chernyshenko S.I. and Baig, M.F. 2005. The mechanism of streak formation in near-wall turbulence. *J. Fluid Mech*., **544**, 99-131.
19. Chernyshenko S.I. 1988. The asymptotic form of the stationary separated circumfluence of a body at high Reynolds number. *Prikl. Mat. i Mekh*., **52**, No.6, 958-966. (In Russian. English translation: Applied Math. Mech. 1988, **52**).

20. Chernyshenko S.I. Mean distance between particles in the dusted gas for the singular averaged particles density. 1984. *Vestnik Moskovskogo Univ.* No.1, 69-70. (In Russian. English translation: Bulletin of MSU.)

Invited talks

Inv1. Chernyshenko S.I. (Keynote speaker) “Linearised Navier-Stokes equations and developed turbulence.” Workshop “From bent layers to broken waves”, 28-29/03 2012, Southampton, UK.

Inv2. Chernyshenko S.I. (Invited Participant) “Recent progress on turbulent drag reduction.” Stability and Transition summer school. NORDITA, May 13-31 2013. Stockholm, Sweden.

Inv3. Chernyshenko S.I. (Invited lecture) “Reduction of turbulent friction.” Aeromechanics remote seminar, TsAGI (Zhukovsky) - ITAM (Novosibirsk) - SPbSPU (St.-Peterburg) - IM MSU (Moscow), 4/03 2014, Moscow, Russia.

Inv4. Chernyshenko S.I. (Invited-session talk) “Recent progress in turbulent skin friction drag reduction: an overview.” 10th UKACC International Conference on Control (CONTROL 2014), 9-11 July, 2014, Loughborough, UK

Inv5. Chernyshenko S.I. (Invited Senior Fellow, with two talks, one on drag reduction and one on polynomial optimisation applied to fluid dynamics). Program on Mathematics of Turbulence, Institute for Pure and Applied Mathematics, 8/09-12/12 2014, Los-Angeles, USA.

Inv6. Chernyshenko S.I. (Invited external speaker) “Recent progress in theoretical research on turbulent drag reduction.” Active Drag Reduction Symposium, 20-21/02 2014, Aachen, Germany.

Inv7. Chernyshenko S.I., Goulart P. (Invited lecture) “Sum of Squares of polynomials technique for stability and bounds in fluid dynamics. XXI Int. Conf. NeZaTeGiUs-2014, 25/02–4/03 2014, Moscow, Russia.

Inv8. Chernyshenko S.I. (Invited lecture course) “The problem of turbulence: bounding solutions to equations of fluid mechanics & other dynamical systems”, The 6th Bremen Winter School Dynamical systems and turbulence, March 12-16, 2018.

Inv9. Chernyshenko S.I. (Keynote speaker) “Polynomial sum of squares in fluid dynamics”, Scientific Computing Across Scales: Extreme Events and Criticality in Fluid Mechanics, The Fields Institute, Toronto, April 15-18, 2019.