1. Plan of specific scientific research from the Russian side (on years)

**Chinese Side**

2019, the Chinese sideWe will focus on developing the high order numerical schemes for some selected non-local equations, such as Volterra-type integro-differential equations with singular kernel or delay, time, space and time-space fractional dynamical systems involving fractional derivatives.

2010, the Chinese side will focus on developing adaptive numerical algorithms for multi-physics problems.

From 1st to 15th August, 2020, the Chinese side is going to visit Russia for communication on high efficient spectral methods for non-local equations.

1. Plan of specific scientific research from the Chinese side (on years)

**Russian side**

2019, the Russian side will focus on applying the high order numerical schemes to some practical problem in fluid dynamics and materials science.

In 1st to 15th September, 2019, the Russian side is going to visit China for communication on high performance computing for extreme scale problems.

2020, the Russian side will focus on developing advanced data-science algorithms and their coupling to model-based multiscale algorithms and applications for multi-physics problems.

1. Cooperation and coordination of Russian team and Chinese team during the implementation of the project

The cooperation priority of the project is to make full use of the experience and research advantages of the Chinese and Russian teams in scientific research and work together to achieve the set scientific research goals.

The program aims to develop new numerical methods with both high accuracy and less complexity for some class of partial differential equation. including

1. High efficient spectral methods for non-local equations. We will develop the high order numerical schemes, including the spectral methods and spectral element methods, for some selected non-local equations, such as Volterra-type integro-differential equations with singular kernel or delay, time, space and time-space fractional dynamical systems involving fractional derivatives. The stability and convergence of the spectral methods will be studied. We also design the adaptive algorithm and fast method by applying the interpolation postprocessing, correction technique, and extrapolation. We will also consider the application to some practical problem in fluid dynamics and materials science.

2) High performance computing for extreme scale problems. We will focus on developing advanced data-science algorithms and their coupling to model-based multiscale algorithms and applications for multi-physics problems, developing adaptive numerical algorithms for multi-physics problems.

Xiangtan University research team will depend on the exiting Hunan International Scientific and Technological Cooperation Base of Computational Science to achieve the research content and target through such ways as academic visit, bilateral conferences and network communication with the Russian team.

1. Expected scientific results for the first year of project implementation

Finish Jacobi spectral collocation method based on Lagrange interpolation polynomials for solving nonlinear fractional integro-differential equations

Finish numerical simulation of time fractional Cable equations and convergence analysis

Finish spectral Collocation Methods for Nonlinear Volterra Integro-Differential Equations with Weakly Singular Kernels

Russian side finish visiting China for communication on high performance computing for extreme scale problems in 1st to 15th September, 2019

1. Substantiation of expediency and necessity of carrying out of researches together with the Chinese partners

China side focus our research on the numerical methods for partial differential equations, adaptive methods and finite element superconvergence. We have been carried out fruitful cooperation with a wide range of experts on high quality mesh generation and optimization, high accurate numerical methods for differential equations and fast solver for for large-scale discrete systems.

1. Publications on the topic research from the Chinese side
2. Yin Yang, Yunqing Huang, Yong Zhou, Numerical simulation of time fractional Cable equations and convergence analysis, Numerical Methods for Partial Differential Equations, DOI: 10.1002/num.22225.
3. Yin Yang, Yanping Chen, Spectral Collocation Methods for Nonlinear Volterra Integro-Differential Equations with Weakly Singular Kernels, Bulletin of the Malaysian Mathematical Sciences Society, DOI 10.1007/s40840-017-0487-7
4. Zuliang Lu, Shuhua Zhang, Lin Li, Longzhou Cao and Yin Yang, Fitted finite volume method of three transboundary pollution of three gorges reservoir area with emission permits trading by cooperative stochastic differential game, Advances in Applied Mathematics and Mechanics, Vol. 10, No. 3, pp. 690-709, June 2018
5. Yin Yang, Yunqing Huang, Yong Zhou, Numerical solutions for solving time fractional Fokker-Planck equations based on spectral collocation methods, Journal of Computational and Applied Mathematics, 339, pp.389–404, 2018
6. Shan Jiang, Meiling Sun and Yin Yang, Reduced multiscale computation on adapted grid for the convection-diffusion robin problem, Journal of Applied Analysis and Computation,7(4): 1488-1502, NOV 2017
7. Zuliang Lu, Shuhua Zhang, Longzhou Cao, Lin Li and Yin Yang, Interpolation Coefficients Mixed Finite Element Methods and l-Infinity - Error Estimates for Nonlinear Optimal Control Problem, Journal of Mathematical Inequalities, 11(4): 1113-1129, DEC 2017
8. Jianwei Zhou, Juan Zhang, Huantian Xie, Yin Yang, Error estimates of spectral element methods with generalized Jacobi polynomials on an interval, Applied Mathematics Letters, 74, 199–206, 2017.
9. Tianliang Hou, Chunmei Liu, Yin Yang, Error estimates and superconvergence of a mixed finite element method for elliptic optimal control problems, Computers and Mathematics with Applications, 74: 714–726, 2017.
10. Yin Yang, Yanping Chen, Yunqing Huang, Huayi Wei, Spectral collocation method for the time-fractional diffusion-wave equation and convergence analysis, Computers and Mathematics with Applications, 73(6): 1218–1232, 2017
11. Yin Yang, Yanping Chen, Jacobi spectral Galerkin and iterated methods for nonlinear Volterra integral equation, Journal of Computational and Nonlinear Dynamics, 11(4), 041027-041027-8, 2016.
12. Yin Yang, Jacobi spectral Galerkin methods for Volterra integral equations with weakly singular kernel, Bulletin of the Korean Mathematical Society, 53(1), pp. 247-262, 2016.
13. Yin Yang, Jacobi spectral Galerkin methods for fractional integro-differential equations, Calcolo, Volume 52, Issue 4 (2015), Page 519-542.
14. Yin Yang, Yanping Chen, Yunqing Huang, Wei Yang, Convergence analysis of Legendre-collocation methods for nonlinear Volterra type integral Equations, Advances in Applied Mathematics and Mechanics, 7(1): 74-88, 2015.
15. Yin Yang, Chebyshev Pseudo-spectral Method for a Class of Space Fractional Partial Differential Equations with Variable Coefficients, Chinese Journal of Engineering Mathematics, 31(5): 745-752, 2014.
16. Yin Yang, Yanping Chen, Yunqing Huang, Convergence analysis of the Jacobi spectral-collocation method for fractional integro-differential equations, Acta Mathematica Scientia, 34 (3) , pp. 673-690, 2014.
17. Yin Yang, Yanping Chen, Yunqing Huang, Spectral-collocation method for fractional Fredholm integro-differential equations, Journal of the Korean Mathematical Society, 51(1): 203-224, 2014.
18. Yin Yang, Yunqing Huang, Spectral-collocation methods for fractional pantograph delay-integro-differential equations, Advances in Mathematical Physics, Volume 2013, Article ID 821327, 14 pages.
19. Yin Yang, Solving a Nonlinear Multi-Order Fractional Differential Equation Using Legendre Pseudo-Spectral Method, Applied Mathematics, 4: 113-118, 2013.
20. Jianjun Xu, Yin Yang, and John Lowengru, A level-set continuum method for two-phase flows with insoluble surfactant, Journal of Computational Physics, 231(17): 5897-5909, 2012.
21. Qin Zhou, Chen Yanping, Yin Yang, Two Improved Algorithms and Implementation for a Singularly Perturbed Problem on Moving Meshes, Journal of Systems Science & Complexity, 24: 1232–1240, 2011.
22. Yang Yin, Chen Yanping, Huang Yunqing, Moving mesh method for a modeling of turbulent flow in circular, Journal of Computational Mathematics, [27](http://www.global-sci.org/jcm/volumes/v27n2/)(2): 388-399, 2009.
23. Guangming Zhou\*, Chao Deng and Kun Wu, Semidefinite Optimization Estimating Bounds on Linear FunctionalsDefined on Solutions of Linear ODEs, Adv. Appl. Math. Mech., Vol. 8, No. 4, pp. 599-615, 2016
24. Yonhui Dong，Guangming Zhou\*, Qin Zhao, Unconstrained optimization models for computing real generalized eigenpairs of weakly symmetric positive definition tensors, ICIC Express Letters Part B: Applications,V7, N11, p2425-2433, 2016
25. Guangming Zhou\*, Chao Deng, Kun Wu, Bounds on Linear Functionals of Solutions of Linear Integral Equations with Polynomial Kernels via Semi- definite Optimization, ICIC Express Letters, Part B: Applications，2015, 6(1): 271-278
26. (4) Guangming Zhou\*, Chao Deng, Kun Wu, Semidefinite Optimization Providing Guaranteed Bounds on Linear Functional of Solutions of Linear Integral equations with smooth Kernels, Journal of Applied Mathematics, 2014, Article ID 340567, 8 pages
27. Guangming Zhou\*,Chunsheng Feng, The steepest descent algorithm without line search for p-Laplacian, Applied Mathematics and Computation, 2013, 224: 36-45
28. Guangming Zhou\*, Pingmin Zhu, Newton-Like Iterative Algorithms for Solving General Nonlinear Algebraic Equation Based on Homotopy Analysis Method. ICIC Express Letters,Part B: Applications, 2012, 3(3):535-542
29. Guangming Zhou\*, Pingmin Zhu, Iterative Algorithms for Solving Three-Order Approximative Algebraic Equation Based on Homotopy Analysis Method, ICIC Express Letters, 2011, 5(12):4487-4494
30. (8) Feng Guo, Li Wang, Guangming Zhou, Minimizing rational functions by exact Jacobian SDP relaxation applicable to finite singularities, Journal of Global Optimization, 2014, 58(2): 261-284
31. J Zhang#, K Chen\*, B Yu, A 3D multi-grid algorithm for the Chan–Vese model of variational image segmentation, International Journal of Computer Mathematics, 2012, 89(2), 160-189.
32. J Zhang#, K Chen\*, Variational image registration by a total fractional-order variation model, Journal of Computational Physics, 2015, 293, 442-461.
33. J Zhang#, K Chen\*, DA Gould, A fast algorithm for automatic segmentation and extraction of a single object by active surfaces, International Journal of Computer Mathematics, 2015, 92(6), 1251-1274.
34. (4) J Zhang#, K Chen\*, B Yu, D Gould, A local information based variational model for selective image segmentation, Inverse Problems and Imaging, 2014, 8(1), 293-320.
35. J Zhang#, K Chen\*, B Yu, An iterative Lagrange multiplier method for constrained total-variation-based image denoising, SIAM Journal on Numerical Analysis, 2012, 50(3), 983-1003.
36. J Zhang#, K Chen\*, A Total Fractional-Order Variation Model for Image Restoration with Nonhomogeneous Boundary Conditions and Its Numerical Solution，SIAM Journal on Imaging Sciences, 2015, 8(4), 2487-2518.
37. J Zhang#, K Chen\*, A New Augmented Lagrangian Primal Dual Algorithm For Elastica Regularization，Journal of Algorithms and Computational Technology，2016.9.26，10（4）：325~338
38. J Zhang#, K Chen\*, Variational image registration by a total fractional-order variation model，Journal of Computational Physics，2015.7.15，293：442~461
39. Hai-Zhuan Yuan #; Chang Shu ; Yan Wang; Shi Shu,A Simple Mass-conserved Level Set Method for Simulation of Multiphase Flows, Physics of Fluids, 2018, 30(4)
40. Hai-Zhuan Yuan# ; Yan Wang ; Chang Shu,An adaptive mesh refinement-multiphase lattice Boltzmann flux solver for simulation of complex binary fluid flows, Physics of Fluids, 2017, 29(12)
41. Hai-Zhuan Yuan# ; Zhen Chen; Chang Shu ; Yan Wang; Xiao-Dong Niu; Shi Shu, A free energy-based surface tension force model for simulation of multiphase flows by level-set method, Journal of Computational Physics, 2017.05.15, 345: 404~426
42. Chun-Hai Ke; Shi Shu; Hao Zhang; Hai-Zhuan Yuan\*，LBM-IBM-DEM modelling of magnetic particles in a fluid, Powder Technology, 2017.06.01, 314:264~280
43. You Li ; Xiao-Dong Niu; Yu-Yue Yang; Shi Shu,Hai-Zhuan Yuan\*, WENOScheme-based Lattice Boltzmann Flux Solver for Simulation of Compressible Flows, Communications in Computational Physics, 2017, 1~25
44. Hai-Zhuan Yuan#, Shi Shu, Xiao-Dong Niu, Mingjun Li, Hiroshi Yamaguchi, A momentum exchange-based immersed boundary-lattice Boltzmann method for simulating a flexible filament in an incompressible flow, Computers and Mathematics with Applications, 2014, 67(5): 1039-1056.
45. Hai-Zhuan Yuan#, Xin-Rong Zhang, Numerical simulation with adaptive finite element methods for CO2 storage in saline aquifers, International Communications in Heat and Mass Transfer, 2013, 45: 55-63.
46. Hai-Zhuan Yuan#, Shi Shu, Xiao-Dong Niu, Mingjun Li, Yang Hu, A numerical study of jet propulsion of an oblate jellyfish using a momentum exchange-based immersed boundary-lattice Boltzmann method, Advances in Applied Mathematics and Mechanics, 2014, 6(3): 307-326.
47. Hao Zhang#, Haizhuan Yuan#, F Xavier Trias, Aibing Yu, Yuanqiang Tan, Assensi Oliva, Particulate Immersed Boundary Method for complex fluid–particle interaction problems with heat transfer, Computers & Mathematics with Applications 2016, 71 (1), 391-407.
48. Yang Hu#, Haizhuan Yuan#, Shi Shu, Xiaodong Niu, Mingjun Li, An improved momentum exchanged-based immersed boundary-lattice Boltzmann method by using an iterative technique, Computers and Mathematics with Applications, 2014, 68(3): 140-155.
49. Yang Hu, Xiao-Dong Niu, Shi Shu, Haizhuan Yuan, Mingjun Li, Natural Convection in a Concentric Annulus: A Lattice Boltzmann Method Study with Boundary Condition-Enforced Immersed Boundary Method, Advances in Applied Mathematics and Mechanics, 2013, 5(3), 321-336.

7. List of the main (not more than 5) publications of the Chinese team leader for the last 5 years.

1. Yin Yang, Yunqing Huang, Yong Zhou, Numerical solutions for solving time fractional Fokker-Planck equations based on spectral collocation methods, Journal of Computational and Applied Mathematics, 339, pp.389–404, 2018
2. Yin Yang, Yanping Chen, Yunqing Huang, Huayi Wei, Spectral collocation method for the time-fractional diffusion-wave equation and convergence analysis, Computers and Mathematics with Applications, 73(6): 1218–1232, 2017
3. Yin Yang, Jacobi spectral Galerkin methods for fractional integro-differential equations, Calcolo, Volume 52, Issue 4 (2015), Page 519-542.
4. Yin Yang, Yanping Chen, Yunqing Huang, Wei Yang, Convergence analysis of Legendre-collocation methods for nonlinear Volterra type integral Equations, Advances in Applied Mathematics and Mechanics, 7(1): 74-88, 2015.
5. Yin Yang, Yanping Chen, Yunqing Huang, Convergence analysis of the Jacobi spectral-collocation method for fractional integro-differential equations, Acta Mathematica Scientia, 34 (3) , pp. 673-690, 2014.