

数学与系统科学研究院
计算数学所系列学术报告

报告人: 刘发旺教授

(澳大利亚昆士兰科技大学数学科学学院)

报告题目:

空间分数阶偏微分方程

邀请人: 唐贻发 研究员

报告时间: 2014 年 6 月 4 日 (周三)

上午 9:30-11:30

报告地点: 科技综合楼三层 311

计算数学所报告厅

摘要:

这一讲包括三部分。第一部分主要介绍有限差分方法解空间分数阶的扩散方程，包括显式方法，隐式方法和 Crank-Nicholson 方法。利用一些不同的分析技巧，给出了稳定性和收敛性分析。第二部分主要介绍求解空间分数阶的对流-扩散方程的数值方法，包括 L1-和 L2-近似, 标准和移位的 Grunwald 近似，分数阶行方法，显式方法，隐式方法和 Crank-Nicholson 方法。第三部分主要介绍分数阶有限体积方法(有限元方法)解变系数的空间扩散方程。

报告人简介:

刘发旺教授是澳大利亚昆士兰科技大学博士生导师，计算数学学科带头人。

刘发旺教授 1975 年毕业于福州大学计算数学专业，毕业后留校工作。1982 年获得计算数学硕士学位。1988 年被破格提升为福州大学当时最年轻的副教授。刘发旺教授于 1988 年得到爱尔兰都柏林大学 Trinity College 提供的奖学金，攻读博士学位。在国际著名的数值分析专家 John Miller 教授的指导下，于 1991 年以优秀的成绩 获得了博士学位。从 1988 年至今，先后在爱尔兰三一学院，爱尔兰都柏林大学学院，澳大利亚昆士兰大学，厦门大学，澳大利亚昆士兰科技大学，从事计算数学 和应用数学的教学和科研工作（副教授，博士后，研究员，高级研究员，教授，博士生导师），已主持和承担多项由澳大利亚国家研究基金和中国国家自然科学基金 资助的科研项目，受到国内外同行专家的高度好评。2002 年 6 月--2005 年 12 月，回国工作，被聘为厦门大学数学科学学院（一级岗位）教授，并于 2005 年获得福建省科学进步奖。2006 年返回到澳大利亚昆士兰科技大学工作。目前是澳大利亚昆士兰科技大学数值方法团队的学科带头人,并多次获得澳大利亚昆士兰科技大学数学类，工程类优秀论文奖。刘发旺教授已指导 15 名博士研究生和 12 名硕士研究生，并应邀担任国际应用数学模型，国际微分方程等杂志的 编委，国际微分方程杂志分数阶微分方程 2010,2011,2012,2013 年专刊主编，国际应用数学模型的计算方法，数值模型 2013 年专刊主编，科学 世界杂志的分数阶动力系统分析 2014 专刊的主编。他已发表学术论文 200 多篇（Sci/EI 文章占 90%，是已发表的绝大部分文章的通讯作者）。刘发旺 教授最近在中国河海大学召开的 2012 年第五届分数阶微分及其应用国际会议上被授予《Mittag-Leffler Award: FDA Achievement Award》(Mittag-Leffler 分数阶微分及其应用成就奖)。

欢迎大家参加!

近几年主要成就及承担的项目:

- 2013-2016: 分数阶微分方程的高精度数值方法和反常动力学行为, 中国国家自然科学基金。
- 2012-2014: 复杂动力系统的计算方法及其应用, 澳大利亚国家研究基金。
- 2008-2012: 数值模拟非均质的多孔介质中传送过程的多尺度逼近, 昆士兰科技大学和澳大利亚国家研究基金。
- 2008-2012: 生物系统中的反问题, 昆士兰大学, 昆士兰科技大学, 英国牛津大学和澳大利亚国家研究基金。
- 2009-2012: 磁共振弥散成像和反常扩散在医学中的应用, 昆士兰科技大学和澳大利亚国家研究基金。
- 2009-2010: 地下水的扩散和传送的分数阶动力模型, 昆士兰科技大学研究基金。
- 2003-2007: 海水在地下水层的扩散和传送, 昆士兰科技大学和澳大利亚国家研究基金。
- 2003-2005: 奇异摄动偏微分方程的数值方法及其应用, 中国国家自然科学基金。
- 2004-2005: 分数阶偏微分方程模拟土壤和植物系统中水和溶质的运动, 中澳合作特别基金。
- 2000-2002: 数值模拟海水入侵地下水层, 昆士兰科技大学和澳大利亚国家研究基金。

PUBLICATIONS LISTS (2013-2014, * Corresponding author):

2014:

- [1] F. Liu*, P. Zhuang, I. Turner, V. Anh and K. Burrage, A semi-alternating direction method for a 2-D fractional FitzHugh-Nagumo monodomain model on an approximate irregular domain, *J. Comp. Physics*, (2014), in press.
- [2] X. Hu, F. Liu*, I. Turner, and V. Anh, A numerical investigation of the time distributed-order and two-sided space-fractional advection-dispersion equation, *ANZIAM J.*, (2014) in press.
- [3] F. Zeng, F. Liu*, C. Li, K. Burrage, I. Turner and V. Anh, Crank-Nicolson ADI spectral method for the two-dimensional Riesz space fractional nonlinear reaction-diffusion equation, *SIAM Journal on Numerical Analysis*, (2014), in press.
- [4] H. Ye, F. Liu*, V. Anh and I. Turner, Numerical analysis for the time distributed order and Riesz space fractional diffusions on bounded domains, *IMA Journal of Applied Mathematics*, (2014), in press.
- [5] H. Zhang, F. Liu*, P. Zhuang, I. Turner and V. Anh, Numerical analysis of a new space-time variable fractional order advection-dispersion equation, *Appl. Math. Comp.*, (2014) in press.
- [6] S. Shen, F. Liu*, Q. Liu and V. Anh, Numerical simulation of anomalous infiltration in porous media, *Numerical Algorithm*, (2014), in press, DOI: 10.1007/s11075-014-9853-9.
- [7] Q. Yu, F. Liu*, I. Turner and K. Burrage, Numerical simulation of the fractional Bloch equations, *J. Comp. Appl. Math.*, 255, (2014), 635-651, DOI: 10.1016/j.cam.2013.06.027.
- [8] H. Hejazi, T. Moroney and F. Liu. Stability and convergence of a finite volume method for the space fractional advection- dispersion equation, *J. Comp. Appl. Math.*, 255, (2014), 684-697, doi.org/10.1016/j.cam.2013.06.039.
- [9] H. Ye, F. Liu*, V. Anh and I. Turner, Maximum principle and numerical method for the multi-term time-space Riesz-Caputo fractional differential equations, *Appl. Math. Comp.*, 227 (2014), 531-540, 10.1016/j.amc.2013.11.015.
- [10] Q. Yang, I. Turner, T. Moroney and F. Liu, A finite volume scheme with preconditioned Lanczos method for two-dimensional space-fractional reaction-diffusion equations, (2014), in press, <http://dx.doi.org/10.1016/j.apm.2014.02.005>.

- [11] Q. Liu, F. Liu*, I. Turner, V. Anh and Y. Gu, A RBF meshless approach for modeling a fractal mobile/immobile transport model, *Appl. Math. Comp.*, 226, (2014), 336-147, <http://dx.doi.org/10.1016/j.amc.2013.10.008>.
- [12] S. Chen, F. Liu* and K. Burrage, Numerical simulation of a new two-dimensional variable-order fractional percolation equation in non-homogeneous porous media, *Computer & Mathematics with Application*, (2014), in press, 10.1016/j.camwa.2014.03.003.
- [13] S. Shen, F. Liu*, V. Anh, I. Turner, and J. Chen, A novel numerical approximation for the space fractional advection–dispersion equation, *IMA J Appl Math* 79(3) (2014) 431-444, doi: 10.1093/imamat/hxs073.
- 2013:
- [14] F. Liu*, M.M. Meerschaert, R. McGough, P. Zhuang and Q. Liu, Numerical methods for solving the multi-term time fractional wave equations, *Fractional Calculus & Applied Analysis*, 16(1) (2013), 9-25, DOI: 10.2478/s13540-013-0002-2.
- [15] S. Chen, F. Liu*, I. Turner and V. Anh, An implicit numerical method for the two-dimensional fractional percolation equation, *Appl. Math. Comp.*, 219 (2013), 4322-4331, 10.1016/j.amc.2012.10.003.
- [16] Q. Yu, F. Liu*, I. Turner and K. Burrage, Stability and convergence of an implicit numerical method for the space and time fractional Bloch-Torrey equation, the special issue of *Fractional Calculus and Its Applications* in *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, A371: 20120150; (2013),1471-2962, doi:10.1098/rsta.2012.0150.
- [17] H. Jiang, F. Liu*, M.M. Meerschaert and R. McGough, Fundamental solutions for the multi-term modified power law wave equations in a finite domain, *Electronic Journal of Mathematical Analysis and Applications*, 1(1) (2013), 55-66.
- [18] J. Chen, F. Liu*, K. Burrage and S. Shen, Numerical techniques for simulating a fractional mathematical model for epidermal wound healing, *Journal of Applied Mathematics and Computing*, 41, (2013), 33–47, DOI 10.1007/s12190-012-0591-7.
- [19] C. Chen, F. Liu*, I. Turner, V. Anh, Y. Chen, Numerical approximation for a variable-order nonlinear reaction-subdiffusion equation, *Numerical Algorithm*, 63, (2013), 265-290, DOI 10.1007/s11075-012-96622-6.
- [20] S. Shen, F. Liu*, I. Turner, V. Anh and J. Chen, A characteristic difference method for the variable-order fractional advection-diffusion equation, *J. Appl. Math. Computing*, 42 (1-2), (2013), 371-386, DOI 10.1007/s12190-012-04642-0.
- [21] H. Zhang, F. Liu*, M.S. Phanikumar and M.M. Meerschaert, A novel numerical method for the time variable fractional order mobile-immobile advection-dispersion model, *Computer & Mathematics with Application*, 66, (2013), 693-701, DOI:10.1016/j.camwa.2013.01.031.
- [22] Q. Yu, F. Liu*, I. Turner and K. Burrage, Numerical investigation of three types of space and time fractional Bloch-Torrey equations in 2D, *Cent. Eur. J. Phys*, 11(6), (2013), 646-665. DOI: 10.2478/s11534-013-0220-6.
- [23] Q. Yu, F. Liu*, I. Turner, K. Burrage and V. Vegh, The use of a Riesz fractional differential based approach for texture enhancement in image processing, *Proceedings of the 16th Biennial Computational Techniques and Applications Conference, CTAC-2012*, 154, *ANZIAM Journal*, 54, 2013, C590-C607.
- [24] H. Ye, F. Liu*, I. Turner, V. Anh, and K. Burrage, Series expansion solutions for the multi-term

- m time and space fractional partial differential equations in two and three dimensions, *Eur. Phys. J.*, Special Topics 222, 1901-1914, (2013), <http://epjst.epj.org/10.1140/epjst/e2013-01972-2>.
- [25] F. Liu*, I. Turner, V. Anh, Q. Yang and K. Burrage, A numerical method for the fractional Fitzhugh-Nagumo monodomain model, 154, *ANZIAM Journal*, 54, 2013, C608-C629.
- [26] F. Zeng, C.P. Li and F. Liu, High-order explicit-implicit numerical methods for nonlinear anomalous diffusion equations, *European Physical Journal*, 222, 2013, 1885-1900.
- [27] F. Zeng, C. Li, F. Liu and I. Turner, The use of finite difference/element approximations for solving the time-fractional subdiffusion equation, *SIAM J. Sci. Computing*, 35(6), (2013), 2976-3000. DOI:<http://dx.doi.org/10.1137/130910865>.
- [28] H. Hejazi, T. Moroney, F. Liu, A finite volume method for solving the two-sided time-space fractional advection-dispersion equation, *Cent. Eur. J. Phys.*, 11(10), (2013), 1275-1283.
- [29] P. Zhuang, F. Liu*, I. Turner and Y.T. Gu, Finite volume and finite element methods for solving a one-dimensional space-fractional Boussinesq equation, *Applied Mathematical Modelling*, (2013), in press, 10.1016/j.apm.2013.10.008
- [30] J. Song, Q. Yu, F. Liu*, and I. Turner, A spatially second-order accurate implicit numerical method for the space and time fractional Bloch-Torrey equation, *Numerical Algorithms*, (2013), in press, DOI: 10.1007/s11075-013-9768-x.
- [31] F. Liu*, P. Zhuang, I. Turner, K. Burrage and V. Anh, A new fractional finite volume method for solving the fractional diffusion equation, *Applied Mathematical Modelling*, (2013), in press, 10.1016/j.apm.2013.10.007.
- [32] H. Hejazi, T. Moroney and F. Liu. A comparison of finite difference and finite volume methods for solving the space-fractional advection-dispersion equation with variable coefficients, 154, *ANZIAM Journal*, 2013, C557-C573.
- [33] F. Liu*, S. Chen, I. Turner, K. Burrage and V. Anh, Numerical simulation for two-dimensional Riesz space fractional diffusion equations with a nonlinear reaction term, *Cent. Eur. J. Phys.*, 11 (10), (2013), 1221-1232, DOI:102478/s11534-013-0296-z.
- [34] J. Chen, F. Liu, Q. Liu, I. Turner, V. Anh, K. Burrage, Numerical simulation for the three-dimension fractional sub-diffusion equation, *Applied Mathematical Modelling*, (2013), in press.
- [35] C. Chen, F. Liu* and K. Burrage, Numerical methods of the variable-order Rayleigh-Stokes problem for a heated generalized second grade fluid with fractional derivative, *IMA J. Appl. Math.*, 78, (2013), 924-944, 10.1093/imamat/HXR079.