Vassilios Mewes

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Research Interests

Computational Relativistic Astrophysics – Numerical Relativity – General Relativistic Magnetohydrodynamics – Scientific Code Development – High Performance Computing – Visualization – Data Analysis

Professional Experience

Sept. 2019 –

Postdoctoral Research Associate in Computational Astrophysics

Scientific Computing Group
Oak Ridge National Laboratory, USA
Mentor: O. E. Bronson Messer

- Lead developer of `SphericalNR`: A dynamical spacetime and GRMHD evolution framework in spherical coordinates for the `Einstein Toolkit` [1].
- Spontaneous creation of circularly polarized photons in chiral astrophysical systems [2].
- Solving hyperbolic PDEs with high order finite differences in a multipatch framework [3].
- Computational general relativisitic force-free electrodynamics [4, 5].

Sept. 2016 – Aug. 2019

Postdoctoral Research Associate

Center for Computational Relativity and Gravitation
Rochester Institute of Technology, USA
Mentor: Prof. Manuela Campanelli

- `SphericalBSSN`: Vacuum numerical relativity in spherical coordinates with the `Einstein Toolkit` [6].
- Gas dynamics in supermassive binary black hole mergers:
  General relativistic magnetohydrodynamics simulations of circumbinary and mini-disk dynamics and predicting their electromagnetic signatures [7, 8, 9, 10].

Aug. 2011 – Jul. 2016

PhD student in Numerical Relativistic Astrophysics

Departamento de Astronomía y Astrofísica
Universitat de València, Spain
Supervisors: Prof. J. A. Font and Dr. P. J. Montero

- First general relativistic hydrodynamics simulations of tilted accretion tori with a fully dynamical spacetime evolution [11, 12].
- Use of fluid tracer particles in general relativistic hydrodynamics simulations of tilted accretion tori [13].
- Measuring black hole spin direction in numerical relativity [14].
- Simulations of self-gravitating scalar fields around collapsing stars [15].
- The Chebyshev-Jacobi method for solving elliptic PDEs [16].

Oct. 2009 – Jun. 2010 | **Natural Sciences Part III Research Project**

University of Cambridge, United Kingdom
SUPERVISOR: Dr. S. Schirmer

- `Matlab` simulations of the control and the dynamics of quantum systems like lambda-systems and spin chains using reservoir assisted control schemes.

Education

Aug. 2011 – Jul. 2016 | **PhD in Numerical Relativistic Astrophysics**

Universitat de València, Spain
SUPERVISORS: Prof. J. A. Font and Dr. P. J. Montero

Oct. 2006 – Jun. 2010 | **Master of Natural Sciences**

University of Cambridge, United Kingdom
Natural Sciences Tripos - Physical Sciences

Publications

[1] **V. Mewes**, Y. Zlochower, M. Campanelli, T. W. Baumgarte, Z. B. Etienne, F. G. Lopez Armengol, and F. Cipolletta, "Numerical relativity in spherical coordinates: A new dynamical spacetime and general relativistic MHD evolution framework for the Einstein Toolkit," Phys. Rev. D **101**, 104007 (2020), arXiv:2002.06225 [gr-qc]

[2] A. del Rio, N. Sanchis-Gual, **V. Mewes**, I. Agullo, J. A. Font, and J. Navarro-Salas, "Spontaneous creation of circularly polarized photons in chiral astrophysical systems," Phys. Rev. Lett. **124**, 211301 (2020), arXiv:2002.01593

[3] D. B. Bowen, M. Avara, **V. Mewes**, Y. Zlochower, S. C. Noble, M. Campanelli, H. Shiokawa, R. M. Cheng, and J. H. Krolik, "PatchworkWave: A Multipatch Infrastructure for Multiphysics/Multiscale/Multiframe/Multimethod Simulations at Arbitrary Order," (2020), arXiv:2002.00088

[4] J.F. Mahlmann, M.A. Aloy, **V. Mewes**, and P. Cerdá-Durán, "Computational General Relativistic Force-Free Electrodynamics: I. Multi-Coordinate Implementation and Testing," (7 2020), arXiv:2007.06580 [physics.comp-ph]

[5] J.F. Mahlmann, M.A. Aloy, **V. Mewes**, and P. Cerdá-Durán, "Computational General Relativistic Force-Free Electrodynamics: II. Characterization of Numerical Diffusivity," (7 2020), arXiv:2007.06599 [physics.comp-ph]

[6] **V. Mewes**, Y. Zlochower, M. Campanelli, I. Ruchlin, Z. B. Etienne, and T. W. Baumgarte, "Numerical relativity in spherical coordinates with the Einstein Toolkit," Phys. Rev. D **97**, 084059 (2018), arXiv:1802.09625

[7] D. B. Bowen, **V. Mewes**, S. C. Noble, M. Avara, M. Campanelli, and J. H. Krolik, "Quasi-Periodicity of Supermassive Binary Black Hole Accretion Approaching Merger," Astrophys. J. **879**, 76 (2019), arXiv:1904.12048

[8] D. B. Bowen, **V. Mewes**, M. Campanelli, S. C. Noble, J. H. Krolik, and M. Zilhão, "Quasi-periodic Behavior of Mini-disks in Binary Black Holes Approaching Merger," Astrophys. J. Letters **853**, L17 (2018), arXiv:1712.05451

[9] D. B. Bowen, M. Campanelli, J. H. Krolik, **V. Mewes**, and S. C. Noble, "Relativistic Dynamics and Mass Exchange in Binary Black Hole Mini-disks," Astrophys. J. **838**, 42 (2017), arXiv:1612.02373

[10] S. d'Ascoli, S. C. Noble, D. B. Bowen, M. Campanelli, J. H. Krolik, and **V. Mewes**, "Electromagnetic emission from supermassive binary black holes approaching merger," Astrophys. J. **865**, 140 (2018), arXiv:1806.05697

[11] **V. Mewes**, J. A. Font, F. Galeazzi, P. J. Montero, and N. Stergioulas, "Numerical relativity simulations of thick accretion disks around tilted Kerr black holes," Phys. Rev. D **93**, 064055 (2016), arXiv:1506.04056

[12] **V. Mewes**, P. J. Montero, N. Stergioulas, F. Galeazzi, and J. A. Font, "General Relativistic Simulations of Accretion Disks Around Tilted Kerr Black Holes," Astrophys. Space Sci. Proc. **40**, 121–127 (2015), Springer International Publishing Cham

[13] **V. Mewes**, F. Galeazzi, J. A. Font, P. J. Montero, and N. Stergioulas, "On the dynamics of tilted black hole-torus systems," Mon. Not. R. Astron. Soc. **461**, 2480 (2016), arXiv:1605.02629

[14] **V. Mewes**, J. A. Font, and P. J. Montero, "Measuring the black hole spin direction in 3D Cartesian numerical relativity simulations," Phys. Rev. D **91**, 124043 (2015), arXiv:1505.07225

[15] N. Sanchis-Gual, J. C. Degollado, P. J. Montero, J. A. Font, and **V. Mewes**, "Quasistationary solutions of self-gravitating scalar fields around collapsing stars," Phys. Rev. D **92**, 083001 (2015), arXiv:1507.08437

[16] J. E. Adsuara, I. Cordero-Carrión, P. Cerdá-Durán, **V. Mewes**, and M. A. Aloy, "On the equivalence between the Scheduled Relaxation Jacobi method and Richardson's non-stationary method," J. Comput. Phys. **332**, 446 (2017), arXiv:1607.03712

Invited Talks/Presentations

1. *SphericalNR: A Dynamical Spacetime and GRMHD Evolution Framework in Spherical Coordinates with the Einstein Toolkit*
   High Energy Physics/Astrophysics **Seminar**, University of Tennessee, Knoxville, TN, USA, January 29, 2020

2. *SphericalNR: A Dynamical Spacetime and GRMHD Evolution Framework in Spherical Coordinates with the Einstein Toolkit*
   Seminar, Computational and Applied Mathematics Group, Oak Ridge National Laboratory, TN, USA, January 16, 2020

3. *SphericalNR: numerical relativity in spherical coordinates with the Einstein Toolkit*
   Seminar, Computational Relativistic Astrophysics group, Max Planck Institute for Gravitational Physics, Potsdam, Germany, April 09, 2019

4. *Addressing computational challenges in numerical relativity with SphericalNR: Black holes, accretion disks, and more in topologically spherical coordinates*
   CTA **Seminar**, Center for Theoretical Astrophysics, Los Alamos National Laboratory, NM, USA, September 13, 2018

5. *SphericalNR: highly accurate numerical relativity in topologically spherical coordinates with the Einstein Toolkit*
   CNLS **Seminar**, Center for Nonlinear Studies, Los Alamos National Laboratory, NM, USA, September 11, 2018

6. *Numerical relativity in the multi-messenger astronomy era*
   Gravitational waves **Seminar** at Nikhef, Amsterdam, Netherlands, July 27, 2018

7. *Numerical relativity in the multi-messenger astronomy era*
   Gravity and Field Theory **Seminar** at Institute for Nuclear Sciences, Autonomous University of Mexico, June 21, 2018

8. *Numerical relativity in spherical coordinates with the Einstein Toolkit*
   Seminar at Universidad del Valle, Cali, Valle del Cauca, Colombia, April 04, 2018

9. *Numerical relativity simulations of BBH coalescence using the Einstein Toolkit*
   Two day lecture series at Universitat de València, València, Spain, July 06, 2016

10. *Numerical relativity simulations of thick accretion disks around tilted Kerr black holes*
    Seminar at Relativistic Astrophysics Group, Institute of Theoretical Physics, Goethe University, Frankfurt, Germany, April 15, 2015

Contributed Talks/Presentations

1. *SphericalNR: Numerical relativity in spherical coordinates with the Einstein Toolkit*
   Conference talk, GR22 and Amaldi13, Valencia, Spain, July 10, 2019

2. *SphericalNR: Numerical relativity in spherical coordinates with the Einstein Toolkit*
   Conference talk, North American Einstein Toolkit workshop 2019, RIT, Rochester, NY, USA, June 14, 2019

3. *Binary neutron star merger models*
   Panel discussion, PAX III meeting, Penn State, PA, USA, February 05, 2018

4. *Relativistic dynamics of binary black hole mini-disks*
   Conference talk, CoCoNut Meeting, València, Spain, December 14, 2016

5. *Numerical relativity simulations of tilted black hole-torus systems*
   Conference talk, Midwest Relativity Meeting, Perimeter Institute, Waterloo, ON, Canada, October 14, 2016

6. *Measuring spin magnitude and direction in 3D GRHD simulations on Cartesian grids*
   Conference talk, CoCoNut Meeting, València, Spain, November 26, 2014

7. *General relativistic simulations of tilted self-gravitating accretion disks around Kerr black holes*
   Conference talk, ERE, València, Spain, September 01, 2014

8. *General relativistic simulations of tilted self-gravitating accretion disks around Kerr black holes*
   Conference talk, Sant Cugat Forum on Astrophysics, Sant Cugat, Spain, April 24, 2014

9. *General relativistic simulations of tilted self-gravitating accretion disks around Kerr black holes*
   Conference talk, Iberian Gravitational Wave Meeting, Granada, Spain, February 28, 2014

10. *General relativistic simulations of thick self-gravitating accretion disks around black holes*
    Conference talk, ERE, Benasque, Spain, September 10, 2013

Teaching

2014/2015	Universitat de València, Spain Teaching Assistant for Mathematics II in Engineering Studies • Responsible for `Mathematica` labs and giving lectures • 6 ECTS credits
2013/2014	Universitat de València, Spain Teaching Assistant for Mathematics II in Engineering Studies • Responsible for `Mathematica` labs • 4 ECTS credits

Technical Skills

Programming Languages	C/C++, Python, Fortran, Shell Scripting.
Computational Physics	Numerically Solving Hyperbolic and Elliptic PDEs, Computational Fluid Dynamics, Finite Volume/Difference Methods, High Resolution Shock-Capturing Methods, Root Finding, Interpolation, Nonlinear Data Fitting.
Scientific Code Development	Main developer of `SphericalNR`, a dynamical spacetime and general relativistic magnetohydrodynamics evolution framework in spherical coordinates for the `Einstein Toolkit`, featuring MPI-parallelized internal boundary conditions for spherical coordinates. Analysis modules for general relativistic hydrodynamics simulations with the `Einstein Toolkit`.
High Performance Computing	OpenMP and MPI parallelization. Compiling, debugging, and running scientific codes on HPC systems. Analyzing and postprocessing terabyte scale data sets from simulations on HPC systems, using grid based data as well as tracer particles.
Visualization	Visualization of simulation data with `VisIt`, featured in Phys. Rev. D Kaleidoscopes, Matplotlib, Gnuplot.
Tools	OpenMP, MPI, HDF5, Make, gdb, Linux/Unix, Windows, Mac OS X, git, mercurial, `Mathematica`, `Matlab`.

Synergistic Activities

- Scientific Organizing Committee, 2017 North American Einstein Toolkit School and Workshop at NCSA.
- Referee for Monthly Notices of the Royal Astronomical Society Letters, Classical and Quantum Gravity, and General Relativity and Gravitation.

Languages

German	native proficiency
English	full professional proficiency
Spanish	professional working proficiency