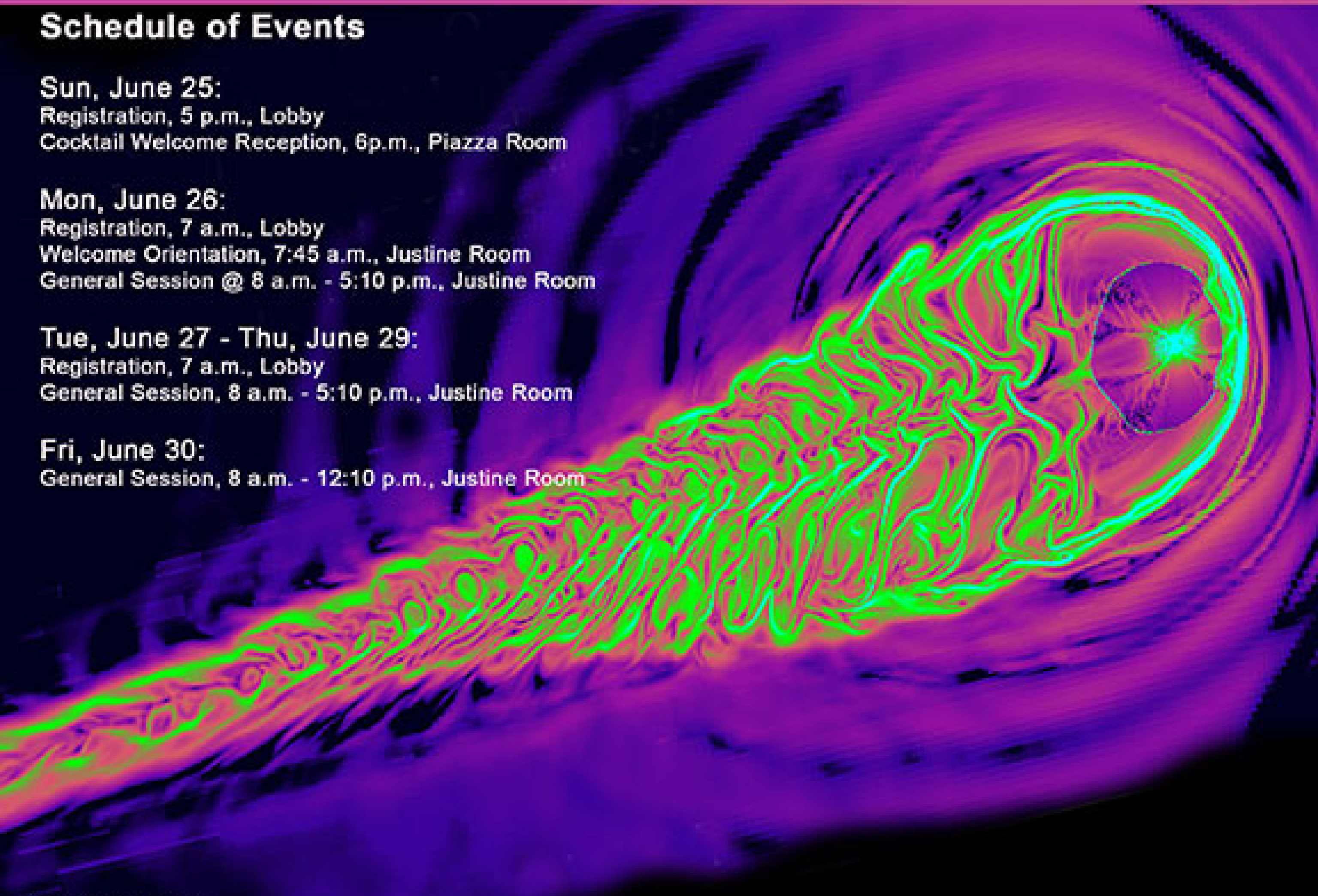
ASTRONUM 2023

15th International Conference on Numerical Modeling of Space Plasma Flows



Schedule of Events

Sun, June 25:
Registration, 5 p.m., Lobby
Cocktail Welcome Reception, 6p.m., Piazza Room

Mon, June 26:
Registration, 7 a.m., Lobby
Welcome Orientation, 7:45 a.m., Justine Room
General Session @ 8 a.m. - 5:10 p.m., Justine Room

Tue, June 27 - Thu, June 29:
Registration, 7 a.m., Lobby
General Session, 8 a.m. - 5:10 p.m., Justine Room

Fri, June 30:
General Session, 8 a.m. - 12:10 p.m., Justine Room

Program Committee:
Nikolai Pogorelov (UAH, USA, chair)
Edouard Audit (CEA/CNRS Maison de la Simulation, France, co-chair)
Wes Bethel (San Francisco State University, USA)
Amitava Bhattacharjee (Princeton Plasma Physics Laboratory, USA)
Phillip Colella (Lawrence Berkeley National Laboratory, USA)
Tomoyuki Hanawa (Chiba University, Japan)
Maria Elena Innocenti (Ruhr University Bochum, Germany)
Kanya Kusano (Nagoya University, Japan)
Dongwook Lee (University of California, Santa Cruz)
Jon Linker (Predictive Science Inc., USA)
Anthony Mezzacappa (University of Tennessee, Knoxville, USA)
Ewald Müller (Max-Planck-Institute for Astrophysics, Garching, Germany)
Dongsu Ryu (Ulsan National Institute of Science and Technology, Korea)
James Stone (Princeton University)
Gary P. Zank (University of Alabama in Huntsville, USA).

Maison de la Simulation

JUNE 26 - 30

PASADENA, CA, USA

ASTRONUM 2023
Pasadena, CA
June 25 – 30

AGENDA

SUNDAY, JUNE 25	
5:00 PM – 8:00 PM	Registration – Lobby
6:00 PM – 6:30 PM	Cocktail Social – Piazza Ballroom
6:30 PM – 9:00 PM	Welcome Reception – Piazza Ballroom

MONDAY, JUNE 26		
7:00 AM - 4:00 PM	Registration – Lobby	
8:00 AM – 5:10 PM	GENERAL SESSION – Justine Ballroom	
	CHAIR: Audit, E.	
8:00 AM - 8:25 AM	Lazarian, Alex	Mechanisms of CR Acceleration in Galaxy Clusters
8:25 AM - 8:50 AM	Fujimoto, Keizo	Ohm's Law in the Reconnection Diffusion Region Dominated by Electromagnetic Turbulence
8:50 AM - 9:15 AM	Cho, Jungyeon	MHD Turbulence and Dust Polarization
9:15 AM - 9:40 AM	Bugli, Matteo	Amplification and Dissipation of Magnetic Fields in Accreting Compact Objects
9:40 AM - 10:05 AM	Endeve, Eirik	On the Nuts and Bolts of a Neutrino Transport Module in Thornado and its Incorporation into the Flash-X Multiphysics Simulation Framework
10:05 AM - 10:30 AM	Morning Break – Piazza Ballroom	
	CHAIR: Pogorelov, N.	
10:30 AM - 10:55 AM	Burrows, Adam	State-of-the-Art 3D Models of Core-Collapse Supernova Explosions
10:55 AM - 11:20 AM	Ryu, Dongsu	A New Code for Relativistic Hydrodynamics and Studies of Radio Jets
11:20 AM - 11:45 AM	Medvedev, Mikhail	Prospects of X-ray Imaging of the Outer Heliosphere
11:45 AM - 12:10 PM	Calder, Alan	FLASH on A64FX: A Guide to Tuning an Astrophysics Code on a New CPU Architecture
12:10 PM - 12:35 PM	Audit, Edouard	Which Strategy to Tackle Exascale Systems for Astrophysics
12:35 PM - 1:30 PM	Lunch Break – Piazza Ballroom	
	CHAIR: Mezzacappa, A.	
1:30 PM - 1:55 PM	Moesta, Philipp	Magnetic Fields, Jets, and Turbulence in the Multimessenger Era
1:55 PM - 2:20 PM	Hoeflich, Peter	Supernovae in the Age of JWST: Finding the 'Right' Questions and the Path to Answers.
2:20 PM - 2:45 PM	Richers, Sherwood	Using Machine Learning to Predict the Outcome of the Fast Flavor Instability
2:45 PM - 3:10 PM	Kim, Woong-Tae	Semi-global Simulations of Star formation in Nuclear Rings of Barred Galaxies
3:10 PM - 3:35 PM	Shingo, Hirano	Exponential Amplification of the Magnetic Field in the Primordial Star-forming Cloud
3:35 PM – 3:55 PM	Afternoon Break – Piazza Ballroom	
	CHAIR: Calder, A.	
3:55 PM - 4:20 PM	Nagakura, Hiroki	Numerical Modeling of Non-equilibrium Neutrino Radiation Field by Solving Quantum Kinetic Equation
4:20 PM - 4:45 PM	Kang, Hyesung	A Simulation Study of Particle Acceleration in High-beta Shocks via Weibel Amplification: Implications for Galaxy Cluster Outskirts
4:45 PM - 5:10 PM	Ripperda, Bart	How Black Holes Shine
	SESSION ADJORNS	

ASTRONUM 2023
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AGENDA

TUESDAY, JUNE 27		
7:00 AM - 4:00 PM	Registration -Lobby	
8:00 AM – 5:10 PM	GENERAL SESSION – Justine Ballroom	
CHAIR: Cho, J.		
8:00 AM - 8:25 AM	Bera, Ratan Kumar	The Role of Pickup Ions in the Interaction of the Solar Wind with the Local Interstellar Medium: Importance of Kinetic Processes at the Heliospheric Termination Shock
8:25 AM - 8:50 AM	Kunz, Matthew	Waves, Turbulence, and Heating in Dilute Astrophysical Plasmas
8:50 AM - 9:15 AM	Most, Elias	Simulating Extreme Plasmas in Neutron Star Mergers
9:15 AM - 9:40 AM	Slavin, Jonathan	Methods and Challenges of Including Dust Evolution in Magnetohydrodynamic Simulations
9:40 AM - 10:05 AM	Pajkos, Michael	Accounting for Relativistic Effects in Core-collapse Supernova Simulations
10:05 AM - 10:30 AM	**Morning Break - Piazza Ballroom**	
CHAIR: Singh, T.		
10:30 AM - 10:55 AM	Pogorelov, Nikolai	Space Weather Prediction Challenges: A Software Suite for Data-driven Modeling of the Solar Atmosphere and Inner Heliosphere
10:55 AM - 11:20 AM	Linker, Jon	An Interactive Tool for Modeling Solar Eruptions
11:20 AM - 11:45 AM	Che, Haihong	Particle Acceleration in Magnetic Reconnection
11:45 AM - 12:10 PM	Oran, Rona	Reconstructing the Magnetospheres of Weakly Magnetized Bodies using Iterative Data-model Fitting
12:10 PM - 12:35 PM	Mezzacappa, Anthony	Will this Never End?
12:35 PM - 1:30 PM	**Lunch Break - Piazza Ballroom**	
CHAIR: Strauss, D.		
1:30 PM - 1:55 PM	Hanawa, Tomoyuki	Achieving Higher Order Accuracy in Space in Hydrodynamic Simulation of Self-Gravitating Gas
1:55 PM - 2:20 PM	Paschalidis, Vasileios	Progress on Magnetohydrodynamic Accretion onto Binary Black Holes
2:20 PM - 2:45 PM	Kolobov, Vladimir	Peculiarities of Electron Kinetics in Collisional Plasmas
2:45 PM - 3:10 PM	Kaneko, Takafumi	Impact of Convective flows on Energy Build-up of Flare-productive Sunspots
3:10 PM - 3:35 PM	Loring, Burlen	Addressing the FLOPS to IOPS gap with Python Based in-situ Processing
3:35 PM - 3:55 PM	**Afternoon Break - Piazza Ballroom**	
CHAIR: Lee, D.		
3:55 PM - 4:20 PM	De Zeeuw, Darren	Interactive Visualization of Space Physics Model Output with the CCMC's Kamodo Python Toolkit
4:20 PM - 4:45 PM	May, Ian	High-Order Genuinely Multidimensional Finite Volume Methods via Kernel-Based WENO
SESSION ADJOURNS		

AGENDA

WEDNESDAY, JUNE 28		
7:00 AM - 4:00 PM	Registration -Lobby	
8:00 AM – 5:10 PM	GENERAL SESSION – Justine Ballroom	
CHAIR: Merkin, S.		
8:00 AM - 8:25 AM	Brchnelova, Michaela	Numerical Challenges of Global Coronal Modelling
8:25 AM - 8:50 AM	Caplan, Ronald	Evaluating a Practical Parabolic Time Step Limit for Unconditionally Stable Schemes in a Thermodynamic MHD Model
8:50 AM - 9:15 AM	Sokolov, Igor	Extended Alfven Wave Turbulence Based Solar Atmosphere Model
9:15 AM - 9:40 AM	Singh, Talwinder	Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning
9:40 AM - 10:05 AM	Shen, Fang	3D MHD Modeling of Interplanetary Solar Wind Using Self-Consistent Boundary Condition Obtained from Multiple Observations and Machine Learning Technique
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Xu, S.		
10:30 AM - 10:55 AM	Radice, David	Neutrinos and Nucleosynthesis in Neutron Star Mergers
10:55 AM - 11:20 AM	Kritsuk, Alexei	Scaling and Energy Transfer in Homogeneous Compressible Turbulence
11:20 AM - 11:45 AM	Zingale, Michael	Modeling Explosive Reactive Flows
11:45 AM - 12:10 PM	Hu, Qiang	Coronal Magnetic Field Extrapolation by Using Ultra High-Resolution Vector Magnetograms
12:10 PM - 12:35 PM	Fraternale, Federico	Modeling the Interaction Between the Solar Wind and the Local Interstellar Medium with Helium and Fluid Electrons: Implications for the Global Heliosphere Properties and Neutral Atoms Distributions
12:35 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Slavin, J.		
1:30 PM - 1:55 PM	Sako, Takashi	Modeling of TeV Galactic Cosmic-ray Anisotropy based on Intensity Mapping in an MHD Model Heliosphere
1:55 PM - 2:20 PM	Xu, Siyao	Turbulence in the Partially Ionized very Local Interstellar Medium and Implications on IBEX Ribbon
2:20 PM - 2:45 PM	Merkin, Slava	High-Resolution MHD Modeling of Interplanetary Coronal Mass Ejections
2:45 PM - 3:10 PM	Papadakis, Konstantinos	Global Hybrid Plasma Simulations of Near-Earth Space Using Vlasiator
3:10 PM - 3:35 PM	Sorathia, Kareem	Modeling Stormtime Geospace: Multiscale Coupling and its Implications
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	
CHAIR: Brchnelova, M.		
3:55 PM - 4:20 PM	Peter, Hardi	MHD Modeling of the Solar Corona and Comparison to Observations
4:20 PM - 4:45 PM	Sadykov, Viacheslav	Modeling Spectral Lines and Broadband Emission for Realistic Simulations of the Sun
SESSION ADJOURNS		
6:00 PM - 9: 00 PM	Group Dinner – Piazza Ballroom	

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June 25 – 30

AGENDA

THURSDAY, JUNE 29		
7:00 AM - 4:00 PM	Registration -Lobby	
8:00 AM – 5:10 PM	GENERAL SESSION – Justine Ballroom	
CHAIR: Fraternale, F.		
8:00 AM - 8:25 AM	Hakobyan, Hayk	Entity: a New-Generation Architecture-Agnostic GR QED PIC code
8:25 AM - 8:50 AM	Wilson, Lynn	The Structure of Collisionless Shocks
8:50 AM - 9:15 AM	Toth, Gabor	MHD-AEPIC: Magnetohydrodynamics with Adaptively Embedded Partice-in-Cell Model
9:15 AM - 9:40 AM	Tarr, Lucas	Data-Driven Boundary Conditions for 3D Magnetohydrodynamic Photosphere to Corona Simulations of the Sun
9:40 AM - 10:05 AM	Kim, Tae	The Variable Potential Field Source Surface Height and the Implications on Solar Wind Predictions
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Lynch, B.		
10:30 AM - 10:55 AM	Zank, Gary	Linear Mode-Decomposition in Magnetohydrodynamics Revisited
10:55 AM - 11:20 AM	Mathews, Nat	Solving 3D Magnetohydrostatics with RBF-FD: Applications to the Solar Corona
11:20 AM - 11:45 AM	van der Holst, Bart	Improvements in the Alfven Wave Solar Atmosphere Model
11:45 AM - 12:10 PM	Woodward, Paul	A New Approach to Strong Scaling
12:10 PM - 12:35 PM	Lee, Dongwook	A Class of High-Order Kernel-Based Shock-Capturing Methods for Astrophysical Flow Simulations
12:35 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Paschalidis, V.		
1:30 PM - 1:55 PM	Minoshima, Takashi	A Quasi All-speed Scheme for MHD Flows in a Wide Range of Mach Numbers
1:55 PM - 2:20 PM	Mackey, Jonathan	Wind-Blown Nebulae from Single and Binary Massive Stars
2:20 PM - 2:45 PM	van Marle, Allard Jan	Diffusive Shock Acceleration at Oblique High Mach Number Shocks
2:45 PM - 3:10 PM	Dubey, Anshu	Flash-X: A Multiphysics Simulation Software Instrument
3:10 PM - 3:35 PM	Michael, Adam	Cross-Scale Modeling of Radiation Belt Variability in a Combined MHD and Test Particle Simulation
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	
CHAIR: Dubey, A.		
3:55 PM - 4:20 PM	Luo, Hongyang	Gas Kinetic Schemes for Solving the Magnetohydrodynamic Equations with Pressure Anisotropy
4:20 PM - 4:45 PM	Nakatani, Riouhei	Evolution from Protoplanetary Disks to Debris Disks: Effects of Photoevaporation
4:45 PM - 5:10 PM	Van Loo, Sven	Dust Accretion onto Circumplanetary Discs
SESSION ADJOURNS		

ASTRONUM 2023
Pasadena, CA
June 25 – 30

AGENDA

FRIDAY, JUNE 30		
7:00 AM - 11:00 AM	Registration -Lobby	
8:00 AM – 11:00 AM	GENERAL SESSION – Justine Ballroom	
Chair: Sorathia, K.		
8:00 AM - 8:25 AM	Lynch, Benjamin	Modeling Reconnection-generated Transients in the Solar Wind
8:25 AM - 8:50 AM	Yuen, Ka Ho	Origin of Low Frequency Fluctuations in Compressible MHD Turbulence: Theory and Observation
8:50 AM - 9:15 AM	Strauss, Du Toit	The Use of the Locally One-Dimensional (LOD) Method in Cosmic Ray Transport Models
9:15 AM - 9:40 AM	Federrath, Christoph	Modelling MHD Turbulence and Star Formation
9:40 AM - 10:05 AM	Tomohisa, Kawashima	PIC Simulations of Mushroom-Instability-Driven Magnetic Reconnections in Collisionless Relativistic Jets
10:05 AM - 10:30 AM	Claes, Niels	Legolas 2.0: Extensions to a Linear MHD Spectroscopic Framework
10:30 AM - 10:55 AM	Morning Break - Piazza Ballroom	
END OF CONFERENCE		

ASTRONUM 2023
Jun 26-30
Pasadena, CA
TALKS BY PARTICIPANT

Audit, Edouard	Mon, Jun 26	12:10 PM - 12:35 PM	Which Strategy to Tackle Exascale Systems for Astrophysics
Bera, Ratan Kumar	Tue, Jun 27	8:00 AM - 8:25 AM	The Role of Pickup Ions in the Interaction of the Solar Wind with the Local Interstellar Medium: Importance of Kinetic Processes at the Heliospheric Termination Shock
Brchnelova, Michaela	Wed, Jun 28	8:00 AM - 8:25 AM	Numerical Challenges of Global Coronal Modelling
Bugli, Matteo	Mon, Jun 26	9:15 AM - 9:40 AM	Amplification and Dissipation of Magnetic Fields in Accreting Compact Objects
Burrows, Adam	Mon, Jun 26	10:30 AM - 10:55 AM	State-of-the-Art 3D Models of Core-Collapse Supernova Explosions
Calder, Alan	Mon, Jun 26	11:45 AM - 12:10 PM	FLASH on A64FX: A Guide to Tuning an Astrophysics Code on a New CPU Architecture
Caplan, Ronald	Wed, Jun 28	8:25 AM - 8:50 AM	Evaluating a Practical Parabolic Time Step Limit for Unconditionally Stable Schemes in a Thermodynamic MHD Model
Che, Haihong	Tue, Jun 27	11:20 AM - 11:45 AM	Particle Acceleration in Magnetic Reconnection
Cho, Jungyeon	Mon, Jun 26	8:50 AM - 9:15 AM	MHD Turbulence and Dust Polarization
Claes, Niels	Fri, Jun 30	10:05 AM - 10:30 AM	Legolas 2.0: Extensions to a Linear MHD Spectroscopic Framework
De Zeeuw, Darren	Tue, Jun 27	3:55 PM - 4:20 PM	Interactive Visualization of Space Physics Model Output with the CCMC’s Kamodo Python Toolkit
Dubey, Anshu	Thu, Jun 29	2:45 PM - 3:10 PM	Flash-X: A Multiphysics Simulation Software Instrument
Endeve, Eirik	Mon, Jun 26	9:40 AM - 10:05 AM	On the Nuts and Bolts of a Neutrino Transport Module in Thornado and its Incorporation into the Flash-X Multiphysics Simulation Framework
Federrath, Christoph	Fri, Jun 30	9:15 AM - 9:40 AM	Modelling MHD Turbulence and Star Formation
Fraternale, Federico	Wed, Jun 28	12:10 PM - 12:35 PM	Modeling the Interaction Between the Solar Wind and the Local Interstellar Medium with Helium and Fluid Electrons: Implications for the Global Heliosphere Properties and Neutral Atoms Distributions
Fujimoto, Keizo	Mon, Jun 26	8:25 AM - 8:50 AM	Ohm’s Law in the Reconnection Diffusion Region Dominated by Electromagnetic Turbulence
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Hoeflich, Peter	Mon, Jun 26	1:55 PM - 2:20 PM	Supernovae in the Age of JWST: Finding the 'Right' Questions and the Path to Answers.
Hu, Qiang	Wed, Jun 28	11:45 AM - 12:10 PM	Coronal Magnetic Field Extrapolation by Using Ultra High-Resolution Vector Magnetograms
Kaneko, Takafumi	Tue, Jun 27	2:45 PM - 3:10 PM	Impact of Convective flows on Energy Build-up of Flare-productive Sunspots
Kang, Hyesung	Mon, Jun 26	4:20 PM - 4:45 PM	A Simulation Study of Particle Acceleration in High-beta Shocks via Weibel Amplification: Implications for Galaxy Cluster Outskirts
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Kolobov, Vladimir	Tue, Jun 27	2:20 PM - 2:45 PM	Peculiarities of Electron Kinetics in Collisional Plasmas
Kritsuk, Alexei	Wed, Jun 28	10:55 AM - 11:20 AM	Scaling and Energy Transfer in Homogeneous Compressible Turbulence
Kunz, Matthew	Tue, Jun 27	8:25 AM - 8:50 AM	Waves, Turbulence, and Heating in Dilute Astrophysical Plasmas

TALKS BY PARTICIPANT

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Linker, Jon	Tue, Jun 27	10:55 AM - 11:20 AM	An Interactive Tool for Modeling Solar Eruptions
Loring, Burlen	Tue, Jun 27	3:10 PM - 3:35 PM	Addressing the FLOPS to IOPS gap with Python Based in-situ Processing
Luo, Hongyang	Thu, Jun 29	3:55 PM - 4:20 PM	Gas Kinetic Schemes for Solving the Magnetohydrodynamic Equations with Pressure Anisotropy
Lynch, Benjamin	Fri, Jun 30	8:00 AM - 8:25 AM	Modeling Reconnection-generated Transients in the Solar Wind
Mackey, Jonathan	Thu, Jun 29	1:55 PM - 2:20 PM	Wind-Blown Nebulae from Single and Binary Massive Stars
Mathews, Nat	Thu, Jun 29	10:55 AM - 11:20 AM	Solving 3D Magnetohydrostatics with RBF-FD: Applications to the Solar Corona
May, Ian	Tue, Jun 27	4:20 PM - 4:45 PM	High-Order Genuinely Multidimensional Finite Volume Methods via Kernel-Based WENO
Medvedev, Mikhail	Mon, Jun 26	11:20 AM - 11:45 AM	Prospects of X-ray Imaging of the Outer Heliosphere
Merkin, Slava	Wed, Jun 28	2:20 PM - 2:45 PM	High-Resolution MHD Modeling of Interplanetary Coronal Mass Ejections
Mezzacappa, Anthony	Tue, Jun 27	12:10 PM - 12:35 PM	Will this Never End?
Michael, Adam	Thu, Jun 29	3:10 PM - 3:35 PM	Cross-Scale Modeling of Radiation Belt Variability in a Combined MHD and Test Particle Simulation
Minoshima, Takashi	Thu, Jun 29	1:30 PM - 1:55 PM	A Quasi All-speed Scheme for MHD Flows in a Wide Range of Mach Numbers
Moesta, Philipp	Mon, Jun 26	1:30 PM - 1:55 PM	Magnetic Fields, Jets, and Turbulence in the Multimessenger Era
Most, Elias	Tue, Jun 27	8:50 AM - 9:15 AM	Simulating Extreme Plasmas in Neutron Star Mergers
Nagakura, Hiroki	Mon, Jun 26	3:55 PM - 4:20 PM	Numerical Modeling of Non-equilibrium Neutrino Radiation Field by Solving Quantum Kinetic Equation
Nakatani, Riouhei	Thu, Jun 29	4:20 PM - 4:45 PM	Evolution from Protoplanetary Disks to Debris Disks: Effects of Photoevaporation
Oran, Rona	Tue, Jun 27	11:45 AM - 12:10 PM	Reconstructing the Magnetospheres of Weakly Magnetized Bodies using Iterative Data-model Fitting
Pajkos, Michael	Tue, Jun 27	9:40 AM - 10:05 AM	Accounting for Relativistic Effects in Core-collapse Supernova Simulations
Papadakis, Konstantinos	Wed, Jun 28	2:45 PM - 3:10 PM	Global Hybrid Plasma Simulations of Near-Earth Space Using Vlasiator
Paschalidis, Vasileios	Tue, Jun 27	1:55 PM - 2:20 PM	Progress on Magnetohydrodynamic Accretion onto Binary Black Holes
Peter, Hardi	Wed, Jun 28	3:55 PM - 4:20 PM	MHD Modeling of the Solar Corona and Comparison to Observations
Pogorelov, Nikolai	Tue, Jun 27	10:30 AM - 10:55 AM	Space Weather Prediction Challenges: A Software Suite for Data-driven Modeling of the Solar Atmosphere and Inner Heliosphere
Radice, David	Wed, Jun 28	10:30 AM - 10:55 AM	Neutrinos and Nucleosynthesis in Neutron Star Mergers
Richers, Sherwood	Mon, Jun 26	2:20 PM - 2:45 PM	Using Machine Learning to Predict the Outcome of the Fast Flavor Instability
Ripperda, Bart	Mon, Jun 26	4:45 PM - 5:10 PM	How Black Holes Shine
Ryu, Dongsu	Mon, Jun 26	10:55 AM - 11:20 AM	A New Code for Relativistic Hydrodynamics and Studies of Radio Jets
Sadykov, Viacheslav	Wed, Jun 28	4:20 PM - 4:45 PM	Modeling Spectral Lines and Broadband Emission for Realistic Simulations of the Sun
Sako, Takashi	Wed, Jun 28	1:30 PM - 1:55 PM	Modeling of TeV Galactic Cosmic-ray Anisotropy based on Intensity Mapping in an MHD Model Heliosphere

TALKS BY PARTICIPANT

Shen, Fang	Wed, Jun 28	9:40 AM - 10:05 AM	3D MHD Modeling of Interplanetary Solar Wind Using Self-Consistent Boundary Condition Obtained from Multiple Observations and Machine Learning Technique
Shingo, Hirano	Mon, Jun 26	3:10 PM - 3:35 PM	Exponential Amplification of the Magnetic Field in the Primordial Star-forming Cloud
Singh, Talwinder	Wed, Jun 28	9:15 AM - 9:40 AM	Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning
Slavin, Jonathan	Tue, Jun 27	9:15 AM - 9:40 AM	Methods and Challenges of Including Dust Evolution in Magnetohydrodynamic Simulations
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Strauss, Du Toit	Fri, Jun 30	8:50 AM - 9:15 AM	The Use of the Locally One-Dimensional (LOD) Method in Cosmic Ray Transport Models
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Tomohisa, Kawashima	Fri, Jun 30	9:40 AM - 10:05 AM	PIC Simulations of Mushroom-Instability-Driven Magnetic Reconnections in Collisionless Relativistic Jets
Toth, Gabor	Thu, Jun 29	8:50 AM - 9:15 AM	MHD-AEPIC: Magnetohydrodynamics with Adaptively Embedded Partice-in-Cell Model
van der Holst, Bart	Thu, Jun 29	11:20 AM - 11:45 AM	Improvements in the Alfven Wave Solar Atmosphere Model
Van Loo, Sven	Thu, Jun 29	4:45 PM - 5:10 PM	Dust Accretion onto Circumplanetary Discs
van Marle, Allard Jan	Thu, Jun 29	2:20 PM - 2:45 PM	Diffusive Shock Acceleration at Oblique High Mach Number Shocks
Wilson, Lynn	Thu, Jun 29	8:25 AM - 8:50 AM	The Structure of Collisionless Shocks
Woodward, Paul	Thu, Jun 29	11:45 AM - 12:10 PM	A New Approach to Strong Scaling
Xu, Siyao	Wed, Jun 28	1:55 PM - 2:20 PM	Turbulence in the Partially Ionized very Local Interstellar Medium and Implications on IBEX Ribbon
Yuen, Ka Ho	Fri, Jun 30	8:25 AM - 8:50 AM	Origin of Low Frequency Fluctuations in Compressible MHD Turbulence: Theory and Observation
Zank, Gary	Thu, Jun 29	10:30 AM - 10:55 AM	Linear Mode-Decomposition in Magnetohydrodynamics Revisited
Zingale, Michael	Wed, Jun 28	11:20 AM - 11:45 AM	Modeling Explosive Reactive Flows

SCHEDULE OF TALKS

Monday, June 26: 8:25 AM - 8:50 AM
Presenter: Fujimoto, Keizo

Ohm's Law in the Reconnection Diffusion Region Dominated by Electromagnetic Turbulence

Keizo Fujimoto, Beihang University, China
Richard Sydora, University of Alberta, Canada

Most of the plasma fluid equations have employed the electrical resistivity to generate the magnetic dissipation required for magnetic reconnection to occur in collisionless plasma. However, there has been no clear evidence that such the model is indeed appropriate in the reconnection diffusion region in terms of the kinetic physics. To address this issue, the present study has performed a large-scale 3D particle-in-cell simulation as well as analytical analysis. The simulation results show that the thin current layer formed around the reconnection x-line is unstable to the flow shear instabilities, leading to intense electromagnetic turbulence in the electron diffusion region (EDR). It is found that the non-ideal electric field in the EDR is consistent with the Ohm's law based on the viscosity rather than the resistivity. The effective viscosity is caused by the turbulence that gives rise to effective momentum transport of the electrons across the EDR. The present result suggests a fundamental modification of the fluid equations using the resistivity in the Ohm's law. In this talk, we will present the simulation results and analytical analysis to demonstrate the dissipation mechanism in the turbulent current layer to drive magnetic reconnection.

Monday, June 26: 8:50 AM - 9:15 AM
Presenter: Cho, Jungyeon

MHD Turbulence and Dust Polarization

Jungyeon Cho, Chungnam National University, Korea (ROK)

In this talk, I will talk about Alfvenic magnetohydrodynamic (MHD) turbulence and its application to dust polarization. Interstellar dust grains are aligned mainly with respect to local magnetic field directions and, as a result, thermal emission from the grains is polarized in the direction perpendicular to the magnetic field. Therefore, we can study magnetic field by observing polarized emission from magnetically-aligned dust grains. I will first talk about Alfvenic MHD turbulence. Then, I will show how we can derive the Davis-Chandrasekhar-Fermi (DCF) method, which use dust polarization and is the most popular method for obtaining magnetic field strengths in molecular clouds. Third, I will briefly discuss the limitations of the DCF method and introduce a modified DCF method. Fourth, I will talk about a new possibility to measure the strength of magnetic field from dust polarization.

Monday, June 26: 9:15 AM - 9:40 AM
Presenter: Bugli, Matteo

Amplification and Dissipation of Magnetic Fields in Accreting Compact Objects

Matteo Bugli, UniTo - CEA Saclay, Italy
Jérôme Guilet, CEA Saclay, France
Luca Del Zanna, UniFi, Italy
Andrea Mignone, UniTo, Italy
Giancarlo Mattia, INFN, Italy
Vittorial Berta, UniTo, Italy

Magnetic fields play a crucial role in shaping the dynamics of accreting compact objects. Whether we consider the formation of a proto-neutron star during the gravitational collapse of a massive star or the accretion disk around a black hole after a compact binary merger, a key process that remains challenging to include in large-scale simulations is the amplification and dissipation of magnetic fields driven by turbulent motions. Despite the enormous increase in computational power currently available, the still large separation between all the relevant scales poses severe limits to what can be achieved with ideal fluid simulations. One way to tackle such issue is to rely on sub-grid models, which however need to be appropriately tuned in light of models probing the small-scale dynamics. I this talk I will present the current state-of-the-art of dynamo models in proto-neutron stars, which aim at describing the amplification of magnetar-like magnetic fields during the gravitational collapse of a massive star. I will also review some of the works from the past few years that included turbulent dynamos in accretion disks around a black holes, relying on a mean-field formalism. Finally, I will present a recent study on polar jets with explicit turbulent resistivity which showcases the importance of employing highly accurate numerical schemes.

Monday, June 26: 9:40 AM - 10:05 AM
Presenter: Endeve, Eirik

On the Nuts and Bolts of a Neutrino Transport Module in Thornado and its Incorporation into the Flash-X Multiphysics Simulation Framework

Eirik Endeve, Oak Ridge National Laboratory, USA

Simulations of core-collapse supernovae (CCSNe) and other systems of interest in nuclear astrophysics demand the inclusion of neutrinos and their interaction with matter. Here we present a DG method for neutrino transport and its implementation in the toolkit for high-order neutrino radiation hydrodynamics (thornado). Specifically, we consider a spectral two-moment model – closely related to that promoted by Lowrie, Mihalas, and Morel (2001; JQSRT, 69, 291-304) – which includes special relativistic effects to order v/c. This model maintains wave speeds bounded by the speed of light and is consistent with laboratory-frame energy and momentum conservation. We also discuss our strategy for solving the nonlinear system modeling the coupling between neutrinos and matter, the incorporation of the thornado transport module into the Flash-X simulation framework, and the coupling with finite-volume hydrodynamics, to enable CCSN simulations with adaptive mesh refinement.

Monday, June 26: 10:30 AM - 10:55 AM
Presenter: Burrows, Adam

State-of-the-Art 3D Models of Core-Collapse Supernova Explosions

Adam Burrows, Princeton University, USA

Using our code Fornax we have simulated the collapse and explosion of the cores of many massive-star models in three spatial dimensions. This is the most comprehensive set of realistic 3D core-collapse supernova (CCSN) simulations yet performed and has provided very important insights intothe mechanism and character of this 60-year-old astrophysical puzzle. Most 3D models explode naturally and without artifice by the neutrino mechanism, aided by turbulent convection. I will present detailed results from this suite of runs and the novel conclusions derived from our new capacity to simulate many 3D full physics models every year.

Monday, June 26: 10:55 AM - 11:20 AM
Presenter: Ryu, Dongsu

A New Code for Relativistic Hydrodynamics and Studies of Radio Jets

Dongsu Ryu, UNIST (Ulsan National Institute of Science and Technology), Korea
Hyesung Kang, Pusan National University, Korea
Jeongbhin Seo, UNIST (Ulsan National Institute of Science and Technology), Korea

We developed a new special relativistic hydrodynamic (RHD) code that can simulate ultra-relativistic flows with Lorentz factors of up to ~ 100 with high-order accuracy. It employs the finite-difference weighted essentially non-oscillatory (WENO) scheme, a high-order scheme for numerical flux calculation, and the strong stability preserving Runge-Kutta (SSPRK), a high-order time integration method. In addition, the code includes an equation of state (EOS) that closely approximates the EOS of the single-component perfect gas in the relativistic regime, and is optimized for reproducing complex structures in ultra-relativistic flows. Using this code, we simulated the dynamical evolution of relativistic jets with a wide range of model parameters covering both FR I and FR II radio galaxies. As in previous studies, we confirm that the jet power mainly governs flow dynamics, while the jet-to-background density and pressure ratios play secondary roles. We also find that jet-induced flows contain numerous structures involving shocks, shear, and turbulence. Furthermore, through Monte Carlo simulations, we followed the transport and acceleration of energetic particles in the jet-induced flows. We find that the particles can be boosted into ultra-high energy cosmic rays (UHECRs) with energies of up to E ~ 10^{20} - 10 10^{21} eV via diffusive shock acceleration (DSA), turbulence shear acceleration (TSA), relativistic shear acceleration (RSA). In this talk, we present the new RHD code and studies of radio jets using the code.

SCHEDULE OF TALKS

Monday, June 26: 11:20 AM - 11:45 AM
Presenter: Medvedev, Mikhail

Prospects of X-ray Imaging of the Outer Heliosphere

M. Medvedev, KU & MIT, USA

Charge-exchange (CX) collisions of SW high-ionization-state minor ions with LISM neutrals are responsible for much of X-ray production in the outer heliosphere. Here we discuss discuss numerical modeling this CX X-ray background. We show that the evolution of the SW ion-composition and the accompanying spectral changes in the outer heliosphere can serve as a useful diagnostic tool for studies of the SW plasma state and evolution. We assess the feasibility of CX X-ray detection.

Monday, June 26: 11:45 AM - 12:10 PM
Presenter: Calder, Alan

FLASH on A64FX: A Guide to Tuning an Astrophysics Code on a New CPU Architecture

A. Calder, Stony Brook University, USA
C. Feldman, Stony Brook University, USA
S. Chheda, Stony Brook University, USA
E. Siegmann, Stony Brook University, USA
A. Curtis, Stony Brook University, USA
J. Dey, Stony Brook University, USA
D. Carlson, Stony Brook University, USA
R. Harrison, Stony Brook University, USA
B. Michalowicz, Ohio State University, USA

High-fidelity astrophysics simulations and other multi-scale, multi-physics applications can readily utilize capable computing. While accelerators like GPUs help greatly enhance application runtime, it is a non-trivial task to port and refactor applications to efficiently use them. An alternative being explored is Fujitsu's ARM-based A64FX processor, which promises the programmability of aÂ CPU with the benefit of a GPU, all at low energy usage. Here, we present our experiences porting and tuning the multi-physics simulation code FLASH on the Ookami testbed platform, an HPE Apollo 80 machine featuring A64FX. FLASH ran right out of the box on this architecture using each of the four available compilers. The next steps were to test memory limitations, perform basic profiling, test the effects of using Linux Kernel Huge Pages, explore options for using the NUMA architecture, and to attempt to make good use of the Scalable Vector Extension (SVE) features. We present an overview of our ongoing journey to improve FLASH's performance on A64FX with minimal code changes and offer a guide for anyone similarly investigating the A64FX architecture.Â This research and the machine Ookami are supported by the US National Science Foundation (NSF) grant OAC 1927880. This research was also supported in part by the US Department of Energy (DOE) under grant DE-FG02-87ER40317.

Monday, June 26: 12:10 PM - 12:35 PM
Presenter: Audit, Edouard

Which Strategy to Tackle Exascale Systems for Astrophysics

Edouard Audit, CEA / Maison de la Simulation, France

Exascale systems are now appearing in the US, Japan, in Europe with two exascale procurements in the coming years and very likely in China. These systems offer great opportunities for the numerical astrophysics community and also raise serious technical challenges. Many legacy codes need to be fully rewritten to benefit from exascale architectures. Performance portability is a key issue as well as the management of the huge amount of data generated by exascale simulation. In this presentation I will discuss the path we have choosen to exascale and the software engineering solution chosen to address performance portability on the long run and data management. A new radiation hydrodynamics code based on the Kokkos library will be presented as well as test runs with preliminary performance analysis on various architectures.

Monday, June 26: 1:30 PM - 1:55 PM
Presenter: Moesta, Philipp

Magnetic Fields, Jets, and Turbulence in the Multimessenger Era

Philipp Mösta, GRAPPA, University of Amsterdam, NL

Magnetic fields, turbulence, and jet-driven outflows play a critical role in core-collapse supernovae and compact-object mergers. These transients belong to the most luminous and energetic events observed in the universe and are key targets for time-domain astronomy surveys. I will discuss the unique challenges in both input physics and computational modelling for these systems and highlight recent breakthroughs in full 3D simulations. I will pay particular attention to challenges in performing these simulations on modern high-performance computational systems and how to extract as much scientific insight as possible from the produced datasets.

Monday, June 26: 1:55 PM - 2:20 PM
Presenter: Hoeflich, Peter

Supernovae in the Age of JWST: Finding the 'Right' Questions and the Path to Answers.

Peter Hoeflich, Tyco Mera, Elham FSU)
Chris Ashall (VT) and the JWST collaboration
D. Baade (ESO) and the SPECPOL Collaboration.

Understanding the Physics of thermonuclear explosions of a White Dwarf star (WD), so called Type Ia Supernovae (SNe~Ia), provide a playground for modern physics and are a key to modern cosmology. We identify new and investigate a variety of observational signatures of underlying physical processes related to the thermonuclear runaway, the flame propagation and the environment. Being intrinsically multi-dimensional phaenomena, probing the physics requires multi-dimensional radiation-hydrodynamics and MHD simulations. For this task, we developed and employed methods for photon transport for the X-, gamma- and of low energy and of positrons under non-LTE conditions. We identify signatures in the light curves and spectra, in particular, line profiles and polarization spectra. Consistent treatment of high energy processes is critical. Therefore, our framework and results can be used directly a variety of scenarios for SNe~Ia including merging WDs and explosions of sub-Chandrasekhar mass WDs. In this talk, we will present numerical methods employed and discuss current limitations. We discuss applications and recent results in light of our JWST, Keck and polarization programs.

Monday, June 26: 2:20 PM - 2:45 PM
Presenter: Richers, Sherwood

Using Machine Learning to Predict the Outcome of the Fast Flavor Instability

Sherwood Richers, Donald Willcox, University of Tennessee Knoxville, USA

The fast flavor instability (FFI) is a plasma-like instability that can cause neutrino flavor to change on timescales of nanoseconds and length scales of millimeters, and is thought to be ubiquitous in neutron star mergers and core-collapse supernovae. It is possible to simulate the behavior of flavor in neutrino radiation transport on small scales in three dimensions using either the full angular distribution of neutrinos or an angular moment-based approach. However, the cost of these simulations makes it impossible to scale up to include in full multidimensional simulations of supernovae and mergers. I will present an effective model that attempts to reproduce the net result of the FFI trained on a large number of direct many-angle simulations that can be used as a sub-grid model in large-scale neutrino radiation transport simulations.

SCHEDULE OF TALKS

Monday, June 26: 2:45 PM - 3:10 PM
Presenter: Kim, Woong-Tae

Semi-global Simulations of Star formation in Nuclear Rings of Barred Galaxies

Woong-Tae Kim, Seoul National University, Korea
Sanghyuk Moon, Princeton Unversity, USA
Chang-Goo Kim, Princeton University, USA
Eve Ostriker, Princeton University, USA

Nuclear rings at the centers of barred galaxies are active in star formation. To understand what determines the star formation rate and structure of nuclear rings, we conduct semi-global, magnetohydrodynamic simulations of nuclear rings subject to various mass inflow rates with/without magnetic fields. We adopt the TIGRESS framework of Kim & Ostriker to handle radiative heating and cooling, star formation, and related supernova (SN) feedback. Our findings suggest that SN feedback cannot destroy the nuclear ring completely or halt star formation within it, while both the mass inflow rate and SN feedback affect the ring star formation rate (SFR). SN feedback is responsible for small-amplitude SFR fluctuations with a timescale of less than 40 million years, while the SFR variations over longer timescales are due to changes in the mass inflow rates. Magnetic fields seed by the inflows are amplified in the ring due to rotational shear and SN feedback, greatly reducing the SFR at late times. Strong magnetic tension in the ring drives radially inward accretion flows from the ring to form a circumnuclear disk in the central region, which is absent in the unmagnetized model.

Monday, June 26: 3:10 PM - 3:35 PM
Presenter: Shingo, Hirano

Exponential Amplification of the Magnetic Field in the Primordial Star-forming Cloud

Shingo Hirano, University of Tokyo, Japan
Masahiro N Machida, Kyushu University, Japan
Shantanu Basu, University of Western Ontario, Canada

One critical remaining issue that is unclear in the initial mass function of the first (Population III) stars is the final fate of secondary protostars that formed in the accretion disk—specifically, whether they merge or survive. We focus on the magnetic effects on the formation of the first star under a cosmological magnetic field. We perform ideal magnetohydrodynamic simulations by adopting a stiff equation of state approach to represent the magnetic field structure connecting protostars. The magnetic field rapidly winds up since the gas near the protostar has undergone several tens of orbital rotations in the first decade after protostar formation. As the mass accretion progresses, the vital magnetic field region extends outward, and magnetic braking eliminates the disk fragmentation that would happen in an unmagnetized model. We also report the magnetic effect on the supermassive first star formation.

Monday, June 26: 3:55 PM - 4:20 PM
Presenter: Nagakura, Hiroki

Numerical Modeling of Non-equilibrium Neutrino Radiation Field by Solving Quantum Kinetic Equation

Hiroki Nagakura, NAOJ, Japan

Neutrinos play important roles in high energy astrophysics phenomena including core-collapse supernovae and binary neutron star mergers as driving mass ejection and synthesizing heavy elements. They can carry thermal energy and leptons across the fluid element with undergoing matter interactions and flavor conversions. Determining neutrino radiation field involving neutrino flavor conversion requires solving quantum kinetic equation that corresponds to the extension from classical Boltzmann equation. Accurate modeling of neutrino quantum kinetics poses, however, a formidable challenge in computational astrophysics. In this talk, I will give an overview of the quantum kinetics neutrino transport and then present some recent progress, paying special attention to the connection to astrophysics.

SCHEDULE OF TALKS

Monday, June 26: 4:20 PM - 4:45 PM
Presenter: Kang, Hyesung

A Simulation Study of Particle Acceleration in High-beta Shocks via Weibel Amplification: Implications for Galaxy Cluster Outskirts

Hyesung Kang, Pusan National University, South Korea
Dongsu Ryu, Ulsan National Institute of Science and Technology, South Korea

Cosmological structure formation simulations predict that external accretion shocks form in the outer region of galaxy clusters owing to supersonic gas infall from filaments and voids in the cosmic web. These shocks are characterized by high Mach numbers and propagate into an almost unmagnetized medium. Using 2D particle-in-cell simulations, we show that collisionless shocks could form via the Weibel-amplified magnetic fields, and that electrons can be pre-accelerated via the stochastic Fermi process to be injected into diffusive shock acceleration. Based on these findings, we propose analytic models for the energy spectra of shock-accelerated cosmic-ray (CR) protons and electrons that utilize conventional thermal leakage injection concept. Applying these model CR spectra to numerical shock zones in structure formation simulations, we estimated nonthermal emissions, including synchrotron and inverse Compton radiation due to CR electrons and pi^0-decay gamma-rays due to CR protons, around simulated clusters. The synthetic synchrotron maps produced by our model calculations are consistent with recent radio observations of the Coma Cluster. However, detecting nonthermal X-rays and gamma-rays from accretion shocks in the outer region of galaxy clusters with current observational facilities would be challenging.

Monday, June 26: 4:45 PM - 5:10 PM
Presenter: Ripperda, Bart

How Black Holes Shine

Bart Ripperda, Institute for Advanced Study, USA

Astrophysical black holes are surrounded by accretion disks, jets, and coronae consisting of magnetized, (near)-collisionless relativistic plasma. They produce observable high-energy radiation and it is currently unclear where and how this emission is exactly produced. The radiation typically has a non-thermal component, implying a power-law distribution of emitting relativistic electrons. Magnetic reconnection and plasma turbulence are viable mechanisms to tap the large reservoir of magnetic energy in these systems and accelerate electrons to extreme energies. The accelerated electrons can then emit high-energy photons that themselves may strongly interact with the plasma, rendering a highly nonlinear system. Modeling these systems necessitates a combination of magnetohydrodynamic models to capture the global dynamics of the formation of dissipation regions, and a kinetic treatment of plasma processes that are responsible for particle acceleration, pair creation and annihilation, and radiation. I will present novel studies of accreting black holes and how they radiate in regions close to black hole event horizon, using both first-principles general relativistic kinetic particle-in-cell simulations and global large-scale three-dimensional magnetohydrodynamics models. With a combination of models, I determine where and how dissipation of magnetic energy occurs, and what kind of emission signatures are typically produced.

SCHEDULE OF TALKS

Tuesday, June 27: 8:00 AM - 8:25 AM
Presenter: Bera, Ratan Kumar

The Role of Pickup Ions in the Interaction of the Solar Wind with the Local Interstellar Medium: Importance of Kinetic Processes at the Heliospheric Termination Shock

R K Bera, UAH, USA
F. Fraternale, UAH, USA
N. V. Pogorelov, UAH, USA
V. Roytershteyn, Space Science Institute, USA
M. Gedalin, Ben-Gurion University of the Negev, Israel
D. J. McComas, Princeton University, USA
G. P. Zank, UAH, USA

Pickup ions (PUIs) are important constituents in the interaction between the solar wind (SW) and the local interstellar medium (LISM). We investigate their role in SW-LISM interaction with 3-D, multi-fluid simulations. The flow of the plasma mixture, comprising all charged particles, is described by the ideal MHD equations with the source terms responsible for charge exchange between ions and neutral atoms. Thermodynamically-distinct populations of neutral atoms are governed by individual sets of gas dynamics Euler equations. PUIs are treated as a separate, co-moving fluid. Since standard conservation laws, such as the Rankine-Hugoniot relations, do not accurately describe the anisotropic behavior of PUIs at the heliospheric termination shocks (TS), we, therefore, derive shock boundary conditions for them from the dedicated kinetic simulations of collisionless shocks. We show that this approach to treating PUIs makes the simulation results more consistent with observational data. In particular, the PUI pressure in the inner heliosheath (IHS) becomes higher by ~ 40-50% in the new model, as compared with the solutions where no special boundary conditions are applied. Hotter PUIs eventually lead to an additional charge-exchange-driven cooling of the IHS plasma, which reduces the IHS thickness by ~15% in the upwind direction, and even more in the other directions. The density of secondary neutral atoms born in the IHS decreases by ~30%, while their temperature increases by ~60%. We validate our simulation results with New Horizons data at distances between 11 and 47 au

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Tuesday, June 27: 8:25 AM - 8:50 AM
Presenter: Kunz, Matthew

Waves, Turbulence, and Heating in Dilute Astrophysical Plasmas

Matthew Kunz, Princeton University, USA

The transport of energy and momentum and the heating of plasma particles by waves and turbulence are key ingredients in many problems at the frontiers of heliospheric and astrophysics research. This includes the heating and acceleration of the solar wind; the observational appearance of black-hole accretion flows on event-horizon scales; and the properties of the hot, diffuse plasmas that fill dark-matter halos. All of these plasmas are magnetized and weakly collisional, with plasma beta parameters of order unity or even much larger. In this regime, deviations from local thermodynamic equilibrium (LTE) and the kinetic instabilities they excite can dramatically change the material properties of such plasmas and thereby influence the macroscopic evolution of their host systems. This talk outlines an ongoing programme of hybrid-kinetic and fluid-kinetic calculations aimed at elucidating from first principles the multi-scale physics of magnetized, weakly collisional, high-beta astrophysical plasmas. Self-sustaining sound waves, microphysically modified magnetosonic modes, and magneto-immutability will feature in a discussion on how self-generated pressure anisotropies fundamentally alter waves, turbulence, and heating in dilute astrophysical plasmas.

SCHEDULE OF TALKS

Tuesday, June 27: 8:50 AM - 9:15 AM
Presenter: Most, Elias

Simulating Extreme Plasmas in Neutron Star Mergers

Elias R. Most, Caltech, USA

Ranging from dense plasmas above nuclear saturation in their interiors to strongly magnetized pair-plasmas in their magnetospheres, neutron stars feature some of the most extreme plasmas in the universe. The delicate interplay between strong gravity, nuclear and plasma physics makes the collision of two neutron stars an ideal playground to study matter in its most extreme form. In this talk, I will present recent advances in the state-of-the-art modeling of relativistic plasmas applicable to neutron star mergers. In particular, I will discuss how eectromagnetic flares could power transients, such as Fast Radio Bursts from the pre-merger stage, or short gamma-ray burst (precursors) from the post-merger phase. All of these models rely to some extend on non-ideal magnetohydrodynamics (MHD) effects. The next-generation modeling of relativistic plasmas in these extreme regimes requires the consistent inclusion of dissipative effects into numerical MHD models. To this end, I will introduce a novel 14-moment based numerical approach to dissipative relativistic MHD. This 14-moment closure can seamlessly interpolate between the highly collisional limit found in neutron star mergers and heavy-ion collisions, and the weakly coupled Braginskii-like limit of extended MHD appropriate for the study of accretion disks around supermassive black holes. Going beyond these collisional limits, I will also provide an outlook on how to describe the collisionless dynamics of electron-ion/positron plasmas using dissipative two-fluid MHD.

Tuesday, June 27: 9:15 AM - 9:40 AM
Presenter: Slavin, Jonathan

Methods and Challenges of Including Dust Evolution in Magnetohydrodynamic Simulations

Jonathan D. Slavin, Harvard & Smithsonian, USA

Dust plays many important roles in the interstellar medium, affecting the heating, cooling and chemistry in all the different phases of the medium. Up until recently though, if dust was included in simulations at all, it was typically assumed that it was tightly coupled to the gas. More recent work has allowed for the dust to decouple from the gas, though this brings with it challenges for including all the dust destruction processes, especially grain-grain collisions. We will discuss methods of simulating dust evolution in the context of magneto-hydrodynamical simulations of the interstellar medium.

Tuesday, June 27: 9:40 AM - 10:05 AM
Presenter: Pajkos, Michael

Accounting for Relativistic Effects in Core-collapse Supernova Simulations

Michael A. Pajkos, California Institute of Technology, USA

Describing the dynamic environment inside core-collapse supernovae requires a multitude of physics. As fluid velocities approach the speed of light and strong gravitational fields create compact objects such as black holes, a proper relativistic description of the internal physics is paramount to reliably predict observables. Furthermore, efficiently dividing the computational cost of a simulation across multiple computing units must be considered, in order to make use of upcoming 'exascale machines'. In this talk, I will review two multiphysics codes that aim to meet these needs. First, I will present relativistic additions to the Flash framework, alongside simulation results incorporating these changes. Second, I will outline recent additions to the SpECTRE code, as it moves towards properly capturing the explosive endings of massive stars.

SCHEDULE OF TALKS

Tuesday, June 27: 10:30 AM - 10:55 AM
Presenter: Pogorelov, Nikolai

Space Weather Prediction Challenges: A Software Suite for Data-driven Modeling of the Solar Atmosphere and Inner Heliosphere

Nikolai V. Pogorelov, University of Alabama in Huntsville, USA
Charles N. Arge, NASA Goddard Space Flight Center, USA
Jon Linker, Predictive Science Inc., USA
Lisa Upton, Southwest Research Institute, USA
Brian Van Straalen, Lawrence Berkeley National Laboratory, USA
Ronald Caplan, Predictive Science Inc., USA
Phillip Colella, Lawrence Berkeley National Laboratory, USA
Cooper Downs, Predictive Science Inc., USA
Christopher Gebhard, Lawrence Berkeley National Laboratory, USA
Dinesha Vasanta Hegde, University of Alabama in Huntsville, USA
Carl Henney, Air Force Research Laboratory, USA
Shaela Jones-Mecholsky, NASA Goddard Space Flight Center, USA
Craig Johnston, NASA Goddard Space Flight Center, USA
Tae Kim, University of Alabama in Huntsville, USA
Miko Stulajter, Predictive Science Inc., USA
Talwinder Singh, University of Alabama in Huntsville, USA
James Turtle, NASA Goddard Space Flight Center, USA
Mehmet Yalim, University of Alabama in Huntsville, USA

To address Objective II of the National Space Weather Strategy and Action Plan "Develop and Disseminate Accurate and Timely Space Weather Characterization and Forecasts" and US Congress PROSWIFT Act 116-181, our team is developing a new set of open-source software that would ensure substantial improvements of Space Weather (SWx) predictions. On the one hand, our focus is on the development of data-driven solar wind models. On the other hand, each individual component of our software is designed to have accuracy higher than any existing SWx prediction tools with a dramatically improved performance. This is done by the application of new computational technologies and enhanced data sources. The development of such software paves way for improved SWx predictions accompanied with an appropriate uncertainty quantification. This makes it possible to forecast hazardous SWx effects on the space-borne and ground-based technological systems, and on human health. Our models include (1) a new, open-source solar magnetic flux model (OFT), which evolves information to the back side of the Sun and its poles, and updates the model flux with new observations using data assimilation methods; (2) a new potential field solver (POT3D) associated with the Wang-Sheeley-Arge coronal model, and (3) a new adaptive, 4-th order of accuracy solver (HelioCubed) for the Reynolds-averaged MHD equations implemented on mapped multiblock grids (cubed spheres). We describe the software and results obtained with it, including the application of machine learning to modeling coronal mass ejections, which makes it possible to improve SWx predictions by decreasing the time-of-arrival mismatch. The tests show that our software is formally more accurate and performs much faster than its predecessors used for SWx predictions.

Tuesday, June 27: 10:55 AM - 11:20 AM
Presenter: Linker, Jon

An Interactive Tool for Modeling Solar Eruptions

Jon Linker, Predictive Science Inc., USA
Tibor Torok, Predictive Science Inc., USA
Cooper Downs, Predictive Science Inc., USA
Ronald Caplan, Predictive Science Inc., USA
Viacheslav Titov, Predictive Science Inc., USA
Andres Reyes, Predictive Science Inc., USA

Coronal Mass Ejections (CMEs) are immense eruptions of plasma and magnetic fields that are propelled outward from the sun, sometimes with velocities greater than 2000 km/s. They are responsible for some of the most severe space weather at Earth, including geomagnetic storms and solar energetic particle (SEP) events. We have developed an interactive tool that allows non-expert users to routinely model multiple CMEs in a realistic coronal and heliospheric environment. The tool features a web-based user interface that allows the user to select a time period of interest, and employs RBSL flux ropes (Titov et al. 2018) to create stable pre-eruptive configurations within a background global magnetic field. The properties of these configurations can first be explored in a zero-beta magnetohydrodynamic (MHD) model, followed by complete CME simulations in thermodynamic MHD, with propagation out to 1 AU. The interface is presently installed on NASA Amazon Web Services (AWS) and is being tested at the Community Coordinated Modeling Center (CCMC). In this presentation, we describe design features of the interface and computations, including the innovations required to efficiently compute results on practical timescales using AWS GPU instances.
Research Supported by NASA and NSF.

Tuesday, June 27: 11:20 AM - 11:45 AM
Presenter: Che, Haihong

Particle Acceleration in Magnetic Reconnection

H. Che, UAH, USA
G. P. Zank, UAH, USA
A. O. Benz, FHNW & ETH Zurich, CH

How magnetic reconnection efficiently produces a huge number of mildly relativistic energetic particles is an outstanding problem in solar physics and heliophysics. In particular, three major problems in solar particle acceleration have to be addressed: 1) the development of power-law energy spectra for both electrons and ions; 2) the Ã¢â‚¬Å“big number problemÃ¢â‚¬ of electrons. Recent observations discovered that the time to accelerate electrons to a power-law energy distribution in solar flares can be shorter than 50 ms while nearly the total number of electrons in the current sheet is accelerated in 1000s. 3) Observations suggest that the acceleration process of ions is related to the electronsÃ¢â‚¬â„¢. In this talk, I will present a novel acceleration mechanism in magnetic reconnection. I will show how the velocity shear stored naturally in force-free currents of solar flares can drive an electron Kelvin-Helmholtz instability (EKHI) during magnetic reconnection. The EKHI efficiently accelerates electrons to a power-law energy spectrum with an index comparable to the observations in a few tens of ion gyro-periods (~ 0.1 ms for solar corona plasma). With the proceeding of reconnection, the EKHI induced Alfvenic turbulence can accelerate ions to broken power-law energy spectra.

Tuesday, June 27: 11:45 AM - 12:10 PM
Presenter: Oran, Rona

Reconstructing the Magnetospheres of Weakly Magnetized Bodies using Iterative Data-model Fitting

Rona Oran, MIT, USA
Benjamin P. Weiss, MIT, USA
Jodie B. Ream, MIT, USA
Jose M. G. Merayo, DTU, Denmark
Kyle D. Cloutier, JPL, USA
Carol A. Raymond, JPL, USA
Carol A. Polanskey, Chris T. Russell, JPL, USA
Lindy Elkins-Tanton, ASU, USA

The upcoming NASA Psyche mission (launch planned for October 2023, arrival in 2029) will be the first to explore a metal-rich asteroid, (16) Psyche. Laboratory studies of metal-rich meteorites (that may be fragments of a Psyche-like body) suggests that Psyche may be sufficiently magnetized given its size (radius of 113km) to stand off the solar wind at up to 4-5 Psyche radii and form a dipole-like inner-magnetosphere that can trap low energy plasma (Oran et al. 2022). Thus, the Psyche mission could be the first to detect and explore an asteroid magnetosphere. However, if the asteroid is weakly magnetized, its remanent field at the spacecraft orbits could be comparable to the magnitude of the solar wind field at the asteroid belt. This, together with solar wind variability and (16) Psyche's rotation period (~4 hours), would imply that the entire structure of the magnetosphere would be highly variable at all altitudes. Thus, characterizing the magnetosphere from orbital data – and inferring the underlying internal magnetization - would be a considerable challenge. To plan the Psyche Magnetometry Investigation, we developed a computational suite that combines hybrid simulations and iterative model-data fitting. The goal is to be able to use magnetometry data to reconstruct the three-dimensional structure of the magnetosphere and constrain the internal magnetization. Preliminary versions of these tools show that we can retrieve the dipole moment and orientation of a uniformly magnetized Psyche within 50% uncertainty for various dipole strength given expected solar wind variability, instrument noise, and stray flight system fields. The tools also allow to plan and constrain instrument performance and orbit design. A large library of hybrid simulations of non-uniformly magnetized Psyche will enable us to expand model-data fitting and infer higher moments of the magnetic field, in preparation to the arrival at the asteroid and the commencement of science operations.

Tuesday, June 27: 12:10 PM - 12:35 PM
Presenter: Mezzacappa, Anthony

Will this Never End?

Anthony Mezzacappa, The University of Tennessee, Knoxville

Recent progress in modeling core collapse supernovae has been most encouraging. Sophisticated three-dimensional models from several groups have been developed, and a consensus is emerging that shock revival via neutrino heating leads to explosions across progenitors of different mass and metallicity. Modeling efforts have now entered a new phase, where quantitative rather than qualitative prediction is more the norm. Nonetheless, significant work remains to further develop these three-dimensional models to address the shortcomings they possess. I will discuss all of the above, as well as present results from ongoing simulations being carried out with the UT-ORNL group's current production code, Chimera, and briefly report on the development of our next-generation simulation framework, thornado, which will be covered in more detail at this conference by thornado's lead developer, Eirik Endeve. I will also present results from our computations of core collapse supernova gravitational wave and neutrino emissions based on our Chimera models.

Tuesday, June 27: 1:30 PM - 1:55 PM
Presenter: Hanawa, Tomoyuki

Achieving Higher Order Accuracy in Space in Hydrodynamic Simulation of Self-Gravitating Gas

Tomoyuki Hanawa, Chiba University, Japan

Modern hydrodynamical simulation codes often employ a higher-order accuracy in space. They succeed in higher spatial resolution and suppressing the numerical damping of waves. However, the accuracy of the self-gravity is limited to second-order accuracy in space as far as I know. If we can evaluate the self-gravity with a higher-order accuracy, we can improve the simulations of self-gravitating objects. Here, we present a scheme to obtain fourth-order accurate self-gravity for a given density distribution on the uniform grid in the Cartesian coordinates. First, we derive the cell-averaged gravitational potential of fourth-order accuracy from the cell-averaged density by solving the Poisson equation. Then, we obtain the cell average of the product of the density and gravitational acceleration, which differs from the cell-averaged density multiplied by the cell-averaged gravitational acceleration. We show the validity by applying it to a uniform sphere with a massive power-law envelope. We also present the scheme's application to self-gravitating slabs in equilibrium and its advection.

Tuesday, June 27: 1:55 PM - 2:20 PM
Presenter: Paschalidis, Vasileios

Progress on Magnetohydrodynamic Accretion onto Binary Black Holes

Vasileios Paschalidis, University of Arizona, USA

Supermassive black hole binaries can form in magnetized plasma following galaxy mergers, via bar-mode instability in rapidly rotating supermassive stars, or by other dynamical processes. After formation, a combination of dynamical friction and gas-driven migration is likely to catalyze the binary inspiral into the gravitational radiation-driven regime. Following this point, accreting binary black holes become prime targets for multimessenger astronomy with gravitational waves. In this talk we will discuss recent progress in understanding magnetohydrodynamic accretion onto binary black holes. We will focus particularly on variability of the mass accretion rate, Poynting outflows and how the existence of minidisks forming onto the individual black holes may affect observable quantities from these systems.

Tuesday, June 27: 2:20 PM - 2:45 PM
Presenter: Kolobov, Vladimir

Peculiarities of Electron Kinetics in Collisional Plasmas

Vladimir Kolobov, UAH, USA
Robert Arslanbekov, CFDRC, USA

The electron distribution function (EDF) is close to isotropic in many collisional plasmas, and a two-term spherical harmonics expansion in velocity space can be used. The kinetic equation for the isotropic part of the EDF describes an anisotropic diffusion in phase space (r,u), where r is the spatial position and u is the electron kinetic energy. The diffusion anisotropy is due to the electric field, which causes electron diffusion over surfaces of total electron energy (kinetic + potential) in phase space. The most important consequence is that the ambipolar electric field may be a source of electron heating. We have developed hybrid models for weakly-ionized low-temperature plasma that couple a kinetic solver for electrons based on the anisotropic diffusion in phase space, a fluid model for ions, and the Poisson equation for the electric field. These models allowed simulations of plasma stratification in noble gases [1] and analysis of alternating current (AC) discharges in dynamic regimes [2]. Our simulations reproduced a variety of experimentally observed ionization waves (striation) in direct current (DC) and radio-frequency (RF) discharges in noble gases. Our simulations of AC positive columns in the kHz frequency range have revealed non-monotonic radial distributions of ionization rate and plasma density not yet observed in experiments. Spatial gradients in the kinetic equation for electrons are responsible for these non-local kinetic effects. The kinetic equation for electrons describing the anisotropic diffusion in phase space has also been proposed in the literature to analyze heat transport in fully ionized plasmas. We will discuss whether this approach may be appropriate for core electrons in the solar wind.

References

[1] V I Kolobov and R R Arslanbekov, Ionization waves in low-current dc discharges in noble gases obtained with a hybrid kinetic-fluid model, Phys. Rev. E 106, 065206 (2022)
[2] N Humphrey and V I Kolobov, Electron Kinetics in a Positive Column of AC Discharges in a Dynamic Regime, to be submitted for publication (2023).

Tuesday, June 27: 2:45 PM - 3:10 PM
Presenter: Kaneko, Takafumi

Impact of Convective flows on Energy Build-up of Flare-productive Sunspots

Takafumi Kaneko, Niigata University, Japan
Hideyuki Hotta, Nagoya University, Japan
Shin Toriumi, ISAS/JAXA, Japan
Kanya Kusano, Nagoya University, Japan

Strong solar flares occur in delta-spots characterized by the opposite-polarity magnetic fluxes in a single penumbra. Sunspot formation via flux emergence from the convection zone to the photosphere can be strongly affected by convective turbulent flows. It has not yet been shown how crucial convective flows are for the formation of δ-spots. The aim of this study is to reveal the impact of convective flows in the convection zone on the formation and evolution of sunspot magnetic fields. We simulated the transport of magnetic flux tubes in the convection zone and the emergence in the photosphere using radiative magnetohydrodynamics code R2D2. We carried out 93 simulations by allocating the twisted flux tubes to different positions in the convection zone. As a result, both delta-type (opposite-polarity fluxes adjacent to each other) and beta-type (opposite-polarity fluxes distant from each other) magnetic distributions were reproduced only by the differences in the convective flows surrounding the flux tubes. The delta-spots were formed by the collision of positive and negative magnetic fluxes on the photosphere. The unipolar and bipolar rotations of the delta-spots were driven by magnetic twist and writhe, transporting magnetic helicity from the convection zone to the corona. We detected a strong correlation between the distribution of the non-potential magnetic field in the photosphere and the position of the downflow plume in the convection zone. The correlation could be detected 20-30 h before the flux emergence. The results suggest that high free energy regions in the photosphere can be predicted even before the magnetic flux appears in the photosphere by detecting the downflow profile in the convection zone.

Tuesday, June 27: 3:10 PM - 3:35 PM
Presenter: Loring, Burlen

Addressing the FLOPS to IOPS gap with Python Based in-situ Processing

B. Loring, E.W Bethel, P. O'Leary, S. Rizzi, V. Mateevitsi, N. Ferier, G. H. Weber

As our ability to generate data continues to outpace the rate at which we can store it in situ methods, which process simulation data as it's generated, are an increasingly important technique. In situ methods naturally balance I/O usage and the competing need for increased access to high spatio-temporal resolution data. In situ processing enables science that, due to I/O constraints, isn't possible with a traditional post processing based approach and can result in a faster over all time to solution. Generic in situ, through a common data model and API, couples a simulation to multiple analytics and visualization solutions through a single instrumentation and makes possible run time selection of one or more of these solutions based on the needs of a particular use case. Python based in situ enables scientists to perform calculations specific to their research on data is being generated at its highest spatio-temporal resolution. I will present the SENSEI generic in situ framework which exposes interfaces to a number of popular visualization solutions and is extensible at runtime via Python. The power, flexibility, and ease of use of Python based in situ is key to putting in situ methods in the hands of researchers in the sciences. I will present our work on in situ data processing in tightly and loosely coupled configurations using SENSEI's Python based in situ capabilities in conjunction with ADIOS's SST engine reducing I/O demands while simultaneously providing access to the full spatio-temporal resolution of the data being generated.

Tuesday, June 27: 3:55 PM - 4:20 PM
Presenter: De Zeeuw, Darren

Interactive Visualization of Space Physics Model Output with the CCMC's Kamodo Python Toolkit

Darren De Zeeuw, NASA GSFC, USA
Lutz Rastaetter, NASA GSFC, USA
Katherine Garcia-Sage, NASA GSFC, USA

Kamodo is an official NASA open-source python package under development by the Community Coordinated Modeling Center (CCMC). It is built upon the functionalization of datasets, which depends on robust interpolation of that data. Once a dataset is functionalized in Kamodo, the core functionalities of Kamodo are then available to the user, including data analysis via function composition, automatic unit conversions, coordinate transformations, and interactive and publication quality graphics. Extraction of simulation values for real or synthetic satellite trajectories can be used for both data/model comparisons and constellation mission planning. Kamodo is designed to be easy to use for a beginner but allow sophisticated analysis and visualizations. Code free interfaces and interlanguage communication (ie. Fortran to Python) are being developed, but the primary interfaces to Kamodo are through the command line or Jupyter notebooks. A variety of visualizations from several of the 15+ models already in Kamodo will be demonstrated.

Tuesday, June 27: 4:20 PM - 4:45 PM
Presenter: May, Ian

High-Order Genuinely Multidimensional Finite Volume Methods via Kernel-Based WENO

Ian May, University of California, Santa Cruz, USA

In this talk a family of fully multidimensional kernel-based reconstruction schemes for use in finite volume methods will be presented. These methods are intended for use in shock dominated problems, and stability is achieved through a suitable adaptation of the Adaptive Order Weighted Essentially Non-Oscillatory (WENO-AO) method to the proposed kernel-based reconstruction schemes. There are a number of key difficulties in the design of high-order finite volume schemes which will be discussed and addressed. High (4th and 6th) order convergence will be demonstrated on smooth exact solutions to the ideal MHD equations. The very same scheme will then be applied to extremely stringent astrophysical benchmark problems. Finally, a brief overview of the implementation strategy will also be given, with particular emphasis on combined MPI and GPU parallelism.

Wednesday, June 28: 8:00 AM - 8:25 AM
Presenter: Brchnelova, Michaela

Numerical Challenges of Global Coronal Modelling

Błażej Kuźma, ISSAT, HIT, China
Barbara Perri, AIM - CEA Saclay, France
Fan Zhang, KU Leuven, Belgium
Andrea Lani, KU Leuven, Belgium
Stefaan Poedts, KU Leuven, Belgium

With the growth of our reliance on space and digital infrastructure, our society is becoming more and more vulnerable to space weather effects. To model these effects accurately, a variety of models are required to propagate the energy budget from the low solar corona all the way to the Earth. In space weather forecasting toolchains such as the Virtual Space Weather Modelling Centre, the first model employed is typically the â€œcoronal modelâ€ , resolving plasma properties at 0.1AU. These then serve as an input to the heliospheric model. For now, semi-empirical techniques such as the WSA model are usually employed. Recently, we have developed the COCONUT global coronal solver based on 3D computational fluid dynamics with an implicit scheme (see e.g. Perri & Leitner et al. 2022), to replace the semi-empirical approximations and provide better physical accuracy. A global coronal model can also help us better understand the physical processes in the corona and the energy transfer between the separate layers once we include chromosphere and the transition region in the simulation in the future. Here, we present some of the numerical challenges and trade-offs that had to be resolved for the COCONUT solver to still provide sufficiently accurate solutions while preserving its speed and robustness such that it is suitable for operational running. We discuss the effects that aspects such as the mesh design, the boundary conditions and the prescribed magnetic fields have on the behavior of the solver and accuracy of the results. We show that through understanding of these effects and through an implementation of the respective modifications in the numerical setup, operational performance and accuracy can be greatly enhanced.

Wednesday, June 28: 8:25 AM - 8:50 AM
Presenter: Caplan, Ronald

Evaluating a Practical Parabolic Time Step Limit for Unconditionally Stable Schemes in a Thermodynamic MHD Model

Ronald M. Caplan, Predictive Science Inc., USA
Craig D. Johnston,George Mason University, NASA Goddard Space Flight Center, USA
Lars K. S. Daldorff, The Catholic University of America, NASA Goddard Space Flight Center, USA
Jon A. Linker, Predictive Science Inc., USA

Unconditionally stable time-stepping schemes for advancing parabolic operators are very useful as they allow one to integrate at time steps larger than the highly restrictive explicit forward Euler limit. However, whether these schemes are implicit or explicit, serious accuracy problems can emerge when taking time steps that far exceed this limit. These problems can include effectively not applying the parabolic operator at all, and a drastic reduction in the ability to dampen high wave modes (oscillations). While sophisticated error-bound methods for selecting a proper time-step size exist, they are often domain, scheme, or problem specific and can be difficult to use efficiently. Here we evaluate an in-development method for selecting a practical time step that is easy to implement. We use the MHD model code MAS to test the method in a large thermodynamic simulation of the solar corona. The accuracy of the resulting solutions are compared to those using the maximum available time step (advection CFL limit). We utilize an implicit backward Euler scheme solved with a preconditioned conjugate gradient (PCG) method, as well as the explicit RKL2 and RKG2 super time-stepping (STS) methods to solve the artificial kinematic viscosity and Spitzer thermal conduction operators. One of the advantages STS methods have over PCG solvers are they can exhibit better overall performance, as well as scale better across many computational units due to the lack of global reduction operations. We discuss how sub-cycling of the parabolic operators at the new practical time step limit affect these performance benefits.
Research Supported by NASA and NSF.

Wednesday, June 28: 8:50 AM - 9:15 AM
Presenter: Sokolov, Igor

Extended Alfven Wave Turbulence Based Solar Atmosphere Model

Igor V Sokolov, University of Michigan, USA
Arcadi V Usmanov, University of Delaware, USA
Bart van den Holst, University of Michigan, USA
and Tamas I Gombosi, University of Michigan, USA

The existing Alfven Wave Turbulence Based Solar Atmosphere Model (AWSoM) as used in the SWMF framework of the University of Michigan to simulate the Solar Corona and Inner Heliosphere (i.e. to 1 AU heliocentric distance) meets an ideological problem while compared with the equations for turbulence usually employed in modeling the outer heliosphere (i.e. beyond 1 AU). While for the turbulence in the outer heliosphere the energy difference (the difference between the averaged kinetic and magnetic energy densities) is used as one of the Reynolds-averaged quantity describing the local state of turbulence, the present AWSoM model lacks the energy difference at all. Besides an evident inconsistency between the models of turbulence, employing the different sets of variables below and beyond 1 AU, to have a full description of turbulence is important by two reasons, both relating to the charged particle transport producing the radiation hazards in space. First, for simulation both solar energetic particle and galactic cosmic rays at 1 AU a computational domain should extend at least to 2-3 AU. Second, even if below 1 AU the energy difference effect on turbulence might be negligible and not necessary to be included into the turbulence model, it is still needed to calculate transport coefficients for the high energy charged particles in the turbulent magnetic field. In the presented research, an extra equation for the energy difference in introduced and solved in such way that at small heliocentric distances the turbulence model reduces to that used in the AWSoM with no loss in generality. On the other hand at larger heliocentric distances it becomes very close (if not identical) to the typical outer heliosphere model.

SCHEDULE OF TALKS

Wednesday, June 28: 9:15 AM - 9:40 AM
Presenter: Singh, Talwinder

Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning

Talwinder Singh, University of Alabama in Huntsville, USA
Bernard Benson, McLeod Software Corporation, USA
Syed Raza, University of Alabama in Huntsville, USA
Tae Kim, University of Alabama in Huntsville, USA
Nikolai Pogorelov, University of Alabama in Huntsville, USA,

Coronal mass ejections (CMEs) are the primary cause of severe space weather which negatively impacts many of our space-related activities. The arrival time prediction of CMEs is an area of active research. Various techniques of varying complexity have been proposed to predict the arrival of CMEs, yet even the most sophisticated models have struggled to reduce the mean absolute error below 12 hours. In our study, we propose a new approach for predicting CME arrival time that employs magnetohydrodynamic simulations of a data-informed flux rope-based CME model, positioned within a data-driven solar wind background. By examining 6 CMEs, we managed to reduce the mean absolute error in arrival time prediction to 8 hours. We further enhanced the precision of our arrival time predictions through ensemble modeling and by comparing the ensemble results with heliospheric imager data from STEREO A and B, by creating synthetic J-maps based on our simulations. We incorporated a machine learning method known as lasso regression for this cross-comparison. By doing so, we were able to bring down our mean absolute error to 4.1 hours, indicating a notable advance in the prediction of CME arrival time. Furthermore, when we incorporated neural networks, we achieved a mean absolute error of 5.1 hours using heliospheric imager data solely from STEREO A. Consequently, our study underlines the critical role of combining machine learning techniques with other models to enhance the accuracy of space weather predictions.

Wednesday, June 28: 9:40 AM - 10:05 AM
Presenter: Shen, Fang

3D MHD Modeling of Interplanetary Solar Wind Using Self-Consistent Boundary Condition Obtained from Multiple Observations and Machine Learning Technique

Fang Shen, CAS, China
Yi Yang, CAS, China

Three-dimensional (3-d) magnetohydrodynamics (MHD) modeling is a key method for studying the interplanetary solar wind. In this research, we introduce a new 3D MHD solar wind model driven by the self-consistent boundary condition obtained from multiple observations and Artificial Neural Network (ANN) machine learning technique. At the inner boundary, the magnetic field is derived using the magnetogram and potential field source surface extrapolation; the electron density is derived from the polarized brightness (pB) observations, the velocity can be deduced by an ANN using both the magnetogram and pB observations, and the temperature is derived from the magnetic field and electron density by a self-consistent method. Then, the 3D interplanetary solar wind from CR2057 to CR2062 are modeled by the new model with the self-consistent boundary conditions. The modeling results present various observational characteristics at different latitudes, and are in good agreement with both the OMNI and Ulysses observations.

Wednesday, June 28: 10:30 AM - 10:55 AM
Presenter: Radice, David

Neutrinos and Nucleosynthesis in Neutron Star Mergers

David Radice, Penn State, USA

This talk will discuss efforts in our group to model binary neutron star mergers using general-relativistic neutrino-radiation hydrodynamics simulations. I will show the numerical techniques we are employing and developing and discuss the impact of neutrinos on the dynamics, thermodynamics, and multi-messenger signatures from mergers.

SCHEDULE OF TALKS

Wednesday, June 28: 10:55 AM - 11:20 AM
Presenter: Kritsuk, Alexei

Scaling and Energy Transfer in Homogeneous Compressible Turbulence

Alexei Kritsuk, UCSD, USA

I shall present results from a new series of high-resolution numerical simulations of stationary near-isothermal turbulence crossing compressibility regimes from nearly incompressible and weakly compressible to transonic and supersonic. The simulations solve the Euler or Navier-Stokes equations using several variants of high-order accurate nonlinear filter schemes with adaptive dissipation control. The simulations employ large-scale stochastic Ornstein-Uhlenbeck forcing (both solenoidal and natural mix) with the energy injection rates spanning just short of three decades, resulting in turbulence Mach numbers between 0.28 and 1.91. I shall use the resulting data collection to discuss scaling and impacts of compressibility on energy transfer across scales.

Wednesday, June 28: 11:20 AM - 11:45 AM
Presenter: Zingale, Michael

Modeling Explosive Reactive Flows

Michael Zingale, Stony Brook University, USA

Tight coupling of hydrodynamics and reactions is essential to accurately modeling explosive reactive flows. When reactions are vigorous, operator splitting methods traditionally resort to cutting the timestep of the simulation to improve the coupling, but this comes at large computational expense. We have been developing several different time integration strategies built on the idea of spectral deferred corrections to tightly coupling hydrodynamics and reactions, and also achieve fully fourth-order in space and time reactive flow capabilities. In this talk, I will describe the different methods implemented in our open source Castro hydrodynamics code (https://github.com/amrex-astro/Castro), show some test problems, and describe the astrophysical applications we are applying these methods to.

Wednesday, June 28: 11:45 AM - 12:10 PM
Presenter: Hu, Qiang

Coronal Magnetic Field Extrapolation by Using Ultra High-Resolution Vector Magnetograms

Wen He, The University of Alabama in Huntsville, USA
Qiang Hu, The University of Alabama in Huntsville, USA

Magnetic field plays an important role in various solar eruption phenomena such as flares, coronal mass ejections, and solar jets, etc. The formation and evolution of characteristic magnetic field topology in solar eruptions are critical processes that will ultimately help us understand the origination of these eruptions in the solar source regions. With the development of advanced techniques and instruments, observations with higher resolutions in different wavelengths and field of views (FOVs) have provided more quantitative information for fine-scale structures. So it is essential to improve our method to study the magnetic topology in the solar source regions by taking advantage of high-resolution observations. In this study, we employ a modified version of the nonlinear force-free field (NLFFF) extrapolation method based on a nonuniform grid setting for an M-class flare eruption event (SOL2015-06-22T17:39:00) with embedded vector magnetograms from the Solar Dynamics Observatory (SDO) and the Goode Solar Telescope (GST). The extrapolation results based on the nonuniform embedded magnetogram are obtained by maintaining the native resolutions of the corresponding GST and SDO magnetograms. We then perform a topological analysis of the connectivity of the field lines corresponding to fine-scale magnetic field structures based on the extrapolation results. We compare it with the simultaneous GST/H_alpha and SDO/AIA observations for these fine-scale structures associated with precursor brightenings. The analysis results indicate that by combining the high-resolution GST magnetogram with a larger FOV magnetogram, the derived magnetic field topology representing a scenario of magnetic reconnection among sheared field lines across the main polarity inversion line (PIL) is consistent with the observed precursor brightenings of the solar flare.

Wednesday, June 28: 12:10 PM - 12:35 PM
Presenter: Fraternale, Federico

Modeling the Interaction Between the Solar Wind and the Local Interstellar Medium with Helium and Fluid Electrons: Implications for the Global Heliosphere Properties and Neutral Atoms Distributions

Federico Fraternale, The University of Alabama in Huntsville, USA
Nikolai V. Pogorelov, The University of Alabama in Huntsville, USA
Ratan K. Bera, , The University of Alabama in Huntsville, USA

We present the recent advancements in our 3-D modeling of the interaction between the solar wind (SW) and the local interstellar medium (LISM). Our simulation framework is the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS), which allows us to perform MHD plasma / kinetic neutrals simulations. We have recently introduced a number of new modules to the code that treat hydrogen and helium atoms and ions in a self-consistent manner. The Boltzmann equations for the neutral H and He atoms are solved using a Monte Carlo method. This new model includes the continuity and pressure equations for electrons and helium ions as separate fluids that co-move with the plasma mixture. The equations include the source terms that describe the ionization sources and losses due to charge exchange and photoionization, as well as the effect of Coulomb collisions between electrons, He+ ions, and protons. We emphasize that the latter process is particularly important in the LISM. The properties of electrons in the distant SW and in the LISM are largely unknown due to the lack of in situ measurements. With the new model we have been able to investigate the impact of various assumptions regarding electron pressure. Simulations assuming hot electrons, in which electrons carry the same pressure of protons, which is largely dominated by pickup ions, cannot reproduce NH measurements accurately. However, our new model shows a better agreement, suggesting that electrons in the SW are colder, with temperatures comparable to core protons. We further show that the enhanced probability of H-H+ charge exchange in the heliosheath leads to cooling of the plasma mixture, subsequently reducing its thickness. Conversely, the mixture of protons becomes hotter, leading to an enhanced production of hotter H atoms in this region. In the LISM near the heliopause, our model successfully reproduces the plasma temperature of approximately 30,000-40,000 K, as inferred from the V2 observations. However, a question is raised about the electron density. The presence of helium ions leads to a significant underestimation of this parameter compared to the previous simulations. Therefore, we suggest that the LISM proton density may need to be revised from ~0.054 cm-3 to values up to 0.75 cm-3.

Wednesday, June 28: 1:30 PM - 1:55 PM
Presenter: Sako, Takashi

Modeling of TeV Galactic Cosmic-ray Anisotropy based on Intensity Mapping in an MHD Model Heliosphere

T. K. Sako on behalf of the Tibet ASgamma Collaboration

A lot of past and present cosmic-ray experiments have reported small anisotropic features with amplitudes of ~0.1% in the arrival directions of TeV galactic cosmic rays observed at the Earth. We are attempting to derive anisotropic features at the boundary of the heliosphere by applying the idea of Liouville mapping to the experimental data of the Tibet ASgamma experiment. Our preliminary results have so far indicated small, possibly spurious, anisotropic structures, with angular scales of ~10 degrees in the cosmic-ray intensity distribution at the heliospheric boundary, and we are suspecting that the higher-order residues of the model anisotropy at the heliospheric boundary could be removed if the stochastic scattering of cosmic-ray particles by magnetic irregularities inside the heliosphere are taken into account. In this presentation we will present the latest results of our improved intensity-mapping method.

Wednesday, June 28: 1:55 PM - 2:20 PM
Presenter: Xu, Siyao

Turbulence in the Partially Ionized very Local Interstellar Medium and Implications on IBEX Ribbon

Siyao Xu, Institute for Advanced Study, USA
Hui Li, Los Alamos National Laboratory, USA

The cascade of magnetohydrodynamic (MHD) turbulence is subject to ion-neutral collisional damping and neutral viscous damping in the partially ionized interstellar medium. By examining the damping effects in the warm and partially ionized local interstellar medium, we find that the interstellar turbulence is damped by neutral viscosity at ~261 au and cannot account for the turbulent magnetic fluctuations detected by Voyager 1 and 2. The MHD turbulence measured by Voyager in the very local interstellar medium (VLISM) should be locally injected in the regime where ions are decoupled from neutrals for its cascade to survive the damping effects. With the imposed ion-neutral decoupling condition and the strong turbulence condition for the observed Kolmogorov magnetic energy spectrum, we find that the turbulence in the VLISM is sub-Alfvenic, and its largest possible injection scale is ~194 au. I will also discuss the implications of the turbulence on explaining the features of IBEX ribbon.

SCHEDULE OF TALKS

Wednesday, June 28: 2:20 PM - 2:45 PM
Presenter: Merkin, Slava

High-Resolution MHD Modeling of Interplanetary Coronal Mass Ejections

Slava Merkin, JHU/APL, USA
Elena Provornikova, JHU/APL, USA
Andrew McCubbin, JHU/APL, USA
Kareem Sorathia, JHU/APL, USA

Coronal mass ejections (CMEs) are the largest transient disturbances in the heliosphere. CMEs that propagate toward Earth are the dominant drivers of major geomagnetic storms and the associated space weather impacts. With solar maximum approaching there is increasing interest in the basic physics of CME propagation through the interplanetary medium, as well as geoeffective properties of CMEs. In this presentation, I'll discuss recent results of simulating CMEs at a particularly high resolution (down to 0.1 solar radius), using the Grid Agnostic MHD for Extended Research Applications (GAMERA) code. GAMERA uses high-order reconstruction with aggressive limiting to achieve high resolving power at modest computational expense. The CME simulations using GAMERA demonstrate highly structured solutions with properties similar to recent high-resolution heliographic imaging from the Parker Solar Mission.

Wednesday, June 28: 2:45 PM - 3:10 PM
Presenter: Papadakis, Konstantinos

Global Hybrid Plasma Simulations of Near-Earth Space Using Vlasiator

Konstantinos Papadakis, University of Helsinki, Finland
Urs Ganse, University of Helsinki, Finland
Yann Pfau-Kempf, University of Helsinki, Finland
Markus Battarbee ,University of Helsinki, Finland
Minna Palmroth, University of Helsinki and Finnish Meteorological Institute, Finland

Vlasiator is a state-of-the-art global magnetospheric plasma simulation code that models plasma dynamics in the near Earth space environment. By solving the hybrid-Vlasov equation system for ion particle distribution functions, it accurately captures the multi-scale processes and self-consistently models various plasma phenomena. This talk will delve into the spatio-temporal scales required to achieve accurate near-Earth space modeling with Vlasiator. We will go over the numerical schemes Vlasiator uses to solve the 6D Vlasov equation coupled to Maxwell's equations, along with the associated computational demands. Additionally, the presentation will highlight the significant numerical and algorithmic advancements such as Adaptive Mesh Refinement (AMR) and heterologous domain decomposition and upcoming GPU acceleration that enable Vlasiator to perform high-resolution global 3D simulations. Finally, the talk will showcase scientific breakthroughs achieved through Vlasiator simulations, highlighting its impact on advancing our understanding of magnetospheric physics.

Wednesday, June 28: 3:10 PM - 3:35 PM
Presenter: Sorathia, Kareem

Modeling Stormtime Geospace: Multiscale Coupling and its Implications

Slava Merkin, JHUAPL, USA
Adam Michael, JHUAPL, USA
Anthony Sciola, JHUAPL, USA
Dong Lin, NCAR, USA
Kevin Pham, NCAR, USA
Shanshan Bao, Rice University, USA

Understanding and ultimately predicting the dynamics of stormtime geospace is a major challenge of Heliophysics. Geospace is a system of systems comprised of interconnected physical domains: the magnetosphere, the ionosphere, and upper atmosphere in which the ionosphere is embedded. The different domains of geospace are populated by neutral gases and plasmas that are immersed in electromagnetic fields and evolve and interact with each other on disparate temporal and spatial scales. Our evolving understanding of geospace has highlighted the critical role of intermediate, or mesoscale, cross-domain coupling processes. Capturing these complex, cross-domain coupling processes in models is important for the science of geospace and for mitigating space weather hazards, such as geomagnetically induced currents which can damage and disrupt power systems on Earth. In this talk I will describe how these considerations have informed model development by the Center for Geospace Storms and highlight several recent modeling studies which illustrate the central role of mesoscale processes.

SCHEDULE OF TALKS

Wednesday, June 28: 3:55 PM - 4:20 PM
Presenter: Peter, Hardi

MHD Modeling of the Solar Corona and Comparison to Observations

Hardi Peter, Max-Planck-Institute for Solar System Research, Germany

The outer atmosphere of the Sun, the corona, as seen during a total solar eclipse is one of the most formidable natural phenomena. While we know since many decades that the corona is at a million Kelvin or more, we only slowly start understanding the processes that sustain the high temperature and govern the structure and dynamics of the coronal plasma. The key to recent significant progress has been the very close interplay between realistic 3D MHD numerical models and high-resolution observations in the extreme UV. These models provide self-consistent explanations for quite a range of observational features from the smallest scales resolved in observations to global scale phenomena like flares or coronal mass ejections. They allow to follow the changes of the magnetic field, e.g., while field lines are braided, and by this show where and when energy is dissipated and what the consequences are for observables, e.g., spectral line profiles in the extreme UV. Using such synthetic observations one can look at the models in the same way as an UV telescope looks at the real Sun. By this we can identify features in the simulations that match those on the real Sun. Examples are the structure of active regions, flare eruptions, or small-scale brightenings called Ellerman bombs. We then carefully investigate these phenomena to understand what drives the changes of the magnetic field and hence the dynamics seen in the changing corona. We can isolate, e.g., swirling motions as an agent transporting energy up into the corona or can identify (component) reconnection as the energy source for small-scale dynamics. In combination, these studies start painting a picture how the corona of the Sun works and show a path to new instrumentation, e.g., the multi-slit UV spectrograph MUSE, that will provide the next step in the interplay between modeling and observations.

Wednesday, June 28: 4:20 PM - 4:45 PM
Presenter: Sadykov, Viacheslav

Modeling Spectral Lines and Broadband Emission

for Realistic Simulations of the Sun

Viacheslav Sadykov, Georgia State University, USA
Irina Kitiashvili, NASA Ames Research Center, USA
Alexander Kosovichev, New Jersey Institute of Technology, USA
Alan Wray, NASA Ames Research Center, USA
Joel Allred, NASA Goddard Space Flight Center, USA
Graham Kerr, NASA Goddard Space Flight Center, Catholic University of America, USA
John Stefan, New Jersey Institute of Technology, USA
Adam Kowalski, University of Colorado Boulder, USA

The insight into the physical properties and processes in the solar atmosphere (propagation of waves and shocks, impulsive deposits and releases of the energy, etc.) often comes from observations of spectral lines and broadband emission of magnetized plasma. However, the formation of the spectral lines and emission is often a non-local and non-equilibrium process, which makes it more complex to build the methods for solar atmosphere diagnostics. One of the ways to interpret remote sensing observations is to combine realistic numerical simulations of the solar atmosphere and processes therein and synthesis of the plasma emission and spectra. In this work, we highlight our recent results in this area, specifically (1) modeling of the chromospheric spectral lines and coronal emission utilized for the analysis of the shock wave propagation in the “StellarBox” 3D Radiative MHD simulations of the quiet Sun, (2) comparison of the synthetic SDO/HMI line-of-sight observables (magnetic field, velocity, continuum intensity, and line depth) with the related physical properties of the atmosphere for local dynamo simulations performed using “StellarBox”, and (3) modeling of the SDO/HMI line-of-sight observables and chromospheric / transition region spectral lines for the 1D radiative hydrodynamic simulations (RADYN) of the solar flare process where the energy is deposited by non-thermal electron and proton beams. We discuss how the results improve interpretations of the remote sensing observations of the Sun and provide a better understanding of the physical properties in the solar atmosphere.

Thursday, June 29: 8:00 AM - 8:25 AM
Presenter: Hakobyan, Hayk

Entity: a New-Generation Architecture-Agnostic GR QED PIC code

Hayk Hakobyan, PPPL, USA
Benjamin Crinquand, Princeton, USA
Alisa Galishnikova, Princeton, USA
Jens Mahlmann, Princeton, USA
Alexander Philippov, UMD, USA
Arno Vanthieghem, Princeton, USA

Particle-in-cell has been a go-to approach for modeling plasmas in the environments of compact astrophysical objects for the last decade. Yet, there is no single publicly available code that includes all relevant radiation-plasma coupling processes and is capable of modeling global systems. In this talk I will describe development of a new-generation PIC code for extreme astrophysical plasmas, Entity. The code is based on the Kokkos framework, which enables efficient implicit multi-architecture portability including GPUs. The code features algorithms for various radiation-plasma coupling processes, such as Compton scattering, production of electron-positron pairs and their annihilation. The code is designed in general coordinate system, defined by the metric functions; this enables the Entity to also efficiently tackle the global (full-system) models of the magnetospheres of compact objects, which require algorithms on non-cartesian (spherical, cubed sphere) non-uniform grids, and even full general relativity.

Thursday, June 29: 8:25 AM - 8:50 AM
Presenter: Wilson, Lynn

The Structure of Collisionless Shocks

Lynn B Wilson III, NASA GSFC, USA

Collisionless shock waves are still a topic of great interest to both the heliospheric and astrophysics communities. They are an ubiquitous phenomena that can also generate and/or drive all the most important plasma phenomena like magnetic reconnection, turbulence, wave-particle interactions, and particle energization. The structure of collisionless shocks is still a bit of a mystery, despite decades of observations. Examples of the four MMS spacecraft crossing different shocks show, in some cases, similar magnetic features while in others, wildly different magnetic features despite inter-spacecraft separations on the order of electron-to-ion scales. In this talk I will discuss some of the more interesting and confusing observations I have stumbled across and highlight some potential paths forward.

Thursday, June 29: 8:50 AM - 9:15 AM
Presenter: Toth, Gabor

MHD-AEPIC: Magnetohydrodynamics with Adaptively Embedded Partice-in-Cell Model

Gabor Toth, University of Michigan, USA
Yuxi Chen, Boston University, USA
Xiantong Wang, University of Michigan, USA
Timothy Keebler, University of Michigan, USA

Kinetic processes can play an important role in large scale plasma simulations. It is computationally difficult, or in fact impossible, to simulate the whole system with a fully kinetic model. In the past decade, we have developed the Magnetohydrodynamics with Embedded Partice-in-Cell (MHD-EPIC) algorithm that allows modeling a part of the computational domain with PIC and the rest with extended MHD. This approach can be many orders of magnitude more efficient than a pure PIC model if the domain size covered by the embedded PIC is much smaller than the full MHD domain. For example, the PIC region may cover the currentsheet in the magnetotail of Earth while the MHD model can perform a global simulation extending to hundreds of Earth radii. Using a static PIC region requires, however, that the kinetic features of interest (for example reconnection sites) do not move much during the simulation. This is not true for a geomagnetic storm, when the magnetotail is flapping and reconnection sites move around. The newly developed MHD-AEPIC algorithm addresses this issue by changing the PIC region adaptively. In particular, we use the new Flexible Exascale Kinetic Simulator (FLEKS) as the PIC model, which allows switching individual grid cells on and off during the simulation. FLEKS uses the AMReX library. We have generalized the MHD-PIC coupling to support the new MHD-AEPIC algorithm. We have devised various criteria to identify potential reconnection sites and adapt the active PIC region accordingly. FLEKS also uses a sophisticated particle splitting and merging algorithm to maintain the number of particles per cell within some user defined threshold. This improves accuracy/efficiency as well as load balancing for parallel execution.

SCHEDULE OF TALKS

Thursday, June 29: 9:15 AM - 9:40 AM
Presenter: Tarr, Lucas

Data-Driven Boundary Conditions for 3D Magnetohydrodynamic Photosphere to Corona Simulations of the Sun

Lucas Tarr, National Solar Observatory, USA
N. Dylan Kee, National Solar Observatory, USA
Mark Linton, United States Naval Research Laboratory, USA
Peter Schuck, NASA/Goddard Space Flight Center, USA
James Leake, NASA/Goddard Space Flight Center, USA

We present a new method for data driven boundary conditions, based on the method of characteristics, that is valid for magnetohydrodynamic (MHD) simulations of the solar atmosphere driven at a photospheric boundary. The boundary condition incorporates observationally derived estimates for the full MHD state vector at every spatial point. We combine an optimization method with the characteristics to find a time evolution of the boundary between sparsely observed instances that is also strictly consistent with the MHD equations. We discuss why such boundary conditions are necessary in the field of solar physics, and then validate our method by replicating the results of a ``ground truth'' simulation of an expanding spheromak. The expanding spheromak mimics the emergence of a magnetic active region on the Sun, and the data-driving algorithm uses a time series of data extracted from just a single layer of the ground truth simulation.

Thursday, June 29: 9:40 AM - 10:05 AM
Presenter: Kim, Tae

The Variable Potential Field Source Surface Height and the Implications on Solar Wind Predictions

Tae Kim, University of Alabama in Huntsville, USA

The potential field source surface (PFSS) model has been widely adopted by the heliophysics community to extrapolate the observed magnetic field from the Sun's surface to a hypothetical surface above the corona where the magnetic field is assumed to be entirely radial. This hypothetical source surface is traditionally placed at 2.5 solar radii, but some studies have suggested that the source surface height may need to be lowered significantly during solar minima to better match the measured values near Earth. We use the Wang-Sheeley-Arge coronal model, which includes a PFSS component, with GONG magnetogram input and varying source surface heights to generate the boundary conditions for a heliospheric MHD model. The MHD simulations results are compared with OMNI, STEREO-A, and STEREO-B data at 1 au and also with Ulysses data at 2-4 au high above the ecliptic plane in 2008 for a three-dimensional, multi-point analysis.

Thursday, June 29: 10:30 AM - 10:55 AM
Presenter: Zank, Gary

Linear Mode-Decomposition in Magnetohydrodynamics Revisited

G.P. Zank, University of Alabama in Huntsville, USA
L.-L. Zhao, University of Alabama in Huntsville, USA
L. Adhikari, University of Alabama in Huntsville, USA
M. Nakanotani, University of Alabama in Huntsville, USA
A. Pitna, Charles University, Czechia
D. Telloni, INAF, Italy

Small amplitude fluctuations in the magnetized solar wind are measured typically by a single spacecraft. In the magnetohydrodynamics (MHD) description, fluctuations are typically expressed in terms of the fundamental modes admitted by the system. An important question is how to resolve an observed set of fluctuations, typically plasma moments such as the density, velocity, pressure and magnetic field fluctuations, into their constituent fundamental MHD modal components. Despite its importance in understanding the basic elements of waves and turbulence in the solar wind, this problem has not yet been fully resolved. Here, we present a new method that identifies between wave modes and advected structures such as magnetic islands or entropy modes and computes the phase information associated with the eligible MHD modes. Our mode-decomposition method identifies the admissible modes in an MHD plasma from a set of plasma and magnetic field fluctuations measured by a single spacecraft at a specific frequency and an inferred wave number. We present data from three typical intervals measured by the WIND and Solar Orbiter spacecraft at ~1 au and show how the new method allows for the identification of both propagating (wave) and non-propagating (structures) modes, including entropy and magnetic island modes. This allows us to identify and characterize the separate MHD modes in an observed plasma parcel and to derive wave number spectra of entropic density, fast and slow magnetosonic, Alfvenic, and magnetic island fluctuations for the first time. We discuss briefly how these results help in identifying the fundamental building blocks of turbulence in the magnetized solar wind.

Thursday, June 29: 10:55 AM - 11:20 AM
Presenter: Mathews, Nat

Solving 3D Magnetohydrostatics with RBF-FD: Applications to the Solar Corona

Nat Mathews, NASA GSFC, USA

We present a novel magnetohydrostatic numerical model that solves directly for the force-balanced magnetic field in the solar corona. This model is constructed with Radial Basis Function Finite Differences (RBF-FD), specifically 3D polyharmonic splines plus polynomials, as the core discretization. This set of PDEs is particularly difficult to solve since in the limit of the forcing going to zero it becomes ill-posed with a multitude of solutions. For the forcing equal to zero there are no numerically tractable solutions. For finite forcing, the ability to converge onto a physically viable solution is delicate as will be demonstrated. The static force-balance equations are of a hyperbolic nature, in that information of the magnetic field travels along characteristic surfaces, yet they require an elliptic type solver approach for a sparse overdetermined ill-conditioned system. As an example, we reconstruct a highly nonlinear analytic model designed to represent long-lived magnetic structures observed in the solar corona.

Thursday, June 29: 11:20 AM - 11:45 AM
Presenter: van der Holst, Bart

Improvements in the Alfven Wave Solar Atmosphere Model

Bart van der Holst, University of Michigan, USA

As part of the Space Weather with Quantified Uncertainty (SWQU) NSF program, we have improved the model efforts with the Alfven Wave Solar atmosphere Model (AWSoM). This model uses low-frequency Alfvén wave turbulence to address the coronal heating and acceleration. Here, we first revise our model, by introducing improvements in the energy partitioning of the wave dissipation to the electron and anisotropic proton heating. Subsequently, we use the first-principles AWSoM model in combination with uncertainty quantification and data assimilation. We have performed about a thousand simulations generating steady state solar wind solutions and coronal mass ejections. Based on these simulations, we have performed uncertainty quantification analysis. We find that the model input parameters depend on the solar cycle. We have identified the most important parameters that impact the background solar wind and CME eruption model. The reduced dimensionality of the parameter space enables reducing the size of the ensemble. Data assimilation can further improve the predictions. We are using in-situ observations at L1 prior to the CME and coronal while-light image observations right after the eruption to find the optimal parameters for the ensemble simulations.

Thursday, June 29: 11:45 AM - 12:10 PM
Presenter: Woodward, Paul

A New Approach to Strong Scaling

Paul Woodward, University of Minnesota, USA

For decades computational astrophysicists have been challenged by the introduction of new computing systems whose clock speeds and node counts are just about the same as the previous systems but whose nodes contain ever more and more CPU cores or CPU core equivalents. At first, as the machines grew larger, we could grow our problems larger too. We could refine the grid. We could add magnetic fields and/or nuclear reactions, even radiation diffusion. But we could not get the machines to solve problems faster. They could only solve bigger problems in the same or larger times. One could say that the specialty of these ever larger machines was to solve outrageously large problems eventually, with time-to-solution for problems keeping the whole machine productively busy extending to about a week, which might require 6 months or a year to be devoted to that problem under a single researcher’s allocation. GPUs make this challenge even harder, by halving the clock and far more than doubling the number of equivalent cores. I will describe my latest plan to get an order of magnitude more hardware to work on the same size problem and solve it in an order of magnitude less time. This is consequently a new approach to strong scaling for my code PPMstar. I believe that this approach is quite general and could be applied to any explicit simulation code, and perhaps to individual iterations of an implicit code’s algorithm as well. Because the next machine is likely to offer an order of magnitude more hardware, this is actually my strategy to keep even with developments up to the exascale level. I will introduce the unusual way in which PPMstar presently works, which allows it to achieve 10% of the 32-bit LinPack performance of the Frontera machine. Then I will describe how to keep this same level of performance working on a problem that is 8 times smaller. Finally, I will explain how this can be implemented on today’s GPUs.

SCHEDULE OF TALKS

Thursday, June 29: 12:10 PM - 12:35 PM
Presenter: Lee, Dongwook

A Class of High-Order Kernel-Based Shock-Capturing Methods for Astrophysical Flow Simulations

Ian May and Dongwook Lee, UC Santa Cruz, USA
Rémi Bourgeois, CEA, France

We present two high-order accurate shock-capturing finite volume methods for systems of hyperbolic conservation laws. These methods are based on non-polynomial reconstruction methods inspired by Gaussian Process (GP) modeling. As the first method, the a-posteriori limited GP-MOOD (Multidimensional Optimal Order Detection) method will be presented, followed by the second method of the a-priori limited GP-WENO (Weighted Essentially Non-Oscillatory) scheme. Both methods use spherical stencils of radius R, yielding (2R + 1)th-order spatial accuracy while using substantially fewer cells than corresponding tensor-product multidimensional polynomial stencils. Furthermore, we show that the GP reconstruction is genuinely multidimensional, avoiding the need for any intermediate quantities during reconstruction. The efficacy, accuracy, and robustness of these methods will be demonstrated on the compressible Euler equations and ideal magnetohydrodynamic equations in two and three spatial dimensions. Further, refinements of the scheme regarding choices of reconstruction variables, local smoothness indicators, and positivity preservation will be discussed in brief. We present that the two GP methods provide high-order and efficient treatment of smooth flow phenomena while also capturing discontinuous phenomena robustly.

Thursday, June 29: 1:30 PM - 1:55 PM
Presenter: Minoshima, Takashi

A Quasi All-speed Scheme for MHD Flows in a Wide Range of Mach Numbers

Takashi Minoshima, JAMSTEC, Japan
Takahiro Miyoshi, Hiroshima University, Japan

Magnetohydrodynamic (MHD) simulations are essential for studying the macroscopic dynamics of laboratory, space, and astrophysical plasmas. For compressible MHD simulations, shock-capturing schemes have been developed based on the solution to the Riemann problem in one-dimensional hyperbolic conservation laws, allowing us to tackle supersonic flows. However, familiar shock-capturing schemes can encounter numerical difficulties in practical multidimensional MHD simulations, such as the numerical shock instability for high Mach number flows (“Carbuncle” phenomena) and the degradation of solution accuracy for low Mach number flows. These issues restrict the availability of shock-capturing schemes to moderate Mach number flows. The preservation of the solenoidal condition for the magnetic field is also challenging. To address these challenges, we propose a new shock-capturing MHD scheme that implements two modifications for shock detection and pressure correction, enabling us to avoid multidimensional shock instability and improve the accuracy of low-speed flows. This "quasi all-speed" scheme is accurate for super-Alfvénic flows, and we will present details of its design, benchmark test results, and practical application to MHD turbulence problems in this talk.

Thursday, June 29: 1:55 PM - 2:20 PM
Presenter: Mackey, Jonathan

Wind-Blown Nebulae from Single and Binary Massive Stars

Jonathan Mackey, Dublin Institute for Advanced Studies, Ireland

Winds from massive stars expand supersonically into their surroundings, creating dynamic and fascinating nebulae that can give us insight into physical processes in interstellar plasma, and into the evolutionary history of the stars. For single stars these are parsec-scale bubbles such as bow shocks and ring nebulae, whereas in colliding-wind binary (CWB) systems the high wind density produces intense time- and space-dependent emission across the electromagnetic spectrum from radio to gamma-rays. Shock physics, particle acceleration and radiative processes can be investigated. I will present recent results on modelling the bow shocks of nearby massive stars such as Zeta Ophiuchi and the Bubble Nebula, compared with multiwavelength observations including radio and X-ray. Differently from single stars, the shocked wind in CWB systems is often dense enough and close enough to the stars such that the shocks are radiative. Comparing the relevant timescales, I will show that inverse-Compton cooling is often the dominant energy-loss mechanism for CWBs in eccentric or close binary orbits, although it is rarely included in models. 3D MHD simulations of the CWB system WR140 show that inverse-Compton cooling of the shocked plasma can trigger runaway cooling when the orbit is near periastron, producing strong compression and dynamical instabilities. I will discuss prospects for using 3D simulations, together with multi-epoch observations, to constrain the stellar wind properties of the massive stars.

SCHEDULE OF TALKS

Thursday, June 29: 2:20 PM - 2:45 PM
Presenter: van Marle, Allard Jan

Diffusive Shock Acceleration at Oblique High Mach Number Shocks

Allard Jan van Marle, LUPM, France
Artem Bohdan, DESY, Germany
Paul Morris, DESY, Germany
Martin Pohl, DESY, Germany
Alexandre Marcowith, LUPM, France

Cosmic ray sare charge particles that are accelerated to relativistic speeds by astrophysical shocks. Numerical models have been successful in confirming the acceleration process for (quasi-)parallel shocks, which have the magnetic field aligned with the direction of the shock motion. For these shocks, acceleration is achieved through the diffusive shock acceleration (DSA) or Fermi-one process, which consists of the particles being reflected back and forth across the shock by perturbations in the magnetic field. However, the process is less clear when it comes to (quasi-)perpendicular shocks. For such shocks, the shock-drift acceleration process can provide the particles with an initial acceleration. However, the angle between magnetic field and flow ensures that only highly energetic particles can travel upstream at all. In order to determine whether such shocks can accelerate particles to relativistic speeds, we use the particle-in-cell (PIC) method to determine what fraction of particles get reflected initially at the shock. We then use this as input for a new simulation that combines the PIC method with grid-based magnetohydrodynamics to follow the acceleration (if any) of the particles over a larger time-period in a two-dimensional grid. We find that quasi-perpendicular shocks are capable of accelerating particles through the DSA process, but only if the shock has a sufficiently high Alfvenic Mach number.

Thursday, June 29: 2:45 PM - 3:10 PM
Presenter: Dubey, Anshu

Flash-X: A Multiphysics Simulation Software Instrument

A. Dubey, University of Chicago, USA
K. Weide, University of Chicago, USA
J. O'Neal, Argonne National Laboratory, USA
A. Dhruv, Argonne National Laboratory, USA
S. Couch, Michigan State University,USA
J.A. Harris, Oak Ridge National Laboratory, USA
M. Wahib, Riken, Japan
Y. Lee, Argonne National Laboratory, USA.
T. Klosterman, Argonne National Laboratory, USA
Steve Fromm, Michigan State University, USA
R. Jain, Argonne National Laboratory, USA
M. Pajkos, California Institute of Technology, USA
J. Carlson, Michigan State University, USA
R. Chu, University of Tennessee, USA
E. Endeve, Oak Ridge National Laboratory, USA.
O.E.B. Messer, Oak Ridge National Laboratory, USA.

Flash-X is a new incarnation of FLASH, a highly composable multiphysics software system, has been fundamentally redesigned for newer heterogeneous platforms. It has the ability to use abstractions and asynchronous operations for performance portability across a variety of platforms, both with and withoutac celerators. With a move towards community development model and an open source license, physics solvers are getting modernized, and new capabilities are getting added. In this presentation I will describe the new architecture with its performance portability layer and also give an overview of new capabilities in the code.

SCHEDULE OF TALKS

Thursday, June 29: 3:10 PM - 3:35 PM
Presenter: Michael, Adam

Cross-Scale Modeling of Radiation Belt Variability in a Combined MHD and Test Particle Simulation

Adam Michael, JHUAPL, USA
Kareem Sorathia, JHUAPL, USA
Sasha Ukhorskiy, JHUAPL, USA
Jay Albert, AFRL, USA
Xiaochen Shen, Boston University, USA
Wen Li, Boston University, USA

Understanding the variability of radiation belt intensities has remained a major challenge due, in part, to local acceleration and loss mechanisms often occurring simultaneously with large-scale convection and discrete, mesoscale (~1 RE) plasma sheet injections. Global magnetosphere and test particle simulations are capable of capturing evolution through realistic global electromagnetic fields, including crucial mesoscale magnetotail dynamics necessary for radial transport and buildup of the radiation belts. In this work, pitch-angle scattering and energization of electrons from local resonant wave-particles interactions are computed using a stochastic differential equation based on analytical expressions for the quasi-linear diffusion coefficients and solved concurrently with the guiding center integration. The diffusion coefficients and wave locations are derived using the instantaneous plasma solution from the global MHD model. We will show that the model is capable of capturing enhancements of multi-MEV electrons during strong wave activity and detail how the evolution of the magnetic field and cold density in the inner magnetosphere strongly impact the energy of resonant electrons and the MLT dependence of scattering, causing higher energy electrons to precipitate where the plasmasphere is eroded.

Thursday, June 29: 3:55 PM - 4:20 PM
Presenter: Luo, Hongyang

Gas Kinetic Schemes for Solving the Magnetohydrodynamic Equations with Pressure Anisotropy

Hongyang Luo, the University of Hong Kong, China
John G.Lyon, Dartmouth College, USA
Binzheng Zhang, the University of Hong Kong, China

In many astrophysical plasmas, the Coulomb collision is insufficient to maintain an isotropic temperature, and the system is driven to the anisotropic regime. In this case, extended magnetohydrodynamic (MHD) models with anisotropic pressure are needed to describe such a plasma system. To solve the anisotropic MHD equation numerically, we develop a robust Gas-Kinetic flux scheme for non-linear MHD flows. Using anisotropic velocity distribution functions, the numerical flux functions are derived for updating the macroscopic plasma variables. The scheme is suitable for finite-volume solvers which utilize a conservative form of the mass, momentum, and total energy equations, and can be easily applied to multi-fluid problems and extended to more generalized double polytropic plasma systems. Test results show that the numerical scheme is very robust and performs well for both linear wave and non-linear MHD problems.

SCHEDULE OF TALKS

Thursday, June 29: 4:20 PM - 4:45 PM
Presenter: Nakatani, Riouhei

Evolution from Protoplanetary Disks to Debris Disks: Effects of Photoevaporation

Riouhei Nakatani, JPL, USA
Neal J. Turner, JPL, USA
Yasuhiro Hasegawa, JPL, USA
Gianni Cataldi, National Astronomical Observatory of Japan, Japan
Yuri Aikawa, The University of Tokyo, Japan
Sebastián Marino, University of Exeter, UK
Hiroshi Kobayashi, Nagoya University, Japan

Protoplanetary disks (PPDs) are gas-rich, optically thick circumstellar disks. They form planets and planetesimals while they themselves disperse. A planetary system, including a debris disk, is left over as the remnant. Understanding the evolution from a gas-rich, optically thick PPD to a gas-poor, optically thin debris disk is one of the critical open questions in the field of planet formation. Classically, the gas and dust of PPDs are thought to disperse within ~10 Myr according to infrared and optical observations. However, recent high-sensitivity observations have revealed gas in tens of debris disks with ages of > 10 Myr (so-called gas-rich debris disks, and the most massive class is called hybrid disks). These aged objects are not expected to have the gas in the classical understandings, and thus the gas origin is unclear. These objects are considered to have a key to understanding the evolution from PPDs to debris disks. Therefore, investigating their origin and fate is essential. Theoretical studies have found that the major disk dispersal processes are viscous spreading, magnetohydrodynamics (MHD) winds, and photoevaporation. Viscous spreading and MHD winds dominate the mass loss at the early stage, while the major process is replaced with photoevaporation at the later stage. Thus, photoevaporation is important in determining the final state of PPDs and the longevity of the gas. To understand the gas origin of gas-rich debris disks, we derive the photoevaporation rates of PPDs by performing self-consistent radiation hydrodynamics simulations with non-equilibrium thermochemistry. In the simulations, a gas-rich, optically-thin disk is irradiated by the central intermediate-mass star and interstellar radiation field. We measure the mass-loss rates and estimate the dispersal timescale of the gas disk. Building on the obtained photoevaporation rates, we construct a long-term disk evolution model to derive the gas disk lifetimes for various stellar masses. We then compare them with the observational detection rate of gas-rich debris disks as a function of spectral types to discuss the gas origin and how applicable our disk evolution model is.

Thursday, June 29: 4:45 PM - 5:10 PM
Presenter: Van Loo, Sven

Dust Accretion onto Circumplanetary Discs

Sven Van Loo, Ghent University, Belgium
Samuel Karlin, University of Leeds, UK
Olja Panic, University of Leeds, UK

The major satellites of Jupiter and Saturn are believed to have formed in circumplanetary discs, which orbit forming giant protoplanets. Gas and dust in CPDs have different distributions and affect each other by drag, which varies with grain size. Yet simulations of multiple dust grain sizes with separate dynamics have not been done before. We seek to assess how much dust of each grain size there is in circumplanetary discs. We run multifluid 3D hydrodynamical simulations including gas and four discrete grain sizes of dust from 1 μm to 1 mm, representing a continuous distribution. We consider a Jupiter-mass protoplanet embedded in a disc around a Solar-mass star. Our results show the typical power-law dust distribution albeit truncated distribution at smaller grain sizes, which starts to tail off by a = 100 μm and is near zero at 1 mm. Large dust grains, which hold most of the dust mass, have very inefficient accretion to the CPD, due to dust filtration. Therefore CPDs' dust masses must be small, with a mass of the order of a millionth of that of the protoplanet. These masses and the corresponding millimetre opacities are in line with CPD fluxes observed to date.

Friday, June 30: 8:00 AM - 8:25 AM
Presenter: Lynch, Benjamin

Modeling Reconnection-generated Transients in the Solar Wind

B. J. Lynch, University of California Berkeley, USA

The solar wind exhibits a tremendous amount of spatiotemporal variability in its bulk plasma, magnetic field, and composition properties. In this presentation, I will review some of the recent progress made towards modeling reconnection-generated transients in the solar corona and their evolution into the open field. Certain, specific magnetic geometries of large-scale coronal source regions can act as a proxy for the location(s) one expects these transients to occur and make significant contributions to the solar wind's variability. In particular, I will discuss signatures of interchange reconnection at the open--closed boundaries of coronal flux systems including at the helmet streamer belt and within the vicinity of coronal pseudostreamers. Ultimately, global time-dependent 3D modeling will be required to unify stationary solar wind solutions with first-principles' modeling of the low-frequency (MHD) component of solar wind turbulence.

Friday, June 30: 8:25 AM - 8:50 AM
Presenter: Yuen, Ka Ho

Origin of Low Frequency Fluctuations in Compressible MHD Turbulence: Theory and Observation

KH Yuen, Los Alamos National Lab, USA
Hui Li, Los Alamos National Lab, USA
Huirong Yan, Deutsches Elektronen-Synchrotron DESY, Germany

The development of magneto-hydrodynamic (MHD) turbulence at high Reynolds numbers remains an open question in the plasma physics community. Traditionally, MHD turbulence is modeled as a combination of linearly independent waves following well-defined dispersion relations. However, recent research via spatial-temporal analysis has shown that the majority of spectral power in turbulence simulations does not follow any dispersion relation, but rather fluctuates at very low frequencies. The cause of these fluctuations is the Lorentzian broadening of the dispersion relations of the three MHD modes due to the nonlinear term acting as a damping term of a harmonic oscillator. The slow magneto-sonic modes contribute the most to the fluctuations at low frequencies, and the Lorentzian broadening widths are inversely proportional to the modes' propagation speed. Despite being constant, the ratio between the nonlinear time and propagation time in compressible modes in the low-beta limit is significantly deviated from unity. These low frequency fluctuations are crucial components of the strong MHD turbulence cascade and have significant implications for understanding various astrophysical processes in interstellar media. Our work confirms the importance of these fluctuations and sheds light on their contribution to MHD turbulence in high Reynolds number limits.

Friday, June 30: 8:50 AM - 9:15 AM
Presenter: Strauss, Du Toit

The Use of the Locally One-Dimensional (LOD) Method in Cosmic Ray Transport Models

Du Toit Strauss, North-West University, South Africa

The Locally One-Dimensional Method (LOD) can be used to transform a N-dimensional partial differential equation into a set of N one-dimensional differential equations. The latter is, of course, much easier to handle numerically. We begin by discussing some early applications of the LOD method from the 1990s where it was extensively applied to cosmic ray studies in the isotropic limit. More recently, the LOD method has been successfully applied to solve the focused transport equation in order to simulate the transport of solar energetic particles. This equation changes from an advective-type to a diffusive-type equation between the Sun and the Earth, posing a problem for more traditional numerical algorithms (e.g. of the Crank-Nicholson type). We discuss details of this application, its numerical implementation, and give details regarding the applied boundary conditions. Example solutions of the resulting solar energetic particle intensities are also presented and discussed.

Friday, June 30: 9:15 AM - 9:40 AM
Presenter: Federrath, Christoph

Modelling MHD Turbulence and Star Formation

Christoph Federrath, Australian National University, Australia

In this talk, I will present recent work from our research group on modelling turbulent magnetohydrodynamical (MHD) flows and star formation. I will explain the key roles that MHD turbulence and feedback (both mechanical and radiative) play for the structure and dynamics of the interstellar medium, and for the formation of stars.

Friday, June 30: 9:40 AM - 10:05 AM
Presenter: Tomohisa, Kawashima

PIC Simulations of Mushroom-Instability-Driven Magnetic Reconnections in Collisionless Relativistic Jets

Tomohisa Kawashima, U of Tokyo, Japan
Seiji Ishiguro, NIFS, Japan
Toseo Moritaka, NIFS, Japan
Ritoku Horiuchi, NIFS, Japan
Kohji Tomisaka, NAOJ, Japan

Relativistic jets launched from supermassive black holes indicates the acceleration of the charged particles. Recent observations of relstivistic jets also display the enigmatic substructure inside jets, e.g., fast jet-spine and slow jet-sheath parts. With respect to the kinetic study of the plasmas, an electron-scale shear instability called mushroom instability (MI) was shown to grow in the plasma with relativistic bulk shear flow. Importantly, the MI dominates the electron-scale Kelvin-Helmholtz instability when relative bulk speed is greater than roughly 30% of the speed of light. Attributed to the MI, the magnetic fields are generated and amplified in the transverse plane of the plasma shear flows. Kinetic plasma phenomena associated with MI may play an important role in the high energy phenomena in relativistic jets. We, therefore, study the kinetic plasma dynamics in collisionless relativistic jets with velocity shear, by carrying out 2D-3V PIC simulations in the transverse plane of a jet. We use a two-dimensional relativistic PIC simulation code PASTEL. It is discovered that intermittent magnetic reconnections (MRs) are driven by MI. We refer to this sequence of kinetic plasma phenomena as "MI-driven MR." The MI-driven MRs intermittently occur with moving the location of the reconnection points from the vicinity of the initial velocity-shear surface toward the jet center. Subsequently, the number density of high-energy electrons that are accelerated by MI-driven MRs increases with time in the region inside the initial velocity-shear surface with the accompanying generation and subsequent amplification of magnetic fields by MI. The maximum Lorentz factor of electrons increases with initial bulk Lorentz factor of the jet. The MI-driven MRs may be related to the origin of the bright synchrotron emission in the jet spine of an active galactic nucleus jet.

Friday, June 30: 10:05 AM - 10:30 AM
Presenter: Claes, Niels

Legolas 2.0: Extensions to a Linear MHD Spectroscopic Framework

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The Legolas code [1, 2, 3] is an open-source, finite element-based, numerical framework to solve the linearised (magneto)hydrodynamic equations for a three-dimensional force- and thermally balanced state with a nontrivial one-dimensional variation. The standard Fourier modes imposed in the other coordinates give rise to a complex, generalised non-Hermitian eigenvalue problem which is then solved to quantify all linear wave modes of the given system in either Cartesian or cylindrical geometries. Physical effects included in the framework are background flows, optically thin radiative losses, anisotropic thermal conduction, external gravity, resistivity, viscosity, and Hall MHD, allowing for a full spectroscopic treatment of highly generalised setups in various environments ranging from laboratory conditions to astrophysical systems. The framework was recently extended to treat subsystems of the eight linearised MHD equations, allowing for pure hydrodynamic setups in 3D, only 1D density/temperature/velocity variations, or even omitting the energy equation altogether to treat specific closure relations. Additionally, the code now has the possibility to fully visualise eigenfunctions associated with a given wave mode in multiple dimensions, such that links between linear stability analysis and fully nonlinear simulations are becoming a reality, along with in-depth studies of system stability and wave mode behaviour. In this talk an overview will be given of all the new updates to the Legolas framework that are currently available and the new possibilities these open up.

References

[1] Claes, N., De Jonghe, J., & Keppens, R. (2020). Legolas: a modern tool for magnetohydrodynamic spectroscopy. The Astrophysical Journal Supplement Series, 251(2), 25.
[2] De Jonghe, J., Claes, N., & Keppens, R. (2022). Legolas: magnetohydrodynamic spectroscopy with viscosity and Hall current. Journal of Plasma Physics, 88(3), 905880321.
[3] https://legolas.science

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June 26 - 30
Pasadena, CA
Poster Presentations

Albarran, Robert	***Kinetic Modeling of Ionospheric Outflows in Pressure Cooker Environments*** Robert Albarran, University of California, Los Angeles, USA Matthew Zettergren, Embry-Riddle Aeronautical University, USA Doug Rowland, NASA Goddard Space Flight Center, USA Jeff Klenzing, NASA Goddard Space Flight Center, USA James Clemmons, The Universi Plasma escape from the high-latitude ionosphere (ion outflow) serves as a significant source of heavy plasma to magnetospheric plasma sheet and ring current regions. Outflows alter mass density and reconnection rates, hence global responses of the magnetosphere. A new fully kinetic and semi-kinetic model is constructed from first principles which traces large numbers of individual O+ ion macro-particles along curved magnetic field lines, using a guiding-center approximation, in order to facilitate calculation of ion distribution functions and moments. Particle forces include mirror and parallel electric field forces, a self-consistent ambipolar electric field, and a parameterized source of ion cyclotron resonance (ICR) wave heating, thought to be central to the transverse energization of ions. The model is initiated with a steady-state ion density altitude profile and Maxwellian velocity distribution and particle trajectories are advanced via a direct simulation Monte Carlo (DSMC) scheme. This outlines the implementation of the kinetic outflow model, demonstrates the model's ability to achieve near-hydrostatic equilibrium necessary for simulation spin-up, and investigates L-shell dependent wave heating and pressure cookers scenarios. This provides quantitative means to interpret sounding rocket data and related remote sensing approaches to studying ion outflows and serves to advance our understanding of the drivers and particle dynamics in the auroral ionosphere and to improve data analysis for future sounding rocket and satellite missions.
Boyd, Brendan	***Low Mach Number Simulations of the Convective Urca Process*** Brendan Boyd, Stony Brook University, USA Alan Calder, Stony Brook University, USA Dean Townsley, University of Alabama, USA A proposed setting for thermonuclear (Type Ia) supernovae is a white dwarf that has gained mass from a companion to the point of carbon ignition in the core. There is a simmering phase in the early stages of burning that involves the formation and growth of a core convection zone. One aspect of this phase is the convective Urca process, a linking of weak nuclear reactions to convection which may alter the composition and structure of the white dwarf. Convective Urca is not well understood and requires 3D fluid simulations to realistically model. Additionally, the convection is relatively slow (Mach number less than 0.005) so a low-Mach method is needed. Using the MAESTROeX low-Mach hydrodynamic software, we present full 3D simulations of the A=23 convective Urca process. These results point to the proper initial conditions needed for the simulation to quickly settle into a quasi-steady state. Our findings on the extent of mixing across the Urca shell, the characteristic velocities of the flow and the energy loss rates can be used to inform 1D stellar models which track the longer-timescale evolution.This research was supported in part by the US Department of Energy (DOE) under grant DE-FG02-87ER40317
Chen, Zhi	***Sensitivity of He Flames in X-ray Bursts to Nuclear Physics*** Zhi Chen, Stony Brook University, USA Through the use of axisymmetric 2D hydrodynamic simulations, we further investigate laterally propagating flames in X-ray bursts (XRBs). Our aim is to investigate the sensitivity of a propagating helium flame to different nuclear physics. Using the \castro\ simulation code, we confirm the phenomenon of enhanced energy generation shortly after a flame is established after by adding ${}^{12}\mbox{C}(\mbox{p}, \gamma){}^{13}\mbox{N}(\alpha, \mbox{p}){}^{16}\mbox{O}$ to the network, in agreement with the past literature. This sudden outburst of energy leads to a short accelerating phase, causing a drastic alteration in the overall dynamics of the flame in XRBs.

Crawford, Chris	***The Scaling of Vortical Electron Acceleration in Thin-Current Magnetic Reconnection and Its Implications in Solar Flares*** C. Crawford, University of Alabama in Huntsville, USA H. Che, University of Alabama in Huntsville, USA A. O. Benz, University of Applied Sciences and Arts Northwestern Switzerland, Switzerland How magnetic reconnection (MR) accelerates electrons to a power-law energy spectrum in solar flares is a challenging problem in solar physics. To investigate this problem, we explore the scaling of a kinetic model proposed by Che and Zank (2020) (CZ) and compare it to observations to evaluate this model. We first propose small-scale MRs are triggered in thin current sheets (~ d_i, d_i the ion inertial length) that are generated by Kelvin-Helmholtz instability (KHI) in large-scale MR. Then we use kinetic theory and particle-in-cell (PIC) simulations to analyze the impact of domain size on the evolution of electron KHI (EKHI) in thin-current-sheet MR. We find that the duration of the growth stage of the EKHI (t_G ~ Omega_{ce}^{-1}) is short and remains nearly unchanged since Omega_{ce} is independent of domain size. The quasi-steady stage of the EKHI t_{MR} is dominant and scales linearly with the size of the simulations as L/v_{A0}, v_{A0} is the Alfv'en speed. We use the analytical electron energy spectrum obtained by CZ to calculate the continuous temporal evolutions of the spectra from PIC simulations. Using a linear scaling method drawn from the PIC simulations, we scale the spectra and the acceleration region sizes to observational scales and find them in good agreement with typical soft-hard-harder solar electron energy spectra and solar flare acceleration region spatial scales, suggesting that we can use PIC MR simulations to investigate the observational electron energy spectral evolution of solar flares if the ratio t_G/t_{MR} is sufficiently small <~ 15%.
Deuja, Atit	***Modeling of Electron Acceleration During the Contraction of Magnetic Islands*** Atit Deuja, University of Alabama in Huntsville, USA Haihong Che, University of Alabama in Huntsville, USA Magnetic reconnection releases the magnetic energy through the contraction of multi-magnetic islands generated by tearing instability leading to the electron acceleration as proposed by Drake et. al in 2006. However, how the released magnetic energy is converted into electron’s kinetic energy is still not well understood. We model this adiabatic process assuming that the contraction of magnetic islands induces an electric field such that the curl of induced electric field is proportional to the magnetic field of the islands and approximate the magnetic island with an ellipse. Under this model, we show that the energy gain is achieved through the work of electrons along the inductive (reconnection) electric field. We further show that the curvature drift term dominates the energy gain. We compared our model with the magnetic islands formed by tearing instability in a 2.5D particle-in-cell simulation of magnetic reconnection and found the model consistent with the simulation.

Feldman, Catherine	***Challenges Modeling the Low-Luminosity Type Iax Supernovae*** Catherine Feldman, Stony Brook University, USA Ellis Eisenberg, Half Hollow Hills High School West, USA Dean M. Townsley, The University of Alabama, Tuscaloosa, USA Alan C. Calder, Stony Brook University, USA Type Iax supernovae, one class of very dim events, produce a slow moving, sparse ejecta that presents challenges for simulation. These events are hypothesized to be to be created from deflagration (subsonic burning), without a subsequent supersonic detonation, of a white dwarf star. The deflagration gives the star time to react and expand, quenching the burning so that the majority of the mass remains unburned and gravitationally bound. The resulting system is a hot, dense core surrounded by sparse material that cools as it expands outwards. The lack of a vigorous explosion makes the results of simulations especially sensitive to the initial conditions and presents additional challenges for the system's evolution. Here, we present an investigative suite of 30 simulations of a hybrid C/O/Ne WD undergoing a deflagration using FLASH, a multi-scale, multi-physics software instrument. We explore how the final state of the simulation changes as we vary the character of the early stages of burning, which influences the outcome of the explosion. We also discuss how the "fluff" parameters, i.e. those pertaining to the low-density gas on the grid in lieu of vacuum, affects the geometry of the deflagration and inhibits the ejecta as it expands. We also discuss strategies for simulating the expansion of the ejecta to late times, which is more challenging than for simulations of SNIa due to the lower ejecta velocities exhibited by SNIax simulations. Finally, we present a comparison between our simulation and observations of these events. The authors would like to thank Stony Brook Research Computing and Cyberinfrastructure, and the Institute for Advanced Computational Science at Stony Brook University for access to the SeaWulf computing system, which was made possible by a $1.4M National Science Foundation grant (#1531492). This research was also supported in part by the US Department of Energy (DOE) under grant DE-FG02-87ER40317 and in part by the US National Science Foundation (NSF) under grant OAC 1927880.
Glines, Forrest	***Exascale Simulations of Magnetized AGN Jets on Frontier with Performance Portable MHD*** Forrest Glines, Philipp Grete, Benjamin Wibking, Deovrat Prasad, Brian O'Shea The magnetically collimated jets emitted by active galactic nuclei (AGN) at the center of galaxy clusters and groups are widely agreed to play a key role in the regulation of cold gas in these systems. The effect of the AGN jet's magnetic fields on the environment, however, is still being explored. These injected magnetic fields can affect dynamics on the large scales of the hundreds of kiloparsecs jet down to the small scales of sub-parsec plasma instabilities. Modeling large portions of this span of dynamical ranges requires great computing resources such as those provided by Frontier, the world's first exascale supercomputer made available this year. To perform such simulations on exascale supercomputers, we developed AthenaPK, an open source magnetohydrodynamics (MHD) code with adaptive mesh refinement (AMR) that is performance portable; AthenaPK runs at high performance on several new computer architectures comprising exascale supercomputers. We present simulations executed on Frontier of magnetized AGN feedback in galaxy clusters and groups. We will also discuss our experiences crafting the performance portable code AthenaPK and using it on the Frontier supercomputer. With exascale resources, we can model the plasma at much higher resolution with higher fidelity than previously possible, allowing us to resolve more physics within these systems. (LA-UR-23-25749)

Johnson, Eric	***Simulating Lateral Flame Propagation in Type I X-ray Bursts*** Eric T. Johnson, Stony Brook University, USA Michael Zingale, Stony Brook University, USA Type I X-ray bursts are thermonuclear explosions that occur on the surfaces of accreting neutron stars. They allow us to probe neutron star properties such as radius and spin rate, and are especially interesting due to their accessible recurrence times of hours to days. One-dimensional simulations can accurately reproduce observed recurrence times and light curves, but not features from multidimensional effects such as convection and flame propagation. Multi-dimensional simulations are much more computationally expensive due to the large range of physical scales involved. We have been performing two-dimensional hydrodynamics simulations of a mixed H/He burst to investigate the structure of laterally-propagating flames during the burst rise. Previous work from our group was limited to pure helium bursts, but performance improvements to our code have allowed us to use larger reaction networks that include hydrogen burning.
Mao, Huaqing	***A new 3d1d Approach to Stellar Evolution Simulations*** Huaqing Mao, University of Minnesota, USA Paul Woodward, University of Minnesota, USA Falk Herwig, University of Victoria, Canada Pavel Denissenkov, University of Victoria, Canada Simon Blouin, University of Victoria, Canada Stellar evolution is computed in 1D, because otherwise time steps would need to be small enough to capture the 3-D gas behavior, such as turbulent convection. 1-D models of convection designed for use in stellar evolution codes have consequently been a key enabling technology. I will describe a set of detailed 3-D simulations of core convection and material mixing in main sequence massive stars, showing how these simulations have informed a new model for the convection zone and its region of convective penetration into the stably stratified layers above it. This new 1-D model has no free paramters, but it does require the knowledge of the kinetic energy dissipation rate as a function of radius in the convection zone. I will discuss how this dissipation function can be obtained with a coarse and short 3-D simulation, and how changes in this function as the star evolves can be obtained by means of interpolation between a small number of such 3-D solutions. We are implementing this new approach to 1-D stellar evolution simulation in the MESA code, and this work will be described.

Narrett, Isaac	***Exploring Impact Plasma Amplification of the Ancient Lunar Magnetosphere*** I. S. Narrett, Massachusetts Institute of Technology, USA R. Oran, Massachusetts Institute of Technology, USA Y. Chen, Plasma Physics Laboratory, USA G. Toth, University of Michigan, USA Katarina Miljković, Curtin University, Australia B. P. Weiss, Mass The source of the lunar crustal field is a longstanding mystery. The Moon lacks a global magnetic field, yet spacecraft observations and laboratory studies of Apollo samples have identified natural remanent magnetization that formed in an ancient magnetic field, possibly reaching >30 µT. However, the inferred size of the lunar core suggests it may be too small to produce an Earth-like dynamo, as core convection dynamo scaling laws struggle to account for surface fields above ~1 µT. In this presentation, we explore a key alternative hypothesis that the low dynamo field was transiently amplified by impact-generated plasmas. However, this hypothesis has not been tested using self-consistent magnetohydrodynamic (MHD) simulations. We combine the results from iSALE-2D shock physics impact simulations and MHD simulations using BATS-R-US to simulate a large basin-forming impact within a lunar magnetosphere. The magnetic field inside the body evolves according to the magnetic diffusion equation (i.e., there is no plasma flow), while outside the body, the plasma is infinitely conducting and the magnetic field evolves according to the induction-advection equation. Importantly, the two fields are coupled to the evolution of the impact vapor cloud engulfing the Moon. Initial results show a complex interaction between the vapor and field, including boundary currents, compression of the magnetospheric field to produce transient enhancement in the cloud periphery, diffusion of the enhanced field into the crust, and dissipation of the field in the various layers of the Moon. Initial results show that the dipole field is amplified by ~40% relative to the magnetospheric field (i.e., from1800 nT to 2600 nT) and lasts for a duration of minutes. This suggests that impact plasma could modify the field recorded by impact melt by a significant amount, implying that lunar remanent magnetization may not be entirely a record of a pure dipole field. This suggests that impact plasma could modify the field recorded by impact melt by a significant amount, implying that the magnetization may not be a record of a pure dipole field. Additionally, this result may highly depend on the location of the impact relative to the dipole axis, which will be explored in future work.
Phillips, David	***An Operator Splitting Approach to Highly Magnetised Relativistic Magnetohydrodynamics*** David Phillips, University of Leeds, UK Serguei Komissarov, University of Leeds, UK Conservative schemes are an extremely powerful tool in Relativistic Magnetohydrodynamics for modelling astrophysical phenomena. But while these able to handle low magnetisation with ease (where the ratio of magnetic components to inertial components is small), these schemes show significant failures at higher magnetisation - in some cases, failing even at ratios as small as 1. On the other extreme, Force-free models that neglect the inertial components entirely are unable to resolve crucial details such as current sheets. Here we present a novel operator splitting approach to the high-magnetisation regime of special relativistic magnetohydrodynamics, and describe 1D and 2D test simulations demonstrating its accuracy in both the low-and high-magnetisation regimes.

Poster Presentations

Sciola, Anthony	***A New High-performance Inner Magnetosphere Simulator for Integrated Global Geospace Modeling*** Anthony Sciola, JHU/APL, USA Kareem Sorathia, JHU/APL, USA Slava Merkin, JHU/APL, USA Shanshan Bao, Rice University, USA Frank Toffoletto, Rice University, USA Adam Michael, JHU/APL, USA Harry Arnold, JHU/APL, USA Formation of the ring current within the inner magnetosphere is a crucial element of Earth's magnetospheric response to heightened solar wind activity. The ring current is central to the strong storm-time coupling of disparate plasma and neutral gas populations of the geospace system, including the global magnetosphere, ionosphere, plasmasphere and exosphere. As such, simulating the ring current from first-principles remains a great challenge to modelling the geospace environment. Recent efforts to model the geospace system in a more holistic manner and at unprecedented resolution and performance have created demand for an inner magnetosphere model designed with these challenges in mind. We present progress towards such a model, named RAIJU, whose key features include a highly conservative scheme with 7th order reconstruction, adaptive domain evolution to optimize time stepping, and energy-resolved coupling between the modeled ionosphere, plasmasphere and exosphere. RAIJU is being developed to be compatible with the Multiscale Atmosphere Geospace Environment (MAGE) model developed by the NASA Drive Science Center for Geospace Storms (CGS).
Seo, Jeongbhin	***A New WENO Magnetohydrodynamic Code with a High-Order Constrained Transport Scheme*** Jeongbhin Seo, Ulsan National Institute of Science & Technology, Korea Dongsu Ryu, Ulsan National Institute of Science & Technology, Korea We have developed a new magnetohydrodynamic (MHD) code for astrophysical applications, which is based on a fifth-order finite-difference weighted essentially non-oscillatory (WENO) scheme and a fourth-order strong stability-preserving Runge-Kutta (SSPRK) time-integration scheme. In particular, to match the high-order accuracy of the WENO scheme, we have implemented a new constrained transport (CT) algorithm of high-order accuracy. In this talk, we describe the MHD code and present its performance. We demonstrate that with the new CT scheme, the code achieves fifth-order accuracy in wave decay tests, including a circularly polarized Alfven wave propagation test. We further demonstrate the high accuracy and robustness of the code through tests involving complex flows.
Smith Clark, Alexander	***pynucastro 2.0: New Features and Implementation of a Python Library for Nuclear Astrophysics.*** Alexander Smith Clark, Stony Brook University, USA pynucastro is an open-source python library that provides the ability to construct and explore astrophysical nuclear reaction networks, providing interacting visualization tools and the capability of interfacing them into languages such as python and C++. In our new version of pynucastro,we implemented new plots that highlight the importance of a rate, nuclei and initial composition, to a particular network. We enabled support to compute the inverse, endothermic, baryonic reaction rates in terms of its exothermic baryonic counterparts, including support of the nuclear partition functions required in high temperature domains. Furthermore, we have included the classical coulomb screening effects and the ability to compute the Nuclear Statistical Equilibrium (NSE) composition, given the density and temperature on which the reaction network takes place. Finally, it is important to highlight that pynucastro has opened a new set of possibilities, and perspectives from the community and developers, such as the implementation of quantum screening, the support of the Helmholtz EOS, and the implementation of network-reduction methods.

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Willcox, Don	***Emu: An Open-Source Particle-in-Cell Code for Multidimensional Quantum Kinetics*** Don E. Willcox, Lawrence Berkeley National Laboratory, USA Sherwood Richers, University of Tennessee, Knoxville, USA Neutron star mergers and core collapse supernovae are extreme multiphysics events with heavy element production largely dependent on the amount of electron flavor content in the event. The importance of nucleosynthetic outcomes in these events has raised neutrino flavor transformations to an area of active research, particularly focused on determining the effects of fast growing neutrino flavor instabilities arising from neutrino-neutrino interactions. Neutrino quantum kinetics is a challenge to research, however, since simulation codes must resolve small length, time, and angular scales in the neutrino distribution in order to accurately compute the neutrino self-interaction potential. Most approaches thus make significant approximations. We have advanced the capabilities of this research field by developing Emu, an open-source particle-in-cell simulation code solving the neutrino quantum kinetics equations with arbitrary angular resolution in three dimensions. Emu achieves this by representing the neutrino distribution with a set of computational particles, each with unique position, momentum, and quantum state. Emu's C++ kernels for evolving each particle's quantum state are symbolically generated from the quantum kinetics equations using Sympy. Emu is also built on top of AMReX, a scalable computational framework with domain-distributed particle-mesh routines offering performance portability on CPUs and GPUs. Emu thus enables detailed multidimensional studies of the neutrino fast flavor instability, resolved in space, angle, and time. This poster will present Emu's design and performance on modern supercomputing platforms before pointing to new opportunities Emu enables for studying the multidimensional fast flavor instability and its astrophysical implications.

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