Joint Space Weather Summer Camp 2018

July 14 – July 29, 2018

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE CSPAR CENTER FOR SPACE PLASMA & AERONOMIC RESEARCH

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

Low-Temperature Plasma Science & Technology

ALABAMA NSF EPSCoR

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ISTITUTO DI ASTROFISICA E PLANETOLOGIA SPAZIALI DI ROMA INAF ISTITUTO NAZIONALE DI ASTROFISICA

Robert Lindquist, Ph.D.

Interim Vice President for Research and Economic Development
Professor, Electrical & Computer Engineering Department
University of Alabama in Huntsville

Dr. Robert Lindquist was appointed to the position of Interim Vice President for Research and Economic Development in May 2018 after serving in the positions of the Associate Vice President for Contracts and Grants, the Director of the Center for Applied Optics, and the Department Chair of Electrical and Computer Engineering at UAH. Dr. Lindquist is a Professor, active researcher, and responsible for administering and overseeing all UAH grants and contracts, including the NSF EPSCoR grant. Dr. Lindquist has secured more than $6.5 million in research funding as the PI from NSF, NASA, the Army, and Industry during the past decade. Dr. Lindquist has over thirty years of experience in research and development in both academic and industrial settings. Dr. Lindquist came to UAH in 2003 from Corning's Sullivan Park Research and Development Center where he was a Senior Research Scientist and the Liquid Crystal Technology Manager. At Corning, he invented, developed, and built liquid crystal components that enabled the product launch of Corning's PurePath™ Wavelength Selective Switch and Dynamic Spectral Equalizer. Bob was born in Poughkeepsie, NY and received his Ph.D. in Electrical Engineering from The Pennsylvania State University in 1992. Dr. Lindquist has over 100 publications to his credit and holds 14 patents.

Gary P. Zank, Ph.D.

University of Alabama Board of Trustees Trustee Professor
Aerojet/Rocketdyne Chair in Space Science
Eminent Scholar and Distinguished Professor
Director, Center for Space Plasma and Aeronomic Research (CSPAR)
Professor and Chair, Department of Space Science
The University of Alabama in Huntsville

Dr. Gary P. Zank received his Ph.D. in Applied Mathematics Applied Mathematics from the University of Natal in South Africa in 1987. Dr. Zank is an Eminent Scholar and Distinguished Professor, Director of Center for Space Plasma and Aeronomic Research (CSPAR), Chair of the Department of Space Science (SPA) at The University of Alabama in Huntsville, and the principal investigator for the EPSCoR CPU2AL grant that supports the Joint Space Weather Summer Camp. Dr. Zank has been recognized in his field through the receipt of numerous honors and awards throughout his career. In 2017, he was named the University of Alabama Board of Trustees Trustee Processor, the first and only University of Alabama System faculty member to achieve this position. In part, this was in recognition of Dr. Zank being elected in 2016 as a Member of the US National Academy of Sciences, the only person in Alabama to be a member of this august body. He was recognized internationally in 2015 with the AOGS Axford Medal, the highest honor given by the Asia Oceania Geosciences Society (AOGS). Other awards include his being a Fellow of the American Geophysical Union, the American Physical Society, and the American Association for the Advancement of Science. In 2017, he was also elected an AGOS Honorary Member. One of his publications has been recognized as one of the twelve "classic papers' ever published in the Journal of Plasma Physics. Dr. Zank is dedicated to his research, which is clearly represented in his achievements over the years and categorizes him as a cutting-edge leader in the world of space physics.

Welcome to the

Joint Space Weather Summer Camp 2018

The 2018 Joint Space Weather Summer Camp is a partnership between:

-The University of Alabama in Huntsville (UAH) and the NSF EPSCoR CPU2AL Project: Connecting the Plasma Universe to Plasma Technology in Alabama
-The German Aerospace Center in Neustrelitz (DLR)
-The South African National Space Agency in Hermanus (SANSA)
-The Italian Institute for Space Astrophysics and Planetology in Rome (IAPS-INAF)

In 2011, the University of Alabama in Huntsville signed a Memorandum of Understanding with the University of Rostock and the German Space Agency (the *Deutsches Zentrum für Luft- und Raumfahrt e.V.*, abbreviated DLR, which is the national center for aerospace, energy and transportation research of the Federal Republic of Germany) agreeing to develop a joint collaborative educational and research program. One of the first joint programs to be developed was the Joint Space Weather Summer Camp (JSWSC). This program was initiated by the combined efforts of Gary P. Zank (director of the Center for Space Plasma and Aeronomic Research [CSPAR] at UAH), John Horack (Vice President for Research at UAH), Wolfgang Mett and Holger Wandsleb (members of DLR), and Wolfgang Schareck (the Rector of the University of Rostock). This was originally envisaged as two 3-week sessions, the initial session being held in Neustrelitz, Germany and the second in Huntsville, USA.

The origin of the Memorandum of Understanding is due in large part to the close connection of Huntsville, Alabama with the state of Mecklenburg-Vorpommern in Northern Germany and the city of Peenemunde, being ("Peene [River] Mouth") a municipality on the Baltic Sea. Peenemunde is (in) famous for being the birthplace of modern rocket science, and was where the famed aerospace engineer Wernher von Braun developed the V1 and V2 rockets used by the Germans in World War 2.

After initially being moved to Fort Bliss, Texas, von Braun and his team of rocket engineers was transferred to Huntsville, Alabama. Being in Huntsville, van Braun was largely responsible for the development of the US missile program. In creating the missile program, van Braun initially developed the Redstone Missile based on his work with the V2 missile. His interest in the peaceful and scientific use of rockets never wavered and he was responsible for the use of the Jupiter-C rocket launch of the US's first satellite, Explorer 1, on January 31, 1958. This event signaled the birth of America's space program, which for von Braun culminated in the development of the Saturn V rocket. Von Braun's dream to help mankind set foot on the Moon was realized on July 16, 1969, when Marshall Space Flight Center-developed Saturn V rocket launched the Apollo 11 astronauts on an extraordinary eight-day mission that culminated in the moon-landing by Neil Armstrong, "Buzz" Aldrin and Michael Collins. The Apollo program and the Saturn V rockets developed by von Braun and his MSFC team enabled six teams of astronauts to reach the surface of the Moon.

This close intellectual, engineering, and social connection between Huntsville, AL and the state of Mecklenburg-Vorpommern, the role of von Braun in creating the University of Alabama in Huntsville and the UAH Research Center makes the Memorandum of Understanding a natural bond. The JSWSC held by the UAH's CSPAR and the DLR can be viewed as an inevitable historic collaboration that spans and connects generations across the divide of history, economics, engineering, and humankind's aspirations to reach to the stars. The JSWSC has been supported with enthusiasm by the joint efforts of several Vice-President's of Research, most recently Prof. Ray Vaughn, and CSPAR, both of whom contribute jointly to the program.

The summer camp was a great success from its start, and over the years, the summer camp went through some re-organization and expansion. The program is four weeks long, and in its initial stage (years 2012, 2013, 2014, 2015), the program consisted of two weeks primarily located in Huntsville, AL (UAH), and of 2 weeks primarily located in Neustrelitz, Germany (DLR). Around 10 undergraduate and graduate students from UAH and 10 students from all over Germany participated in the summer program each year. The program is not restricted to these primary locations only, and both parties always made a great effort to make the program interesting and inspiring for students. The German part typically includes visits to participating research institutions, such as the Leibniz-Institute for Atmospheric Physics (IAP) at Kuhlungsborn, the University of Rostock, or the German Research Centre for Geosciences (GFZ) in Potsdam. The US part typically includes a visit to the Oak Ridge National Laboratory in Tennessee, which is one of the largest laboratories in the United States.

Over the years, the South African SANSA Agency started to slowly participate in the program, first by sending 2-3 students to the German part of the camp, and steadily increasing the number of students. In 2016, SANSA organized the full leg of the summer camp in Hermanus, with participating students from South Africa, Germany & UAH, ultimately becoming a 3rd pillar and full-member-organization of the Joint Space Weather Summer Camp. The 2016 JSWSC was organized in Hermanus (South Africa) and Neustrelitz (Germany). The 2017 JSWSC was organized in Huntsville (USA), and in Neustrelitz (Germany). Each of the 3 major institutes participated with 8 students. Importantly, last year, we welcomed the Institute for Space Astrophysics and Planetology located in Rome, Italy.

This year's camp is organized by Huntsville (UAH), sponsored by the NSF EPSCoR CPU2AL project, and Neustrelitz (Germany), sponsored by DLR. We are excited to see what this camp will hold with new adventures and memories to be made.

The camp covers several topics related to space weather, with various introductory lectures in plasma physics, solar physics, heliospheric physics, cosmic ray transport, Earth's ionosphere, and radio emissions from the Sun, numerical simulations, remote sensing and others. In addition to lectures, students work in groups on one of the main projects, where they have direct hands-on experience in analyzing publicly available data from satellites.

The summer camp is much more than just scientific lectures and project work. The camp provides a wonderful opportunity for students to engage in multi-cultural experience with international students from the United States, Germany, South Africa and Italy. Welcome to the JSWSC 2018, and we hope that you will enjoy the program.

The Joint Space Weather Summer Camp is supported by the NSF EPSCoR RII-Track-1 Cooperative Agreement OIA-1655280 and the German Aerospace Center or Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR).

Schedule Week One

Time	Sunday July 15	Monday July 16	Tuesday July 17	Wednesday July 18	Thursday July 19	Friday July 20	Saturday July 21
8:00 - 8:30	**Unwind from Travel**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	Hotel **Breakfast**	Hotel **Breakfast**
9:00 - 9:45		**Summer Camp Introduction**	**Peter Hunana** Fluid Models with Kinetic Effects in Astrophysical Plasmas	**Tae Kim** The Aurorae of Uranus past Equinox & Probabilistic Forecasting of Extreme Space Weather Events	**Navdeep Panesar** Structure and Dynamics of Solar Prominences	**Tour of Oak Ridge National Laboratory** **Make sure you carry Passport / Visa with you to the lab** [arrive by 8:45]	**Nashville***
9:45 - 10:00		Break	Break	Break	Break		
10:00 - 10:45		**Dean Christopher** (College of Science) and **Sabrina Williams** (Director, International Student Recruitment & Processing)	**Dennis Gallagher** Inner Magnetospheric Physics	**Michael Briggs** Terrestrial Gamma-Ray Flashes	**Linda Krause** The Grand Tour of Space Weather: An E-Ticket Ride		
10:45 - 11:00		Break	Break	Break	Break		
11:00 - 12:00		**Alphonse Sterling** Temperature Structure of the Sun	**David Falconer** Active Regions, Flares, CMEs: Drivers of Severe Space Weather	**Ed Buckbee** The Real Space Cowboys	**Monica Laurenza** Impact of Solar Energetic Particles on Earth's Environment	**Lunch in Main Cafeteria from 11:30-12:15***	
12:00 - 13:30	**Welcome Lunch** located at *Grille 29* at 12:30	CRH 1010 **Lunch**	CRH 1010 **Lunch**	CRH 1010 **Lunch**	CRH 1010 **Lunch**		
13:30 - 14:15		**Alabama Credit Union** (ACU)	**Lingling Zhao** Transport of Cosmic Rays in the Inner Heliosphere	**Gary Webb** Conservation Laws in MHD and Fluid Dynamics	**Travel to Oak Ridge National Laboratory**	**Tour of Oak Ridge National Laboratory** [depart by 2:45]	
14:15 - 14:30	**Unwind from Travel**	Break	Break	Break			
14:30 - 15:15		**Jacob Heerikhuisen** The Global Heliosphere and Neutral Atoms	**Vladimir Kolobov** Adaptive Kinetic-Fluid Models for Plasma Simulations	**Ashraf Moradi** Propagation of Solar Energetic Particles in the Interplanetary Magnetic Field		**Travel to Nashville**	
15:15 - 15:30		Break	Break	Break			
15:30 - 16:30		**Unwind from Travel**	**Sarp Yalim** Data-driven Magnetohydrodynamic Modeling of Solar Corona & the Solar Wind/Earth's Magnetosphere Interaction	**Amy Winebarger** Advancing Knowledge of the Coronal Heating Problem Using the Sounding Rocket Platform			
	Dinner located at *Newks* at 18:00 (6:00)	**Dinner***	**Dinner***	**Dinner***	**Dinner** located at *The Double Tree* in Salon C at 18:00 (6:00)	**Dinner** located at *Five Odd Fellow* at 19:00 (7:00)	

Lodging:

The University of Alabama in Huntsville
301 Sparkman Drive
Huntsville, AL 35899
(256) 824-1000

Double Tree - Oak Ridge, Tennessee
215 S Illinois Ave.
Oak Ridge, TN 37830
(865) 481-2468

Embassy Suites- Nashville, Tennessee
1811 Broadway Nashville, TN 37203
(615) 320-8899

Tours:

U.S. Space & Rocket Center
One Tranquility Base
Huntsville, AL 35805
(256) 837-3400

Oak Ridge National Lab
1 Bethel Valley Road
Oak Ridge, TN 37830
(865) 576-7658

Restaurants:

Newks
4925 University Dr.
Huntsville, AL 35816
(256) 430-9662

Cantina Laredo
300 The Bridge Street
Huntsville, AL 35806
(256) 327-8580

Golden Corral
4920 University Drive
Huntsville, AL 35816
(256) 430-9565

Schedule Week Two

Time	Sunday July 22	Monday July 23	Tuesday July 24	Wednesday July 25	Thursday July 26	Friday July 27	Saturday July 28	Sunday July 29
8:00 - 8:30	Hotel **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	CRH 4078 **Breakfast**	**Preparation for Departure**	**DEPARTURE**
9:00 - 9:45	**Nashville***	**Vladimir Florinski** The Guide to Space Magnetofluids	**Parisa Mostafavi** Shock Wave Observations by Voyager 1 and 2	**Tyson Littenberg** The Hunt for Gamma-Ray Counterparts to Gravitational Wave Sources	**Projects**	**Preparation of Presentations**		
9:45 - 10:00		Break	Break	Break		Break		
10:00 - 10:45		**Nikolai Pogorelov** Numerical Modeling of High-speed Flows with Discontinuities.	**Gary Zank** An Overview of Shock Waves throughout the Heliosphere	**Laxman Adhikari** Turbulence Transport in the Solar Wind		**Project Presentations**	**Brunch at Golden Corral**	
10:45 - 11:00		Break	Break	Break				
11:00 - 12:00		**Ed Thomas** Using Complex Plasmas to Study All Four States of Matter	**J.D. Perez** Seeing the Invisible	**Jakobus Le Roux** Basic Aspects of Solar Energetic Particle Transport and Acceleration at Traveling Shocks				
12:00 - 13:30		CRH 1010 **Lunch**	Bridge Street **Lunch**	CRH 1010 **Lunch**	CRH 1010 **Lunch**	CRH 1010 **Lunch**		
13:30 - 14:15		**Projects**	**Projects**	**Projects**	**Projects**	**Preparation for Departure**	**Space and Rocket Center Tour and Movie**	
14:15 - 14:30								
14:30 - 15:15								
15:15 - 15:30								
15:30 - 16:30								
		Dinner*	**Dinner***	**Dinner***	**Dinner***	**Departure Dinner** located at *Dr. Zank's Home* from 17:00 to 20:00 (5:00-8:00)		

* Indicates meal is not provided

All Lectures will be located in CRH 2078

Projects by Dr. Hu and Graduate Student Keyvan Ghanbari will be held in lab CRH 4085

Project by Ms. Adams will be held in CRH 2015 (Department of Space Science Computer Lab)

Projects

The Grad-Shafranov Reconstruction of Magnetic Flux Ropes in Space Plasmas

Led by Dr. Qiang Hu

The students will work with a software package written in Matlab, in the form of a Graphic User Interface, which enables quick and easy analysis of spacecraft observations of one type of transient structures in space. These structures as originated from the Sun, carry along the solar agnetic field which interacts with the Earth's magnetic field and sometimes causes significant disturbances. Thus, to study quantitatively the internal magnetic field configuration of these structures has always been a focus area of current space weather research. The students are expected to be able to successfully run the software package and analyze a few selected events mostly by running through the GUI platform within the Matlab environment. Students will work individually at the beginning and as the project progresses, they will start to work collaboratively on more complex tasks that require certain in-depth analysis. Depending on the students' interest, capabilities and experiences, certain amount of programming, i.e., code writing, might be required.

Requirements: College level physics and math are necessary. No specific programming skills are required. But experience with any programming languages (other than MS Office) or scientific visualization would help.

Cosmic Rays at Corotating Interaction Regions in the Solar Wind

Led by K. Ghanbari, assisted by Dr. V. Florinski

Corotating interaction regions (CIRs) are ubiquitous compressive structures that develop via an interaction between slow and fast solar wind streams. A typical CIR consists of a pair of compression, or shock waves, a stream interface, and may contain a sector boundary separating magnetic fields of opposing polarity. CIRs are known to modulate galactic cosmic rays, a principal component of the space radiation environment in the solar system. This project will involve identifying CIRs in plasma and magnetic field data from solar wind monitoring platforms by detecting stream interfaces and sector boundaries, and subsequently performing superposed epoch analysis of galactic cosmic ray intensities during CIR passages.

Requirements: College level physics and math are necessary. No specific programming skills are required. But experience with any programming languages (other than MS Office) would help.

Finding Coronal Holes

Led by Mitzi Adams, M.S.

The students will examine 193 Angstrom SDO data beginning April 30, 2010 to find coronal holes that are as close to the center of the solar disk as possible and will compile a list of these in a text file. For this work, the students will use this website:

http://www.solarmonitor.org

From the list of equatorial coronal holes, each student will then select one coronal hole to examine for jets over twelve hours, six hours before the coronal hole reaches the disk center and six hours after. Understanding jets in coronal holes is important for understanding how the magnetic field is involved in explosive solar events.

Requirements: The student should be able to use a web browser. Knowledge of Linux and IDL is a plus.

Abstracts

Monday, July 16

Dr. Alphonse Sterling

Temperature Structure of the Sun

We present an overview of the Sun's interior and atmosphere, from the standpoint of it's temperature structure: The core region, where energy is generated via nuclear fusion reactions, is an extremely hot 15 MK; at its visible surface the temperature falls to a comparatively balmy 6000 K; and then, for reasons that are still mysterious, the temperature begins to rise moving radially away from the surface, exceeding several MK in the outer atmosphere, the corona. Our discussion will include scientific aspects and consequences of this temperature structure, and also some historical perspectives on the discovery of that structure.

Dr. Jacob Heerikhuisen

The Global Heliosphere and Neutral Atoms

The heliosphere forms from the continuous injection of solar wind into the galactic environment. The motion of the sun through the interstellar medium creates a heliosphere with a well-defined nose and tail. While the solar and interstellar ions are separated by the heliopause, neutral articles can cross this boundary and collide with ions on either side. In this talk I will introduce the concept of the global heliosphere, show how it is influenced by neutral atoms, and indicate how energetic neutral atoms can be used to probe distant plasma regions.

Abstracts

Tuesday, July 17

Dr. Peter Hunana

Fluid Models with Kinetic Effects in Astrophysical Plasmas

Astrophysical collisionless plasmas are often found in a state with anisotropic temperatures, a state that cannot be addressed with the classical magnetohydrodynamic (MHD) description that employs a scalar pressure. We will present a brief introduction to the simplest fluid models that can account for anisotropic temperatures and that are generalizations of a fluid model developed by Chew, Goldberger and Low, known as the CGL description or the collisionless MHD. We will concentrate on the parallel and oblique firehose instability, which are two out of four basic instabilities that are believed to be crucial for understanding and correct modeling of solar wind dynamics, the other two being the mirror instability and the ion-cyclotron anisotropy instability.

Dr. Dennis Gallagher

Inner Magnetospheric Physics

The terrestrial magnetosphere is that region of space near Earth where the terrestrial magnetic field dominates over the Sun's magnetic field. The outer regions of the magnetosphere are where the solar wind and solar magnetic field interact with Earth's magnetic field and the enclosed plasma. In this region solar wind driven electric currents store energy by distorting Earth's magnetic field and dissipate energy through Joule heating in the ionosphere. The solar wind also applies a large dawn to dusk electric field across the magnetosphere that drives ExB convection throughout the interior and at high latitudes in the magnetic polar regions. Interior of this outer region, the inner magnetosphere is where plasma mostly originating from Earth's upper atmosphere is energized, additional electric currents form, and highly coupled physical processes involving the energetic plasma, cold magnetospheric plasma, the ionosphere, and upper neutral gas atmosphere take place. This presentation will provide an overview of the physical processes taking place in the inner magnetosphere with references suitable for independent exploration of this local astrophysical magnetized planetary environment.

Abstracts

Tuesday, July 17 - *Continued*

Dr. David Falconer

Active Regions, Flares, CMEs: Drivers of Severe Space Weather

As we become ever more reliant on technologies such as GPS and power grids, we also increase our susceptibility to space weather. The most severe space weather is driven by solar flares - especially eruptive flares that produce fast Coronal Mass Ejection (CMEs). Flares and CMEs are powered by explosive releases of energy stored in the coronal magnetic fields, with the biggest events coming from active regions (AR). MAG4 (Magnetogram Forecast) is a fully automated Research-to-Operation (R2O) tool that measures a free-energy proxy from line-of-sight or vector magnetograms. The free-energy proxy is then converted to a predicted event rate using empirically derived forecast curves. The forecast is then made available to The National Oceanic and Atmospheric Administration (NOAA) as well as Johnson Space Center. Besides being a R2O tool, MAG4 can also be used as Operation-to-Research (O2R). It produces a large data set that can be used in studying how to better forecast flares and CMEs, as well as coronal heating. MAG4 was developed to support the astronauts in collaboration with the Space Radiation Analysis Group (SRAG) at the Johnson Space Center, who monitor and reduce the radiation exposure received by astronauts.

Dr. Lingling Zhao

Transport of Cosmic Rays in the Inner Heliosphere

During the recent solar minimum, the intensity of galactic cosmic rays (GCR) measured at the Earth was the highest ever recorded since space age. In order to resolve the most plausible mechanism for this unusually high intensity, we calculated GCR proton energy spectra at the Earth for the last three solar minima based on a simulation of Markov stochastic process. Besides weak IMF magnitude and slow solar wind speed, we find that a possible low magnetic turbulence, which increases the parallel diffusion and reduces the perpendicular diffusion in the polar direction, might be an additional possible mechanism for the high GCR intensity in this unusual solar minimum.

Abstracts

Dr. Vladimir Kolobov

Adaptive Kinetic-Fluid Models for Plasma Simulations

Partially ionized plasma is a collection of charged (electros, ions) and neutral (atoms, photons) particles collectively interacting with electromagnetic fields. The particle transport in plasma can be described by either kinetic or hydrodynamic (fluid) models. Kinetic models provide detailed description in terms of velocity distributions of the particles, which obey the Boltzmann, Vlasov, and Fokker-Planck kinetic equations. The kinetic modeling is done using either statistical particle methods or a direct numerical solution of the kinetic equations employing discrete velocity methods. The fluid models express conservation laws for density, mean velocity and temperature of different plasma species. They describe plasma on a macroscopic level and provide coupling between the particle transport and electromagnetics (Maxwell equations) via electric charge density and currents. The fluid equations are easier to solve but have limited range of applicability.

In this lecture, we will describe the development of hybrid kinetic-fluid models combining the accuracy of kinetic solvers with the efficiency of fluid models. This is particularly important for plasma, which is characterized by a wide range of temporal and spatial scales due to the disparity of electron mass and the masses of heavy species (ions, atoms). The research challenges in this field are associated with identifying correct criteria for selecting appropriate models (which are different for electrons, ions, atoms, and photons), closure of fluid models for collisional and collisionless plasmas, coupling kinetic and fluid solvers at interfaces (which can dynamically evolve), and implementing these hybrid algorithms into smart software for practical plasma engineering on modern computing systems.

We will also demonstrate how hybrid method can be applied for space and laboratory plasma. Low temperature plasma is among the top technologies of the XXI century. It forms the foundation of microelectronics, material processing, nanotechnologies and has emerging applications in biomedical, agriculture and food safety industries. We will illustrate how computer simulations of low temperature plasma can help design plasma devices and processes.

Dr. Sarp Yalim

Data-driven Magnetohydrodynamic Modeling of Solar Corona and the Solar Wind/Earth's Magnetosphere Interaction

The solar wind which is the plasma emerging from the Sun is the main driving mechanism of the solar storms which can lead to geomagnetic storms that are the primary causes of the space weather disturbances that affect the magnetic environment of the Earth and can have hazardous effects on the space-borne and ground-based technological systems as well as human health. Therefore, accurate modeling of the solar wind is very important in order to be able to understand the underlying mechanisms of solar storms.

In this presentation, I present results of a data-driven magnetohydrodynamic (MHD) model of solar wind in the solar corona and time-dependent 3D data-driven global MHD simulations of the solar wind interaction with the Earth's magnetosphere using time-varying data from the NASA Advanced Composition Explorer (ACE) satellite during a few big geomagnetic storm events of previous solar cycles, namely the 06 April 2000, 20 November 2003 and 05 April 2010 storms. I introduce a numerical magnetic storm index and compare the geo-effectiveness of these events in terms of this storm index which is a measure for the resulting global perturbation of the Earth's magnetic field.

Abstracts

Wednesday, July 18

Dr. Tae Kim

The Aurorae of Uranus past Equinox

The aurorae of Uranus were recently detected in the far ultraviolet with the Hubble Space Telescope (HST) providing a new, so far unique, means to remotely study the asymmetric Uranian magnetosphere from Earth. We analyze here two new HST Uranus campaigns executed in September 2012 and November 2014 with different temporal coverage and under variable solar wind conditions numerically predicted by three different MHD codes. Overall, the HST images taken with the Space Telescope Imaging Spectrograph reveal auroral emissions in three pairs of successive images (one pair acquired in 2012 and two in 2014), hence 6 additional auroral detections in total, including the most intense Uranian aurorae ever seen with HST. The detected emissions occur close the expected arrival of interplanetary shocks. They appear as extended spots at southern latitudes, rotating with the planet. They radiate 5-24 kR and 1.3-8.8 GW of ultraviolet emission from H_2, last for tens of minutes and vary on timescales down to a few seconds. Fitting the 2014 observations with model auroral ovals constrains the longitude of the southern (northern) magnetic pole to 104 ± 26° (284 ± 26°) in the Uranian Longitude System. We suggest that the Uranian near-equinoctial aurorae are pulsed cusp emissions possibly triggered by large-scale magnetospheric compressions.

Probabilistic Forecasting of Extreme Space Weather Events

The occurrence rates of extreme space weather events, such as the Carrington Event of 1859, are very difficult to estimate due to their rarity. However, statistical methods may be used in conjunction with available space physics data to derive reasonable estimates of the probability of occurrence of extreme space weather events. In one approach, an inverse power law relationship between the frequency of data and the severity of events is extrapolated to higher magnitudes to estimate the probability of a Carrington-type event occurring within the next decade to be ~12%. Such statistical technique contains limitations due to many simplifying assumptions and cannot be used for prediction of specific events. However, it may be useful for policy making and risk analysis.

Dr. Michael Briggs

Terrestrial Gamma-Ray Flashes

Terrestrial gamma-ray flashes are bright, sub-ms flashes of gamma-rays observed from orbit. The gamma-rays are produced from bremsstrahlung from electrons that are accelerated in thunderstorms. An uncommon type is detected via electrons and positrons instead of gamma-rays. TGFs are associated with intra-cloud lighting. Ground-based radio observations of radio emission from lighting and TGFs provide more information, including more accurate locations. With these locations, specific storms that produce TGFs are identified. A wide range of thunderstorms, including very ordinary ones, are found to produce TGFs. Relativistic particle acceleration is a common atmospheric phenomena.

Dr. Gary Webb

Conservation Laws in MHD and Fluid Dynamics

Examples of conservation laws in magneto-hydrodynamics (MHD) and fluid dynamics are discussed. In particular, the role of vorticity and potential vorticity and helicity in MHD and fluid dynamics will be studied. The main emphasis will be in deriving the conservation laws by elementary means. We note briefly the connection between conservation laws and Lie symmetries of the equations and Noether's theorems, but this will not be the main emphasis of the talk.

Abstracts

Ashraf Moradi

Propagation of Solar Energetic Particles in the Interplanetary Magnetic Field

Solar Energetic Particles (SEPs) travel along the field lines. Ulyssess observations during impulsive events did not show any significant change in the density of SEPs from lower to higher latitudes. Possible explanations can be that the field lines are not Parker anymore. There have been many attempts to introduce new models for interplanetary magnetic field that extend from lower to high latitudes. Since the magnetic field lines are shaped by the footpoint motion in the photosphere which is not static and there are many different surface flows that lead to meandering of the field lines that make the fields access different latitudes. In this study, we consider fluctuating field lines that are caused by the motions of the footpoints and follow the trajectories of test particles and drifts from the initial Parker lines for different latitudes and different surface flow parameters.

Dr. Amy Winebarger

Advancing Knowledge of the Coronal Heating Problem Using the Sounding Rocket Platform

Marshall Space Flight Center have recently launched or have in development three instruments that address the coronal heating problem that will utilize the sounding rocket platform. The High-resolution Coronal Imager (Hi-C) was launched in 2012, 2016 and 2018. Hi-C achieved the highest resolution images of the solar corona. The Chromospheric Lyman-Alpha Spectropolarimeter (CLASP) was launched on September 3, 2015. The scientific goal of CLASP was to detect scattering polarization in the Lyman-alpha line and use the Hanle effect to infer the chromospheric magnetic field. The Marshall Grazing Incidence X-ray Spectrometer (MaGIXS) is currently in development for a 2019 launch. The goal of MaGIXS is to determine the frequency of heating in active region cores. In this talk, I will discuss the scientific motivation for each instrument, review the initial results from flight data, and give the future development plans. I will also discuss the development of a low-noise camera suitable for sub-orbital flights.

Abstracts

Thursday, July 19

Dr. Navdeep Panesar

Structure and Dynamics of Solar Prominences

Solar prominences are spectacular features. They are highly dynamic, and consist of relatively cool and dense material compared to the surrounding corona. On the solar limb, they appear as huge sheets of plasma, extending up to heights of several hundreds of Mm above the chromosphere. They are referred to as filaments on the solar disk. Prominence plasma is embedded in the dips of helical magnetic fields. High resolution observations are needed for a better understanding of prominence structure and for verifying theoretical models. In this talk, I will present the results of 3D observations (SDO and STEREO views) of three different types of prominences: 1. We investigate flows in a polar crown prominence observed by SDO on the limb, and find upflows originating from on-disk brightenings seen in STEREO images. 2. We investigate the triggering mechanism of a giant solar tornado, and suggest that the tornado is the dynamical response of the helical prominence field to expansion of the overlying coronal field (cavity). 3. We diagnose the dynamics of a prominence/filament cavity system during a series of eight homologous flares. The repeated homologous flares gradually destabilized the prominence/filament system, removed the coronal field above the active region, leading to the CME via the 'lid removal' mechanism.

Dr. Linda Krause

The Grand Tour of Space Weather: An E-Ticket Ride

What is the difference between Space Science and Space Weather? Well, it is a lot like the difference between atmospheric dynamics and what you would see on the Weather Channel. In order to understand and predict tropospheric (i.e. "normal") weather, it is important to understand atmospheric dynamics behind it, but that isn't enough to predict it. This is why we have the discipline of meteorology: a field of expertise that studies atmospheric processes relevant to weather and uses that knowledge to develop tools for prediction. Also, whereas atmospheric dynamics is interesting for its own sake, meteorology is focused on understanding specific processes that affect various aspects of societal life. Finally, as increased understanding is obtained, a network of sensors and computer models are used to produce and disseminate weather predictions. And, voilà! We have the Weather Channel! Space weather is similar to tropospheric weather in these ways. In this talk, we will take a rip-roaring tour of the space environment from the Sun to the Heliopause (the edge of our solar system!) Next, we will cover an overview of different types of Space Weather storms. We'll see how these storms affect societal life. Finally, we'll take a look at diagnostic methods, missions, and models all working together to improve our understanding of the space environments and relevant physics-based processes - all working toward the ability to predict Space Weather. Who knows… maybe one day, we will have our very own Space Weather Channel!

Dr. Monica Laurenza

Impact of Solar Energetic Particles on Earth's Environment

Energetic particles constitute an important component of the heliospheric plasma environment. In particular, solar energetic particles (SEPs) generated at the Sun, affect the whole Heliosphere and are responsible for a variety of Space Weather effects. The major characteristics of SEP events are described including their association with flares and coronal mass ejections (CMEs), their ion composition and energy spectra as well as the physical processes responsible for their acceleration and transport. Finally, SEP events are discussed in a Space Weather perspective.

Abstracts

Monday, July 23

Dr. Vladimir Florinski

The Guide to Space Magnetofluids

Much of interplanetary and interstellar matter exists in the plasma state, where charged particles are not interacting with each other via collisions, but move collectively in what resembles the motion of a highly conductive fluid. Cosmic magnetic fields provide the “glue” that makes plasma behave like a medium, rather than a collection of non-interacting particles. This presentation will review the fundamental physical principles governing the evolution of a magnetofluid and provide examples of dynamical phenomena in the solar wind. Small amplitude waves, simple equilibrium structures, and different classes of discontinuities will be discussed.

Dr. Nikolai Pogorelov

Numerical Modeling of High-speed Flows with Discontinuities.

The subject of computational science is formulated with the emphasis of the relation between the physics of a problem and the choice of a numerical method. This includes the choice of coordinate systems, knowledge about uniqueness and existence of solutions, and their stability. Examples start with a simple approximation of a convection equation and extend to aerodynamics, astrophysics, and space physics applications. All these examples have one common feature: they are governed by hyperbolic systems of equations and therefore prone to formation of discontinuities. The importance of testing and validation of numerical models is discussed.

Dr. Ed Thomas

Using Complex Plasmas to Study All Four States of Matter

Plasmas (or ionized gases) are often referred to as a “fourth” state of matter – but perhaps, they should be the “first”. This is because the plasmas are the most common state (over 95%) of matter in the visible universe. From technologies such as fluorescent lighting and microelectronics manufacturing to natural systems such as lightning, the Aurora, and the solar wind, plasmas are ubiquitous in our lives. Even more remarkably, over the last three decades plasma scientists have learned how to control a certain type of plasma – a “complex” or “dusty” plasma – to make it have solid-like, fluid-like, or gas-like properties. This means that dusty plasmas are not just a fourth state of matter – they can take on the properties of all four states of matter. This presentation will provide an introduction to the physics and applications of plasmas and will describe some of the fascinating aspects of complex/dusty plasma research. This presentation will also highlight a broad range of research opportunities in plasma physics, condensed matter physics, and atomic physics in the Auburn University Physics Department.

Abstracts

Tuesday, July 24

Parisa Mostafavi

Shock Wave Observations by Voyager 1 and 2

Voyager 1 and 2 were launched over 40 years ago. Voyager 2 observations of heliospheric termination shock (HTS) crossing showed that the HTS is mediated by energetic pickup particles. On 25 August 2012, Voyager 1 made history and entered the local interstellar medium region, and it is now making in situ measurement for the first time ever of the interstellar medium. A remarkable discovery made by Voyager 1 was to identify shock waves in the interstellar space. The interstellar shocks are remarkable and have different properties than shocks inside the heliosphere. There was no accepted theoretical explanation for the structure of the observed interstellar shocks. We have developed a theory describing the structure of interstellar shocks. We have discovered that the interstellar medium is collisional with respect to the thermal plasma. Firstly, this talk will cover a summary of the Voyager 1 and 2 missions and their discoveries. Then I will show that the very puzzling observations of the unusually broad structure of interstellar shocks observed in situ by Voyager 1 can be explained very well by our theory.

Dr. Gary P. Zank

An Overview of Shock Waves throughout the Heliosphere

Collisionalless shocks are one of the fundamental plasma processes in the heliosphere, representing both a fundamental dissipation process and a mechanism for accelerating particles to high energies. In this necessarily brief survey, we will address four topics.

1) A brief review of the dissipation processes at quasi-perpendicular and quasi-parallel shocks will be presented, including the acceleration of particles at shock waves.
2) We will discuss briefly planetary bow shocks, distinguishing between the physics governing magnetized and unmagnetized solar system bodies.
3) Interplanetary shocks and the role of the inhomogeneous solar wind and gradual solar energetic particle events will be discussed.
4) The structure and physics of the heliospheric termination shock will be discussed.

Dr. J.D. Perez

Seeing the Invisible

The Earth's magnetosphere is formed by the interaction between the wind from the Sun and the Earth's magnetic field. Energy and mass are transported from the solar wind through the magnetosphere to the Earth's ionosphere which can influence wave transmission and satellite communications. For the past 18 years, satellites have been imaging this formerly invisible region surrounding the Earth. Space plasma scientists in Auburn University's Physics Department have played a key role in interpreting these images and producing a new understanding of this important region around the Earth. We will discuss the measurements, the analysis, and the discoveries that have resulted.

Abstracts

Wednesday, July 25

Dr. Tyson Littenberg

The Hunt for Gamma-Ray Counterparts to Gravitational Wave Sources

NASA's Fermi Gamma-ray Space Telescope is the most prolific observatory of high-energy transient sources in operation. Owing to its wide field of view and broad energy coverage, the gamma-ray burst monitor (GBM) onboard Fermi is ideally suited to monitor the sky for flashes of high-energy light coming from gravitational wave events detected by the LIGO/Virgo network. This talk will introduce the Fermi GBM instrument, broadly survey GBM's role in gravitational wave follow-up, and delve into the spectacular multi-messenger observations of the binary neutron star merger GW170817 and associated gamma-ray burst GRB 170817A.

Dr. Laxman Adhikari

Turbulence Transport in the Solar Wind

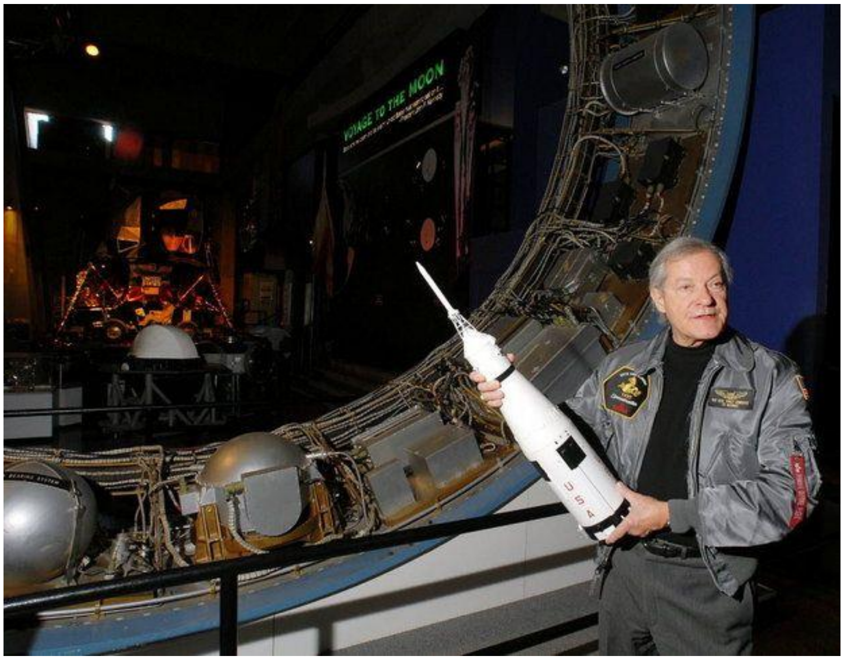
Turbulence is an universal phenomenon and exists everywhere in the solar wind. Turbulence is thought to be responsible for several important phenomena in the solar wind such as coronal and solar wind heating, acceleration of the solar wind, scattering of the solar energetic particles and so forth. In understanding these phenomena, it is required to understand the transport of low-frequency turbulence in the solar wind. Three types of source of turbulence are considered which drive turbulence in the heliosphere. It is also thought that shocks, which are common in the solar wind, are responsible for the generation of turbulence. We study turbulence in the solar wind and in the upstream and downstream shock by solving 1D turbulence transport model equations obtained from the Zank et al 2012. We compute several turbulent parameters such as the energy in forward and backward propagating modes, the normalized residual energy and cross-helicity, the fluctuating magnetic and kinetic energy, the correlation lengths corresponding to forward and backward propagating modes and the residual energy, the solar wind temperature and so on. We compare our theoretical results with Voyager 2, Ulysses, IMP, ACE, and WIND spacecraft data sets, and find that our theoretical results are in reasonable agreement with observations.

Dr. Jakobus Le Roux

Basic Aspects of Solar Energetic Particle Transport and Acceleration at Traveling Shocks

It is generally understood that the highest energy solar energetic particles (SEPs) which pose a threat to astronauts are produced at extremely fast coronal mass ejection driven shocks propagating between the Sun and Earth. A certain class of sophisticated numerical models of SEP transport and acceleration at traveling shocks in the solar wind plasma is fundamentally based on the single particle guiding center theory of charged particle motion in slowly varying electromagnetic fields. Therefore, in this presentation the following material will be presented: (i) The different basic motions of single charged particles in uniform and non-uniform electric and magnetic fields, and their unification in single particle guiding center theory, (ii) the close connection between this guiding center theory, and the guiding center kinetic and focused transport equations for a distribution of charged particles, (iii) the many different ways that SEPs can gain energy at a traveling shock on the basis of focused transport theory, and (iv) examples of idealized solutions of the time-dependent focused transport model for SEP acceleration at a fast planar shock propagating between the Sun and Earth.

Special Guest



Ed Buckbee

Remembering the Real Space Cowboys

The Soul of an Explorer Lives In Us All!

Over fifty years ago, Alan Shepard climbed aboard a Huntsville-developed Mercury Redstone rocket and blasted off from Cape Canaveral to become the first American to ride in a rocket. That was the beginning for U.S. manned space flight. He had been selected to train with America's first astronauts—John Glenn, Wally Schirra, Gordon Cooper, Gus Grissom, Scott Carpenter and Deke Slayton -- who accepted their country's call to service and would become known as the Mercury 7. These men who had jockeyed for the best flying jobs in the military, began competing for rides on rockets. Most would eventually vie for the ultimate ride to the moon. This was the dream—a chance to ascend to the top of the pyramid—a lion-hearted pilot's deepest desire. Ed Buckbee, who has enjoyed a 50+ year association with the U.S. space program, follows these brave pioneers. From Alan Shepard's sub-orbital flight to the last man to walk on the moon, Gene Cernan, Buckbee covers all the manned missions of that era. Through time and personal friendships, he captures their dreams of flying higher, faster and farther than anyone in the known universe. You are taken behind the scenes to witness the competition between chimpanzees and astronauts and the conflict between NASA engineers designing capsules and those who would pilot them. They were our first astronauts. The path they blazed now shines for others; on a voyage that is a measure of the best in us all. The Mercury 7 astronauts were the first, the bold, and the brave. They had the right stuff. They were The REAL Space Cowboys.

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

1. ELC Early Learning Center
2. NCH North Campus Residence Hall
3. FFH Frank Franz Hall
4. MOR Morton Hall
4a. Studio 106/Black Box Theatre
5. UGG Union Grove Gallery and Meeting Hall
6. SPR Spragins Hall
7. ROB Roberts Hall
7a. Roberts Recital Hall
8. CTC Conference Training Center
8a. Exhibit Hall
9. CCH Central Campus Residence Hall
10. BEV Bevill Conference Center & Hotel
11. NUR Nursing Building
12. LIB M. Louis Salmon Library
13. Amphitheater
14. WIL Wilson Hall/Disability Support
14a. Wilson Theatre
15. DDC D.S. Davidson Invention to Innovation Center (I²C)
16. BAB Business Administration Bldg
16a. Chan Auditorium
17. UFC University Fitness Center
18. IMF Intermodal Parking Facility
18a. Public Safety
19. CGU Charger Union/Campus Visits
20. SST Shelby Center for Science and Technology
21. Fraternity/Sorority Row
22. SCH Southeast Campus Housing
23. Charger Village Food Court
24a. CGV Charger Village I
24b. CGV Charger Village II
25. ACU Alabama Credit Union
26. University Greenway
27. SSB Student Services Building/Admissions
28. CRH Robert "Bud" Cramer Research Hall (National Space Science and Technology Center and NOAA Weather Forecasting Office)
29. SWI SWIRLL (Severe Weather Institute Radar and Lightning Laboratories)
30. CGP Charger Park
31. OPB Optics Building
32. MSB Materials Science Building
32a. McDonnell Douglas Auditorium
33. ENG Engineering Building
34. VBH Wernher von Braun Research Hall
35. VBH Annex
36. PPB Physical Plant Building
37. REC Central Receiving and Shipping
38. JRC Johnson Research Center
39. Propulsion Research Lab
40. LRH WLRH Radio Station
41. BSB Business Services Bldg./Copy Center
42. SKH Shelbie King Hall
43. OKT Olin B. King Technology Hall
43a. Oak Ridge-Huntsville Partnership
44. UPK University Park