Solar Physics Division of the American Astronomical Society

The Coronal Courant

Shining Light on the Sun

Volume 1, Issue 1 October 26, 2009

Why We Study the Sun

There are many reasons why we study the Sun, but foremost amongst these is almost certainly scientific curiosity and the thrill of discovery. As scientists we are captivated and fascinated by the Universe we live in and we're curious as to how it works. The Sun is just one of many examples of complex and dynamic objects for study. For those of us who do study the Sun there are three big questions we seek answers to: How is the 11-year cycle of activity produced? How are solar eruptions produced and triggered? and, How is the solar corona heated and solar wind accelerated? Almost without exception, even the smaller questions we seek to answer are related to one or more of these three big questions.

Scientific curiosity about the Sun also extends to the Sun as a star and to other basic questions in physics and astrophysics. The Sun is the star by which all other stars are measured. It is the only star close enough to reveal details about its structure and dynamics. By measuring the age of the Earth and meteorites we set the age of the Sun which is used to calibrate stellar evolution models. By measuring the oblateness and internal rotation of the Sun we help to constrain theories of gravitation that predict the advance of the perihelion of Mercury's orbit. By measuring neutrinos from the Sun we help to constrain theories of elementary particle physics. And the list goes on.

Scientific curiosity is not, however, the only reason to study the Sun.

There are three big questions we seek answers to:

- *How is the 11-year cycle of activity produced?*
- *How are solar eruptions produced and triggered?*
- *How is the solar corona heated and solar wind accelerated?*

Solar activity and solar variability have real social and economic impacts on humankind. Solar activity can disrupt communications, interrupt electric power distribution, incapacitate or destroy satellites, and injure humans in space. Solar variability affects terrestrial climate in ways that are still not fully understood. These practical and socially significant problems are added incentives for studying the Sun.

As an undergraduate and first year graduate student my primary interest was in stellar structure and evolution. That was at a time when the existence of black holes was an open question and the final stages of the evolution of massive stars were highly uncertain. Until I was introduced to solar physics at the University of Colorado, I had thought of the Sun as a rather mundane and uninteresting star. This couldn't have been further from the truth. For thirty years now I have jumped (OK, rolled) out of bed every morning eager to make new discoveries about this most fascinating object and, incredibly, I can get paid to do it!

Those new to solar and heliospheric physics should have no problem finding interesting and rewarding problems to tackle. Those of us who have been at it for decades have uncovered more than we started with.

David Hathaway
NASA/Marshall

See David Hathaway's Solar Physics Educational website at:
http://solarscience.msfc.nasa.gov

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We're on the Web!
http://spd.aas.org

MISSION STATEMENT

The Coronal Courant is a newsletter for students. The target audience will be both students within the solar community as well as students with no access to solar physics education. We hope to serve the more advanced undergraduates and graduate level students who have started to build specific interests and expertise, as well as students from high school level on up through early undergraduate years where students may not have declared their interests yet.

The purpose of this newsletter is to provide scientific and technical articles, descriptions of the scientific experience, news and announcements pertaining to students, career information, listing of student activities (student talks, papers, summer projects, and theses), mission and satellite descriptions, data analysis and modeling techniques, a picture gallery, web link directories, fun stuff, and whatever else people want to submit. In other words, we offer a little of this, a little of that, and something for everyone!!!

Both faculty and students are invited to submit to the newsletter.

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<u>The Making of a Scientist - *Part I*</u>

Loren W. Acton, Research Professor of Physics

B.S., MSU, '59, Engineering Physics
Ph.D., U. Colo., '65, Astro-Geophysics

Henry David Thoreau in "Walden" writes,

> *I have lived some thirty years on this planet, and I have yet to hear the first syllable of valuable or even earnest advice from my seniors. They have told me nothing, and probably cannot tell me anything to the purpose. Here is life, an experiment to a great extent untried by me; but it does not avail me that they have tried it. If I have any experience which I think valuable, I am sure to reflect that this my Mentors said nothing about.*

Taking this insight to heart, this essay is not intended as advice or career guidance. Rather, I offer a friendly, personal story about an old guy who "made good" in science --- a story that I hope you may find interesting.

OFF TO MONTANA STATE

During the summer of 1955 I worked for the U.S. Army Corps of Engineers on an airbase construction project outside Anchorage, AK. Having already decided to attend Montana State College (MSC in those days), I dropped in to visit my oldest brother Winston in Vancouver, WA on the way to Bozeman. Win graduated from MSC in EE in 1950 under the GI bill and made his career with the Bonneville Power Administration. During that short visit we had what turned out to be the most significant conversation of my professional life.

Our chat started with a totally predictable conversation between oldest and youngest brothers: "What do you intend to study?" Upon my explaining that I planned to matriculate to MSC in Mechanical Engineering, Win thought a moment before responding with a surprising question, "Why don't you take physics? It's harder." His logic was good. As a beginning freshman without definite plans and career goals, my taking the hardest course of study in my general area of interest would keep open the most options as I advanced in my academic studies.

I found that I enjoyed learning "the way things work" from the perspectives of physics and math.

I took my brother's advice, registered in Engineering Physics at MSC – and thereby hangs this tale. I found that I enjoyed learning "the way things work" from the perspectives of physics and math. The subjects were not that hard after all, and the department was a good academic home for an undergraduate. For me, the most difficult course, grade-wise, was physical education. Skill at sports is not one of my inherent assets.

Summer jobs were critically important, both educationally and fiscally. In the 50's a male student in science could earn about enough to attend MSC for nine months if supplemented by scholarships. In the summer of 1956 I returned to the Yukon in central

Physics picnic, circa 1957. Left to right, Arthur. J. M. Johnson, department head, and professors Georgeanne Caughlin, Hack Arroe, and Roy Wiegand. Lady on the right unknown.

Alaska as a soils tester on another airbase construction job. The summer of 1957 was spent mapping neutron fluxes in the Experimental Test Reactor Critical Facility at the nuclear test facility near Arco, ID. This experience convinced me that I wanted a career a bit "closer to nature" than reactor physics, which was a popular career choice for physics graduates at that time.

Before my junior year I married a lovely young woman, Evelyn, who was a Bozeman native. Income from her work put me through my last two years at MSC. Was this a good choice or what? (Fifty-two years later we both remain convinced it was the right move.) Prof. John Hearst, head of the Math Department and one of my professors, did not approve. I got my only C in math that term for not turning in enough homework, even though I aced the final- - - a small price to pay for a good lifetime partner!

I wanted a career a bit "closer to nature" …

As graduation approached, the pressing question of "what next" filled my field of view. I had applied for an NSF fellowship for graduate studies without success. One day I noticed on the physics bulletin board a 3x5 card announcing a new graduate fellowship offered by the University Committee for Atmospheric Research, funded at $4000 per year by the Alfred P. Sloan Foundation. In 1958 that was BIG MONEY for a graduate fellowship, and the topic was closer to nature. Of course, I knew practically nothing about the jargon of atmospheric or sun-earth physics, certainly not enough to write a good application for this fellowship. This is where the Physics Department really came through for me.

One of the physics professors, Prof. Kurt Rothschild, agreed to teach an undergraduate seminar on atmospheric/ionospheric physics. As I recall, three of us worked together intensively for a quarter. Even though the library resources at MSC were limited, I learned enough to write an application that won the UCAR fellowship. After a visit I decided to attend the University of Colorado in Boulder, which had a small but active program in astro-geophysics. It was a good decision. Once again a chance occurrence, seeing the small announcement about the UCAR fellowship, set the course for future science and adventure.

Next Issue:

University of Colorado, and another unexpected turn of events.

Once again a chance occurrence … set the course for future science and adventure.

Tackling the Quandary: Elucidating the Relationship Between Coronal Waves and Coronal Mass Ejections

Dr. Gemma Attrill, Post-doctoral Researcher
Solar and Stellar X-Ray Group (SSXG)
Harvard-Smithsonian Center for Astrophysics

Abstract:

An aspect of the Solar and Stellar X-Ray Group's (SSXG's) work concerns solar eruptions called coronal mass ejections (CMEs). This article discusses some of the recent research on the low-atmospheric signatures of CMEs conducted by Dr Gemma Attrill and Dr Meredith Wills-Davey, as well as work undertaken in conjunction with Solar REU '09 students Joel Leja of (UC-Berkeley) and James Robertson (University of Michigan).

Introduction:

Explosions from the Sun

Coronal mass ejections (CMEs) are gigantic ejections of plasma (typically 10^{15-16} g) and embedded magnetic flux (10^{20-22} Mx) that originate from the lower solar atmosphere (the "corona"), and are expelled (at a wide range of velocities from <100 to >3000 km s^{-1}) into the interplanetary medium. CMEs are most generally observed by space-borne coronagraphs (essentially artificial eclipses), since the bright surface light from the photosphere must be blocked to observe the faint and tenuous corona. The morphology of CMEs varies, but they can be described as a bubble-shaped ejection of coronal material (see Figure 1).

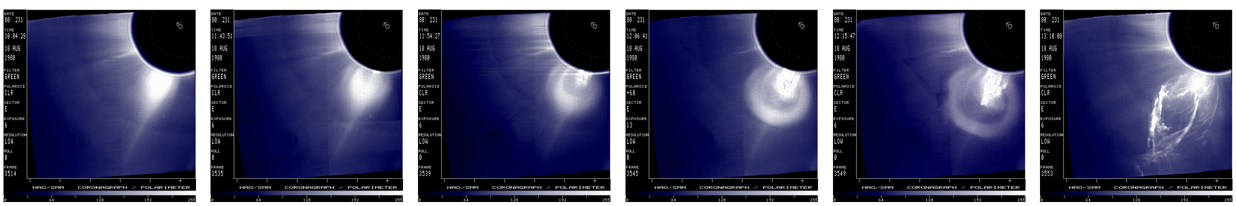


Figure 1: A coronal mass ejection (CME) captured by the Solar Maximum Mission white-light coronagraph. The black disk is the coronagraph occulting disk.

CMEs were first discovered in 1973 with a coronagraph on-board the Orbiting Solar Observatory OSO-7, and further observations were made by Skylab that same year. The frequency of CMEs is related to the solar cycle (which has a period of roughly 11 years), and they range from one every few days at solar minimum to about three per day at solar maximum. Many details of the CME initiation process are still not well understood, but most theoretical models generally assume that CMEs are initiated as a result of magnetic energy release due to instability or loss of equilibrium.

CMEs and Space Weather

"Space weather" is a term used to describe the effects of solar-generated magnetic fields and high-energy particles on the heliospheric environment. While the most constant source of space weather is the solar wind, CMEs make a significant, if intermittent, contribution. Earth-directed CMEs in particular have the potential to greatly impact the near-Earth space environment. CME-driven shocks can accelerate charged particles to high energies, and when a CME interacts with the Earth's magnetic shield (magnetosphere), they have the possibility to produce intense geomagnetic storms. These geomagnetic disturbances create beautiful aurora, but they can also disrupt and destroy satellite communications (e.g. instrumentation in orbiting satellites can be degraded and damaged by high-energy particle impacts; they cause major disruptions in radio traffic; and, by inducing electric currents along power lines, they have the ability to materially damage power stations, which may result in long-term blackouts). Predicting when and how such solar storms occur is clearly a priority in our modern technologically dependent world.

Connecting CMEs to their coronal origins:

Clues to the early stages of CME development

Due to the incredibly high temperatures of the solar corona (millions of Kelvin), the primary emission of the solar atmosphere is at high-energy, short wavelengths such as X-rays and the Extreme Ultra-Violet (EUV). We have to go to space to make observations in the EUV and X-rays, since (fortunately for us!) Earth's atmosphere absorbs light at these wavelengths (see Figure 2).

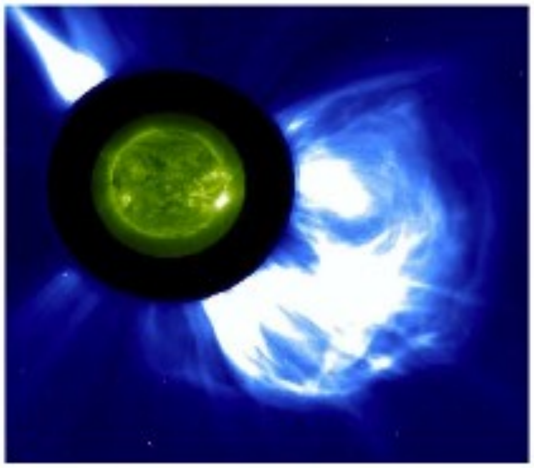


Figure 2: A coronal mass ejection observed by the LASCO/C2 white-light coronagraph on board SOHO, which was launched in 1995. The C2 occulting disk (shown in black), blocks the bright surface (the "photosphere") enabling us to observe the faint outer atmosphere. At the same time, the lower, hotter atmosphere (the "corona", shown here in green), is observed in EUV by SOHO/EIT.

We primarily use three space-borne instruments to image the global solar corona:

(i) the Extreme ultra-violet Imaging Telescope (EIT) on board the Solar and Heliospheric Observatory (SOHO). SOHO was launched in 1995 and orbits the L1 Lagrangian point;

(ii) the Extreme Ultra-Violet Imagers (EUVI) on board the Solar and Terrestrial Relations Observatory (STEREO). STEREO was launched in September 2006 and consists of two identical spacecraft, one in an orbit slightly smaller than Earths, and the other in one slightly larger, so that the two spacecraft move gradually further ahead and behind of the Earth. The separation of the two STEREO spacecraft increases by 22 degrees each year;

(iii) the X-Ray Telescope (XRT), on board the *Hinode* spacecraft (a Japanese-UK-US) mission, also launched in September 2006. *Hinode* occupies a Sun-synchronous orbit around the Earth, at an altitude of about 600 km.

When we study EUV observations of the lower corona, they reveal two (often global-scale), dynamic phenomena closely linked to the origins of CMEs: "coronal waves" and "dimmings".
Connecting CMEs to their origins in the low corona is an active area of work.

Coronal Waves

Coronal waves appear as a bright front of enhanced EUV emission, expanding away from a source region. Processed "differenced" images are used to study coronal waves because they are often too subtle to easily detect in raw data. "Running difference" images - where each image has the previous frame subtracted - may be used to show the location of a disturbance, (see Figure 3), whilst "base difference" images - where instead a pre-event image is subtracted from all subsequent images - must be used to show real enhancements in intensity (brightenings) and depletions (dimmings).

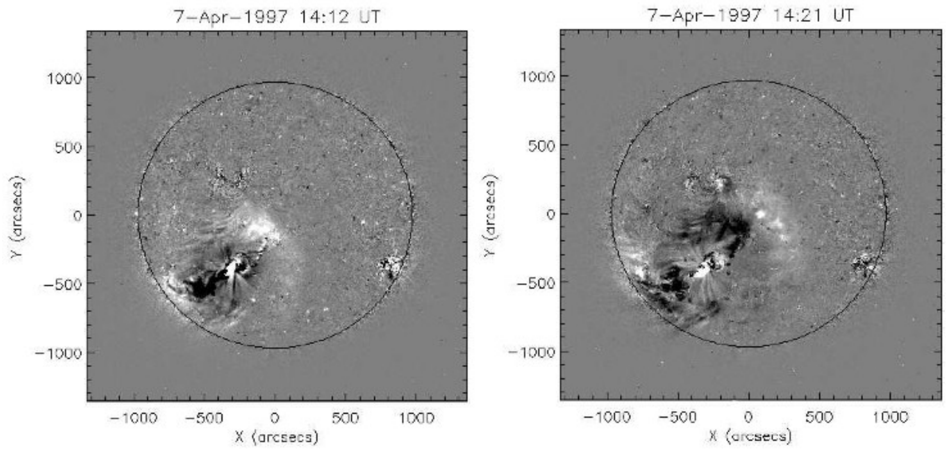


Figure 3: Running difference images of the EUV corona, as observed by SOHO/EIT, showing a global coronal wave.

Research has established that there is a strong statistical connection between coronal waves and CMEs (Biesecker et al. 2002), although there is a lack of consensus concerning the physical nature of the relationship. More than a decade after their initial discovery, their physical nature continues to be hotly debated; multiple theories interpret these events as various types of magnetohydrodynamic (MHD) waves, and non-wave hypotheses explain the bright fronts using mechanisms including electric currents, pressure increases and heated, dense plasma.

Coronal Dimmings

Coronal dimmings are generally observed as intensity decreases in soft X-rays and EUV data. They can appear relatively suddenly, on timescales of minutes (see Figure 4). At present, there is strong evidence to suggest that the observed dimming is due to density depletion caused by an evacuation of plasma, as the local magnetic field expands out into interplanetary space during a CME. Spectroscopic measurements provide evidence of outflows from coronal dimming regions, and comparison of multi-wavelength data showing that dimmings are observable across multiple temperatures. We primarily use base difference data to study coronal dimmings.

Although plasma evacuation is a widely accepted interpretation of the dimming signature, it should be noted that a decrease in intensity in coronal plasma may alternatively be caused by either heating or cooling out of the range of temperatures observed in a narrow passband.

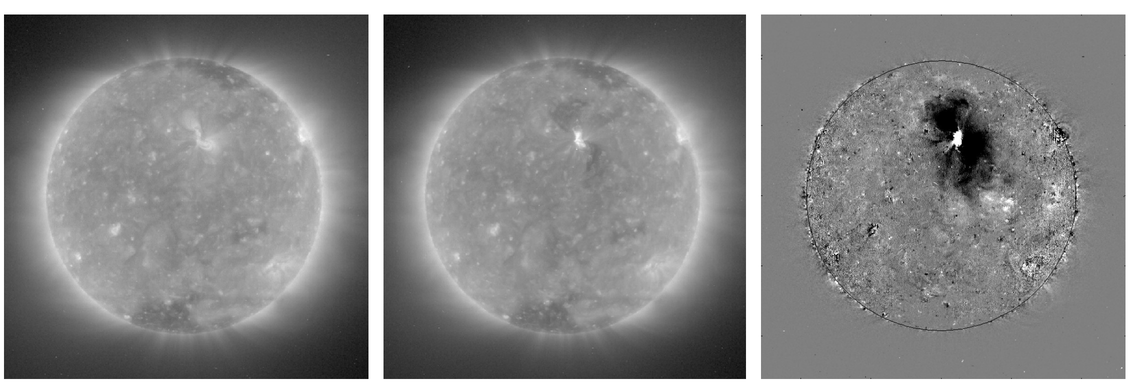


Figure 4: Intensity images from SOHO/EIT taken at 195 Å. The images were taken just before (left) and just after (centre) a coronal mass ejection occurred. In the central image, two coronal dimming regions have developed near to the bright flare loops just North of the center of the disk. The coronal dimmings (black regions) are most easily seen in base difference data (right).

New research

As part of the SSXG at CfA, our work focuses on understanding how CMEs develop into global disturbances. We also study the evolution of their magnetic orientation and connectivity as they expand into interplanetary space. Given the potential geoeffectiveness of CMEs and their impact on human ground and space-based activities, these aspects are of significant scientific interest as well as being directly relevant to our lives.

Several of our recent projects study the dynamics of CME source regions in relation to their associated CMEs. Two recently accepted papers, which will shortly appear in the Astrophysical Journal, seek to study the dynamics of the region obscured by the coronagraph occulting disk during CME events. That elusive region is crucial to understand since it is the lynch-pin of the connection between CMEs and their origin in the low-corona. These works show that this region is where the CME can demonstrate interesting and unexpected behaviour, greatly elucidating the connection between the CME and its low coronal counterparts, the coronal wave and coronal dimmings.

One study (Attrill et al., 2009), combines Hinode/XRT and STEREO/EUVI data, to study an event that occurred on 23rd May 2007. This is the first time that a diffuse coronal wave has been observed by the XRT, and the XRT observations help us to understand the environment surrounding the eruption site. The EUVI data observe the Sun out to 1.7 $R_\odot$ (solar radii), and actually overlap the STEREO/COR1 coronagraph field of view, which starts at 1.3 $R_\odot$. As a result, with some careful image processing, it is possible to actually study the CME below the coronagraph's occulting disk in the EUVI data (see Figure 5). Our results show that the CME maps directly to the coronal wave front, even though from a comparison of the COR1 white-light and EUVI data, this does not initially appear to be the case.

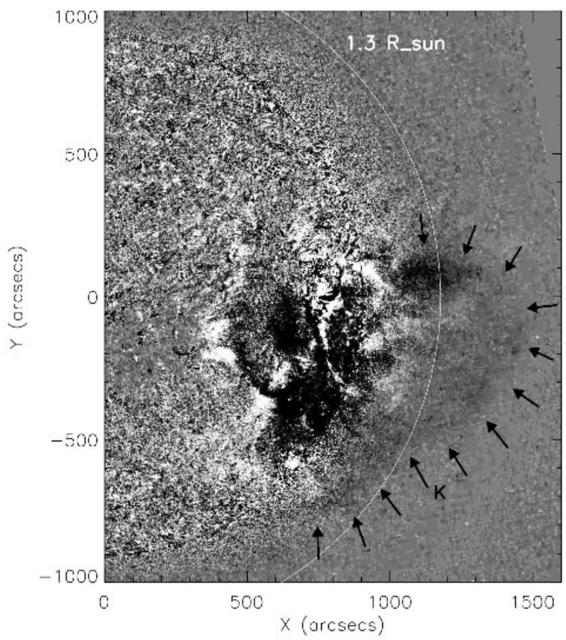


Figure 5: The relationship between the coronal wave, dimmings and CME on 23rd May 2007 is revealed by a 195 Å EUVI running difference image from the STEREO (B) spacecraft at 07:42 UT. The white ring marks the location of the COR1 coronagraph occulting disk at 1.3 solar radii. The black arrow marked "K" highlights a kink in the outer shell of the CME, also seen in the coronagraph white-light images. The CME extension to the South maps directly to the coronal wave front. Using the COR1 coronagraph data alone would likely lead the observer to conclude (erroneously) that the CME and coronal wave are spatially unrelated. This observational study highlights the importance of the CME development below the coronagraph occulting disk (Attrill et al., 2009).

Another study (Cohen et al., 2009), combines observations from STEREO with a 3-D global magnetohydrodynamic (MHD) model for the solar corona. The numerical simulation is driven and constrained by observations and real data of the Sun's surface magnetic field. The observations for this event were taken when the two STEREO spacecraft were separated by 91 degrees, and thus provide the first observation of a coronal wave—CME—dimming event in quadrature. Employing the numerical simulation to allow us to study the region obscured in observations by the coronagraph occulting disk, we again find that the CME extension in the low corona maps directly to the coronal wave front (see Figure 6).

Constraining this advanced numerical simulation with such an unparalleled set of multi-wavelength observations allows us to draw meaningful conclusions regarding the much-debated and enigmatic nature of the coronal wave observed on 13 February 2009. We find that the increased intensity that characterises the diffuse coronal wave is the result of mass density enhancement, caused by a combination of CME-driven wave and non-wave mechanisms.

Our results also show that the CME experiences considerable lateral expansion in the low (< 200 Mm) corona. This lateral expansion is facilitated by reorganization of the magnetic field through reconnection, which leads to far-reaching compression and "opening" of the surrounding magnetic field. These "openings" are further found to correlate with the formation of secondary coronal dimmings that form across the solar disk.

Interestingly, our simulation suggests that the coronal wave consists of two components. The brighter component, (which is primarily observable in base difference EUVI data), is due to plasma being compressed by the expanding CME. Some of the bright patches correspond to locations where magnetic reconnection occurs. This non-wave component maps directly to the CME footprint at every stage of the evolution. Thus, there is a strong coupling between the development of the coronal "wave" bright front, CME and associated dimmings.

Unlike its bright counterpart, the weaker component ultimately decouples from the bright component after the CME ceases lateral expansion late in the event. Such behaviour is consistent with an MHD wave, driven directly by the expanding CME through most of the event, and later becoming freely propagating. In spite of the comparative weakness of this second component, it is most likely to be detected in running difference EUVI data, and is found to be present throughout the event, although in the early stages, it is difficult to distinguish from the dominant brighter component.

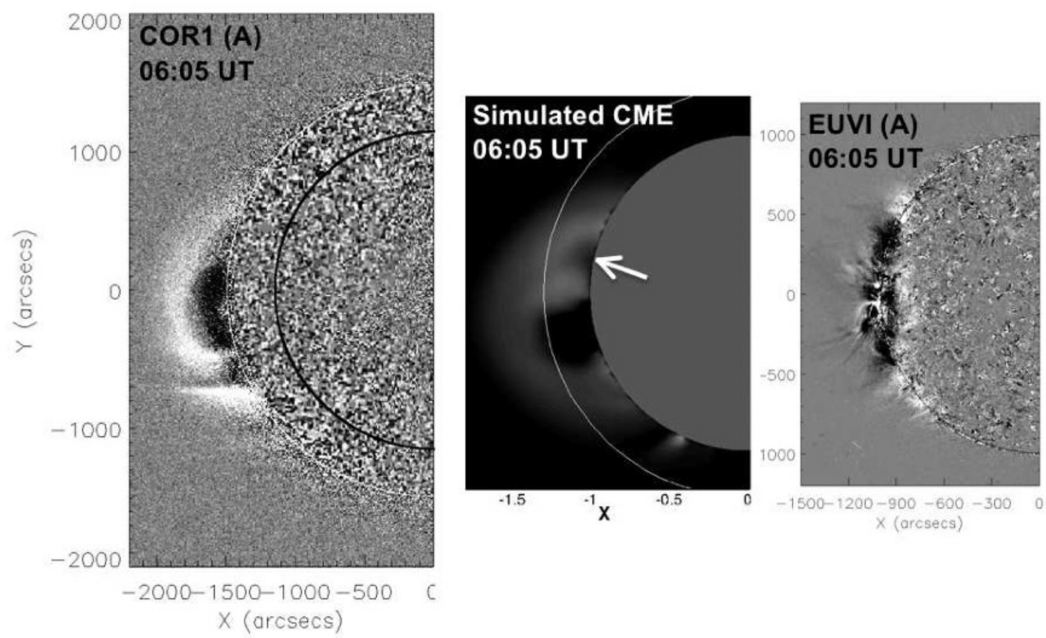


Figure 6: These panels compare STEREO observations to our simulation results. Left panel shows the COR1 white-light coronagraph data from the STEREO A spacecraft at 06:05 UT. The data have been processed into a running difference image to show the subtle outer shell of the CME. Center panel shows the white-light simulated base difference image of the CME from the numerical simulation at 06:05 UT. The white ring indicates the outer edge of the COR1 coronagraph at 1.3 solar radii. The right panel shows an EUVI running difference image of the coronal wave front at 06:05 UT. Directly comparing the COR1 and EUVI data, one might conclude that the CME and coronal wave are spatially unrelated. However, the simulation allows us to study the extent of the CME in the realm blocked by the coronagraph's occulting disk in observations. We find that the CME extension maps directly to the coronal wave front (Cohen et al., 2009).

Both of these papers highlight the importance of studying the true lateral extent of the CME in the low corona before comparing it to the coronal wave and associated coronal dimmings.

Continued on Page 17

Solar Cinematheque: NASA Goddard Scientific Visualization Studio

NASA Goddard Collection of Scientific Visualization

Go to: http://svs.gsfc.nasa.gov/
Click on Imagery by Keyword
Sample Solar Keywords include: Active Region#, Eclipse, Incoming Solar Radiation, Magnetic Fields, Magnetic Reconnection, Magnetohydrodynamics, SDO (Solar Dynamics Observatory), Sun#, Solar#, Space Weather

Typically a movie can be played by double clicking on the MPEG entry.
More information on playing the movies can be found here:
http://svs.gsfc.nasa.gov/site_usage/site_reqts.html (underscores appear after 'site')

Sample movie:
http://svs.gsfc.nasa.gov/vis/a010000/a010000/a010074/Sunspots.mpg

Advanced Techniques: Non-LTE Radiative Transfer

How do you go about calculating solar spectra to compare with observations? Current courses usually cover LTE radiative transfer and optically thin line formation. The general field of non-LTE optically thick radiative transfer has almost become a lost art, but continues to be necessary to interpret solar and stellar chromospheric emission lines. This subject is addressed in the Lecture Notes: Introduction to Non-LTE Radiative Transfer and Atmospheric Modeling, which can be found at http://www.cfa.harvard.edu/~avrett.

Recent Research Article Submissions

Recently Dr. K. M. Hiremath, Indian Institute of Astrophysics, Bangalore-560034, India; (E-mail : hiremath@iiap.res.in) has submitted the following research articles to arxiv eprint at: http://arxiv.org/ .

Any comments/suggestions on all or any of the following articles are solicited.

(i) Physics of the Solar Cycle : New Views (arXiv:0909.4420)

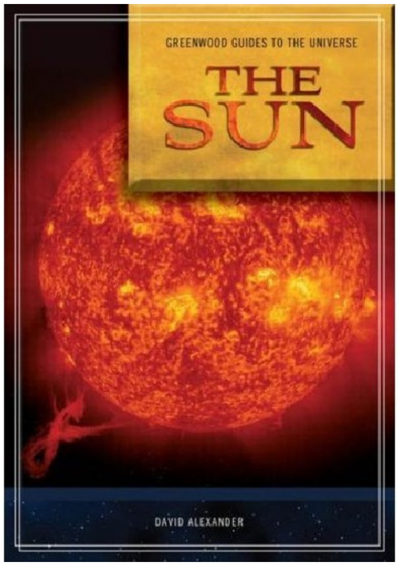
(ii) Periodicities in the occurrence of solar coronal mass ejections (arXiv:0909.4376)

(ii) Cosmic GRB energy-redshift relation and Primordial flares as possible energy source for the central engine (arXiv0909.2147)

(iv) Primordial flares, flux tubes, MHD waves in the early universe and genesis of cosmic gamma ray bursts (arXiv0909.2127)

(v) Solar Forcing on the Changing Climate (arXiv0906.3110)

New Books



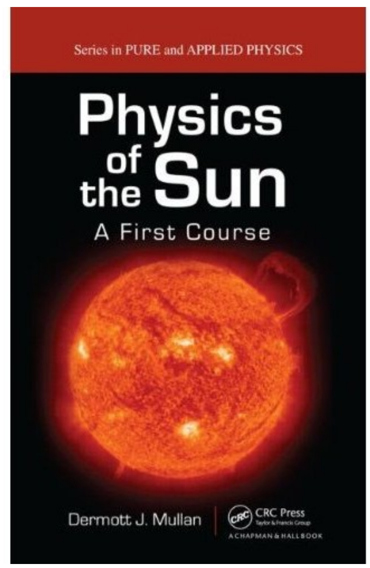
The Sun *by David Alexander* ISBN-13: 978-0-313-34077-2

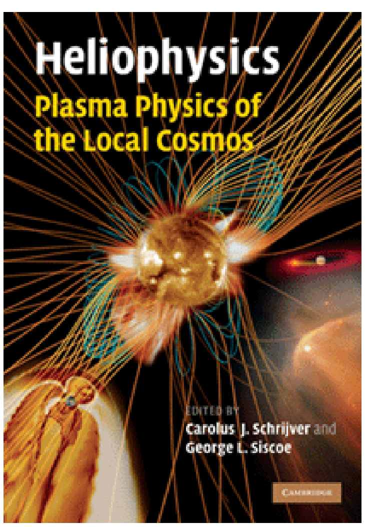
EXCERPT

"A volume in the Greenwood Guides to the Universe Series, *The Sun* provides a basic introduction to one of the best-studied astrophysical objects in the universe. In some sense, the Sun is one of the most basic of cosmic entities, that is, a fairly average star, and yet our ability to observe it up close has shown it to be a highly complex system exhibiting a wide range of physical processes and phenomena. Understanding the physics governing the behavior of the Sun, therefore, has a powerful impact on our understanding of the physics at work in the universe. By observing the Sun, we now have a good idea of how magnetic field and plasma interact, how energetic particles produce the wide range of electromagnetic radiation observed, and how the dynamic motions of the interior are connected to the activity of the surface and the atmosphere. These are all processes that drive astrophysical phenomena throughout the universe."

Physics of the Sun *A First Course* *by Dermott J. Mullan*

With an emphasis on numerical modeling, the book introduces the student to a quantitative examination of the physical structure of the Sun, both below and above the photosphere. It gives step-by-step instructions for students to calculate realistic but simplified numerical models of photosphere, convection zone, and radiative interior. The barrier penetration aspect of nuclear reactions is discussed in the context of quantum "fuzziness" bridging the Coulomb gap. There are instructions to solve the equations of helioseismology in the Cowling approximation, with examples of applications to polytropic models, also computed by the student with detailed instructions. Temperatures in the chromosphere and in the corona are evaluated from energy balance arguments. Magnetic effects are discussed, including cyclic generation on decade-long time-scales. The book, including 18 chapters, is aimed at advanced undergraduates in physics, as well as graduate students in their first or second year of graduate study.
(Reprinted from SolarNews: Posted by Dermott J. Mullan)
CRC Press ISBN: 978-1-4200-8307-1





Heliophysics *Plasma Physics of the Local Cosmos*
Edited by Carolus J. Schrijver and George L. Siscoe

Written by Carolus J. Schrijver, George L. Siscoe, Thomas J. Bogdan, Matthias Rempel, Dana W. Longcope, Terry G. Forbes, Mark B. Moldwin, Charles W. Smith, Viggo H. Hansteen, Vytenis M. Vasyliūnas, Frank R. Toffoletto, Tim Fuller-Rowell, Frances Bagenal

Material taught at the Heliophysics Summer School sponsored by NASA's 'Living with a Star' program and hosted by the University Corporation for Atmospheric Research, Visiting Scientist Programs.

(underscores in URL)
http://www.vsp.ucar.edu/HeliophysicsScience/resources/Helio_Textbook_I.htm
Cambridge University Press ISBN-13: 978-0-521-11061-7

That's Fiction Not Friction … Solar Sci-Fi

The Sun

Benford, Gregory & Eklund, Gordon *If the Stars Are Gods.* 1977, Berkley. Proposes that the Sun might have an intelligence within.

Brin, David *Sundiver.* 1980, Bantam. Involves a trip into the Sun. Brin has a PhD in astrophysics.

Clarke, Arthur "The Wind from the Sun" in *The Wind from the Sun.* 1973, Signet. About the effect of a solar flare on a solar wind "sailing race" of the future.

Clayton, Donald *The Joshua Factor.* 1986, Texas Monthly Press. A novel by an astronomer involving intrigue and neutrinos from the Sun.

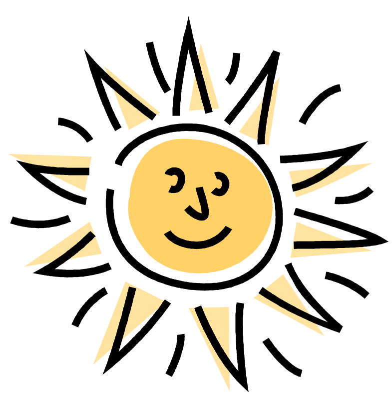
Clement, Hal "Proof" in Asimov, Isaac, ed. *Where Do We Go from Here?* 1971, Fawcett. About possible life-forms within the Sun.

Niven, Larry "Inconstant Moon" in *All The Myriad Ways.* 1971, Ballantine. A giant flare on the Sun wreaks havoc with civilization.

A Listing Compiled by **Andrew Fraknoi** *(Foothill College)* Version 5.1; August 2009

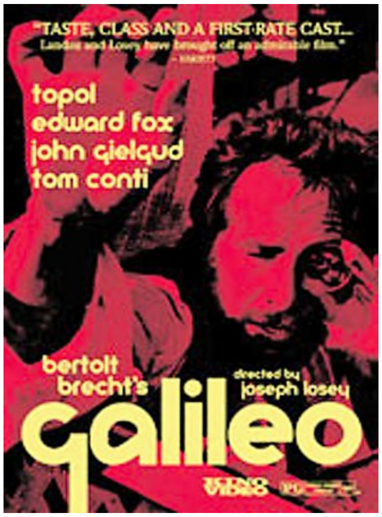
The Sun category taken from
Science Fiction Stories with Good Astronomy & Physics: A Topical Index

For the rest of the list Andrew Fraknoi has compiled:
http://www.astrosociety.org/education/resources/scifi.html



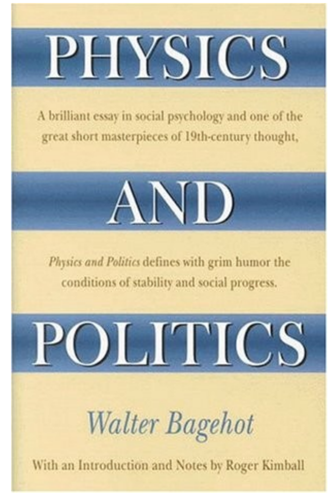
Science and Politics

The Classics



Bertolt Brecht's Galileo (1975) DVD

Walter Bagehot, 19th Century Editor-In-Chief of the Economist, author of the classic book 'The English Constitution' applies Darwinian thinking to political construct.



Download this book or read it online:
http://cupid.ecom.unimelb.edu.au/het/bagehot/physics.pdf
http://www.fullbooks.com/Physics-and-Politics.html

Graduate Opportunity: The National Academies Christine Mirzayan Science & Technology Policy Graduate Fellowship Program

Science and technology policy program for graduate students who have completed their studies within the past five years may apply for this program. (Also available to post-docs.)
http://sites.nationalacademies.org/PGA/policyfellows/index.htm
DEADLINE: **May 1st** for Fall Program (dates: August 30-Nov 19, 2010)
Nov 1st for Winter/Spring Program
For more information contact: policyfellows@nas.edu.

Undergraduate Opportunity: Posters on the Hill

Offered by the Council on Undergraduate Research, this opportunity enables undergraduate students to present their scientific research in the form of a poster session on Capitol Hill while Congressman learn what the research funding is spent on. Some Congressional representation will be present at the event but students may also contact individual Congressman depending on their availability. Advisors may attend along with student. No travel funding is provided. Either student's institution must be a member ($800) of the Council on Undergraduate Research or the advisor must be an individual member ($73). For more information contact: cur@cur.org.
http://www.cur.org/postersession.html
APPLICATION DEADLINE: November 10, 2009
Approximate Date of Event: 2 days sometime between mid-April to mid-May (exact dates TBA after Congressional schedule set in mid-Dec.)

Conference for Undergraduate Women in Physics

West, Midwest, and Northeast Conferences are taking place simultaneously with keynote speaker teleconferenced to all sites. This conference provides the student with networking opportunities, career discussion, laboratory tours, scientific lectures, and a chance to present their own research. Panels may include graduate student discussions, career options in academia, government, and industry, as well as exposure to non-traditional career pathways for physicists.

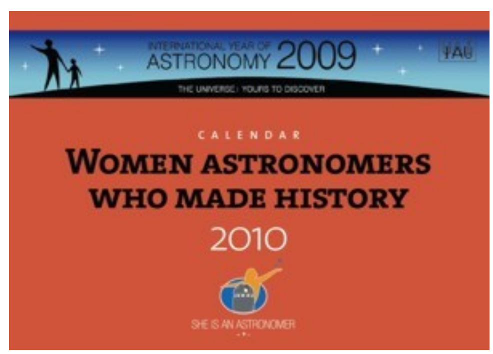
2010 Dates: January 15th to 17th, 2010
Details and information on registration, travel funds and conference program can be found at the following links and will be updated for 2010 very soon:

West Conference: University of Southern California
http://physics.usc.edu/~wiphys/conference/index.html

Midwest Conference: Ohio State University
http://www.physics.ohio-state.edu/undergrad/Women_in_Physics/index.html

Northeast Conference: Yale University
http://www.yale.edu/spsyale/cuwpy/

Women Astronomers Who Made History 2010 Calendar



"SHE IS AN ASTRONOMER" 2010 CALENDAR
International Year of Astronomy and
'Ella es una Astrónoma" group from Spain

This beautifully and artfully illustrated calendar celebrates the accomplishments of women in astronomy. The contributions of the women astronomers span space and time including women from different countries across the ages.

In addition, several of the women astronomers made contributions to the study of the sun.

The calendar can be downloaded here (also available in Spanish):
http://www.sheisanastronomer.org/index.php/downloads/calendar

Continued from Page 11

Students Joel Leja (UC-Berkeley) and James Robertson (University of Michigan) participated in the 2009 summer National Science Foundation funded Solar REU program in the Solar and Stellar X-Ray Group at the Harvard-Smithsonian Center for Astrophysics.

Tackling the Quandary: Elucidating the Relationship Between Coronal Waves and Coronal Mass Ejections

Dr. Gemma Attrill, Harvard-Smithsonian Center for Astrophysics

REU 2009 Research Contributions:

Joel Leja: Connecting CMEs to their lower coronal counterparts

Joel's project focused on comparing the lateral extent of CMEs to their low-coronal signatures (i.e. to coronal waves and dimmings).

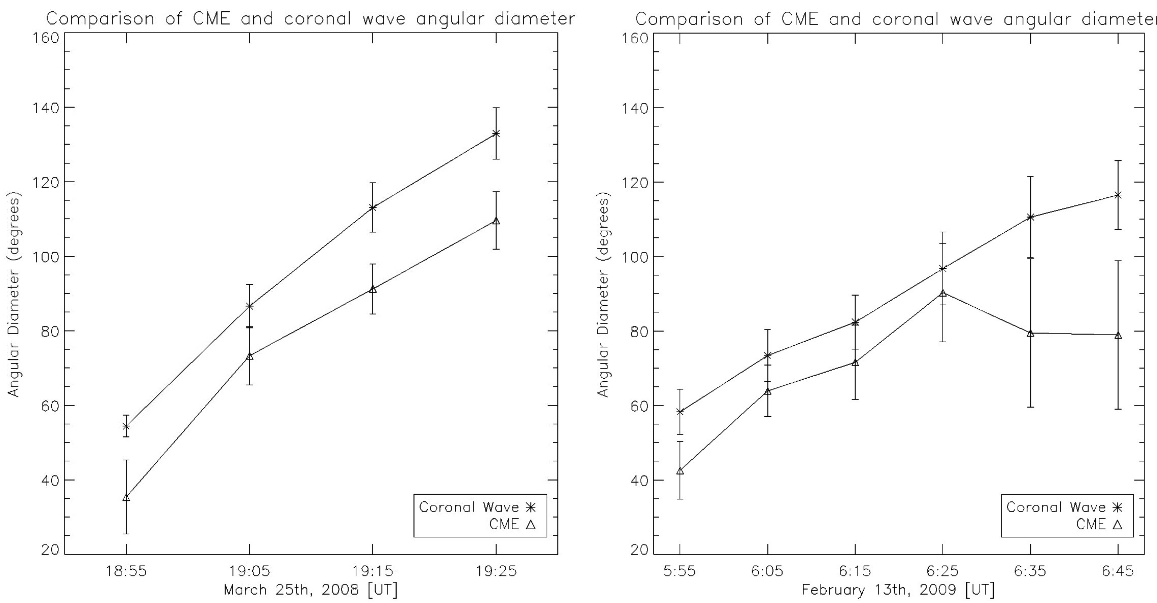


Figure 7: Evolution of the coronal wave vs. CME angular diameters for two coronal wave-CME-dimming events (Leja et al., 2009, in prep).

Joel measured the angular expansion of the coronal wave and CME in contemporaneous STEREO EUVI and COR1 data. Figure 7 shows the results from two of the events that were studied. In each case, the CME flanks map strongly to the coronal wave throughout the period of CME lateral expansion. This observational evidence strongly supports a CME-driven model for coronal waves. The 13 February 2009 event (right panel, Figure 7) displays strong mapping of the CME flanks to the wave throughout most of the event; however, a decoupling takes place late in the CME lateral expansion, as the wave front continues to expand beyond the now-stationary CME flanks. This observation appears to be consistent with the Cohen et al. (2009) result (discussed above), which indicates that coronal waves possess a dual structure.

All of the events in Joel's study indicated some form of CME-coronal wave connection. He also considered the associated coronal dimmings that were observed to form during the events (not shown), in the context of the related CME-coronal wave relationship. Joel concluded that the different morphology and kinematics of any given CME/wave relationship may imply slightly different theoretical underpinnings for each eruption. A full write-up of this work is in preparation.

James Robertson: Relating CME Kinematics to Observable Source Properties

For his project, James quantitatively examined the interplay between coronal waves, their associated CMEs, and the magnetic properties of their source regions and surrounding magnetic environment. Surprisingly, there is still little understanding of what determines many dynamic properties of CMEs and related lower coronal events. These include: CME heliospheric propagation velocities, coronal wave speeds and maximum coronal wave lateral extent. James considered the hypothesis that greater magnetic pressure could lead to wider (and possibly faster) expansion of the CME and therefore also of the associated coronal wave.

James studied 12 events in detail, taken from both the current and previous solar minimums, and examined different factors expected to influence propagation speed and lateral extent. One aspect of the work focused on finding a proxy for the CME's magnetic flux by measuring the flux of the (post-eruption) flare arcade associated with the source region.

Ultimately, James found a correlation between coronal wave velocities and their maximum lateral extents. This suggests that they both relate to the energetics of the event. Additionally, the wave's maximum extent was found to correlate with post-eruptive arcade (PEA) flux (see Figure 8).

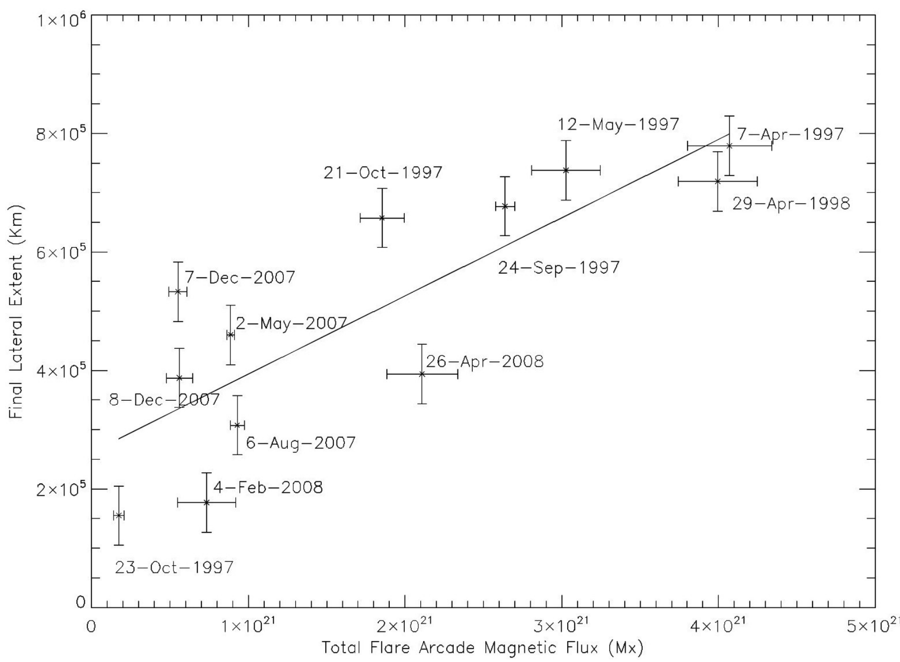


Figure 8: The relationship between the coronal wave maximum lateral extent and the magnetic flux of the post-eruptive arcade associated with each event (Robertson et al., 2009, in prep).

These findings are in line with those of Moore, Sterling and Suess (2007), who found a relationship between the final angular extent of the CME bubble measured in coronagraph data, and the flux of the PEA.

Summary:

The research discussed focuses on the connection between CMEs and low-coronal signatures of their source regions. The region of interest is often obscured by the coronagraph occulting disk during the crucial early stages of CME events. The resulting ambiguity has prevented the development of a coherent picture of the CME-coronal wave relationship, despite a strong statistical connection being established in 2002. We have shown that the CME can exhibit surprising behaviour in the low corona during the first hour or so of its development. Specifically, this research clarifies the direct relationship between CMEs and their coronal wave "footprints" in the low-corona.

The REU students' work this summer focused on studying the relationship between the flanks of CMEs that show a considerable lateral expansion in the low corona, and coronal waves. The final extent reached by coronal waves is also found to be related to the post-eruptive arcade flux, which in turn is also related to the angular width of the CME. Collectively, this work makes a significant contribution toward elucidating the physical nature of the relationship between coronal waves and CMEs.

Look to the future

Due to the somewhat limited cadence of SOHO/EIT - one full-disk image at 195 Å (the preferred passband for coronal wave observations) is made every 12-17 minutes - coronal waves observed by EIT are typically only caught in one, maybe two or three frames at most, allowing for only the most rudimentary dynamical studies. The recently launched STEREO and *Hinode* missions are already starting to address this somewhat frustrating situation, although the EUVI imagers on-board STEREO still only take 195 Å images at a cadence of ~ 10 minutes. The contribution from NASA's Solar Dynamics Observatory/Atmospherics Imaging Assembly (SDO/AIA), which will provide full-disk observations in 10 different wavelengths (6 in the EUV), at 10 *second* cadence is eagerly anticipated.

Acknowledgements:

This work was supported in part by the National Science Foundation under Grant ATM-0851866. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation. G.D.R. Attrill and M.J. Wills-Davey are supported by NASA grants NNX09AB11G and NNX08BA97G. *Hinode* is a Japanese mission developed and launched by ISAS/JAXA, collaborating with NAOJ as a domestic partner, NASA and STFC (UK) as international partners. Scientific operation of the *Hinode* mission is conducted by the *Hinode* science team organized at ISAS/JAXA. This team mainly consists of scientists from institutes in the partner countries. Support for the postlaunch operation is provided by JAXA and NAOJ (Japan), STFC (U.K.), NASA, ESA, and NSC (Norway). The *STEREO/*SECCHI data are produced by an international consortium: NRL, LMSAL, NASA, GSFC (USA); RAL (UK); MPS (Germany); CSL (Belgium); and IOTA, IAS (France). *SOHO* is a project of international cooperation between ESA & NASA. I would like to thank M.J. Wills-Davey for helpful comments on this article.

Bibliography:

Attrill, G. D. R., Engell, A.J., Wills-Davey, M. J., Grigis, P. and Testa, P.: Hinode/XRT and STEREO Observations of a Diffuse Coronal "Wave"-Coronal Mass Ejection-Dimming Event, Astrophys. J., **704**, 1296-1308, doi: 10.1088/0004-637X/704/2/1296, 2009.

Cohen, O., Attrill, G. D. R., Manchester, W. B. and Wills-Davey, M. J.: Numerical Simulation of an EUV Coronal Wave Based on the February 13, 2009 CME Event Observed by STEREO, Astrophys. J., **704**, 1-16, doi:10.1088/0004-637X/704/1/1, 2009.

Biesecker, D. A., Myers, D. C., Thompson, B. J., Hammer, D. M., and Vourlidas, A.: Solar Phenomena Associated with "EIT Waves", Astrophys. J., **569**, 1009–1015, doi:10.1086/339402, 2002.

Moore, R. L., Sterling, A. C., and Suess, S. T.: The Width of a Solar Coronal Mass Ejection and the Source of the Driving Magnetic Explosion: A Test of the Standard Scenario for CME Production, Astrophys. J., **668**, 1221–1231, doi:10.1086/521215, 2007.

Graduate Program Spotlight:
Solar Astronomy at New Mexico State University

Jason Jackiewicz, New Mexico State University

New Mexico State University (NMSU) and the Department of Astronomy now offers master's and doctoral degrees in astronomy specializing in solar physics research. Currently, the department has several faculty and students working in various areas of solar physics including helioseismology, coronal structures, and eruptive phenomena in the solar atmosphere. Faculty members in the departments of physics, electrical engineering, and mechanical engineering are also active in solar-related studies and conduct joint research projects within the framework of the NMSU Space and Aerospace Cluster, an interdisciplinary group of research faculty from science and engineering departments. Additional faculty hires in solar/space physics will be joining the university over the next several years. Within the Astronomy Department solar research is carried out as part of the Solar, Stellar, and Exoplanet Group, and therefore strong overlap exists among group members in closely-related topics such as stellar photometry and spectroscopy, and asteroseismology.

New Mexico State University is located in southern New Mexico, about 80 miles west of the Nation Solar Observatory (NSO) headquarters in Sunspot, NM. It is a Hispanic Serving Institution with a main campus enrollment of about 18,300 students, approximately 41% of whom are Hispanic. In the Carnegie Foundation's classification of public institutions of higher education, NMSU is designated Research University/High Research activity. Only 103 out of 1737 institutions have been awarded this distinction. NMSU is a comprehensive university offering 51 master's and 24 doctoral degrees. The Department of Astronomy has 10 faculty, 5 college faculty, and over 30 graduate students.

New Mexico is host to many valuable scientific resources. The close proximity to the NSO (both the Sunspot, NM and Tucson, AZ locations) offers exciting possibilities to work with world-class solar physicists. The Air Force Research Lab's Space Weather Center for Excellence in Albuquerque is also involved in a variety of solar research projects and supports graduate student work within the department. NMSU operates the Apache Point Observatory in Sunspot, NM, is a member of Sloan Digital Sky Survey, and is also a member of the Association of Universities for Research in Astronomy (AURA). Graduate students have access to the Apache Point Observatory 3.5m telescope and the department's fully robotic 1m telescope which is equipped with a CCD camera and multi-color photo-diode photometer.

Graduate Program Spotlight:
Solar Astronomy at New Mexico State University

NMSU Astronomy is actively seeking students with interests in solar physics. Competitive graduate student assistantships are available. Graduate application materials typically arrive by mid January, and initial offers of admission for the Fall semester are usually announced in late February.

For questions contact:

Jason Jackiewicz
NMSU Department of Astronomy
PO Box 30001, MSC 4500
Las Cruces, NM 88003
575.646.1699
jasonj "at" nmsu.edu

See the following links for further information:
NMSU: http://www.nmsu.edu/
NMSU Department of Astronomy: http://astronomy.nmsu.edu/
Solar, Stellar, Exoplanet Group page: http://astronomy.nmsu.edu/jasonj/GROUP/
Apache Point Observatory: http://www.apo.nmsu.edu/

More Universities with Solar Physics and Astronomy Programs

Montana State University: http://solar.physics.montana.edu/sol_phys/ ('sol' underscore)

New Jersey Institute of Technology: http://physics.njit.edu/

Rice University: http://www.ruf.rice.edu/~solar/

University of Alabama at Huntsville: http://physics.uah.edu/
http://cspar.uah.edu/www/about/index.htm

University of California at San Diego: http://cass.ucsd.edu/

University of Colorado at Boulder: http://lasp.colorado.edu/
http://aps.colorado.edu/

University of Glasgow, Scotland: http://www.astro.gla.ac.uk

University of Hawaii: http://www.solar.ifa.hawaii.edu/
http://www.ifa.hawaii.edu/research/research.htm

University of Memphis: http://physics.memphis.edu/SOLAR/index.htm

University of New Hampshire: http://www.physics.unh.edu/index.html
http://www.sttg.sr.unh.edu/

University of St Andrews, Scotland: http://www-solar.mcs.st-and.ac.uk/

Graduate Opportunity: National Science Foundation
East Asia and Pacific Summer Institutes
For U. S. Graduate Students Pursuing Science and Engineering

Opportunity for graduate students to spend the summer doing research in one of: Australia, China, Japan, Korea, New Zealand, Singapore, or Taiwan. "Students may approach hosts at nearly any academic or research institution in a participating location to seek acceptance and placement." Hence, students may seek out solar astronomy or related laboratories. The purpose of this program is to foster international collaboration as well as give the student an opportunity to observe/participate in science done in an East Asian and Pacific Institute's setting. This provides a unique opportunity to observe first-hand working style, culture, infrastructure and science policy.

http://nsfsi.org/
Application DEADLINE: December 8th, 2009 (second Tuesday in December) for participation during Summer 2010.
For more information contact: eapsi@asee.org.

Post Doc Opportunities

NASA Postdoctoral Program: (administered by Oak Ridge Associated Universities)

The NASA Postdoctoral Program (NPP) offers unique research opportunities to highly talented national and international individuals to engage in ongoing NASA research programs at a NASA Center, NASA Headquarters, or at a NASA-affiliated research institution. These one- to three-year Fellowship appointments are competitive and are designed to advance NASA's missions in space science, earth science, aeronautics, space operations, exploration systems, and astrobiology.

http://nasa.orau.org/postdoc/
http://nasa.orau.org/postdoc/files/nasa-postdoc-postcard07.pdf
Deadlines: March 1, July 1, November 1 annually

NRC Research Associateship Programs (RAP)

http://sites.nationalacademies.org/pga/rap/
Deadlines: Feb 1, May 1, August 1, Nov 1 annually
(with supporting docs due by the 15th)

CEDAR, GEM, and SHINE Postdoctoral Research Program

The Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR) program, the Geospace Environment Modeling (GEM) program, and the Solar, Heliosphere and Interplanetary Environment (SHINE) program are special programs within the Aeronomy, Magnetospheric Physics and Solar-Terrestrial Research programs in the Atmospheric Sciences Division of the Geosciences Directorate. Each of the programs has its own Program Solicitation, but they also have a common commitment to support researchers who have recently received their Ph.D. degree, allowing them to request limited support for CEDAR/GEM/SHINE research activities of their own devising.

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12779
Full Proposal Deadline Data: February 1st, 2010 (then first Monday in February annually thereafter)

LWS (Living With a Star) Post-Doc Fellowship Program

Applications are invited to a new postdoctoral fellowship program designed to train the next generation of researchers in the emerging field of Heliophysics. The program is sponsored by the NASA Living With a Start (LWS) program and administered by the UCAR Visiting Scientist Programs Office.

http://lws-trt.gsfc.nasa.gov/lws_postdoc.htm ('lws' then underscore)
Application Deadline: January 8, 2010

AAS/SPD Student Reception Survey

On June 14, 2009 the AAS/SPD hosted their first reception for students of the Solar Physics Division in Boulder, CO. All students, graduate and undergraduate were invited to get to know each other and learn some of the science that members of the SPD are involved in. It was an opportunity for the students to be introduced to not only the breadth of study that the SPD encompasses but to the scientists responsible for the work. Science meetings are places to network, be part of a team, and share knowledge and experiences. Communication among people is a vital part of any field and that was the goal of this event.

A short survey about the reception was emailed in September. The response rate was relatively low (14%) but respondents were very informative. All who attended the event had positive comments. In particular, those with little or no experience at science meetings found the reception to be the most helpful. Some of the comments offered were:

"It gave me "permission" to walk to up people I didn't know and introduce myself, something that can be very intimidating as a student."

"It did exactly what it was designed to do. It introduced me to both experienced scientists and other students that were in similar positions as myself. It worked to calm my nerves (although I wasn't particularly nervous to begin with) and, more importantly, allowed me to introduce myself and my accomplishments to various researchers. This made talking to them later much easier because they already had an idea of who I am and what I've been doing and vice versa. It is much easier to give a poster presentation when one knows the audience."

"The solar community is pretty tight knit and very welcoming."

"In other areas of science, I've heard student nightmares about feeling nervous, being ignored, and a general struggle to become accepted. Here, it is the total opposite. Everyone is inviting and open; no one resents being "forced" to mingle."

And from those not in attendance:

"I couldn't attend the AAS/SPD student reception due to the late flight schedule that day. BUT, I believe that holding student reception is a good idea and must have helped students to feel more connected to the meeting. In my case, it was my very first time [attending] the SPD meeting and everything was strange and unfamiliar [...] I found out that there were many excellent and interesting works done by students, and it would have been better if I knew that earlier and [had] a chance to talk to them."

We also gleaned a few interesting suggestions for future receptions, such as:

"Maybe a sports event or something. Friendly soccer match or the like."

OK, we'll ask Dr. Keith Strong to bring Cricket bats to the next student reception ......

The survey results show that an SPD student reception is more than useful and we will continue to work with the AAS to provide this important resource for students.

Zoe Frank
LMSAL
(for the SPD E/PO Committee)

Learn more about the Solar Physics Division of the American Astronomical Society:

http://spd.aas.org/

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