Harvard-Smithsonian Center for Astrophysics

60 Garden St., MS-19, Cambridge, MA 02138

25 August 2013

Dear Harvard Students,

The Harvard-Smithsonian Center for Astrophysics (CfA, http://www.cfa.harvard.edu/), located at 60 Garden Street opposite the Quadrangle, is one of the world's great centers for research in astrophysics, with over 300 scientists and access to powerful astronomical observatories worldwide and in space. The following is a partial list of CfA research opportunities for undergraduates. I encourage students to contact these scientists directly to inquire about these opportunities. Harvard has several programs to provide partial support for student research, described at:
http://undergrad-research.harvard.edu.

If you have questions about getting involved in research at the CfA, please do not hesitate to contact me.

Best regards,

Edo Berger,
Director of Undergraduate Studies, Astrophysics
John L. Loeb Associate Professor of the Natural Sciences
Associate Professor of Astronomy
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Dr. Warren Brown wbrown@cfa.harvard.edu

Stellar Dynamics: I use the technique of optical spectroscopy to measure the nature and motions of stars. I'm best known for the discovery of "hypervelocity stars," stars escaping the Milky Way. I have a couple of open projects on measuring the distribution of runaway stars ejected from the Galactic disk, and using stellar motions to measure the dark matter distribution of the Milky Way halo. I also have a discovery program for ultra-compact binaries that are strong gravitational wave sources and possible supernova progenitors, and we could ramp-up a project to obtain time-series photometry to find eclipsing and tidally distorted binary systems.

Dr. David W. Latham dlatham@cfa.harvard.edu

My group is actively involved in follow-up observations of candidate transiting planets, both from ground-based surveys such as the Hungarian Automated Telescope Network (HATNet), the Kilodegree Extremely Little Telescopes (KELT), the Qatar Exoplanet Survey (QES), and from NASA's Kepler mission. We use KeplerCam on the 1.2-m telescope at the Whipple Observatory for high-quality light curves, the Tillinghast Reflector Echelle Spectrograph (TRES) on the 1.5-m telescope, also on Mount Hopkins, for spectroscopic determinations of host star parameters and for orbital solutions and mass determinations for giant planets, and the High Accuracy Radial velocity Planet Searcher for the Northern hemisphere (HARPS-N) on the Telescopio Nazionale Galileo on La Palma to determine masses of small planets. This is an opportunity to learn about astronomical photometry and/or spectroscopy while working on exoplanet candidates of current interest.

Dr. James Moran jmoran@cfa.harvard.edu

High angular resolution observations of supermassive black holes at radio wavelengths: I have been investigating the inner accretion disks around supermassive black holes using high-resolution radio observations of their maser emission. I have data on several masers that should be able to provide very accurate masses for the black holes as well as their trigonometric distances. I am also involved in a project to image the radio emission near the event horizon of the supermassive black hole in our galaxy (aka SgrA*), which is highly distorted by relativistic light bending. With the Submillimeter Array, I am currently monitoring the G2 cloud, which is presently undergoing tidal disruption by SgrA*. Understanding what happens or doesn't happen would make an interesting Ay99 project. You can find out more about these projects on my website, https://www.cfa.harvard.edu/~jmoran.

Dr. Qizhou Zhang qzhang@cfa.harvard.edu

As one of the building blocks in the visible universe, massive stars dominate the appearance and the evolution of galaxies. However, their formation is not well understood. My research focuses on studying different evolutionary stages of massive star formation using high-resolution radio and sub-millimeter interferometers. Possible projects for undergraduate research involve processing and analyzing data taken from the Submillimeter Array, Karl Jansky Very Large Array, and Herschel Space Telescope.

Dr. Philip M. Sadler psadler@cfa.harvard.edu

The CfA has a large and active Science Education Department that conducts educational research. My efforts focus on developing standardized tests that measure scientific misconceptions, the effectiveness of MOOCs as an alternative to classroom instruction, and how pre-college coursework and out-of-school-time activities contribute to persistence and performance in college science and mathematics.

Dr. Gerhard Sonnert gsonnert@cfa.harvard.edu

Gerhard Sonnert works on large-scale survey studies in the area of science and mathematics education. Current projects include an examination of the factors influencing students' success in college calculus, a study of what predicts beginning college students' career interests, and an investigation of the extent to which professional development institutes for middle school life science teachers actually improve their scientific knowledge and pedagogical skills. He is particularly interested in the gender aspects of science careers.

Dr. Karin Oberg koberg@cfa.harvard.edu

Star and planet forming regions present a rich chemistry, which regulates important aspects of planet formation, including delivery of prebiotic material to Earth analogs. The presence of molecules in these regions can also be used to trace the star and planet formation process through observations of molecular lines that are sensitive to e.g. the details of the radiation fields, temperature and density profiles. In the astrochemistry group we combine laboratory experiments and radio observations of protostars and protoplanetary disks to characterize this often exotic chemistry that results in the formation of molecular probes and prebiotic molecules. Undergraduate projects are available in the areas of spatially resolved molecular line observations ('astrochemical imaging') of different astronomical objects, interpretation of radio astrochemical spectra, and, starting in the fall of 2014, in laboratory astrochemistry, focused on the physics and chemistry of analogs to interstellar icy grain mantles.

Dr. Poppenhager, Katja kpoppenhager@cfa.harvard.edu

I study exoplanets and their host stars, with a focus on magnetic phenomena that occur in the atmospheres of the host stars, such as starspots and flares. The project I am currently offering is about analyzing flares in the chromosphere of a Hot Jupiter host star. The host star is orders of magnitude more magnetically active than the Sun, and a large number of flares were observed during a recent observational campaign. The analysis will involve working with optical high-resolution spectra; the time profiles of the flares will be measured using spectral lines, which trace chromospheric temperatures. The goal of this project is to test whether the occurrence of the flares correlates with the orbit of the Hot Jupiter, which has been speculated by some recent studies.

Dr. Belinda Wilkes bwilkes@cfa.harvard.edu

Multiwavelength Studies of Powerful 3CR Radio Sources: Along with a large, international team, Belinda Wilkes is investigating the radio-to-X-ray spectral energy distributions (SED) of high-redshift ($z>0.5$), 3CR radio-loud active galaxies (AGN). These sources are amongst the most luminous in the Universe, with central super-massive black holes hosted by massive galaxies and relativistic jets which emanate along the poles of the accretion disk and result in complex radio-emitting structures often extending over tens of thousands of light years. The team is in the midst of analyzing recent Herschel far-infra-red data, collecting high signal-to-noise optical spectra and obtaining Chandra (new and archival) X-ray snapshots of the full 3CR sample in the redshift range 0.5-2. Our primary motivation is to study the properties of the central AGN as a function of its orientation in this complete, orientation unbiased sample. Other projects include the search for high-redshift clusters, for which luminous radio sources may be a sign-post, study of the non-thermal radio and X-ray emission related to the jets and lobes and geometric and physical modeling of the central obscuring material. A student could become involved in any aspects of this project, either as research experience or for a thesis project.

Dr. Edo Berger eberger@cfa.harvard.edu

The Dynamic Universe: The universe is a highly dynamic place teeming with the explosions and eruptions of massive stars, neutron stars, and black holes. In this context my research group is focused on two exciting areas:

[1] The study of gamma-ray bursts and the search for their mysterious progenitors – GRBs are the most energetic explosions known in the universe and their study requires observations from gamma rays to radio wavelengths.

[2] We are leading a search for never before seen transients using the PanSTARRS survey, the most ambitious all-sky optical survey ever undertaken.

Students involved in these projects will have an opportunity to work with data from observatories around the world (including the 6.5m Magellan and MMT telescopes), and to be involved in perhaps the most fast-paced branch of astronomy. More information is available from: https://www.cfa.harvard.edu/~eberger.

Dr. Katrien Kolenberg kkolenberg@cfa.harvard.edu

My work lies in the field of asteroseismology, the science that studies the internal structure of pulsating stars through the interpretation of their frequency spectra. Indeed, many stars pulsate, in various stages of their evolution. I mostly work on RR Lyrae stars, stars that oscillate with large amplitudes and periods of about half a day. They play an important role in astrophysics, e.g., as standard candles (to measure cosmic distances). Though these stars have been extensively studied for over a century, they remain puzzling in their pulsation behavior. I use different kinds of data to probe the inner workings of pulsating stars, obtained from ground-based observatories and from space, e.g., delivered by NASA's planet-hunting Kepler mission. (The Kepler data do not only boost the discoveries of planets orbiting other stars, but they also open a window on the inner workings of the stars themselves.) I would be delighted to work with undergraduate students on the analysis and interpretation of Kepler and ground-based data of RR Lyrae stars.

Dr. John Johnson jjohnson@cfa.harvard.edu

My research interests are focused on the detection and characterization of planets around stars other than the Sun, commonly known as exoplanets. Thus far, exoplanetary scientists have discovered more than 800 confirmed planets outside of our Solar System, with roughly 2000 additional planet candidates from the highly successful NASA *Kepler* Mission. Beyond discovering new planets, I am interested in the statistical correlations between exoplanet properties and the physical characteristics of their host stars. For this reason, much of my research is concentrated on measuring the properties of stars, ranging from low-mass red dwarfs up to A-type stars like Vega and giant stars like Pollux. The varying properties of planets in these different stellar environments provide vital clues about the conditions and mechanisms of planet formation. Students in my group are encouraged to hone their computer programming skills; expand their knowledge and understanding of Bayesian statistics; and gain hand-on experience at various telescopes around the world.

Dr. Edward Deluca edeluca@cfa.harvard.edu

The Solar & Stellar X-Ray Group has ongoing research programs in solar coronal physics, solar and stellar dynamo models and heliospheric physics. Scientists are working on both theory and modeling of observations from Chandra, IRIS, Hinode, SDO, STEREO, Wind, ACE and LRO. We currently have a major hardware program: the SWEAP instrumentation package for the Solar Probe Plus mission. We have had good experience with previous Harvard undergraduate students and would be willing to consider an interested student, preferably a sophomore or junior as the learning curve is fairly steep. Our group consists of 18 PhD scientists with interests outlined below:

Thermal structure of the solar atmosphere: Alisdair Davey, Vinay Kashyap, Steve Saar, Paola Testa, Mark Weber, Trae Winter, Hui Tian

Magnetic structure of the solar atmosphere: Ed DeLuca, Kathy Reeves, Yingna Su, Mah Asgari-Targhi, Antonia Savcheva

Mass and energy flow in the solar atmosphere: Leon Golub, Kelly Korreck, Paola Testa, Hui Tian

Solar flares, CMEs and particle acceleration: Justin Kasper, Kelly Korreck, Kathy Reeves, Yingna Su, Trae Winter

Solar wind structure and acceleration: Justin Kasper, Kelly Korreck, Mike Stevens, Kamen Kozarev, Hui Tian

Cosmic ray physics: Tony Case, Justin Kasper, Kelly Korreck

Solar and Stellar Activity: Steve Saar, Paola Testa

Dr. Edward Tong etong@cfa.harvard.edu

For students interested to get their hands on testing and learning about astronomical instrumentation, the Submillimeter Receiver Lab is a place that offers a lot of practical research possibilities. We have ongoing projects of building and testing ultra low noise superconducting receivers for radio telescopes. We welcome the participation of students into our team to perform testing of these state-of-the-art instruments.

Dr. August (Gus) Muench gmuench@cfa.harvard.edu

Our group is utilizing an informatics approach for studying the basic properties of young stars and their circumstellar/protoplanetary disks in nearby star forming regions of our local Galaxy. An informatics approach combines the construction and maintenance of large databases of source properties with the application of statistical tools that mine these databases, characterize individual sources and infer source properties through comparison to models. Data mining and information science are already or will soon become dominant aspects of astronomical research and we welcome students of any computational science background who are interested in engaging in these challenges now. We are also an open science research group, utilizing web based notebooks and social media to document and disseminate our results and perform outreach to the general public about how panchromatic observations are used in concert to deduce the properties of distant stars and their planetary systems.

Dr. Ruth Murray-Clay rmurray-clay@cfa.harvard.edu

I am a theorist studying the formation and evolution of planetary systems, including our own. My interests include the evolution of protoplanetary disks, the growth of solid planetesimals and planets in gaseous environments, formation of giant planets, dynamics of planetary systems, dynamics of small bodies in the solar system, and the escape of gas from planetary atmospheres. Current projects available to undergraduates include: (1) a search for dynamical histories of the solar system that are consistent with the orbits of Kuiper belt objects, (2) a study of when and where gas in protoplanetary disks helps solid planets grow, and (3) compilation of known atmospheric escape processes in the solar system for generalization to extrasolar planets (particularly good for a student involved in both the Astronomy and Earth and Planetary Science departments).

Dr. Scott Randall srandall@cfa.harvard.edu

My work focuses on the study of various aspects of clusters and groups of galaxies. Galaxy clusters are the largest virialized structures in the Universe, and as such are important to the study of cosmology and large-scale structure. This research will likely focus on analyzing X-ray observations, although working with data at other wavelengths or performing N-body/hydrodynamical simulations are also possibilities. Possible projects for a motivated undergraduate student include the study of AGN feedback between the gas in clusters and their central supermassive black holes, X-ray properties of an optically selected group sample, the study of the outskirts of merging galaxy clusters at the viral radius, and the study of large scale structure filaments.

Dr. Rosanne DiStefano rd@cfa.harvard.edu

From Planets to Black Holes: Gravitational lensing by nearby dark masses. Gravitational lensing is a powerful tool to study dark masses. We are developing a unique research program to study lensing events generated by masses within about a kpc of Earth. We are, for example, working to understand what we can learn about possible planets orbiting a star only 6 pc away, when this star produces the first-ever predicted lensing event in December 2011. We are also working on predicting other events, studying ongoing events that are likely to be due to nearby masses, and are searching through data collected by the Kepler space mission. In the Kepler data we expect to find events that should be the best-sampled lensing events to date, allowing exquisitely detailed tests of lensing, while also searching for evidence of planets. Several key portions of this program are well suited to undergraduates interested in observations, data analysis, or theory. Undergraduates have already contributed significantly to this research program.

What are the Progenitors of Type Ia Supernovae? Type Ia supernovae are powerful explosions that have been used to map the Universe and to discover and study cosmic acceleration. We know that Type Ia supernovae are exploding white dwarfs, but we are still uncertain about nature or natures of the astrophysical systems within which the white dwarfs explode. Are they single-degenerate binaries, in which the white dwarf accretes mass from a non-degenerate companion? Or are they double-degenerate binaries in which two white dwarfs merge? Undergraduates can contribute to work in this area through binary evolution calculations, or through the analysis of archival data, to try to discover evidence of the progenitors. We know that, in both models, the progenitor systems are highly luminous during an interval of 105-107 years. This means that many progenitors in our own Galaxy can be discovered through multiwavelength searches. The theoretical work would be devoted to predicting the observational signatures, while the observational work would be devoted to testing the predictions.

Dr. Aneta Siemiginowska aneta@head.cfa.harvard.edu

My research focuses on topics related to active galactic nuclei (AGN) and quasars. In my studies I consider many aspects of AGN activity including properties of accretion flow onto a black hole, relativistic jets, interactions between AGN and the environment as well as different emission processes responsible for the observed emission. I have several projects that incorporate data from Chandra, XMM-Newton and Fermi and could involve undergraduate students.

Dr. Sayan Chakraborti schakraborti@cfa.harvard.edu

Massive stars end their lives in supernovae. These powerful explosions drive fast shock waves into the slowly moving wind from the original star. Such strong shocks can produce plasma at a billion Kelvin and accelerate cosmic rays. The radio and X-ray emission, resulting from this interaction, traces the history of mass loss from these stars. Thus, powerful observatories operating at these wavelengths provide us an unique window into the final moments of stellar evolution. I would like to involve students in either observational, theoretical or both aspects of these investigations.

Dr. Sheperd Doeleman sdoeleman@cfa.harvard.edu

Work in my group is focused on building the Event Horizon Telescope (EHT): a global array of mm and submm wavelength dishes that form an Earth-sized network. When phased together using the Very Long Baseline Interferometry (VLBI) technique, the EHT achieves an angular resolution of 10's of micro arcseconds, the sharpest of any astronomical technique. With just a few networked dishes, our group has resolved event horizon scale structure in SgrA*, the 4 million solar mass black hole at the Galactic Center, and in the much more luminous and massive black hole at the center of the giant elliptical galaxy M87. Over the next 2-3 years, this international project will add new sites and increase observing bandwidth to focus on astrophysics at the black hole boundary with the ultimate goal of imaging an event horizon. We are interested in working with students on instrumentation (primarily digital signal processing to enhance observing bandwidths) and on processing and analysis of ever richer data sets. There are opportunities for observing in exotic (and some not-so-exotic) locations around the Globe. EHT data products will soon have an unprecedented combination of sensitivity and resolution with excellent prospects for imaging strong-field General Relativity signatures, detecting magnetic field structures through full polarization observations, time-resolving black hole orbits, new tests of GR, and modeling black hole accretion, outflow and jet production.

Dr. Jonathan Weintroub jweintroub@cfa.harvard.edu

My group develops digital signal processing (DSP) instrumentation ("back ends") primarily for radio astronomy, with a few applications in other wavebands. We use ultra-fast analog to digital converters on wideband signals, and run the DSP algorithms in field programmable gate arrays (FPGAs). We participate in an international open source group, the "Collaboration for Astronomy Signal Processing and Electronics Research", or CASPER (http://casper.berkeley.edu). My research might be of interest to observational astronomy students with an interest in instrumentation. Still there are quite dramatic astronomical applications, including sub millimeter VLBI observations at event-horizon scales on super massive black holes, including SgrA*, the black hole at the center of our own galaxy.

Dr. Daniel Eisenstein deisenstein@cfa.harvard.edu

I work on cosmology and galaxy evolution, using both theoretical and observational tools. My primary focus has been on the use of large-scale structure to determine the composition of the Universe. I use sound waves that propagate in the first million years after the Big Bang to infer the expansion history of the Universe and the properties of dark energy. Much of my work uses data from the Sloan Digital Sky Survey III, of which I am Director. My group is also actively developing a new code for enormous cosmological simulations. I would be happy to meet with interested undergraduates to consider projects.

Dr. Mah Asgari masgari-targhi@cfa.harvard.edu

The high temperature of the Sun's corona remains one of the most important problems in Astrophysics. The coronal heating problem is trying to identify and develop an understanding of the physical mechanism responsible for heating the corona to millions of degree temperatures, several hundred times hotter than the underlying photosphere. My research focuses on the magnetic heating of the coronal loops by waves, in particular Alfven waves. The energy necessary to heat the corona may be provided by turbulent motions in the convection zone below the photosphere.

Dr. Alyssa Goodman agoodman@cfa.harvard.edu

Project 1: Milky Way Star Forming Regions. Recently, it has become possible to map out the distribution of star-forming molecular clouds in nearby galaxies. But, meanwhile, we do not yet have a full catalog of all the star-forming regions in our own Milky Way! Our vantage point on Earth, buried within the disk of the Milky Way, makes it hard to understand the 3D positions of distant star-forming regions, but new software tools are allowing us to decompose maps of molecular gas into a 3D catalog of Milky Way clouds.

Project 2: ADS All-Sky Survey. We have begun to create a map of all of astrophysical literature on the sky. An undergraduate interested in using either the map of "why and how the sky is/was studied where", or in extracting historical images of objects or classes of objects from the literature should come talk with us about joint astronomy--history of science--information science options for research. (http://arxiv.org/abs/1111.3983)

Project 3: The Spiral Structure of the Milky Way as seen in Infrared Dark Clouds. Thanks to the Sun's position slightly "above" the Galactic plane, it is possible to map out evidence for the Milky Way's spiral arms using the dust distribution as seen projected onto the sky.

Project 4: Data Visualization with Glue. Astronomical data has become more and more three-dimensional as spectrally-resolved imaging becomes more pervasive (see http://astrobites.com/2012/05/24/data-overload-how-to-deal-with-multidimensionaldata-sets/). In a joint effort with Prof. Hanspeter Pfister in SEAS, our group is developing a Python-based visualization environment intended to link views into multi-dimensional data. Students interested in combining CS and Astronomy research should contact us to learn more, and visit http://projects.iq.harvard.edu/seamlessastronomy/software/glue to learn more about the software effort.

Dr. Mari Paz Miralles mmiralles@cfa.harvard.edu

There are still many mysteries to unveil regarding our closest star, the Sun. In particular, there is not consensus on how the solar corona is able to generate, accelerate, and heat plasmas. In my research, I study both dynamic and steady phenomena that take place in the atmosphere of the Sun and its wind. By studying the physical properties of the plasma we can provide constraints to theoretical models and test different mechanisms. Possible projects for undergraduate research involve the analysis and interpretation of data from polar jets, solar flares, coronal mass ejections, coronal cavities, and fast/slow wind coronal-source regions. Students involved in these projects will have the opportunity to work with spectral and imaging data from space-based instruments aboard the Hinode, SDO, SOHO, and STEREO spacecraft. Undergraduate participation in any of these projects is welcomed and will result in a publication.