Harvard-Smithsonian Center for Astrophysics

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1 September 2012

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 300 scientists and powerful astronomical observatories worldwide and in space. The following is only 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 contact me.

Best regards,

Director of Undergraduate Studies, Astrophysics
Professor of Astronomy, Harvard University
dcharbonneau@cfa.harvard.edu *617-496-6515*

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. 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. We seek an undergraduate to help analyze the distribution and physical properties of the Milky Way's star forming regions, and ultimately to compare the Milky Way's clouds to those of other nearby galaxies.

Project 2: ADS All-Sky Survey
In a new project, 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. Undergraduates interested in gleaning the 3D geometry of the Milky Way from its appearance on a 2D sky should come here more!

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-multidimensional-data-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. Matthew Holman mholman@cfa.harvard.edu

The Pan-STARRS-1 survey began full-scale scientific operation in May 2010. Roughly 60% of the observing time of the Pan-STARR-1 telescope is dedicated to a "3pi steradian" survey with an observing cadence that is suitable for the detection of near-Earth asteroids and slow-moving solar system bodies. Over this course of its science mission, Pan-STARRS-1 survey will discover a large number of asteroids, Trojans, Centaurs, comets, and trans-neptunian objects (TNOs) brighter than the limiting magnitude of the survey (r=22 to r=22.5). This census will be used to address a large number of questions regarding the physical and dynamical properties of the various small body populations of the solar system. In addition, this survey will determine the population of large, distant, and rare members of the outer solar system and have the potential to detect planet-sized objects at great distances.

The undergraduate researcher will work with Matthew Holman to further develop an independent software pipeline that is optimized for the detection of outer solar system bodies. This pipeline will used both in Pan-STARRS-1 and in future wide-field surveys such as LSST.

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. Joseph Hora jhora@cfa.harvard.edu

I have several active projects in star formation using observations from the Spitzer and Herschel infrared space telescopes.

One example of a potential student project is studying the near-IR variability of Young Stellar Objects (YSOs). An important technique to study YSO disks and accretion flows is photometric monitoring to detect and characterize their variability at multiple wavelengths. We have an ongoing Spitzer program to perform time-series monitoring of the Orion Nebula Cluster and 10 other very young star-forming regions. In conjunction with the Spitzer observations, we have conducted a ground-based near-infrared observing program of these fields using PAIRITEL, the automated infrared telescope at the Whipple Observatory. The simultaneous near-IR and Spitzer observations will allow us to distinguish between different models to explain the origin of the variability.

Another potential project is studying massive protostars and star-forming clouds in the Cygnus-X region. We recently obtained Herschel imaging data that along with our existing Spitzer and near-IR data will allow us to construct complete Spectral Energy Distributions (SEDs) of objects from 1-500 microns. With these data we can address questions such as what are the properties of the youngest massive protostars, how the SEDs of high-mass protostars evolve over time, and how dense cores form from the collapse of filaments in the molecular clouds.

Dr. Kelly Chance kchance@cfa.harvard.edu

Previous undergraduate research with me resulted in successful development of instrument and algorithm requirements for measuring Earth's atmosphere polluting gases from space, with particular application to geostationary monitoring. This was for both a NASA-funded study to explore a mission recommended by the National Academy of Science for Earth monitoring in the near future, and for an approved Korean geostationary mission to measure pollution over Asia.

The research combined radiative transfer modeling of synthetic atmospheres to determine measurement requirements for basic classes of pollutants. Research during the coming academic year would refine the calculations for choices of polluting regions and conditions in North America, the detailed needs for spatial and temporal sampling, and the geophysical conditions for measurements, particularly surface reflectances. The scope is appropriate to a thesis for a student seriously interested in Earth or other planetary atmospheres.

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. You can find out more about these projects on my website https://www.cfa.harvard.edu/~jmoran/

Dr. Ed DeLuca edeluca@cfa.harvard.edu, **Dr. Leon Golub** golub@head.cfa.harvard.edu, and many colleagues as listed below.

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, Hinode, SDO, STEREO, Wind, ACE and LRO. We currently have two hardware programs: the SWEAP instrumentation package for the Solar Probe Plus mission and the Hi-C rocket. 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 15 PhD scientists with interests outlined below:

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

Magnetic structure of the solar atmosphere: Aad van Ballegooijen, Ed DeLuca, Kathy Reeves, Yingna Su

Mass and energy flow in the solar atmosphere: Aad van Ballegooijen, Leon Golub, Kelly Korreck, Paola Testa

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

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

Solar and Stellar Activity: Andres Munoz-Jaramillo, Steve Saar, Paola Testa

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Dr. Alberto Pepe apepe@cfa.harvard.edu
Dr. Alyssa Goodman agoodman@cfa.harvard.edu

Seamless Astronomy (and other projects at the intersection of astronomy and information science).

The Seamless Astronomy Group at the Harvard-Smithsonian Center for Astrophysics brings together astronomers, computer scientists, information scientists, librarians, and visualization experts involved in the development of tools and systems to study and enable the next generation of online astronomical research. Current projects include research on the development of systems that seamlessly integrate scientific data and literature, the semantic interlinking and annotation of scientific resources, the study of the impact of social media and networking sites on scientific dissemination, and the analysis and

visualization of astronomical research communities. More information about ongoing efforts by the Seamless Astronomy Group can be found at
http://projects.iq.harvard.edu/seamlessastronomy/pages/projects

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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. Catherine Espaillat cespaillat@cfa.harvard.edu

My research focuses on characterizing the observable properties of planet-disk interactions occurring in a planet's nascent stages. Forming planets are expected to interact with the disk, clearing the material around themselves and leaving behind observable signatures in the disk in the form of gaps. I have projects which involve using sophisticated irradiated, accretion disk models to model multi-wavelength data of disks in nearby star-forming regions. The goal is to discern which disks display evidence for gaps in order to better understand how these disks evolve from initially well-mixed distributions of gas and dust to systems composed mostly of rocky planets and gas giants like our own solar system.

Dr. Douglas Finkbeiner dfinkbeiner@cfa.harvard.edu

Prof. Finkbeiner's group searches for astronomical signals from dark matter annihilation using the latest data from particle astrophysics. Current data sets include the photon and particle data from the Fermi Gammaray Space Telescope and the positron spectrum from the PAMELA satellite. The group also collaborates with particle theorists to explore a broad class of models for dark matter known as "Sommerfeld enhanced" dark matter, where a new dark sector force acts on dark matter but couples only very weakly to ordinary matter.

Dr. Patricia Udomprasert pudompra@cfa.harvard.edu

WorldWide Telescope Ambassadors Program

Do you enjoy helping others understand how the Universe works? Are you interested in helping to improve science education? The WorldWideTelescope Ambassadors Program is looking for undergraduate students who can help:

--create interactive Tours about astronomy topics that are of interest to you

--develop new curricular materials for use in local schools

--curate existing tours, tutorials, and educational resources on our website

--tally and analyze results from student surveys

--teach others how to use WWT, including navigating through space using the Kinect controller.

http://wwtambassadors.org

Dr. Ramesh Narayan rnarayan@cfa.harvard.edu

Topics in theoretical astrophysics, including gravitational lensing, accretion disks, black holes, and gamma-ray bursts.

Dr. Katrien Kolenberg kkolenbe@cfa.harvard.edu

Astrophysics with Kepler

The spectacular data delivered by NASA's Kepler mission 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. My work lies in the field of asteroseismology, the science that studies the internal structure of pulsating stars by the interpretation of their frequency spectra. I mostly work on RR Lyrae stars, stars that pulsate with large amplitudes and periods of about half a day and that 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. There are over 40 RR Lyrae stars in the Kepler field and each of them provides us with information to better understand the whole class. I would be delighted to work with undergraduate students on the analysis and interpretation of Kepler and ground-based data of RR Lyrae stars. The goal for a research project is to result in a publication.

Dr. Gianni Bernardi gbernard@cfa.harvard.edu 617-496-7646
Dr. Lincoln Greenhill lgreenhill@cfa.harvard.edu 617-495-7194

When and how did the first stars form? The question represents a new frontier in cosmology and is driving construction of new radio telescopes sensitive to emission from neutral Hydrogen in the intergalactic medium at high redshift. However, detection of the faint signal from the early Universe also requires development of extremely accurate instrument calibration and precision techniques for subtraction of foreground emission (e.g., our galaxy). Students now have the opportunity to become involved in the Large Aperture Experiment to Detect the Dark Age (LEDA) and the Murchison Wide-field Array (MWA), including work on instrument design and development, and on reduction of early data.

Dr. Laura Brenneman lbrenneman@head.cfa.harvard.edu

My research focuses primarily on active galactic nuclei (AGN) and the supermassive black holes (SMBHs) at their cores. I study the emitting and absorbing structures close to the SMBH which can inform us about the structure of the nucleus, the dynamics of the gas therein, and the nature of the SMBH itself. The angular momentum of the black hole is of particular interest to me. I have an ongoing project devoted to constraining black hole angular momentum in AGN via multi-epoch X-ray spectroscopy and would welcome student involvement in this work.

Dr. Martin Elvis elvis@cfa.harvard.edu

1. Hot Dust Poor Quasars.

A longstanding dogma of quasar research is that all of these "active galaxies" are surrounded by a molecular obscuring torus. But my student Heng Hao found that about -10% of quasars in the COSMOS survey lacked the classic signature of emission from hot dust in the near infrared (JHK, 1-2microns). Why? Is the torus destroyed by a galaxy collision? warped by a misaligned black hole? We don't know, yet. We are combining SDSS (optical), UKIDSS (near-IR) and WISE (mid-IR) data for thousands of quasars to look for patterns in how much hot dust they have. Preliminary results are interesting, but there's a lot more to do. We may even find some stranger quasars yet.

2. Easily Accessible near-Earth Asteriods

An asteroid is easy to get to if it takes less energy to get there (and back), or equivalently, a small change in velocity (delta-v). The ultra-low delta-v near-Earth Asteroids (NEAs) may enable human exploration of the asteroids, as smaller - affordable - rockets can be used to get there.

However, most surveys are inefficient at finding these NEAs, possibly by substantial but unknown factors. So we don't even know how many such NEAs there are. We are using asteroid population models to estimate the size of this population, calculate good trajectories and find out how bright they will get on passes near the Earth so we can see how big a telescope we will need to learn more about them.

Dr. Julia Lee jclee@cfa.harvard.edu

Research on topics related to neutron star and energetic black hole systems, big and small. Spectral studies using data from X-ray satellites to determine accretion physics and system geometry. Topics of interest range from measuring black hole spin to jet physics to determining plasma conditions in these systems and interstellar space.

Dr. Patrick Slane slane@cfa.harvard.edu

My research centers on a number of areas in Galactic high energy astrophysics, with a particular focus on pulsar winds and supernova remnants. I have several projects in which undergraduate participation would be welcomed. These studies, centered on observational and modeling efforts involving data from Chandra, XMM-Newton, Fermi, and other facilities, are most appropriate as junior or senior thesis topics, and include:

o Cosmic Ray Acceleration and Gamma-Ray Production in Supernova Remnants

o The Formation and Fate of Pulsar Winds

Dr. Jonathan Grindlay josh@head.cfa.harvard.edu

DASCH for Time domain astrophysics

Our Digital Access to a Sky Century @ Harvard (DASCH) project is now in "production mode" scanning-digitizing of the Harvard sky survey plates. This collection of a half-million plates, by far the world's largest-longest duration of images of the full sky, provides unique access to time domain astrophysics (TDA) on days-weeks-decades timescales over the 100 year span of the plates.
Junior or Senior thesis type projects for TDA surveys of particular classes of object or development of new analysis tools can be carried out. See DASCH website: http://hea-www.harvard.edu/DASCH/

Designing REXIS for X-ray imaging an asteroid

Harvard is the major partner with MIT for the "student experiment" on the major NASA mission ORIRIS-

REx to an asteroid (RQ36) for a ~3-month closeup survey and then landing and sample return. REXIS (Regolith X-ray Imaging Spectrometer) is the Harvard-designed coded aperture wide-field (30 deg !) X-ray telescope that will image X-ray fluorescence (from solar X-rays exciting the RQ36 surface) to measure and map the elemental abundance (O, Al, S, Mg, etc.) variations over the asteroid. This will be done during a ~1 month survey phase from a ~500m altitude orbit around the asteroid and will help in site selection for the landing/sample return. We have immediate need for a student with C programming or Python skills to work on simulations of this novel type of "diffuse-source" coded mask imaging which is essential for final design of the coded mask. This can be an independent study course for joint Harvard-MIT credit. Students from SEAS/CS, Astronomy or EPS are particularly appropriate. See REXIS (at Harvard) website (to be updated): http://hea-www.cfa.harvard.edu/REXIS/

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. Alicia Soderberg asoderbe@cfa.harvard.edu

The most massive stars in their Universe (more than 20 times the mass of our own Sun) end their lives in catastrophic explosions known as supernovae. Using a suite of ground and spacebased telescopes we study the explosion properties and environments of these violent cosmic events across the electromagnetic spectrum. Through this dedicated effort we are able to trace back the last moments in the life of a dying star and study the dramatic effect of the explosion on its environment. I would be delighted to have Harvard undergraduates join this exciting effort.

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 10^5-10^7 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. Randall Smith rsmith@cfa.harvard.edu

I might have a position available for a student interested in atomic data for X-ray spectroscopy. I'm the lead scientist in charge of the AtomDB project (www.atomdb.org), and have a number of projects that would involve compiling and/or calculating atomic data and comparing the results against a range of existing X-ray spectroscopic observations. The work would be particularly timely for someone considering graduate school in X-ray astronomy, since the Astro-H mission is currently scheduled for a 2014 launch and its calorimeter detector will revolutionize high-resolution X-ray spectroscopy.

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. 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 our group is focused on two exciting projects. First, 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. Second, we are leading a search for never before seen transients using the new 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 fastpaced branch of astronomy.

Dr. David Charbonneau dcharbonneau@cfa.harvard.edu

By targeting nearby stars smaller than 0.3 solar radii, a transit search using modest equipment is capable of discovering planets as small as 2 Earth radii in the habitable zones of their host stars. The discovery of such planets is important for two reasons: First, their transiting geometries permit direct estimates of the planetary masses and radii, and hence provide fundamental constraints on the physical structure of planets that are primarily rock and ice in composition. Second, by differencing spectra gathered when the planet is in view from those when it is occulted by the star, we can study the atmospheric chemistry of potentially habitable worlds. The MEarth Project consists of 8 identical, automated 16inch telescopes in a single enclosure at Mt Hopkins, Arizona. Students are invited to join in the fun of analyzing MEarth data and hunting for these elusive worlds.

Dr. Jonathan Weintroub jweintroub@cfa.harvard.edu

I develop 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). The FPGA development environment is based on Matlab/Simulink. 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 submillimeter VLBI observations at event-horizon scales on the Galactic Center super massive black hole.

Dr. Hagai Perets hperets@cfa.harvard.edu

I'll be happy to continue involving students in my research this year. I'm interested in a wide variety of astrophysical fields, mostly theoretical. These include extra-solar planet formation, evolution and dynamics; asteroids, Kuiper belt objects and moons in the Solar system; stellar dynamics with special focus on triple systems, stars near massive black holes and dense stellar systems. In addition I'm intersted in the study of irregular supernovae and their implication on the formation of atomic elements in the universe.and in addition supernovae. For more details please look at my site https://www.cfa.harvard.edu/~hperets/index.html or better - just contact me!

Dr. John Kovac jmkovac@cfa.harvard.edu

Dr. Abigail Vieregg avieregg@cfa.harvard.edu

The Cosmic Microwave Background (CMB) group at the CfA works to design, build, operate, and analyze data from a series of polarization sensitive microwave telescopes, including BICEP2, the Keck Array, and POLAR-1, which observe the CMB from the South Pole. Our telescopes search for a signature of Inflation that would be imprinted as a specific pattern of polarization in the CMB. Our group has very active instrumentation and analysis efforts. This year, we are gearing up for another season at the South Pole and running a full telescope testing program here at Harvard.

We have current projects potentially suited to committed undergraduates ranging from design, development, and construction of instrumentation for CMB telescopes operating at the South Pole to analysis of data returned by these telescopes to constrain inflationary observables and simulation of future CMB weak lensing observations. Visit the group website (http://www.cfa.harvard.edu/CMB/) to see a little more about what we do or contact us to come by and check out what is going on in the lab.

Dr. Henry (Trae) Winter hwinter@cfa.harvard.edu

Large solar flares generate more energy than the United States would use in 100,000 years. It is known that a large fraction of this energy goes into the acceleration of non-thermal particles to very high energies. The mechanisms that generate these non-thermal particles are not well understood and solar flare conditions are currently impossible to reproduce in a lab. Students will learn how to use numerical techniques to simulate particle acceleration and transport within a solar flare and run experiments using different acceleration scenarios. Students will also learn how to scale problems to Graphics Processing

Units (GPUs) and super-computer clusters. Previous programming experience in any computer language is required.

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

In my research, I study the atmosphere of the Sun and its wind using spectral and imaging data from space-based instruments aboard SOHO, Hinode, SDO, and STEREO. Possible projects for undergraduate research involve processing and analysis of coronal data. The measured plasma properties will be used to test theoretical models of coronal heating and solar wind acceleration.

Dr. Sven Van Loo svanloo@cfa.harvard.edu

Star formation occurs primarily in giant molecular clouds (GMCs), but is usually restricted to a small fraction of the volume of a GMC, as most stars form in or near relatively small clusters. This would seem to suggest that the processes setting the Galactic star formation rate are those that generate the dense clumps within GMCs. By using numerical simulations we can study the processes that dominate the formation of GMCs and dense clumps within them.

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. Suzanne Romaine romaine@head.cfa.harvard.edu

We are involved in instrument development and are developing optics for X-ray astronomy satellites - and have some applications that extend to physics of plasmas for work in laboratory astrophysics. The student could be involved in experimental work or could be more involved in computer simulations and modelling.

I'd be happy to talk more about opportunities with any interested students.

Dr. Christopher Stubbs stubbs@physics.harvard.edu

Understanding the optical transmission of the atmosphere is an essential aspect of improving the precision of flux measurements. We are engaged in a number of projects to determine the variable aspects of atmospheric transmission, namely clouds, aerosols and water vapor. This involves both the construction of new apparatus and the analysis of data sets. There are ample opportunities for undergraduates to contribute to this effort.

Dr. Matthew Walker mwalker@cfa.harvard.edu

I study the phenomenology of dark matter, the nature of which has remained a mystery for more than 80 years. Specifically, I study the internal dynamics of dwarf galaxies, which are fundamental to the dark matter problem because 1) they have the largest mass-to-light ratios of any galaxy type (suggesting that they consist almost entirely of dark matter), and they are the smallest objects that exhibit evidence for a dark matter component. I would like an interested student to work with me to analyze scaling relations involving the dark matter properties of the Milky Way's dwarf satellite galaxies.

Dr. Matthew Schneps mschneps@cfa.harvard.edu

Understanding the vast scale of space is among the most challenging concepts in astronomy education. The Laboratory for Visual Learning is conducting experiments to investigate whether comprehension of astronomical scale is enhanced through real time tactile control of 3D visualizations. Apple iPads will be used to allow high school students to explore solar system environments in true vs exaggerated scale and differences in cognition assessed.

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.

Drs. James Phillips and Robert Reasenberg

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rreasenberg@cfa.harvard.edu *617-495-7108*

Experimental relativity The weak equivalence principle (WEP) states that objects under the influence of gravity alone fall at the same rate, independent of composition and internal structure. The WEP is an essential postulate of general relativity. WEP violations are predicted by most theories unifying gravity with the strong, electromagnetic, and weak forces. The present best limit on the fractional acceleration difference, eta, is 2x10^-13. Our Principle Of Equivalence Measurement has a ground-based version, G-POEM, and a version based on a sounding rocket, SR-POEM. We expect that G-POEM can advance limits on eta to 5x10^-14 or better, and that SR-POEM will advance the limits to at least 2 10^-17. Both use our state-of-the-art subpicometer laser distance gauge. The G-POEM experimental chamber rides on a vertical air bearing, undergoing 0.9 s episodes of free fall every 1.3 s. We are readying the G-POEM apparatus to make measurements, and are testing aspects of technology needed for SR-POEM.

Dr. Igor Chillingarian igor.chilingarian@cfa.harvard.edu

I have a few ongoing projects related to observational studies of galaxy evolution and also to some more technical stuff related to Virtual Observatory, data reduction and analysis.

Some of the projects are:

(1) Stellar population and internal dynamics of ultracompact dwarf galaxies (data from Magellan-IMACS, GEMINI, ESO VLT)

(2) Evolution of dwarf elliptical galaxies in clusters (IFU spectroscopy from 3.5m at Calar-Alto, GMOS; archival long-slit data from various telescopes)

(3) Properties and evolution of early-type galaxies at low to intermediate redshifts ($z<1$) -- analysis of publicly available datasets from Sloan, UKIDSS, GALEX, DEEP2.

(4) Development of the spectrophotometric inversion technique (full spectral fitting of high resolution spectra + a broadband SED) for constraining star formation history and internal dynamics of nearby galaxies.

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

My team is involved in follow-up observations to confirm and characterize transiting planets, especially for candidates identified by the Kepler mission, but also for ground-based surveys. We work with spectroscopic observations to characterize the host stars and derive orbital solutions for mass determinations, and with photometric observations for the analysis of light curves. We use the facilities at SAO's Whipple observatory on Mount Hopkins, Arizona, and HARPS-N on La Palma, in the Canary Islands. Some of the most interesting Kepler planets are in orbit around eclipsing binaries, where a photometric/dynamical solution can use the orbital solution for the binary to help pin down the masses and radii of everything that shows in the light curve. That's just one example where a student could get involved.

Hossein Sadeghpour hrs@cfa.harvard.edu

Studies of large-scale ordered carbon structures in the Universe

The seminal detection of regular carbon cages (C60 and C70) in the infrared (IR) emission of several planetary sources has captured the imagination of the scientific community, but has also spawned a number of intriguing questions. The mere fact that such atomistically pristine molecules are now known to exist in the dust of the interstellar medium (ISM), while their natural terrestrial abundance is low, has led to such fundamental questions as how they form, and do other regular carbon macromolecules, such as nanotubes or graphene, also exist in the ISM? Because carbon nanotubes and other ordered carbon structures possess distinctive spectroscopic signatures, they may too be detectable in space. In this work, we will attempt to answer these questions by calculating their properties, understanding the formation pathways through transient states, and lay the groundwork for selective and sensitive detection of these or other new species in the near future. The undergraduate student will assist a graduate student in calculations with quantum mechanical methods.

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. Matthew Ashby mashby@cfa.harvard.edu

I'm coordinating a multinational collaboration to better understand star formation. Our current focus is on increasingly detailed observations of a well-chosen study set of nearby galaxies, in order measure the rates at which they are forming new stars. We have recently acquired images from the AKARI satellite in four far-infrared bands at 60, 90, 110, and 160 microns covering hundreds of galaxies. We're seeking a motivated student to take ownership of these images, photometer them, integrate the results into our extensive UV-to-radio database, and finally, measure the ongoing star formation via modeling of the augmented spectral energy distributions.

The European Space Agency's AKARI page:
http://www.sciops.esa.int/index.php?project=ASTROF&page=index

The project homepage here at the CfA:
http://www.cfa.harvard.edu/sfrs/

Dr. Justin Kasper jkasper@cfa.harvard.edu

Justin studies the flow of energy in astrophysical plasmas, including the solar corona, the solar wind, and planetary magnetospheres. He is interested in how the atmosphere of the Sun is heated to millions of degrees, how this hot atmosphere or corona produces a supersonic solar wind that spreads throughout interplanetary space, and how shock waves and solar flares accelerate particles to reletavistic energies. He has worked on the development, construction, and analysis of spacecraft instrumentation for the in-situ and remote measurement of particles and fields. He is the Principal Investigator for the Solar Wind Electrons Alphas And Protons (SWEAP) Investigation on the NASA Solar Probe Plus mission, the first spacecraft to enter the outer atmosphere, or corona, of the Sun. Research opportunities for undergraduates include studies of the solar wind and laboratory experience with the development of new technologies for future instrumentation.

Dr. Xiong Liu xliu@cfa.harvard.edu

My research focuses on the following areas: (1) Make atmospheric measurements especially O3 profile and tropospheric O3 from satellites such as the Ozone Monitoring Instrument (OMI), Global Ozone Monitoring Experiment (GOME-2), Ozone Mapping and Profiler Suite (OMPS), validate satellite retrievals with other in-situ or remote sensing measurements, and develop a long-term consistent dataset from multiple satellites; (2) Make atmospheric measurements of O3, NO2, HCHO, SO2, CHOCHO, H2O, and aerosols from aircraft measurements (e.g., Airbone Compact Atmospheric Mapper during the Earth Venture Mission DISCOVER-AQ) and conduct validation with other in-situ or remote sensing measurements; (3) Combine satellite data and chemical transport model simulations, meteorological fields to investigate processes controlling tropospheric ozone; (4) Design instrument and perform retrieval sensitivity studies about measuring air quality species from the geostationary orbit.

Dr. Alexey Vikhlinin avikhlinin@cfa.harvard.edu

Dr. Alexey Vikhlinin is an expert on cluster of galaxies, working on both astrophysics of these objects and using them for cosmological constraints. Observations of the cluster mass function evolution is currently one of the most sensitive methods to study the effects of Dark Energy on the growth of large scale structure. Dr. Vikhlinin leads several prominent long-term observing programs with the Chandra X-ray Observatory, and is involved in studies of galaxy clusters detected with the South Pole Telescope. He is also involved in the development of next-generation adjustable X-ray optics and in applications of a powerful future X-ray observatory for observations of the high-redshift universe and galaxy formation.

Dr. Christine Jones cjones@cfa.harvard.edu

Clusters of galaxies are the most massive gravitationally bound structures in the Universe. With the Chandra X-ray observatory, we are obtaining images of a full sample of massive clusters in the local ($z<0.35$) Universe. These clusters were detected by the Planck mission through the Sunyaev-Zeldovich (SZ) decrement in the cosmic microwave background. Many of these clusters show evidence of undergoing major mergers. Each merging cluster is worthy of detailed study to characterize the cluster mass as well as the merger characteristics. By participating in this work, the student would have an opportunity to carry out research that is fundamental for understanding the growth of large-scale structures.

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 know for my 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.

The opportunities listed above represent only a subset of the science investigations at the Harvard-Smithsonian Center for Astrophysics. In addition to the individuals above, students are always welcome to consult the complete listing of researchers and projects at the webpage below and to contact these individuals and David Charbonneau directly.

http://www.cfa.harvard.edu/