MARAC 2018

Friday, April 13, 1:00 – 6:00

Miller Nichols Learning Center (= the library)

REGISTRATION: 1:00 – 1:30

Session I 1:30 – 3:00

1:30 – 1:45

The Mechanism Which Causes Asteroids to Tumble

Annett, Clarence H., The Prairie Research Center, Kansas City

At the 8th Midwest Regional Astrophysics Conference in 1978, David Tholen of Lowell Observatory (Flagstaff, AZ) presented observational results consisting of light curves and high-resolution photographs which showed for the first time that a few asteroids tumble end-over-end (rotate around an axis which is 90 degrees from their direction of travel). The mechanism by which an asteroid could begin this mode of travel was not clear at the time and has remained unclear. I will give a very preliminary physical explanation that the tumbling motion begins when the asteroids cross from less dense to more dense interplanetary matter and discuss how this conclusion was derived from terrestrial physical aerodynamics.

1:45 – 2:00

Modeling Rotation States and Light Curves of Rocket Bodies in Low Earth Orbit

Ojakangas, Gregory W., Drury University

Detailed computer models of the evolving orbital debris population indicate that in coming decades, collision hazards to spacecraft will increase substantially, and that catastrophic collision rates will be substantially driven by impacts involving large, intact objects. Therefore, in recent years, the international community has become increasingly interested in Active Debris Removal (ADR) strategies, i.e. technologies directed toward intentional removal of individual large debris objects from earth orbit. To aid in designing effective ADR architectures, it is important to understand the rotational states of these objects. Most are spent rocket bodies (RBs) -- nearly cylindrical in shape and inertial characteristics. Therefore, to a first approximation, their dynamics should resemble those of symmetric tops exhibiting free precession. However, rotational dynamics are non-intuitive and misconceptions inconsistent with relevant physics are common, even in the published literature. In a state of free precession, the total angular momentum of the object is constant, while kinetic energy decreases due to internal friction, approaching rotation about the axis of maximum inertia. For solid internal friction, the timescale is hundreds to thousands of years for quality factors of ~100 and assuming metallic rigidities, but for turbulent friction in partially-filled liquid fuel tanks I predict that the preferred rotational state is approached rapidly, within days to months. In free precession, the 3-1-3 Euler angle rates $\dot{\phi}$ (precession rate of long axis about fixed angular momentum with cone angle θ) and $\dot{\Psi}$ (roll rate around long axis) have comparable magnitudes until very close to $\theta = \pi/2$, so that the true "rotation period" is not simply twice the primary light curve period. Furthermore, $d\theta/dt$, nonzero due to friction, becomes asymptotically smaller as $\theta = \pi/2$ is approached, so that θ can linger within several degrees of flat spin for a relatively long time. Such a condition is likely common, and cannot be distinguished from the "wobble" of a cylinder with a skewed inertia tensor unless the RB has non-axisymmetric reflectivity characteristics. Simulations of light curves from modeled debris objects of known origin are being generated at Drury University using a unique laboratory in which appropriately painted, 3D-printed objects are suspended within a three-axis computer-controlled gimbal system, illuminated by an incandescent lamp representing the sun, and observed with a CCD camera. These are compared to computer generated theoretical light curves representing various rotation states, and to actual light curves of catalogued debris objects acquired by the Drury University Observatory.

2:00 – 2:15

Fundamental Milky Way Parameters

Camarillo, Tia; Ratra, Bharat; Dredger, Pauline, Kansas State University

We have been working on constraining the rotation curve of the Milky Way galaxy using various methods of statistical analysis on the observed error distributions. In this talk, I present our current values for the fundamental Galactic constants R_o, the distance from the Sun to center of the Milky, and V_o, the circular

Galactic rotation speed at the position of the Sun. I describe drawbacks of the data sets previously used for this purpose as well as our process for compiling our current data sets from which we determine these constants.

2:15 – 2:30

Massive and Distant Clusters of WISE Survey (MaDCoWS)

Brodwin, Mark, on behalf of the MaDCoWS Collaboration

The Massive and Distant Clusters of WISE Survey (MaDCoWS) is a comprehensive program to detect and characterize the most massive galaxy clusters in the Universe at z ~ 1, and is the only all-sky survey sensitive to galaxy clusters at this epoch. The foundation for this program is data from the NASA Wide-field Infrared Survey Explorer (WISE). The primary goal is to study the evolution of massive galaxies in the most overdense environments at z > 1 when star formation and AGN activity may be peaking in these structures. Spitzer follow-up imaging of 2000 MaDCoWS clusters has allowed us to select the richest and/or most distant clusters for detailed study. To date we have spectroscopically confirmed over 30 MaDCoWS clusters, spanning a wide range of masses (2-10 x 10^{14} $M_{\odot}$), out to z = 1.5. This includes the discovery of the most massive cluster yet found -- by any method -- at z > 1.15 and a z = 1.23 cluster that is lensing a z = 2.22 SN Ia. I will describe the multi-wavelength follow-up of these distant clusters and briefly describe several projects that are underway.

2:30 – 2:45

Dependence of AGN Activity on Halo Mass and Redshift in the SPT-SZ Cluster Survey

Floyd, Benjamin; Brodwin, Mark, University of Missouri - Kansas City

The number of active galactic nuclei (AGN) in galaxy clusters has been observed to grow by nearly two orders of magnitude from the local universe to z ~ 1.5. Star formation rates in clusters have also been observed to rise rapidly over this redshift interval. These trends, along with several other recent observations of high-redshift clusters, have led to the idea that this enhanced star formation and AGN activity may be driven by galaxy mergers within the clusters. Since mergers are more efficient in lower mass clusters with smaller galaxy velocity dispersions, the expectation is that AGN incidence should scale inversely with cluster mass. A recent study using X-ray selected AGN has offered some support for this model in low-redshift clusters, though with large uncertainties. We select infrared bright AGN from a large, uniform, mass-selected galaxy cluster sample from the South Pole Telescope spanning a redshift range of $0.5 < z < 1.7$ for which we have acquired follow-up Spitzer Space Telescope observations. With these data we explore the incidence of AGN in clusters as a function of cluster mass, redshift, and projected cluster-centric radius.

2:45 – 3:00

The Effect of Local Environment on the Size of Star-Forming Disks

Rudnick, Gregory, University of Kansas

The speed with which the star formation in galaxies is shut off when they enter clusters is a long-standing topic of controversy. On one hand, dense environments such as clusters and groups show enhanced levels of galaxies with post-starburst spectra, indicating a fast quenching of star formation. In addition, the lack of star-forming galaxies with significantly suppressed star formation rates (SFRs) indicate that the quenching must be fast. On the other hand, attempts to model the fraction of passive galaxies in clusters and its evolution with time argue for a quenching timescale on the order of a few billion years. An attempt to reconcile these seemingly disparate results has been proposed in which galaxies experience a delay period during which their SFRs are not modified, followed by a fast quenching phase. But this picture must be tested. A key diagnostic of how SFRs are modulated is the spatial extent of the star-forming disk relative to the stellar disk, as different quenching mechanisms make different predictions for this quantity. We use observations of the dust distribution in galaxies residing in 9 nearby clusters to understand how the star-forming disk is affected by the environment. We find that gas disks in clusters are smaller than in the field at a fixed bulge-to-total ratio, and more so for less massive galaxies. This implies that the distribution of star-forming material in the period before a putative rapid environmental quenching event is being modified. One interpretation is that there is a long timescale for the suppression of star-formation, even in the absence of a rapid quenching event.

BREAK: 3:00 – 3:30

SESSION II 3:30 – 4:45

3:30 – 3:45

Identifying Distant Galaxy Clusters Using Dust-obscured galaxies as Signposts at Redshift >~ 1.3

Saha, Ripon; Brodwin, Mark, University of Missouri-Kansas City

Recent studies of high-redshift galaxy clusters have revealed a high concentration of star formation and AGN activity in cluster cores at z > ~1.4. This suggests that dusty, highly star-forming and/or active high-redshift galaxies, such as Ultra-luminous Infrared Galaxies (ULIRGs) or Dust-obscured galaxies (DOGs), might be employed to detect high redshift galaxy clusters. In order to test this proposition, we compared the distribution of ~2600 DOGs at z ~ 2 with a sample of 50 distant (z > ~1.3) galaxy clusters from the IRAC Shallow Cluster Survey (ISCS). The ISCS is an IR-selected sample of 0 < z < 2 galaxy clusters located in the $10^{o\,2}$ Spitzer Deep, Wide-Field Survey (SDWFS). This well-studied cluster sample is selected completely independently of the DOGs. The sky surface density of DOGs in 0.5’ radius apertures around the ISCS clusters is found to be 0.46 ± 0.12 arcmin^{-2}. This detection is overdense by a factor of 5.3 ± 1.4 relative to the surface density of randomly distributed objects (0.087 arcmin^{-2}), corresponding to a detection significance of $\sim 3\sigma$. This result indicates that DOGs aren't randomly distributed, rather they preferentially reside in rich environments, often within ~250 kpc of a galaxy cluster. This physical association, along with previous studies, has motivated us to employ DOGs as signposts to detect new distant clusters. We developed and tested a pipeline to isolate and rank our detections, and using it have found 360 new cluster candidates (overdensities) above a 3σ-detection significance. This pipeline has re-discovered 80% of all the ISCS clusters lying at $z \geq 1.3$, including IDCS J1426.5+3508 at z = 1.75, the most massive galaxy cluster known at z > 1.5. To characterize the sample, we calculated the two-point angular autocorrelation function of the cluster candidates in order to measure their clustering strength. The correlation length is found to be ~18 h^{-1} Mpc, which is consistent with the results from other infrared distant cluster search methods and demonstrates conclusively that the sample has the mass scale of galaxy clusters. We conclude that distant, highly star-forming galaxies selected in the mid- or far-IR with Spitzer or Herschel are sensitive signposts of massive cluster and protocluster halos at the highest redshifts.

3:45 – 4:00

Synergy of WISE and SDSS in Stripe 82

Musin, Marat, University of Missouri-Columbia

We report the current results from our effort to synergize WISE and SDSS in the ~ 300 square degree Stripe 82 region. Using the SDSS images as the prior, we fit the SDSS-detected objects to the WISE W1/W2 images to obtain consistent optical-to-IR SEDs. The major outcome will consist of two catalogs: (1) one the "SDSS-WISE" photometric catalog on ~ 22 million SDSS-detected sources, and (2) the other one is the "WoDrop" catalog that are optical-dropouts detected on the residual W1/W2 images that do not have SDSS counterparts. The applications and the implications of our results will be briefly discussed.

4:00 – 4:15

Stellar Mass Fractions of Infrared-Selected Galaxy Clusters at z ~ 1

Decker, Bandon; Brodwin, Mark, University of Missouri-Kansas City

Galaxy clusters are the most massive gravitationally-bound objects in the universe and are excellent tools to study both cosmology and galaxy evolution. Whereas many cluster surveys look for signatures of the intracluster medium (ICM) in either X-ray or radio light, the complementary Massive and Distant Clusters of WISE Survey (MaDCoWS) uses infrared WISE data to find the most significant galaxy overdensities at z ~ 1. Using follow-up observations with the Combined Array for Research in Millimeter-wave Astronomy (CARMA) and the Spitzer space telescope, we have determined stellar mass fractions for a subset of these infrared-selected clusters and compare these fractions to those from a sample of ICM-selected clusters with similar masses and redshifts from the South Pole Telescope (SPT)-SZ Survey. We find a significantly higher average stellar mass fraction for the infrared-selected cluster sample than the ICM-selected sample, suggesting that cluster selection methods have an important impact on the measured properties of clusters. Our next step is to extend this analysis with deeper Spitzer data, better analysis of cluster members and more MaDCoWS clusters.

4:15 – 4:30

HaloSat: An X-ray Analysis of the Halo of the Milky Way

LaRocca, Daniel; Kaaret, Philip, University of Iowa

Observations of the nearby universe fail to locate about one third of the baryons observed in the early universe. Hot galactic halos are thought to be one possible reservoir for these missing baryons. Observing the closest of such hot galactic halos can provide insight to the extent to which baryonic mass is contained in the halos of galaxies. HaloSat is a dedicated X-ray CubeSat capable of detecting X-ray signature from the Milky Way halo and slated for launch in May 2018. It is comprised of three independent X-ray detector units, each with the capability to detect X-rays between 0.4 and 8 keV. Use of a CubeSat enables an observing strategy that can maximize the scientific outcome of the mission by scheduling observations in such a way as to reduce foreground contamination. The large field of view and the high spectral resolution make HaloSat optimal for spectral analysis of large, diffuse structures such as the galactic halo. HaloSat will be the first comprehensive, spectrally well-resolved survey of the Milky Way Halo.

4:30 – 4:45

Measuring X-ray Binary Accretion State Distributions in Extragalactic Environments using XMM-Newton

West[1], Lacey; Lehmer[1], Bret; Yukita[2], Mihoko; Hornschemeier[3], Ann E.; Ptak[3], Andrew; Wik[4], Daniel R.; Zezas[5], Andreas, University of Arkansas[1], Johns Hopkins University[2], NASA/GSFC[3], University of Utah[4], Crete[5]

X-ray binary systems (XRBs) in the MW can exist in several different accretion states, and many have been found to evolve along specific tracks on intensity-color diagrams. Observationally measuring the distributions of these accretion states in a variety of environments can aid in population synthesis modeling and ultimately help us to understand the formation and evolution of XRBs and their compact object components (i.e., black holes and neutron stars). Recent innovative studies with NuSTAR have demonstrated the utility of color-color and intensity-color diagrams in differentiating between XRB accretion states in extragalactic environments (NGC 253, M83, and M31). The key to NuSTAR's success is its sensitivity above >>10 keV, where spectral differences between accretion states are most pronounced. However, due to the relatively low spatial resolution and large background of NuSTAR, the constraints from these diagrams are limited to only bright sources in nearby galaxies. In this talk, we will present evidence that XMM-Newton observations of M83 and M33 in the 4.0-12.0 keV range can be used to create similar color-intensity and color-color diagrams and therefore differentiate between these accretion states. We will further discuss plans to leverage XMM-Newton's vast archive and 17-year baseline to dramatically expand studies of accretion state distributions and state transitions for XRB populations in extragalactic environments.

BREAK: 4:45 – 5:00

SESSION III 5:00 – 6:00

5:00 – 5:15

Actively Encouraging Learning and Degree Persistence: How to Facilitate Interactive Engagement in Advanced Astro Courses

McIntosh, Daniel H., University of Missouri-Kansas City

The need to grow and diversify the STEM workforce remains a critical national challenge. Less than 40% of college students interested in STEM achieve a bachelor's degree. These numbers are even more dire for women and URMs, underscoring a serious concern about the country's ability to remain competitive in science and tech. A major factor is persistent performance gaps in rigorous 'gateway' and advanced STEM courses for majors from diverse backgrounds leading to discouragement, a sense of exclusion, and high dropout rates. In short, very capable students with less experience and confidence in science, who belong to groups that traditionally are less identified with STEM careers, are effectively and efficiently 'weeded out' by traditional education practices. The good news is that education research has clearly demonstrated that interactive-engagement ('active learning') strategies increase performance, boost confidence, and help build positive 'identity' in STEM. I will share my insights and experiences from successfully implementing active learning in advanced astrophysics courses. I will provide simple guidelines for adding active learning to your established courses to encourage students from all backgrounds synthesize complex ideas, build bedrock conceptual frameworks, gain technical communication skills, and achieve mastery learning outcomes - all necessary to successfully complete rigorous degrees like astrophysics. By creating an inclusive and active learning experience in upper-division extragalactic and stellar interiors/atmospheres courses, I am helping students gain fluency in their chosen major and the ability to 'think like a scientist', both critical to improving STEM degree retention and degree-completion rates. My long-term mission is to see STEM degree programs at U.S. colleges and universities adopt active-learning strategies as the curricular norm. Understanding the benefits of this evidence-based best practice is a key step to increasing and diversifying the national STEM degree recipient pool.

5:15 – 5:30

Quantifying and Reducing Light Pollution

G*okhale*[1]*, Vayujeet; Caples*[2]*, David; Herdman*[1]*, Ashley; Goins*[1]*, Jordan; Wren*[1]*, Emily*
Truman State University[1], Moberly Area Community College[2]

We describe the current level of light pollution in and around Kirksville, Missouri and around Anderson Mesa near Flagstaff, Arizona. We quantify the amount of light that is projected up towards the sky, instead of the ground, using Unihedron sky quality meters installed at various locations. Presently, light fixture shields and ‘warm-colored’ lights are being installed on Truman State University’s campus in order to reduce light pollution. We discuss the experimental procedure we use to test the effectiveness of the different light fixtures shields in a controlled setting inside the Del and Norma Robison Planetarium. We will also discuss ways in which astronomers can take the lead in becoming proponents of smart outdoor lighting in order to preserve our night skies, and to make our campuses and communities healthier and more environmentally friendly.

5:30 – 5:45

Mass Distribution and Bar Formation in Growing Disk Galaxy Models

Berrier[1]*, Joel; Sellwood*[2]*, J.A.*, University of Nebraska-Kearney[1], Steward Observatory[1]

We report idealized simulations that mimic the growth of galaxy disks embedded in responsive halos and bulges. The disks manifested an almost overwhelming tendency to form strong bars that we found very difficult to prevent. We found that fresh bars formed in growing disks after we had destroyed the original, indicating that bar formation also afflicts continued galaxy evolution, and not just the early stages of disk formation. This behavior raises still more insistently the previously unsolved question of how some galaxies avoid bars. Since our simulations included only collisionless star and halo particles, our findings may apply to gas-poor galaxies only; however, the conundrum persists for the substantial unbarred fraction of those galaxies. Our original objective was to study how internal dynamics rearranged the distribution of mass in the disk as a generalization of our earlier study with rigid spherical components. With difficulty, we were able to construct some models that were not strongly influenced by bars, and found that halo compression and angular momentum exchange with the disk did not alter our earlier conclusion that spiral activity is largely responsible for creating smooth density profiles and rotation curves.

5:45 – 6:00

A Tale of Two Sides of the Star Formation Histories of Dwarf Galaxies beyond the Local Universe: bursts and quenching

Guo, Yicheng, University of Missouri-Columbia

Galaxies with stellar mass hundreds or thousands times smaller than our Milky Way (hereafter dwarf galaxies) are important for understanding galaxy formation and evolution, because they are believed to be the most sensitive probes of both the macro-physics of dark matter halos and the micro-physics of the different physical mechanisms that regulate the star formation of galaxies. In this talk, I will present our recent results on two seemingly opposite but closely related aspects of the star formation histories (SFHs) of dwarf galaxies: bursts and quenching. First, we show that dwarf galaxies' SFHs are more bursty than those of massive galaxies, with the timescale of bursts of a few to tens of Myrs. The star formation occurring in starburst phases in dwarf galaxies is five times higher than that in a smooth star formation phase, while, for massive galaxies, the bursty phases of star formation is negligible. Second, we demonstrate that environments play an essential role in turning off (quenching) the star formation of dwarf galaxies. We find evidence of a smooth transition of the quenching timescale and quenching mechanisms (external vs. internal) around M_* of $10^{9.5}$ $M_\odot$ at $0.5 < z < 1.0$.

SATURDAY APRIL 14, 2018 9:00 – 5:00

Miller Nichols Learning Center (= the library)

REGISTRATION: 9:00 – 9:30

Session IV 9:30 – 11:00

9:30 – 9:45

Multi-filter Photometric Analysis of Six W Ursae Majoris (W UMa) type Eclipsing Binary Stars

Akiba, Tatsuya; Neugarten, Andrew; Gokhale, Vayujeet, Truman State University

We present light curve analysis of six variable stars, KID 11405559, V0342 Boo, AZ Vir, KID 7259917, V2363 Cyg, and KID 10253421. These objects are selected from the Kepler Eclipsing Binary Catalog and lists of eclipsing binaries published by Kreiner (2004) and Hoffman et al. (2008). Light curves are generated using data collected at the 31-inch NURO telescope at Lowell Observatory in Flagstaff, Arizona in three filters: Bessell B, V and R. Additional observations were made using the 17-inch PlaneWave telescope at the Truman State Observatory in Kirksville, Missouri using Johnson B, V, and R filters. We generate truncated Fourier fits for the light curves of these six objects from which we classify KID 11405559, V0342 Boo, AZ Vir, and V2363 Cyg as W UMa type systems, KID 7259917 as a Beta-Lyrae system, and KID 10253421 as a candidate Algol type system. Additionally, we analyze the asymmetries in the light curves by calculating the “Light Curve Asymmetry” (LCA) and the “O’Connell Effect Ratio” (OER).

9:45 – 10:00

GALEX Absolute Calibration and Extinction Coefficients Based on White Dwarfs

Wall[1], Renae E.; Kilic[1], Mukremin; Rolland[2], Benoit; Genest-Beaulieu[2], Cynthia; Bergeron[2], P.; Gianninas[1], A. University of Oklahoma[1], Universite de Montreal[2]

We use 3257 DA white dwarfs from the Sloan Digital Sky Survey to verify the absolute calibration and extinction coefficients for the Galaxy Evolution Explorer (GALEX). We use white dwarfs within 100 pc to determine an improved linearity correction to the GALEX data. We also use DA white dwarfs beyond 250 pc to calculate new extinction coefficients in the Far Ultraviolet (FUV) and Near Ultraviolet (NUV) bands. With well understood optical spectra and state-of-the-art model atmosphere analysis, these white dwarfs currently provide the best constraints on the extinction coefficients for the GALEX data.

10:00 – 10:15

Measuring Cosmological Parameters of the Tilted Flat and the Non-Flat ΛCDM Inflation Models from the Recent Observational Data

Park[1,2], Chan-Gyung; Ratra[2], Bharat, Chonbuk National University[1], Kansas State University[2]

We constrain cosmological parameters of the physically-consistent tilted spatially-flat and non-flat ΛCDM inflation models with the Planck 2015 cosmic microwave background (CMB) anisotropy data and recent Type Ia supernovae measurements, baryonic acoustic oscillations (BAO) data, growth rate observations, and Hubble parameter measurements. The most dramatic consequence of including the non-CMB data sets is the significant strengthening of the evidence for non-flatness in the non-flat ΛCDM model, from 1.8σ for the CMB data alone to 5.1σ for the full data combination, where the BAO data is the most powerful in tightly constraining model parameters and in favoring a spatially-closed Universe. The non-flat ΛCDM model gives results more consistent with the Dark Energy Survey constraints on mass fluctuations and matter density. We compare the two models with a focus on which model better fits the individual data sets and how different the estimated parameter values are.

10:15 – 10:30

Dark Energy Constraints from Hubble Rate and Baryon Acoustic Oscillation Data

Ryan[1], Joseph; Doshi[2], Sanket; Ratra[1], Bharat, Kansas State University[1], Indian Institute of Technology Bombay[2]

We present best-fit constraints on three different dark energy models. We analyzed 31 measurements of the Hubble expansion rate, as well as 11 distance measurements scaled to the sound horizon set by baryon acoustic oscillations. Our analysis finds that the data favor a slightly closed Lambda-CDM model (as opposed to the conventional flat Lambda-CDM model), although not above the 1-sigma level.

10:30 – 10:45

Hubble Parameter and Baryon Acoustic Oscillation Measurement Constraints on Cosmology Parameters

Yu, Hai, Kansas State University

We compile a complete collection of reliable Hubble parameter H(z) data to redshift $z \leq 2.36$ and use them with the Gaussian Process method to determine continuous H(z) functions for various data subsets. From these continuous H(z)'s, summarizing across the data subsets considered, we find $H_o \sim 67 \pm 4$ km/s/Mpc, more consistent with the recent lower values determined using a variety of techniques. In most data subsets we see a cosmological deceleration/acceleration transition at 2σ significance, with the data subsets transition redshifts varying over $0.33 < z_{da} < 1.0$ at 1σ significance. We find that the flat-ΛCDM model is consistent with the H(z) data to a z of 1.5 to 2.0, depending on data subset considered, with 2σ deviations from flat-ΛCDM above this redshift range. Using the continuous H(z) with baryon acoustic oscillation distance-redshift observations, we constrain the current spatial curvature density parameter to be $\Omega_{K0} = -0.03 \pm 0.21$, consistent with a flat Universe, but the large error bar does not rule out small values of spatial curvature that are now under debate.

BREAK: 10:45 – 11:15

SESSION V 11:15 – 12: 15 INVITED TALK

Dr. Claudia Scarlata

Results from the WFC3 IR Spectroscopic Parallel Survey

I will present an overview of the WFC3 Infrared Spectroscopic Parallel Survey (WISP) that we are conducting on the Hubble Space Telescope. This large program (awarded more than 2000 orbits so far) is identifying thousands of galaxies across a wide range of redshifts spanning more than two thirds of the age of the universe. In this talk, I will describe the main results of the survey and highlight the important role that it is playing in the context of future space based missions such as WFIRST and Euclid.

LUNCH 12:15 - 1:30

SESSION VI 1:30 – 3:00

1:30 – 1:45

TeV Gamma-Rays from the Pulsar Wind Nebula DA495

Wilcox, Patrick, University of Iowa

Nineteen new TeV gamma-ray sources were recently discovered in a survey of the Northern sky conducted by the High Altitude Water Cherenkov observatory (HAWC). Using the Very Energetic Radiation Imaging Telescope Array System (VERITAS), we performed targeted follow-up of several of these. The VERITAS observations led to an association between the previously unidentified source 2HWC J1953+294 and pulsar wind nebula (PWN) DA495. DA495 is an aged PWN, previously identified in radio and X-ray, with unusually strong magnetic fields. In this talk, I will discuss the methods used to detect gamma rays using ground-based telescopes and present results from the TeV detection of PWN DA495.

1:45 – 2:00

Variability of the HD 163296 Protoplanetary Disk

Rich[1], Evan; Wisniewski[1], John; Fukagawa[2], Misato; Grady[3], Carol; Sitko[4], Michael, University of Oklahoma[1], Osaka University[2], Goddard Center for Astrobiology[3], University of Cincinnati[4]

We present the scattered light H-band imagery of the protoplanetary disk around HD 163296 along with contemporaneous infrared spectral observations. The disk forms an image of a broken ring that is offset from the center of the star, which matches previous scattered light observations of HD 163296. However, more recent observations have found an asymmetry in disk flux on each side the major axis, while our scattered light observations show equal flux on each side of the major axis. We conclude that the change in flux is caused by the shadowing either from dust ejected above the plane of the disk or local warping of the disk. We also modeled our contemporaneous data with a Monte Carol Radiative Transfer code and were able to show that the H-band image and SED of HD 163296 can be explained with a thin disk and an optically thin envelope around the star.

2:00 – 2:15

Planet Hunters: White Dwarf Edition

Dame[1], Kyra; Belardi[2], Claudia; Kilic[1], Mukremin; Rest[3], Armin; et al, University of Oklahoma[1], University of Leicester[2], The Johns Hopkins University[3]

We present minute cadence photometry of 31732 point sources observed in a DECam pointing over eight consecutive half-nights. We use these data to search for eclipse-like events and other sources of variability. We do not find any significant evidence for minute-long transits around our targets, hence we rule out planetary transits around ~370 white dwarfs that should be present in this field. We also identify 49 variables, including 40 new systems. Results from the remaining two fields in our survey will allow us to place more stringent constraints on the frequency of planets orbiting white dwarfs in the habitable zone.

2:15 – 2:30

Optical Confirmation of X-ray Selected Galaxy Clusters from the Swift AGN and Cluster Survey

Bhatiani, Saloni; Dai, Xinyu; Griffin, Rhiannon, University of Oklahoma

To understand structure formation in the universe and impose stronger constraints on the cluster mass function and cosmological models, it is important to produce a large galaxy cluster catalog. The Swift AGN and cluster survey is a serendipitous X-ray survey aimed at building the largest X-ray selected cluster catalog with 1200 cluster detections expected by its final release. Our initial SDSS follow-up study has confirmed 50% of clusters in the SDSS footprint as $z < 0.5$ clusters. Here, we present further optical follow-up analysis of 143 (out of 442) X-ray selected cluster candidates from the Swift cluster catalog using multi-band imaging from the Kitt Peak 4m telescope, MDM 2.4m, and the Pan-STARRS survey. We report the optical confirmation of 7 clusters with $> 3\sigma$ over-density and 33 clusters with $> 2\sigma$ galaxy over-density. We also observe the red sequences in the color-magnitude space for all these confirmed clusters. The KPNO and Pan-STARRS confirmed clusters are all low redshift clusters with $z < 0.2$ mostly due to weather conditions and the depth of the survey, while the MDM detected clusters are higher redshift clusters extending up to $z < 0.6$. The remaining unidentified clusters are potentially higher redshift clusters that are excellent targets for infrared observations.

2:30 – 2:45

Non-parametric Star-formation Histories of Nearby and Deep-field Galaxies from LIGHTNING

Eufrasio, Rafael; Lehmer, Bret, University of Arkansas

In this talk, we present an analysis of the star-formation histories (SFHs) of deep-field galaxies, as well as resolved, nearby galaxies. We introduce LIGHTNING (Eufrasio et al. 2017), a new spectral energy distribution (SED) fitting procedure, capable of quickly and reliably recovering star formation history (SFH) and extinction parameters. We employ the code to model SFH as discrete steps in time, with lookback times of 0–10 Myr, 10–100 Myr, 0.1–1 Gyr, 1–5 Gyr, and 5–13.6 Gyr. There are many advantages in modeling the SFH as "non-parametric" steps, as it retrieves SFHs have no pre-conceived shape and therefore more reliable stellar masses and star-formation rates. We present applications of these SFHs to decompose the IR spectrum (Eufrasio et al. 2017), as well as the X-ray luminosity functions (Lehmer et al. 2017), across the M51 interacting system into different ages. Indeed, our procedure allows us to break any map of a galaxy into components associated with different stellar ages, i.e., derive an empirical evolution of that emission component with the underlying stellar population age. We also show an in-progress expansion of this analysis to a sample of 25 resolved, nearby galaxies and thousands of galaxies in the GOODS (North and South) fields.

2:45 – 3:00

Effects of Tidal Interactions and Mergers on the Star Formation of EDisCS Galaxies

Deger, Sinan; Rudnick, Gregory, University of Kansas

Apart from having effects on the morphology of galaxies, tidal interactions and mergers (TIM) are events also capable of affecting galaxy star formation properties. In a recent paper, we identified TIM galaxies in galaxy clusters, groups, and the field for the EDisCS sample at $0.4 < z < 0.8$. We found little dependence of the TIM fraction with redshift, and no trend with cluster velocity dispersion. However, our results indicate that the fraction of TIM galaxies shows a tentative yet suggestive peak in intermediate density environments, such as groups and cluster outskirts. We now focus on how the TIM and undisturbed galaxies differ in their stellar populations. Our preliminary results indicate that a significant fraction of our TIM population in dense environments are star forming, whereas our undisturbed galaxies are predominantly quiescent. Furthermore, we find that there is a higher fraction of TIM galaxies with higher emission and younger stellar populations. In this talk I will be presenting some of these results, commenting on how these results compare with our findings from our analysis of TIM fraction at different environments.

BREAK 3:00 – 3:30

SESSION VII 3:30 – 5:00

3:30 – 3:45

Illuminating on the Physical Properties of Tidal Debris with CANDELS: A New Feature Extraction Analysis

Mantha, Kameswara Bharadwaj; McIntosh, Daniel H.; Ciaschi, Cody; Evan, Rubyet; Fries, Logan; Landry, Luther, CANDELS Collaboration, University of Missouri-Kansas City & CANDELS institutions

Gravitational tidal forces during galaxy-galaxy merger events cause the host galaxies to exhibit transient tidal features, which are considered as hallmark identifiers of the merging process. Theoretical simulations predict that physical properties of tidal features (e.g. color, stellar mass) hold essential information (dynamics, gas content) about the merging process. To robustly detect and quantify the strength of tidal features, we study a large sample of 10,000 $M_* > 5 \times 10^9 M_\odot$ galaxies spanning $1 < z < 3$ from the Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey (CANDELS). We isolated a subset of galaxies hosting tidal features by visually inspecting their 2D light-profile fitting based model-subtracted images. We present a new automated method to robustly extract tidal features and quantify their H-band (F160W) surface brightness. We apply this technique on synthetic F160W observations of galaxy mergers from the VELA zoom-in hydrodynamic simulations to investigate the impact of merger stage, orientation, and observational depth on the detection and extraction of tidal features. In the VELA simulations, we track a major merger (stellar-mass ratio ~1:2) over a redshift range $1.8 < z < 1.2$ (~1.5 Gyr) and confidently extract tidal features over a span of 0.8 Gyr (observability time) at CANDELS/Wide observational depth. During this observability period, we find the tidal feature surface brightness roughly remains constant. At a fixed redshift snapshot, we extract tidal features at different viewing angles and find that orientation effects can induce a surface brightness measurement scatter ranging between 0.1-0.2 mag/arcsec^2. Finally, in the context of upcoming James Webb Space Telescope, we present future prospects of using our method to probe high-redshift merging systems.

3:45 – 4:00

Using Tidal Features in the Nearby Universe to Determine Dynamical History and Incidence of Gas-Rich and Gas-Poor Mergers

Fries, Logan; Mantha, Kameswara; McIntosh, Daniel, H., University of Missouri-Kansas City

Gravitational interactions between massive galaxies are predicted to produce tidal features during the first close pericentric passage and the final merging phases. Hallmark tidal features are used by many studies to quantify the rate of major galaxy-galaxy merging. We present a new pilot study to analyze the optical color of tidal features from a select sample of visually-identified SDSS galaxy interactions and mergers from Weston et al. 2017 ($M_* > 10^{10} M_\odot$, $z < 0.08$) to gain new insights into the nature of these dynamical encounters. In our trial, we select two interactions – a spiral-spiral (gas-rich) and an elliptical-elliptical (gas-poor) – plus one gas-rich, plausible post-major-merger train wreck. We employ a new tidal extraction and quantification method by Mantha et al. to SDSS g and r-band images that are first analyzed using GALFIT to remove a symmetric galaxy radial light profile. We measure the color and estimate the stellar mass of each tidal feature. We use the color of the galaxy and of the tidal features to learn whether the interactions are quiescent or star-forming according to the *urz* color-color plane. We plan to compare the tidal feature mass in the post-merger with predictions from merger simulations to constrain the mass ratio of the progenitors. Ultimately, we hope to define new tidal feature metrics to be employed to the analysis of larger samples.

4:00 – 4:15

Incidence of Tidal Features Hosted by Massive CANDELS Galaxies from 1<z<3

Ciaschi,Cody; Mantha, Kameswara; Evan, Rubyet; Fries, Logan; Landry, Luther, University of Missouri-Kansas City

The importance of major merging at z > 1 is still to be determined. It has been shown that star formation in galaxies was highest at z ~ 2 in an era some call "Cosmic High Noon". Since then, star formation has been highly quenched, and the number of disk-dominated galaxies has significantly decreased. Models and observations have shown that major mergers can quench star formation and produce massive spherical bulges but might not be the sole contributor. Theories and observations have also suggested that non-major merging hierarchical processes, such as clump migration, may be more important in the growth of spherical bulges and assembly of massive galaxies than previously thought. By determining the fraction of mergers within the sample, it can be shown how important mergers were in the creation of spherical bulges. Using better constraints of massive 1 < z < 3 galaxies hosting hallmark tidal features, a signature created by gravitational tidal forces during galaxy mergers, we hope to find important calibrations for converting tidal detections into merger fractions and develop a neural network that will robustly identify transient and faint tidal signatures. identify tidal features, we developed a Graphical User Interface (GUI) to visually classify ~10000 galaxies from all 5 CANDELS fields. Current observations show 0.15-0.2% of galaxies in the sample host tidal features depending on specific metrics. In the future, we will use the detected tidal features in the H-Band residual images and compare them to H-Band galaxy classifications to determine the fraction of mergers hosting tidal features.

4:15 – 4:30

Spectral Energy Distribution Analysis of Major Mergers from the SDSS

Weston, Madalyn; McIntosh, Daniel, University of Missouri-Kansas City

The connection between merging galaxies and active galactic nuclei (AGNs) is widely debated in the literature. Central to this debate is the simultaneous presence of star formation (SF) and AGNs, which emit light at similar wavelengths. Dust produced during SF can also obscure an AGN. Therefore, disentangling SF and AGN activity in these systems is key to understanding the major merger-induced growth of stellar mass and central supermassive black holes. In this ongoing research, we will use spectral energy distribution (SED) analysis to quantify the amount of SF and AGN activity in a sample of merging galaxies and a sample of statistically-matched control galaxies, presented in Weston et al. (2017). We will use the results of SED analysis to answer the following research questions: (1) Do all merging galaxies host an AGN that contributes significantly to the IR energy output (20% of the total IR light or more), regardless of optical emission type? (2) Do mergers identified as Seyfert or dusty AGNs by Weston et al. (2017) host more SF or AGN activity than those classified as non-AGNs? (3) Are previously selected AGNs in mergers different than those in non-merging galaxies? (4) Does the amount of AGN activity found through SED analysis scale with the [OIII] luminosity (a proxy for AGN power) of the host galaxy?

4:30 – 4:45

Using CANDELS Visual Classification to Identify Massive Peculiar and Irregular Galaxy Targets for JWST

Landry, Luther; *McIntosh, Daniel; Mantha, Kameswara; Ciaschi, Cody; Evan, Rubyet; Fries, Logan,* University of Missouri-Kansas City

Measuring the frequency of major galaxy-galaxy interactions over cosmic timescales is a key step toward quantifying the rate of galaxy merging and constraining its role in galaxy evolution. Distinguishing major mergers from other mass-assembly processes is exceptionally difficult, yet, quite important as merging is predicted to affect a wide range of galaxy properties: mass, luminosity, AGN activity, star formation, and structure. In hopes of improving on plausible identifications based on Hubble Space Telescope data from the Cosmic Assembly Near-IR Deep Extragalactic Legacy Survey (CANDELS), we produced a target list of irregular and peculiar massive galaxies for the first cycle of James Webb Space Telescope (JWST) observations. We selected 900 targets among nearly 8000 galaxies in the Extended Groth Strip (EGS) field using CANDELS visual classifications described in Kartaltepe et al. Mining the premiere CANDELS data for targets was only possible owing to our efforts to complete visual classifications in EGS. The target sample, defined by consensus (>65%) peculiar/irregular flag agreement among at least 3 classifiers, contains 80 (9%) mergers, 209 (22%) interactions, and 260 (28%) irregular disks based on consensus subtype classifications. Our targets were included in a JWST proposal submitted for the Cosmic Evolution Early Release Science Survey (CEERS; PI Steve Finkelstein), which was one of 13 international teams to be awarded observation time with the next-generation space observatory starting in summer 2019. We describe our target sample selection and the physical nature of these galaxies. Deep JWST imaging holds promise to better identify a variety of predicted physical processes that may be responsible for disturbing the morphologies of these massive galaxies including major/minor merging, disk instabilities, and non-merging hierarchical compaction.

4:45 – 5:00

Mining CANDELS Data to Identify Massive Compact Targets from the Early Universe for JWST

Evan, Rubyet; Fries, Logan, University of Missouri-Kansas City

Recent findings by Barro et al. and Kocevski et al. based on HST data from the Cosmic Assembly Near-IR Deep Extragalactic Legacy Survey (CANDELS) suggest that the most dense ("compact") examples of massive (>10^{10} $M_{\odot}$) galaxies at redshifts z > 1.5 (look-back times >9 billion years ago) likely represent a critical evolutionary step in the early development of massive elliptical galaxies that exist in the present-day universe. Deep JWST imaging and spectroscopy hold promise for gaining new insights into why these important galaxies appear to go through brief phases of active star formation and black hole growth. We selected 126 massive z > 1.5 galaxies meeting specific compact density criteria defined in Kocevski et al. for JWST observations using physical parameters available in the CANDELS database for galaxies in the Extended Groth Strip (EGS) field. We included these targets in a JWST proposal (Cosmic Evolution Early Release Science Survey; PI Steve Finkelstein), which was one of 13 international teams to be awarded observation time with the next-generation space observatory starting in summer 2019. We subdivided this sample of targets into subsamples with CANDELS visual classifications, optical and near-IR colors, and available X-ray data to prioritize the planned JWST observations from rare (10%), high-priority targets with active black-hole growth to low-priority (60%) inactive and non-star-forming systems.

POSTERS

Li in Open Clusters: Cool Dwarfs in the Young, Subsolar Metallicity Cluster M35 (NGC 2168)

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University of Kansas[1], Indiana University[2]

Hydra spectra of 85 cooler dwarfs in the young open cluster, M35, in the Li 6708 A line region have been analyzed. From radial velocities, 82 are classed as likely single-star members which, when combined with previous work, produces a sample of 119 stars ranging from T_{eff} = 6150 K to 4000 K as defined by multicolor, broad-band photometry, E(B-V) = 0.20, and [Fe/H] = -0.15, though there are indications that the metallicity of M35 may be closer to solar. A(Li) follows a well-delineated decline from 3.15 for the hottest stars to upper limits of 1.0 or less among the coolest dwarfs. Contrary to earlier work, M35 includes a significant subset of single stars positioned at systematically higher A(Li) than the mean cluster relation. This subset exhibits higher V_{ROT} than the more Li-depleted sample and, from photometric rotation periods, is dominated by stars classed as *convective* (C), while all others are *interface* (I) stars. The M35 A(Li) distribution with color and rotation period, when compared to recent work on the Hyades/Praesepe and the Pleiades, is consistent with gyrochronological analysis placing M35 intermediate in age between the older M34 and the younger Pleiades. However, the Pleiades stars display a more excessive range in A(Li) and rotation period than M35 on the low Li, slow-rotation side of the distribution, with supposedly younger stars at a given T_{eff} in the Pleiades spinning slower, with A(Li) reduced by more than a factor of four compared to M35 stars.

Growth Rate in the Dynamical Dark Energy Models

Avsajanishvii, Olga; Arkhipova, Natalia ; Samushia, Lado; Kahniashvili ,Tina, Ilia State University, Astro Space Center of the P.N. Lebedev Physical Institute, Kansas State University, Carnegie Mellon University

Dark Energy models with slowly-rolling cosmological scalar field provide a popular alternative to the standard, time-independent cosmological constant model. We study simultaneous evolution of background expansion and growth in the scalar field model with the Ratra-Peebles self-interaction potential. We use recent measurements of the linear growth rate and the baryon acoustic oscillation peak positions to constrain the model parameter α that describes the steepness of the scalar field potential.

WIYN Open Cluster Study: Abundances in the Pre-Main Sequence Cluster IC 4665

Bogner[1], Benjamin M; Maderak[1], Ryan M; Deliyannis[2], Constantine P., Benedictine College[1], Indiana University[2]

As part of the Maderak et al. study of the evolution of Galactic oxygen as traced by open clusters, we present the results of a spectroscopic abundance analysis of solar-type dwarfs in the 30 Myr old pre-main sequence cluster IC 4665. Spectra of the near-infrared oxygen triplet at 7774 A were acquired with the Hydra multi-object spectrograph on the WIYN 3.5m telescope. Our equivalent width analysis of 9 single-star, slowly-rotating, radial-velocity-selected cluster members yielded cluster average abundances of [Fe/H] = 0.30, [O/H] = 0.11, [Al/H] = 0.23, [Si/H] = 0.23, and [Ni/H] = 0.38. While our Fe, Si, and Ni abundances are substantially higher than the near-solar values found by the one previous spectroscopic study of this cluster (Shen et al. 2005), our [O/H] is fully consistent with the [O/H] versus age relationship exhibited by open clusters, and our implied [O/Fe] value is not inconsistent with the Galactic [O/Fe] versus [Fe/H] relationship based on both field stars and open clusters.

Understanding Supermassive Black Hole Growth Mechanisms in the SSA 22 Protocluster

Bonine, Brett; Lehmer, Bret, University of Arkansas

The SSA22 protocluster is a collection of galaxies at redshift z = 3.09, corresponding to a look back time of 11.6 billion years. Observations of the protocluster allow for the investigation of galaxy properties of such protocluster environments in the early universe, potentially giving insight into the formation and evolution of galaxy clusters visible in the local universe (e.g., the Coma Cluster). Compared to other field galaxies at a similar redshift, a larger fraction of galaxies in SSA22 has been found to possess active galactic nuclei (AGN). This enhanced AGN activity suggests a relationship between the environment within the cluster and the growth of supermassive black holes (SMBHs). We will clarify the role that the protocluster environment at z = 3.09 plays in enhancing the growth of SMBHs in the cluster. To accomplish this, we are analyzing recently obtained WFC3 F160W data from the Hubble Space Telescope (HST) in SSA22, and equivalent archival CANDELS data in the Hubble Deep Field-North, to compare the merger rates and stellar mass distributions of galaxies in the SSA22 protocluster and in the field. Our goal is to assess the relative role that mergers play in enhancing the SMBH growth observed in over-dense regions in the z = 3 Universe.

Logic and Quantitative Reasoning in an Introductory Astronomy Class

Delgado, Jennifer, University of Kansas

Introductory astronomy courses for non-majors are often a popular option for meeting a required science credit in undergraduate curricula. As such, some gains in rudimentary logic, quantitative reasoning and the scientific method are to be hoped for in students of such courses. We present initial findings in adapting and using an objective-style grading system (ALPaCA) in an introductory astronomy course. The main motivation for utilizing this system is to better isolate what areas students find most difficult and potentially drive further insight into what kinds of teaching strategies may be most effective in addressing these difficulties.

Models of Interacting Supernovae: Understanding the Physics and Probing the Circumstellar Environment

DerKacy[1], James M.; Baron[1], E.; Hoeflich[2], Peter, University of Oklahoma[1], Florida State University[2]

Within the last decade, the data collected by a large number of photometric surveys has revealed a more diverse than expected population of supernovae, including a new class of supernovae (termed superluminous supernovae, SLSNe) with absolute magnitudes greater than -21. This new class of supernovae is divided into two sub-classes: SLSN-I (those with spectra lacking H) and SLSN-II (spectra with H). While SLSN-II almost certainly derive their large luminosities from the conversion of kinetic energy in the SN ejecta to X-rays due to interaction with the progenitor star's circumstellar material (CSM), it is unclear whether SLSN-I originate from a similar ejecta-CSM interaction mechanism or from energy deposited in the ejecta by a central engine, for example a magnetar. These events are expected to be visible with next-generation telescopes like JWST to high redshifts, allowing us to probe a wide array of stellar physics in the early universe. While waiting for these telescopes to come online, radiation-hydrodynamic and radiative transfer simulations can inform our understanding of what we expect these events to look like, and provide context to the data from SLSNe already discovered. We specifically focus on simulating both SLSN-I and SLSN-II originating from ejecta-CSM interactions with HYDRA and

PHOENIX, a generalized NLTE stellar atmospheres code, which require careful treatment due to the complex structure of the SN caused by the ejecta-CSM interaction.

X-ray Binaries within Young Stellar Populations

Ferrell, Andrew; Lehmer, Bret; Eufrasio, Rafael, University of Arkansas

Low mass X-ray binaries (LMXBs) are good tracers of compact objects and close binary stars. Theoretical predictions suggest LMXBs should become less prevalent as stellar populations age. Due to the difficulty in identifying counterparts to X-ray sources in nearby galaxies, LMXBs found within the field of galaxies (field LMXBs) and those found within globular clusters (GC LMXBs) are difficult to study separately. However, it is thought that field LMXBs form on the evolutionary timescales of the stars in the binary systems, while GC LMXBs are constantly forming due to tidal and multi-body interactions with other stars, so differentiation between field and GC LMXBs is important. Lehmer et al. (2014) addressed these issues by studying field and GC LMXBs separately, as a pilot to this study, and found suggestive evidence that field LMXBs were more numerous within a single relatively young galaxy that was observed, NGC3384. However, the Lehmer et al. study did not provide a statistically robust result as only the one young galaxy was studied. In this poster, we will present efforts to study field LMXBs of NGC3384 (for comparison to Lehmer et al. 2014), and 2 additional young elliptical galaxies, NGC4382 and NGC3585 with stellar ages of 1.7 and 3.2 Gyr respectively. We will then utilize our results combined with those of Lehmer et al. 2014 to compare to the older LMXB populations in the literature and further constrain how the field LMXB formation rate, and X-ray luminosity function, varies as a function of host stellar population age.

A Physical Parameterization of the Evolution of X-Ray Binaries

Gilbertson, Woodrow; Lehmer, Bret; Eufrasio, Rafael, University of Arkansas

The Chandra Deep Field-South (CDF-S) and North (CDF-N) surveys, 7 Ms and 2 Ms respectively, contain measurements spanning a large redshift range of $z = 0$ to 7. These data-rich fields provide a unique window into the cosmic history of X-ray emission from normal galaxies (i.e., not dominated by AGN). Scaling relations between normal-galaxy X-ray luminosity and quantities, such as star formation rate (SFR) and stellar mass (M*), have been used to constrain the redshift evolution of the formation rates of low-mass and high-mass X-ray binaries (LMXB and HMXB, respectively). However, these measurements do not directly reveal the driving forces behind the redshift evolution of X-ray binaries (XRBs). We hypothesize that changes in the mean stellar age and metallicity of the Universe drives the evolution of LMXB and HMXB emission, respectively. By studying the properties of the galaxies in the CDF, this study examines the correlations between the physical quantities of stellar age and metallicity with LMXB and HMXB emission, respectively. This study uses star-formation histories, derived through fitting broad spectrum, to estimate the stellar mass in various age bins for each galaxy. By looking at different stellar ages and metallicities we can achieve a physical model for X-ray luminosity. We show that this physical model provides a more useful parameterization of the evolution of X-ray binary emission, as it can be extrapolated out to high redshifts with more sensible predictions. This meaningful relation can be used to better estimate the emission of XRBs in the early Universe, where XRBs are predicted to play an important role in heating the intergalactic medium.

Correlated Variability of Molecular Masers in Massive Star Forming Regions

Lambert, Richard; Araya, Esteban, Western Illinois University

The process of high-mass star formation is not well understood, and clues to their formation could lie in masers. We present details on the development of a code intended to systematically measure line parameters of spectral lines detected in a monitoring program of 23 sources observed for a year with the Arecibo Radio Telescope. The program generates light curves to explore how the peak flux density, velocity integrated flux density, peak velocity and line width change over time. From these light curves, we can determine if the masers display variability and if variability is present across different maser species and velocity components.

Estimating the Evolution of X-ray Binary Populations in Nearby Galaxies

Lehmer, Bret, University of Arkansas

Recently, we have found, in the Chandra Deep Field-South, that the emission from X-ray binary (XRB) populations in galaxies evolves significantly with cosmic time, most likely due to changes in the physical properties of galaxies like star-formation rate, stellar mass, stellar age, and metallicity. However, it has been challenging to directly show that these same physical properties are connected to XRB populations using data from nearby galaxies. We present a new technique for empirically calibrating how XRB populations evolve following their formation in a variety of environments. We first utilize detailed spectral energy distribution modeling of far-UV to far-IR broadband data of the nearby (~8.5 Mpc) face-on spiral galaxies M51 to construct a map of its star-formation history (SFH) on subgalactic scales. Using Chandra data, we then identify the locations of the XRBs and correlate their formation frequencies with local SFH, as characterized by the mean mass-weighted stellar age. I will show first constraints on how the shape and normalization of XRB luminosity function evolves with time based on our analysis of M51. I further discuss how expanding our sample to an archival sample of ~25 face-on spirals will lead to a detailed empirical timeline for how XRBs form and evolve in a variety of environments and throughout cosmic time.

Construction of a Laboratory for Simulation of Light Curves from Rotating Space Debris

Martin, Cale; Kaneko, Sage; Simms, Austin; Omair, Jasmine; Adams, Jaxon; Ojakangas, Gregory, Drury University

In order to increase understanding of the information contained in telescopic observations of orbiting space debris, a unique laboratory has been constructed at Drury University. Small 3D-printed models of common rocket bodies in the USSPACECOM catalog are painted appropriately, then suspended in the center of a system of three nested gimbal rings, each of which is driven by a stepper motor and independently controlled by an Arduino microprocessor communicating with a personal computer. The outer, middle, and center rings prescribe the standard 3-1-3 Euler angles commonly known as phi, theta, and psi, while a collimated incandescent lamp on a moveable cart, representing the sun, illuminates the debris model. Light reflected from the model is observed with a ZWO ASI-174mm CCD camera fitted with a telephoto lens. Before entering the camera, the reflected light passes through a long cardboard tube painted with flat black spraypaint on its inside surface, thus restricting the light directionally. The entire laboratory is shrouded in black cloth. With this apparatus, virtually any observation geometry can be simulated for a modeled debris object, and reflected light over a large range of solar phase angles and for a large range of possible rotation states can be gathered as functions of time. Initial light curves generated with this system will be presented, representing possible rotation states of actual catalogued rocket bodies in Low Earth Orbit. These data will be compared with corresponding observational data acquired of the same specific objects using Drury University's 14-inch Schmidt Cassegrain telescope, which is attached to a Paramount MX+ robotic mount at the Drury University Observatory.

Estimations of Targets Reachable by North Korean Missiles

Medina, Michelle; Alcantara, Jose; Wood, Mark; Ojakangas, Gregory, Drury University

North Korea has launched approximately 76 ballistic missiles in the last 5 years, with gradually increasing capability for reaching more distant potential targets. The country has been gaining range capability with successive launches, and due to tensions between the United States and North Korea, these developments are worrisome. Their most recent missile, launched nearly vertically in November, 2017, reached an altitude of 2,800 miles. As an exercise in orbital mechanics we use this piece of information to estimate the initial kinetic energy and total mechanical energy of such a missile, and consequently, the semimajor axis value of its ballistic orbit. When initial launch directions are specified, angular momentum, orbital eccentricity, and the true anomaly at launch can also be immediately computed. For our first estimates of missile targets, we ignore velocity imparted by the earth's rotation and compute ranges for an array of launch directions, and consequent possible targets. We then add the effect of the earth's spin. We will present our results graphically, and show the regions of the earth which are under potential threat by North Korea at the time of this presentation.

A New Code for Calculations of Two-Point Correlation Functions

Montero-Alcaraz, Gamaliel; Berrier, Joel, University of Nebraska-Kearney

The two-point correlation function is a tool used to quantify the clustering of Galaxies. We have created an optimized program to calculate quickly the two-point correlation function from large-scale simulation data in order to make direct observational comparisons. Correlation functions are computed for the dark matter halos of two different publicly available simulations, the MDR1 simulation from the MultiDark project and the Illustris-1. Our main objective was to develop a tool to study the clustering of the galaxies in these simulations for use in further studies. This tool aids in the selection of different populations with a desired clustering to do further analysis of their internal properties to see if they match what observations.

Stunted Outbursts in Cataclysmic Variable UU AQR
Robertson, Jeff, Arkansas Tech University
Stunted outbursts are ~0.6 mag eruptions, typically lasting 5–10 days, which are found in some novalike cataclysmic variables, including UU Aqr. The mechanism responsible for stunted outbursts is uncertain but is likely related to an accretion disk instability or to variations in the mass transfer rate. A campaign to monitor the eclipse light curves in UU Aqr has been conducted in order to detect any light curve distortions due to the appearance of a hot spot on the disk at the location of the impact point of the accretion stream. If stunted outbursts are due to a temporary mass transfer enhancement, then predictable deformations of the orbital light curve are expected to occur during such outbursts. This study used 156 eclipses on 135 nights during the years 2000–2012. During this interval, random samples found the system to be in stunted outbursts 4%–5% of the time, yielding ~7 eclipses obtained during some stage of stunted outburst. About half of the eclipses obtained during stunted outbursts showed clear evidence for hot spot enhancement, providing strong evidence that the stunted outbursts in UU Aqr are associated with mass transfer variations. The other half of the eclipses during stunted outburst showed little or no evidence for hot spot enhancement. Furthermore, there were no systematic changes in the hot spot signature as stunted outbursts progressed. Therefore, we have tentatively attributed the changes in hot spot visibility during stunted outburst to random blobby accretion, which likely further modulates the strength of the accretion stream on orbital timescales.

Assessing the Calibration of Continuum and Spectral Line Interferometric Observations of a High-Mass Star-Forming Region
Sakib, Md Nazmus; Araya, Esteban, Western Illinois University
Using the Karl G. Jansky Very Large Array, we observed radio continuum and the 6cm H2CO maser in the region of high-mass star formation G32.74-0.07. Calibration was done by observing a nearby quasar to derive amplitude and phase corrections that were applied to the G32.74-0.07 visibilities. We checked the consistency of the amplitude and phase calibration by exploring the data in frequency, polarization and time domains. We present two-dimensional (2D) Gaussian fits of 6 cm formaldehyde maser as a function of channel and compared to 2D fits of the quasar within a similar channel range. All peak positions of the maser are well within synthesized beam and we detect no trend in position offset as a function of frequency. We also generated continuum images of the right-hand and left-hand circular polarizations and different scans and find consistent results in time and polarization domains. We also present spectral index measurements of the radio continuum in G32.74-0.07, which are indicative of thermal-Bremsstrahlung emission.

Disentangling 2 cm Formaldehyde Emission and Absorption in NGC7538
Shuvo, Onic Islam; Araya, Esteban D., Western Illinois University
NGC7538 is one of the most prominent regions of high-mass star formation in the Milky Way, in particular, it is rich in molecular masers. The first 6 cm H2CO maser was detected toward NGC7538 in the 1970s, which was found to be superimposed with extended 6 cm H2CO absorption. More recent observations have shown that the 2 cm H2CO line also shows emission superimposed with absorption toward the hot molecular core in NGC 7538 IRS1, but in contrast to the 6 cm maser, the 2 cm emission is extended. We present the analysis of GBT observations designed to disentangle the 2 cm H2CO emission from the extended absorption. We found a deconvolved size (at half maximum) of the 2 cm emission of 52” ± 12”, which is somewhat larger than the angular size of the hot molecular core (but still within 3σ errors). We discuss the distribution of 2 cm H2CO emission in the context of the hot molecular core and the infrared environment in NGC7538.

The Precise Determination of the Number of Satellites around Luminous Red Galaxies
Townsend, Mindy; Rudnick, Gregory, University of Kansas
Using spectroscopic data from the Sloan Digital Sky Survey (SDSS) LOWZ BOSS sample and photometric data from the DECam Legacy Survey (DECaLS), we look to precisely determine the number of satellite galaxies around luminous red galaxies (LRGs) by doing a statistical subtraction of background galaxies. We intend to make this determination as a property of LRG mass, redshift, and satellite star formation history. DECam photometric data is desirable since, relative to SDSS, DECaLS can image approximately two magnitudes fainter in three optical bands.