MARAC 2017: Schedule and Abstracts

SATURDAY APRIL 8, 2017 9:00 – 5:15 PM

2048 Malott Hall (newer wing of Malott)

REGISTRATION: 9:00 – 9:30

Session I 9:30 – 11:00

9:30 – 9:45

Star Formation Histories Across M51, the Whirlpool Galaxy

Eufrasio, Rafael; Lehmer, Bret; Markwardt, Larissa
University of Arkansas

We present a pixel-by-pixel UV-to-IR spectral energy distribution (SED) modeling in order to determine the star formation histories (SFHs) across the Whirlpool system, M51. The system is composed of two interacting galaxies, the spiral M51a and the lenticular M51b, and contains a large variety of physical conditions. We use SFHs composed of five discrete steps of time (0 - 10 Myrs, 10 - 100 Myrs, 0.1 - 1 Gyr, 1 - 5 Gyr, 5 -13.6 Gyr) and employ a flexible extinction curve controlled by three parameters that accounts for possible higher attenuation in the youngest regions. Our code is very computationally efficient, fully parallelized and vectorized, and uses inversion techniques to minimize running time. It currently runs hundreds to thousands of times faster than other state of the art similar codes. The resulting maps contain derived quantities (i.e., star formations, stellar masses, luminosities, ionizing photon rates, attenuations) associated to all five epochs. We find the SFH of the spiral galaxy to peak between 1 and 5 Gyr ago and its companion's to peak at the oldest SFH step (5 - 13.6 Gyr) and progressively decline. We also find an enhancement of the SFR between 0.1 and 1 Gyr due to the interaction that affected mainly the outskirts of the spiral galaxy. We present how the FUV + IR hybrid SFR law changes across the system and the contribution of different ages to the IR luminosity.

9:45 – 10:00

The Star-Formation History Dependence of X-ray Binary Formation: Clues from M51 (NGC 5194)

Lehmer, Bret; Eufrasio, Rafael; Markwardt, Larissa; et al.
University of Arkansas

Recently, we 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 X-ray binary (XRB) populations evolve over time following their formation. We first utilize detailed stellar population synthesis modeling of far-UV to far-IR broadband data of nearby (< 12 Mpc) face-on spiral galaxies to construct maps of the star-formation histories on subgalactic scales. Using Chandra data, we then identify the locations of the XRBs within these galaxies and correlate their formation frequencies with local galaxy properties. In this talk, I will show promising first results for the Whirlpool galaxy (M51 or NGC 5194), and will discuss how expanding our sample to an archival sample of roughly 20 face-on spirals will lead to a detailed empirical timeline for how XRBs form and evolve in a variety of environments.

10:00 – 10:15

The Star Formation Histories of Merging Galaxies in Intermediate Redshift Clusters

Deger, Sinan; Rudnick, Gregory
University of Kansas

Though unclear to what extent, galaxy mergers are one of the processes that affect both the morphology and star formation of galaxies. In a recent work, we've analyzed the merger fraction and its dependence on redshift, velocity dispersion, and environment for the EDisCS sample at $0.4 \leq z \leq 0.8$. To further study the effects of merger events on these galaxies, we now focus our attention on the stellar populations and the star formation properties of the EDisCS sample. In this talk I will be presenting preliminary results I obtained recently, including color-color plots of our merging and undisturbed galaxies. These plots are tools that separate dusty star-forming galaxies from red galaxies that stopped forming stars, constituting an important first step in our study of the effects of mergers on the star formation of galaxies.

10:15 – 10:30

Star Formation in the Outskirts of Galaxy Clusters

Mann, Justin; Rudnick, Gregory
University of Kansas

In an attempt to characterize the dependence of galactic star formation rates on environment, we analyze MIPS 24 micron data for 11 EDisCS clusters spanning a redshift range of roughly $0.5 < z < 0.8$ (where the cosmic star formation rate density is monotonically decreasing). The mid-infrared data extends to roughly 6*R200, covering the infall regions of each cluster and incorporating galaxies that will, at z=0, be virialized members of the central cluster. Inclusion of the infall regions also allows for examination of substructures within the cluster, which is important because environmental mechanisms that suppress star formation have been shown to operate at all density scales higher than the cosmic average. We have also performed several spectroscopic surveys to distinguish field from cluster-member galaxies in this spatially extended EDisCS study. Preliminary results do not yield any significant correlation between star formation rate and clustercentric radius within our data. This calls for further investigation, which will mainly focus on preprocessing within groups in the infall regions by studying star formation rates versus local density.

10:30 – 10:45

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 $z \sim 1$. Using follow-up observations with the Combined Array for Research in Millimeter-wave Astronomy and the Spitzer space telescope, we have determined stellar mass fractions for 14 of these infrared-selected clusters and compare these fractions to those from a sample of 33 ICM-slected 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.

10:45 – 11:00

Surface Density of Dust-Obscured Galaxies Around z ≥ 1.3 Galaxy Clusters

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

Dust-obscured galaxies (DOGs) are distant (z ~ 2) UltraLuminous Infrared Galaxies, defined by an IR to optical flux ratio, $F_{24}/F_R \geq 1000$. We report a significant relationship between ~2600 DOGs and 50, $z \geq 1.3$ galaxy clusters from Spitzer/IRAC Shallow Cluster Survey (ISCS) in the Boötes field of the NOAO Wide Deep-Field Survey(NDWFS).The sky surface density of DOGs in a 0.5' radius around galaxy clusters is found to be 0.46 ± 0.12 arcmin^{-2}.The 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 ~ 3 σ. This result indicates that DOGs aren't randomly distributed. Rather, DOGs preferentially reside in rich environments, often within ~ 250 kpc of a galaxy cluster. We also show that the surface density of DOGs isn't significantly dependent on their (R - [24]) color nor on their IR flux density. This gives us a simple technique to identify high redshift galaxy cluster candidates using DOGs as signposts. We calculate the richness within 1' radius of these DOGs using the Spitzer Deep Wide-Field Survey (SDWFS) galaxy catalog in the Boötes field. We isolate high redshift galaxies in our analysis by selecting galaxies with [3.6] - [4.5] > 0.367 and an I-band magnitude cut of I > 21.5. Approximately 227 regions are found to be overdense at ≥ 2 σ; 70 regions are overdense at ≥ 3 σ.

BREAK: 11:00 – 11:15

Session II 11:15 – 12:15 INVITED TALK

Star Formation and Feedback in Low Metallicity Galaxies at z~2

Dr. Dawn Erb

University of Wisconsin – Milwaukee

Low mass, low metallicity galaxies are the most likely source of the photons that reionized the universe, but the relationships between low metallicity star formation, galactic outflows, and the escape of ionizing radiation at high redshifts are still unclear. Using rest-frame UV and optical spectra of lensed and unlensed low metallicity galaxies at z ~ 2, I will discuss constraints on the velocity and ionization state of outflows, the rate and geometry of star formation, and the covering fraction and column density of neutral hydrogen.

Lunch 12:15 – 1:30

Session III 1:30 – 3:00

1:30 – 1:45

Terrestrial Effects of Nearby Supernovae in the Early Pleistocene

Melott, Adrian
University of Kansas

Evidence from finding 60Fe in numerous terrestrial, lunar, and space-borne samples points to a series of supernovae at distances of 50 pc or so, 2.5 and 7 million years ago. We have conducted a series of simulations of the propagation of cosmic rays and photons from the event to the Earth. We have found that the usual ozone depletion catastrophe is unimportant, but the high-energy cosmic rays have important effects in the lower atmosphere and on the ground,

including muon irradiation and atmospheric ionization. A role in human evolution is tentatively suggested.

1:45 – 2:00

MSSM Neutralino as a Dark Matter Candidate

Maleki Sanukesh, Mehdi
Creighton University

Historically, one of the most promising dark matter candidates has been the Neutralino from the Minimal Supersymmetric Standard Model (MSSM). Although Supersymmetry has not been experimentally confirmed, it has been tightly constrained by both accelerator limits and astrophysical bounds. DarkSUSY is a computer code that is based on the MSSM, and which allows for the calculation of Neutralino densities, cross sections, and expected detection rates in both direct and indirect detection experiments. In this work we use DarkSUSY, together with the latest accelerator constraints and astrophysical bounds, to explore parameter space. Beginning with 700,000+ randomly generated models we explore if the MSSM has been experimentally ruled out. Surviving models and interesting regions of surviving parameter space will be presented and discussed.

2:00 – 2:15

Automatically Measuring Stellar Parameters Using an Artificial Neural Network

Lee-Brown, Donald; Anthony-Twarog, Barbara; Twarog, Bruce
University of Kansas

Spectroscopy serves as an observational foundation for all stellar astronomy. In recent years, new instrumentation has made possible the simultaneous observation of hundreds to thousands of stars, dramatically improving our ability to answer important astrophysical questions. However, this volume of data is difficult to analyze using manual or semi-automated techniques, and recent studies have shown that human-based measurement often biases results in difficult-to-reproduce ways. To resolve these issues, I have developed a new, Python-based tool to automatically measure stellar spectra. The tool is built around an artificial neural network (ANN), a machine learning algorithm that automatically determines which input data features best translate into a set of desired outputs. After training the ANN on synthetic stellar spectra, real spectra can be classified with accuracies exceeding 100 K, 0.04 dex, and 3 km/s in surface temperature, [Fe/H], and rotational velocity, respectively. Furthermore, the ANN-based approach eliminates much of the systematic variance introduced by human measurement and requires < 0.1 seconds to parameterize a spectrum. In this talk, I will demonstrate of the potential of the ANN as a standard spectroscopic analysis technique.

2:15 – 2:30

Milky Way Rotation Curve Models

Camarillo, Tia; Crandall, Sara; Ratra, Bharat
Kansas State University

Previously, our group presented introductory statistics on the non-gaussianity of error distributions of the most recent compilation of Milky Way rotation curve measurements. To test baryonic and dark matter mass distribution models we continue gaussianity analysis in various binning methods and fit a linear and power fit curve to the data as a whole, and in our slicing methods. We will present our best fits found from minimizing chi-squared for both the linear and power fit models.

2:30 – 2:45

Rotation Curves and the Mass Distribution of Growing Disk Galaxy Models

Berrier, Joel; Sellwood, J.A.
University of Nebraska Kearney, Rutgers University

We present evidence that spiral activity is responsible for the creation of featureless rotation curves. We examine a variety of simulations of disk galaxies beginning in equilibrium and allow them to evolve while adding particles in annuli to the hot disk using a variety of rules. Two unstable spiral modes develop when this new material forms a ridge-like feature in the surface density profile of the disk. The extra material is redistributed radially by the spiral activity, and the associated angular momentum changes remove more particles from the ridge than are added to it. This process eventually removes the density feature from the galaxy and creates a locally flat rotation curve. We argue that the lack of a feature when transitioning from disk to halo dominance in the rotation curves of disk galaxies, the so called "disk-halo conspiracy", could also be accounted for by this mechanism. These results are verified in idealized simulations that mimic the growth of galaxy disks embedded in responsive halos and bulges. In these "live" simulations the disks manifested an almost overwhelming tendency to form strong bars that we found very difficult to prevent. 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.

2:45 – 3:00

Optimal Weights for Measuring Redshift Space Distortions in Multitracer Galaxy Catalogues

Pearson, David; Samushia, Lado; Gagrani, Praful
Kansas State University

Since the volume accessible to galaxy surveys is fundamentally limited, it is extremely important to analyze available data in the most optimal fashion. One way of enhancing the cosmological information extracted from the clustering of galaxies is by weighting the galaxy field. The most widely used weighting schemes assign weights to galaxies based on the average local density in the region (FKP weights) and their bias with respect to the dark matter field (PVP weights). They are designed to minimize the fractional variance of the galaxy power-spectrum. We demonstrate that the currently used bias dependent weighting scheme can be further optimized for specific cosmological parameters. We develop a procedure for computing the optimal weights and test them against mock catalogues for which the values of all fitting parameters, as well as the input power-spectrum are known. We show that by applying these weights to the joint power-spectrum of emission line galaxies and luminous red galaxies from the Dark Energy Spectroscopic Instrument survey, the variance in the measured growth rate parameter can be reduced by as much as 36 per cent.

BREAK: 3:00 – 3:30

Session IV 3:30 – 5:15

3:30 – 3:45

Testing Accretion Disk Winds Models of Broad Absorption Line Quasars with SDSS Spectra

Lindgren, Sean; Gabel, Jack
Creighton University

We present an investigation of a large sample of Broad absorption line (BAL) quasars (QSO) from the Sloan Digital Sky Survey (SDSS) Data Release 5 (DR5). Properties of the BALs, such

as absorption equivalent width, outflow velocities, and depth of BAL, are obtained from Gibson et al. (2009). We perform correlation analysis on these data to test the predictions made by the radiation driven, accretion disk streamline model of Murray et al. (1995). We find the CIV BAL maximum velocity and the continuum luminosity are correlated, consistent with radiation driven models. The mean max velocity of CIV is higher in low ionization BALs (LoBALs), than highly ionized BALs (HiBALS), suggesting an orientation effect consistent with the Murray et al model. Finally, we find that HiBALs greatly outnumber LoBALs in the general BAL population, supporting prediction of Murray et al. that HiBALs have a greater global covering factor than LoBALs.

3:45 – 4:00

Synergy of WISE and SDSS in Stripe 82

Musin, Marat
University of Missouri

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

Incidence of WISE-selected Obscured AGNs in Major Mergers and Interactions from the SDSS

Weston, Madalyn; McIntosh, Daniel; Brodwin, Mark; Mann, Justin; Cooper, Andrew; McConnell, Adam; Neilsen, Jennifer
UMKC, UMKC, UMKC, UMKC & KU, UMKC & University of North Carolina at Chapel Hill, UMKC, UMKC & KU

We use the Wide-field Infrared Survey Explorer (WISE) and the Sloan Digital Sky Survey (SDSS) to confirm a connection between dust-obscured active galactic nuclei (AGNs) and galaxy merging. Using a new, volume-limited ($z \leq 0.08$) catalog of visually-selected major mergers and galaxy-galaxy interactions from the SDSS, with stellar masses above 2×10^{10} $M_{\odot}$, we find that major mergers (interactions) are 5 - 17 (3 - 5) times more likely to have red [3.4]-[4.6] colors associated with dust-obscured or `dusty' AGNs, compared to non-merging galaxies with similar masses. Using published fiber spectral diagnostics, we map the [3.4]-[4.6] versus [4.6]-[12] colors of different emission-line galaxies and find one-quarter of Seyferts have colors indicative of a dusty AGN. We find that AGNs are five times more likely to be obscured when hosted by a merging galaxy, half of AGNs hosted by a merger are dusty, and we find no enhanced frequency of optical AGNs in merging over non-merging galaxies. We conclude that undetected AGNs missed at shorter wavelengths are at the heart of the ongoing AGN-merger connection debate. The vast majority of mergers hosting dusty AGNs are star-forming and located at the centers of $M_{halo} < 10^{13}$ $M_{\odot}$ groups. Assuming plausibly short duration dusty-AGN phases, we speculate that a large fraction of gas-rich mergers experience a brief obscured AGN phase, in agreement with the strong connection between central star formation and black hole growth seen in merger simulations. We will use the WISE-selected AGNs (and AGNs selected by other methods) to perform SED analysis of mergers and interactions and dissect the SEDs to disentangle AGN and SF activity.

4:15 – 4:30

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 plan to test this hypothesis using a large, uniform, mass-selected galaxy cluster sample from the South Pole Telescope for which we have acquired deep follow-up Spitzer Space Telescope observations. These data will allow us to correlate the incidence of infrared-selected AGN with cluster mass over a wide redshift baseline extending to beyond z = 1.

4:30 – 4:45

Disk Colors in Field and Cluster Spiral Galaxies at 0.5 < z < 0.8

Rudnick, Gregory; Jablonka, Pascale; Cantale, Nicolas
University of Kansas, École Polytechnique Fédérale de Lausanne (EPFL), EPFL

Traditionally studies of environmental quenching at redshifts beyond the local universe have focused on spatially integrated colors and stellar populations. However, different physical processes for suppressing star formation affect the structure and colors of bulges and disks separately and may induce color gradients in galaxy disks. A bottleneck in making progress on spatially resolved color profiles has been the lack of multi-band HST data on intermediate redshift clusters. To alleviate this, and enable a broad range of new science, Cantale et al. have developed a robust deconvolution technique that can convert deep high quality ground-based data into near HST-quality images with minimal assumptions. We test this technique on real HST data and find an excellent match using no prior knowledge of the HST morphology. With this technique we use VLT images of intermediate redshift clusters to compute pure disk colors (removing the bulge) of cluster and field galaxies. We find that cluster galaxies have redder disks at a fixed stellar mass and Hubble type compared to those in the field. The disk color is not an effect of dust but rather of older stellar population in cluster disks, reflecting the suppression of disk star formation rates. Using multi-color diagnostics of the star formation history we conclude that the mechanisms that are suppressing star formation in disks in our clusters is occurring on extended timescales.

4:45 – 5:00

Galaxy Populations in IDCS 1426.5+3508 at z = 1.75

Shanaberger, Daniel; Brodwin, Mark
University of Missouri - Kansas City

IDCS 1426.5+3508 is a massive and distant galaxy cluster, z_{spec} = 1.75. Discovered in 2012, it is still the most massive galaxy cluster known at a redshift z > 1.5. Studying this distant galaxy cluster gives us a chance to understand the evolution of clusters in the high-redshift universe. In particular, deep exposures have been collected on IDCS 1426.5+3508 from the Hubble Space Telescope and the Spitzer Space Telescope, which will enable a measurement of the cluster stellar mass fraction at high redshift. However, blending in the IRAC images makes photometry difficult. In order to get the most from these data, we are employing GALAPAGOS and PYGFIT to use morphological information from the high resolution HST image to derive

PSF-matched profile fitting photometry in the lower resolution Spitzer bands.

5:00 – 5:15

Are Galaxy Major Mergers Frequent at Early Cosmic Time? Critical Data-Theory Tension, Selection Biases, and Future Prospects

Mantha, Kameswara Bharadwaj; McIntosh, Daniel H.; Brennan, Ryan; Conselice, Christopher J.; Ferguson, Henry C.; CANDELS collaboration

UMKC, UMKC, U. Rutgers, U. Nottingham, STScI, Multiple Institutions

Major galaxy-galaxy merging is expected to be important in the development and growth of massive galaxies (stellar masses > 2 x 10^{10} $M_{\odot}$) over the cosmic history, but especially during early times according to the simulations based on cosmological expectations. We test this prediction by measuring major merger rate of massive galaxies over the past 11 Billion years (0 < z < 3) based on major (1 < SM1/SM2 < 4) galaxy-galaxy pairs in close proximity from Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey (CANDELS) and Sloan Digital Sky Survey (SDSS). We find that major merger rate increases from z ~ 0 to z = 1.0 - 1.5, then turns over and decreases towards z = 3, which is in good agreement with previous studies up to z ~ 1 - 1.5 but is in critical tension with those predicted by simulations at z > 1.5. One of the plausible reasons for this tension is that stellar mass ratios (SM1/SM2) might be a biased tracer of major merging owing to an increasing cold gas content of galaxies towards cosmic high-noon (z ~ 2 - 4). Leveraging the exclusive CANDELS cold gas information from Popping et al., for the first time, we find observational evidence that stellar mass ratio selection excludes major mergers that are significant according to the total baryonic content of the galaxies (SM1/SM2 > 4 but BM1/BM2 < 4). These findings motivate us to test close pair selection methods and novel machine learning based algorithms in the realistic mocks of CANDELS from state of the art Semi-Analytic Model (SAM) and Illustris, to improve our understanding of the calibrations to empirical results.

POSTERS

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

West, Lacey; Lehmer, Bret; Yukita, Mihoko; Hornschemeier, Ann; Ptak, Andrew; Wik, Daniel; Zezas, Andreas
University of Arkansas, University of Arkansas, Johns Hopkins University, NASA/GSFC, NASA/GSFC, NASA/GSFC, Crete

X-ray binary systems (XRBs) in the MW can exist in several different accretion states, and many have been found to vary 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 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 poster, we present evidence that XMM-Newton observations of M83 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.

A First Robust Measurement of the Aging of Field Low Mass X-ray Binary Populations from Hubble and Chandra

Ferrell, Andrew; Lehmer, B.D.; Eufrasio, R.
University of Arkansas

Due to the difficulty in identifying counterparts to X-ray sources in nearby galaxies, low mass X-ray binaries (LMXBs) found within the field of galaxies (field LMXBs) and globular clusters (GC LMXBs) are not usually studied 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. A study conducted by Kim & Fabbiano (2010), found that young galaxies contain more LMXBs per unit stellar mass compared to galaxies with "old" stellar populations. Another study, conducted by Zhang et al. (2012), found that LMXBs were found in greater numbers within older galaxies; however, the number of GCs also increases with galaxy stellar age, suggesting that there are likely more GC LMXBs in older galaxies. Lehmer et al. (2014) studied field and GC LMXBs separately, as a pilot to this study, and found field LMXBs were more numerous within a single relatively young galaxy that was observed, NGC3384. However, the Lehmer study did not provide a statistically robust result. This study will focus on looking within the field LMXB environments of 16 elliptical galaxies of stellar age between ≈ 2 – 12 Gyr. We will then be able to empirically constrain how the field LMXB formation rate, and X-ray luminosity function, varies as a function of host stellar population age.

Information Content of the Angular Multipoles of Redshift-Space Galaxy Bispectrum

Gagrani, Praful; Samushia, Lado
Kansas State University

The redshift-space bispectrum (three point statistics) of galaxies depends on the expansion rate, the growth rate, and geometry of the Universe, and hence can be used to measure key cosmological parameters. In a homogeneous Universe the bispectrum is a function of five variables and, unlike its two point statistics counterpart, the power spectrum, which is a function of only two variables, is difficult to analyze unless the information is somehow reduced. The most commonly considered reduction schemes rely on computing angular integrals over possible orientations of the bispectrum triangle, thus reducing it to sets of function of only three variables describing the triangle shape. We use Fisher information formalism to study the information loss associated with this angular integration. Without any reduction, the bispectrum alone can deliver constraints on the growth rate parameter *f* that are better by a factor of 2.5 compared to the power spectrum, for a sample of luminous red galaxies expected from near future galaxy surveys at a redshift of $z \approx 0.65$, if we consider all the wavenumbers up to $k \leq 0.2$ h Mpc^{-1}. At lower redshifts the improvement could be up to a factor of 3. We find that most of the information is in the azimuthal averages of the first three even multipoles. This suggests that the bispectrum of every configuration can be reduced to just three numbers (instead of a 2D function) without significant loss of cosmologically relevant information.

Understanding Supermassive Black Hole Growth Mechanisms in the SSA 22 Protocluster
Bonine, Brett
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 have 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). I 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 data from the Hubble Space Telescope (HST), using both visual and computational morphology classifications, to determine whether galaxy mergers and/or the presence of larger galaxies and SMBHs are responsible for the enhanced AGN activity. The results will then be compared with archival HST data of field galaxies at the same redshift to assess how more typical galaxies and SMBHs in the z = 3 universe grow.

A Physical Parameterization of the Evolution of X-Ray Binary Emission
Gilbertson, Woodrow; Lehmer, Bret; Eufrasio, Rafael
University of Arkansas
The 7 Ms Chandra Deep Field-South (CDF-S) survey contains measurements spanning a large redshift range of z = 0 to 7. This data-rich field provides 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-S, this study examines the correlations between the physical quantities of stellar age and metallicity with LMXB and HMXB emission, respectively. This study uses an X-ray stacking technique to group galaxy populations with similar metallicities and stellar ages and quantify the relationships between LMXB/M* versus stellar age and HMXB/SFR versus metallicity 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.

Missing Mass: Gravity Wells Independent of Mass

Gruber, Jason; Seyedmadani, Kimia; Gruber, Jace; Laviano, Ricki; Reed, Bryan
IMSG Laboratories-Astronomy Division, University of Colorado Boulder-Aerospace Sciences, Chiles Elementary Advanced Gifted, IMSG Laboratories-Astronomy Division, IMSG Laboratories-Astronomy Division

Dark matter is the longest standing problem in astrophysics. The search for a weakly interactive massive particle (WIMP) has had zero detection in the last 30 years. Attempts of Modified Newtonian Dynamics (MOND) haven't worked on small scales and don't account for dark matter halos observed separately from baryon matter. A new direction may be required. According to General Relativity, gravity is a consequence of spacetime curvature when mass is present, but it is important to point out the gravity is a direct result of the warped geodesics, not the mass. The actual question of what dark matter is should be what is causing the unaccounted for spacetime curvature? Our novel approach to the dark matter theory is our hypothesis that dark matter is just distortions in spacetime by which the curvature alone is the cause of the gravity. Spacetime has been observed to react like a fabric by warping, twisting, and propagating waves. These properties have been proven with observations of gravitational lensing, frame dragging, and recently gravitational waves. Fabrics can be stretched, pressured, and/or heated to the point of deformation losing elasticity. Such extreme conditions were all present during inflation, so it is plausible that spacetime's elastic nature hit its yield point and deformed. Therefore, if gravity is the direct result of warped spacetime, and fabrics can be deformed, then a deformation of spacetime could create a gravitational effect independent of mass. Dark matter may simply be a particle of the spacetime's structure, instead an exotic particle sitting in spacetime causing the warped geodesics. Using the cosmic microwave background we predict that N-body simulations will show an agreement in how imprints of the quantum fluctuations caused by inflation correspond and produce the amounts and locations of the dark matter gravity observed today.

Light Elements in Chondrite Meteorites from the Baker Collection

Mills, Jack; Watters, Colby; Wheatley, Camden; Flores-Tores, Maria, Brinegar, Dalton; Dennehy, Russel; Sivron, Ran
Baker University

We provide evidence through Baker Universities rediscovered meteorite collection that $Z < 10$ elements, such as Carbon, Oxygen, and Nitrogen, could have originated from chondrite meteorites. X-ray fluorescence analysis was used to determine composition of elements with $Z > 10$ elements in these rocks. Taking known densities of the elements we found, we hypothesized a detected density for our meteorites and compared with known densities found using Archimedes Principle. The much smaller density implied the presence of low Z elements, and calculations have shown the most likely elements. We are in the process of using NMR and other technique as independent method of confirmation for our hypothesis.

photPARTY: Python Automated Square-Aperture Photometry

Symons, Teresa; Anthony-Twarog, Barbara
University of Kansas

As CCD's have drastically increased the amount of information recorded per frame, so too have they increased the time and effort needed to sift through the data. For observations of a single star, information from millions of pixels needs to be distilled into one number: the magnitude. Various computer systems have been used to streamline this process over the years. The

CCDPhot photometer, in use at the Kitt Peak 0.9-m telescope in the 1990's, allowed for user settings and provided real time magnitudes during observation of single stars. It is this level of speed and convenience that inspired the development of the Python-based software analysis system photPARTY, which can quickly and efficiently produce magnitudes for a set of single-star or un-crowded field CCD frames. Seeking to remove the need for manual interaction after initial settings for a group of images, photPARTY automatically locates stars, subtracts the background, and performs square-aperture photometry. Rather than being a package of available functions, it is essentially a self-contained, one-click analysis system, with the capability to process several hundred frames in just a couple minutes. Results of comparisons against present systems such as IRAF will be presented. The support of the National Science Foundation through grant AST-1211621 is gratefully acknowledged.

Redshirt's Revenge: Studying the Importance of Mergers in the Assembly of 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 constrain the importance of mergers in the assembly of massive passive galaxies. I intend to look for non-axisymmetries in low-z luminous red galaxies (LRGs). DECam photometric data is desirable since, relative to SDSS, DECam can image approximately two magnitudes fainter in three optical bands. This allows for detection of low surface brightness features at higher redshift. I will then inspect target galaxies by eye for evidence of mergers, e.g. tidal features, which will then be quantified statistically.

Spectroscopic Analysis of the Metal-Deficient, Old Open Cluster NGC 2506

Anthony-Twarog, B. J.; Deliyannis, C.P.; Lee-Brown, D.; Twarog, B. A.
University of Kansas, Indiana University, University of Kansas, University of Kansas

NGC 2506 is an older open cluster located in the galactic anticenter and, typical of anticenter clusters, found to be metal-deficient from broad-band photometry and moderate-dispersion spectroscopy. We recently completed an analysis of the proper-motion cluster members on the extended Stromgren system, finding [Fe/H] = -0.32 $\pm$ 0.03 and E(B-V) = 0.058 $\pm$ 0.001 from 257 turnoff stars, leading to a cluster age of 1.85 Gyr. This combination of age and low metallcity makes the cluster a crucial testing ground for the evolution of Li in stars of lower mass. Preliminary analysis of HYDRA spectroscopy of over 200 cluster stars from the turnoff through the giant branch leads to [Fe/H] = -0.35, in excellent agreement with the photometry, and a well-defined decline in Li abundance from the cluster turnoff through the subgiant branch and up the first-ascent red giant branch. A bimodal Li distribution among giants brighter than V = 14.75 may be an indication of the first dredge-up at the base of the giant branch.

Masters in Astronomy at Missouri State University

Dr. Peter Plavchan
Missouri State University

The Department of Physics, Astronomy and Materials Science at Missouri State University now offers a primary emphasis in Astronomy as part of the interdisciplinary Masters in Natural and Applied Sciences Program. Get hands on experience working on cutting edge research ranging from a new NASA mission study called EarthFinder to discovery exoplanets with the radial velocity technique, to studying the pulsations of exotic subdwarf B stars. Applications are being accepted now through June 1st for enrollment in the Fall 2017 semester. See for more information and how to apply: http://science.missouristate.edu/mnas/ Please contact Dr. Peter Plavchan at peterplavchan@missouristate.edu for any questions.

A Photometric Study of Four Eclipsing Binaries

Ryan, Austin; Powell, Lee; Gokhale, Vayujeet; Hahs, Gage
University of Nebraska Kearney, Truman State University

As part of a program to study eclipsing binary stars that exhibit the O'Connell Effect (OCE) we are observing a selection of binary stars in a long term study. The OCE is a difference in maximum light across the light curve, possibly caused by starspots. We observed for seven nights at McDonald Observatory using the 30” telescope in July 2015, and used the same telescope remotely for a total of 30 additional nights in August, October, December of 2015, as well as January, May, and June of 2016. We will present light curves for four stars from this study, characterize the OCE for these stars, and present our model results for the physical parameters of the star making up each of these systems.

Simulating Radial Velocity Precursor Surveys for Target Yield Optimization for Future Direct Imaging Missions

Newman, Patrick; Plavchan, Peter
Missouri State University

Future direct imaging missions such as WFIRST, HabEx, and LUVOIR aim to catalog and characterize Earth-analogs around nearby stars. With the scope and expense of these missions, the exoplanet yield is strongly dependent on the frequency of Earth-like planets and the a priori knowledge of which stars specifically host suitable planetary systems. Ground-based radial velocity surveys can potentially perform the preselection of direct imaging missions at a fraction of the cost of a blind direct imaging survey. We present the first phases of a simulation of such a survey. We consider multiple telescopes, including their locations, weather conditions, observation time limitations, and instrument sensitivities. From this, we generate realistic measurement frequencies, qualities, and RV precision. We intend to next inject and recover the masses and orbital parameters of real and simulated planets, estimating the effectiveness and optimizing the yield of a precursor radial velocity survey.