Great Lakes Cosmology Workshop 09
Carnegie Mellon University
Bruce and Astrid McWilliams Center for Cosmology
June 8-11, 2008

Presenter, Title & Abstract

Fred Adams, University of Michigan
Orbits and Instabilities in Triaxial Dark Matter Halos - Oral

We construct an analytic form for a triaxial potential that describes the dynamics of a wide variety of astrophysical systems, including the inner portions of dark matter halos, the central regions of galactic bulges, and young embedded star clusters. Specifically, this potential results from a density profile of the form \propto l/m, where the radial coordinate is generalized to triaxial form so that m^2 = x^2/a^2 + y^2/b^2 + z^2/c^2. Using the resulting analytic form of the potential, and the corresponding force laws, we construct orbit solutions and show that a robust orbit instability exists in these systems. For orbits initially confined to any of the three principal planes, the motion in the perpendicular direction can be unstable. We map out the range of parameter space for which these orbits are unstable, find the growth rates and saturation levels of the instability, and develop a set of analytic model equations that elucidate the essential physics of the instability mechanism. This orbit instability has a large number of astrophysical implications and applications, including understanding the formation of dark matter halos.

Steve Allanson, University of Waterloo
The Star Formation Histories of Red Sequence Galaxies – Poster

The star formation histories of red-sequence galaxies are a long standing puzzle in astronomy. Previous studies of intermediate resolution spectra of red galaxies in clusters from the NOAO Fundamental Plan Survey have shown less luminous galaxies are younger than more luminous galaxies, assuming stars formed in a single burst. Here we investigate more complex star formation models, generate synthetic spectra, and use AAOmega spectra to determine the star formation history. From these star formation histories we predict other observables and compare with results from other groups. In particular, we find that star formation histories with recent star formation, such as an exponentially declining star formation history, are inconsistent with dynamical mass-to-light ratios from the SAURON group. However, the single stellar population is the only model to accurately reproduce and fundamental plane of the Coma cluster. We find large differences in faber Jackson, and colour-velocity dispersion relations between models which can be used as a good discriminator for observations.

Gabriel Altay, Carnegie Mellon University
SPHRAY Tracing Low Mass Galaxies with a View Towards Reionization – Oral

What were the sources that reionized the Universe? The simplest scenario is that galaxies full of population II stars that formed with a Salpeter Initial Mass Function provided the majority of photons that reionized the Universe. Recent work has uncovered the possibility of a low mass function that contains many more low mass halos than high mass halos and so if this cut off is real, other stellar populations or sources all together may be responsible for reionization.

Cristian Armendariz-Picon, Syracuse University
Preheating with Derivative Couplings - Oral

In this talk, I discuss the impact of derivative couplings on preheating at the end of inflation. The talk begins with a brief review of preheating, and the theoretical motivations for derivative couplings in "natural" inflationary models. It then proceeds to present the new phenomena associated with derivative couplings and concludes discussing the efficiency of preheating in these models.

Catherine Bailey, Case Western Reserve University
First 5 Tower CDMS Analysis Results - Oral

The Cryogenic Dark Matter Search (CDMS) is searching for Weakly Interacting Massive Particles (WIMPs) with low-temperature detectors that have the ability to discriminate between candidate (nuclear recoil) and background (electron recoil) events with extremely high accuracy. The CDMS II experiment has recently completed analysis of the first data run with all 30 semiconductor detectors at the Soudan Underground Laboratory. This talk will present an overview of the experiment along with the analysis results, with a focus on the data quality studies that remove outlier events.

Phillip Barbeau, Enrico Fermi Institute, University of Chicago
New Constraints on Dark Matter from a Large Mass Ultra-Low Noise Germanium Detector Intended for Coherent Neutrino Scattering - poster

The COGENT collaboration has developed a new type of HPG3 detector to measure coherent neutrino-nucleus scattering of reactor antineutrinos. The detector features a low noise threshold achieved by drastically reducing its capacitance, thus it is sensitive to the sub keV nuclear recoils induced by the neutrinos. For the first time, a detector has the large mass (~500 g), low background and low threshold (~300 eVeee) necessary to observe this process. The status of the measurement at the San Onofre Nuclear Generating Station will be discussed. The detector characteristics also make it ideal for low mass (<10 GeV) Dark Matter searches unachievable with higher threshold devices. Limits from a low mass WIMP search performed at ~300 m.w.e. are presented. Other applications including novel Dark Matter, double-beta decay and neutrino magnetic moment experiments will be briefly discussed.

Matthew Bayliss, University of Chicago
Cosmological Constraints from Cluster-scale Gravitational Lenses: Leveraging New Large Lens Samples - Poster

Statistical properties of galaxy cluster-scale strong lenses inform us about both the structure formation history of the universe and also the halo density profiles of the most massive structures in the universe, as well as the overall cosmology in which these structures are embedded and arise from. The small samples of cluster lenses available in the literature – and especially the limited range in redshift and heterogeneous selection of the known lenses – have limited previous studies of cluster lenses in the context of cosmology. We present current progress on two large surveys for strong lensing clusters which, when complete, will total several hundred such lenses out to redshifts as high as $z = 1.0$. These numbers represent an order of magnitude increase in total sample size, which will allow us to student cluster lens properties as a function of both mass and redshift. Furthermore, our two surveys provide a sample of lenses which originate from homogeneous pools of data with consistent and quantifiable selection functions. This unprecedented ability to robustly characterize our lens sample is crucial for typing observations back to cosmological simulations and halo profile theory.

John Beacom, Ohio State University
A New Era in High-Energy Astronomy- Oral

What are the sources of the cosmic rays? Deflections due to magnetic fields hide the luminous and efficient accelerators that we know must exist. Sensitive new observatories for high energy gamma rays and neutrinos, e.g., GLAST and IceCube, will reveal high-energy astrophysical sources. These data will be essential for understanding feedback processes in galaxies and for attempts to isolate dark matter annihilation signals.

Rachel Bean, Cornell University
Observational signatures of brane inflation. - Oral

We discuss how CMB observations can be used to investigate the properties of inflation beyond the standard slow roll paradigm, for which observational predictions could be markedly different. We discuss a variety of brane inflation models which could exhibit rich observational signatures, potentially offering a way to distinguish the underlying microphysical properties of such an inflationary theory.

Rahul Biswas, University of Illinois at Urbana-Champaign
Bayesian Forecasting of Cosmological Parameter Constraints for Future Experiments - Oral

In the era of precision cosmology, observational efforts are driven by expensive well planned missions. As we move towards more precise measurements, it is thus imperative to estimate the constraints from the proposed observational survey, more accurately. Here, we propose a method of forecasting cosmological parameter constraints from future surveys which go beyond the usual method of Fisher Information Matrix.

Suman Bhattacharya, University of Pittsburgh
Measuring Mean Pairwise Velocity from LSST Supernovae Survey - Oral

We propose to use future observations of type Ia Supernovae (SNIa) from LSST to measure the mean pariwise motion of galaxies out to redshift ~1. Type Ia supernovae are excellent standard candles and hence give a distance measure to their host galaxies. We show that using light curve measurements of millions of SNe Ia, combined with photometric redshifts for either the supernovae or their hosts, it I possible to measure the streaming motion of the galaxies over a cosmological volume out to redshift ~1. such measurements require no additional observational efforts beyond the LSST survey, and provide constraints on cosmological parameters complementary to those provided by the SN Ia distance measurements.

Silvia Bonoli, Max Planck Institute for Astrophysics

Co-evolution of Supermassive Black Holes and Galaxies: Models for BH Accretion and Quasar Lightcurve - Oral

Super-massive black holes (SMBHs) appear to be ubiquitous in the centers of elliptical galaxies and bulges, and their masses are tightly correlated with physical properties of their host galaxies. This suggests that the processes that form spheroids also trigger black hole growth and quasar activity, and that galaxies and their SMBHs may influence each other during their evolution. Using semi-analytic models of galaxy formation applied to the outputs of the Millennium Simulation we modeled the co-evolution of galaxies and their central SMBHs. We investigated different physical processes that could be responsibnle both for BJ accretion and for bulge formation, and we tested these models through a comparison with observed properties of galaxies and SMBHs, and with the observed luminosity function of active galactic nuclei as a function of redshift. Moreover, we investigated different theoretical models for the quasar lightcurve of individual accretion events, and for the dependence of the lifetime on BH mass. We are also exploring how the clustering of our simulated quasars depends on luminosity and how it evolves with cosmic time.

Sean Bryan, Case Western Reserve
SPIDER: A Balloon-Borne Experiment to Measure CMB Polarization on Large Angular Scales Oral

SPIDER is a balloon-borne experiment designed to measure the polarization of the Cosmic Microwave Background (CMB) on large angular scales. During the course of a mid-latitude, long-duration flight around the world from Australia, the array of 2000 polarization-sensitive bolometers in the payload will make a half-sky map of the CMB. A half-wave plate will be rotated between two or more positions in front of each of the five telescopes. This will allow each bolometer to make a map of both polarization states of the light on the sky, dramatically reducing systematic effects. The primary goal of SPIDER is to detect or set an upper limit on the curl component (B-mode) of the CMB polarization pattern on the sky, which is a signature of the gravity wave background generated by inflation. The instrument will also measure the curl-free (E-mode) polarization pattern to high precision, which will break cosmological parameter degeneracies and improve measurements of the optical depth to reionization.

Cliff Burgess, McMaster University/PI/CERN
String Inflation - /Oral

This talk provides a review of some of the motivations for, and preliminary results from, the search for inflation within string theory.

Jane Charlton, Penn State University
Mapping the Gas in the Universe - Oral

I will survey the distribution of gas in the universe and its evolution from redshift 6 until the present. This review will include results on the Lyman-alpha forest clouds, the Lyman limit absorbers that are generally associated with galaxies, and the damped Lyman-alpha absorbers. I will also highlight the mysterious weak MgII absorbers, which have high metallicities (close to the solar value) despite their locations far from galaxies, and which cover the same fraction of the sky as these galaxies. Quasar absorption lines are an important tool for cosmology and galaxy evolution because they allow us to "view" processes such as galaxy formation, gas infall, and feedback. A common theme is the build-up and redistribution of metals in the universe.

Douglas Clowe, Ohio University
Cosmological Constraints from Weak Lensing Observations of Galaxy Clusters

Weak gravitational lensing provides a means of measuring the mass of a cluster independent of its dynamical state. I will review the basic steps of a weak lensing measurement and give an overview of the current status of lensing by clusters of galaxies, with an emphasis on the recent results from merging clusters of galaxies. Finally, I will discuss the future of this field, and how one can use a cluster lensing survey to constrain the dark energy equation of state is multiple ways.

Neal Dalal, University of Toronto
Halo Assembly Bias - Oral

We investigate the origin of halo assembly bias, the dependence of halo clustering on assembly history. We relate halo assembly to peak properties measured in the Lagrangian space of the initial linear Gaussian random density field, and show how these same Lagrangian properties determine large-scale bias. We focus on the two regimes where assembly bias has been observed to be significant: at masses very large and very small compared to the nonlinear mass scale. At high masses, we show that assembly bias is expected from the statistics or the peaks of Gaussian random fluctuations, and we show that the extent of assembly bias found in N-body simulations of rare halos is in excellent agreement with our theoretical prediction. At low masses, we argue that assembly bias largely arises from a subpopulation of low mass halos whose mass accretion has ceased. Due to thjeir arrested development, these halos naturally become unbiased, in contrast to their anti-biased peers. We show that a simple toy model incorporating these effects can roughly reproduce the bias trends found in N-body simulations.

Barun Dhar, University of Minnesota
Reconstructing Dark Matter Distribution in Clusters of Galaxies: A New Approach - Oral

We introduce a novel concept of reconstructing the mass distribution in clusters of galaxies using strong lensing, which combines the advantages of para-metric and non-parametric approaches. Since the dark matter profiles of galaxies in a cluster environment are not well understood, we choose to model sub-structures in a cluster non-parametrically. The cluster halo9 on the other hand is modeled parametrically. In situations where observations like distribution of hot gas permits an analytical model, we chose such physicaally motivated forms as our parametric form; while in other cases, we use forms deduced from numerical simulations. We test our models using synthetic clusters, and illustrate a few ideas of quantifying errors in reconstruction. Finally, since sub-structures have been modeled non-parametrically, we show how this method can be used to check how well mass follows light of galaxies in a cluster environment.

Jonathan Dudley, McGill University
Modeling the Vishniac Effect

To be modeled is the Vishniac effect, a small-scale CMB temperature anisotropy created by the Compton scattering of CMB photons by free electrons caught in a line-of-sight bulk flow. The Vishniac effect arises due to a density enhancement in the electrons caused by gravitational potentials in both the linear and nonlinear regimes and contributes significant power to the CMB temperature anisotropy power spectrum on small scales.

Ross Fadely, Rutgers University
Dark and Luminous Matter in the Gravitational Lens Q0957+561 - Oral

We present an HST/ACS legacy dataset for the first gravitational lens, Q0957+561. We use deep imaging of the central 30" to discover 19 new strongly lensed features of the quasar host galaxy at z = 1.41, and a high-quality 6' x 6' map to do a weak lensing analysis of the cluster surrounding the lens galaxy at z=0.36. We use the weak lensing to constrain the mass sheet and environmental terms in the lens potential. For the strong lensing, we fit luminous and dark matter components separately, and we are able to robustly measure the dark matter distribution by testing multiple density profiles. We find that the recovered values of the Hubble constant are consistent with distance ladder measurements and consistent with a range of dark matter profiles. We combine the lensing analysis with stellar population synthesis models of Bruzual and Charlot (2003) to measure the masses of both the stellar and dark matter components of the lens galaxy.

Chad Fendt, University of Illinois at Urbana-Champaign
Pico: Parameters for the Impatient Cosmologist - Oral

We present a fast and accurate method of accelerating cosmological parameter estimation. The algorithm, called Pico, can compute the CMB power spectrum and matter transfer function in about 20 milliseconds. This is approximately 1500 times faster than CAMB at default accuracies and 250,000 times faster at high accuracy. By removing the major bottlenecks in parameter estimation codes, Pico decreases the time required to explore the parameter posterior by 1 or 2 orders of magnitude. The computational burden then involves generating a training set of parameters and power spectrum for Pico. This step, however, can be done completely in parallel using the distributed computing project Cosmology@Home. For a 9 parameter cosmological model, our code computes the TT, TE and EE power spectra to better than 1% of cosmic variance for nearly all 1-values over a large region of parameter space and produces nearly identical posteriors as CAMB when applied to WMAP data.

Michele Fontanini, Syracuse University
The Limits of Cosmological Perturbation Theory - Oral

We apply the effective field theory approach to the coupled metric-inflation system, in order to investigate the impact of higher dimension operators on the spectrum of scalar and tensor perturbations in the short-wave length regime. We find in both cases that the cutoff that sets the validity of the theory is reached when the Hubble parameter becomes of the order of the Planck mass, or the physical wave number of a cosmological perturbation mode approaches the square of the Planck mass divided by the Hubble constant. Thus we conclude that the scale at which the perturbation theory breaks down is much smaller than the Planck length.

Peter Freeman, Carnegie Mellon University
Nonparametric Estimation of CMB Foreground Emission - Oral

A critical aspect of the analysis of the CMB temperature and polarization fields is estimating foreground emission. Parametric methods of foreground estimation (based on, e.g., template fitting) are complex, and problematic in a number of ways: the models may be incomplete, and resulting estimates may be biased – necessitating sky cuts for further CMB analysis – or may lack useful estimates of uncertainty. Such problems motivate our use of nonparametric statistical procedures for foreground estimation within an inference scheme in which we estimate both foreground emission and the values of cosmological parameters simultaneously. We model the diffuse foreground over the full sky using needlet functions, while treating the sum of the temperature (or polarization) fields and the pixel noise as a Gaussian random field with covariance computable directly an assume CMB power spectrum. Our assumption of a power spectrum makes our algorithm stand in contrast to blind component separators such as WMAP's Internal Linear Combination (ILC) method. We demonstrate our foreground estimation algorithm using WMAP 5 YR data.

David Friedenberg, Carnegie Mellon University
Object Detection in Arcminute-Resolution Microwave Background Maps with Statistical Error Control - Oral

The Atacama Cosmology Telescope (ACT) is designed and dedicated to finding galaxy clusters via their Sunyaev-Zeldovich (SZ) signature. Developing techniques for analyzing these images is an active area of research. Most of the effort to date has focused on filters which isolate the SZ signal and eliminate confounding cosmological signals. Significantly less effort has gone into identifying the clusters after filtering. This task is commonly accomplished using simple peak finding algorithms. Such procedures can find clusters, however, they make no guarantees about purity or completeness, they produce no measure of error. We propose a new statistical approach to the problem that provides a rigorous probabilistic bound on purity that the peak finding algorithms lack. This is a more efficient use of the data since we not only identify the locations of the clusters but also get a bounded error rate. This error rate can then be easily incorporated into downstream inferences that will be made using the clusters. We also are developing a procedure that bounds the purity and simultaneously makes a probabilistic guarantee on detection of all clusters above a certain integrated area, which is a proxy for the cluster mass. We believe both of these procedures will prove valuable not only in analyzing the ACT data but in many other object detection problems in Astronomy and Observational Cosmology.

Josh Frieman, Fermilab/University of Chicago
First Results from the SDSS Supernova Survey - Oral

The SDSS-II Supernova Survey discovered and measured light curves for over 500 type Ia supernovae in the redshift range z~0.05-0.4, filling in the redshift desert between low- and high-redshift SN samples. In this talk I will present the SN Hubble diagram and cosmological results from the first of the 3 observing seasons.

Christopher Genovese, Carnegie Mellon University
Nonparametric Inference for the Dark Energy Equation of State using Type Ia Supernova Data Oral

We present a new method for making sharp stataistical inferences about the dark energy equation of state from observations of Type Ia Supernovae (SNe). The method is based on a nonparametric, nonlinear inverse problem that expresses the co-moving distance function in terms of the equation of state. This work stands in contrast to approaches that involve estimating derivatives of the co-moving distance as a function of redshift. We describe methods for testing hypotheses about the equation of state with a minimum of assumptions, for efficiently estimating a time-varying equation of state, and for deriving valid confidence bands. We also show that commonly used bases can produce statistically inefficient results. Using our approach, we evaluate the strength of statistical evidence for various competing models of dark energy. We find that with the currently available Type Ia SNe data, it is not possible to distinguish statistically among popular dark energy models. In particulalr, there is no support in the data for rejecting a cosmological constant. A sample size increase by a factor of 10 would likely be sufficient to overcome this problem. Such data should become available with NASA's Joint Dark Energy Mission.

David Gilbank, University of waterloo
Cosmology with the Red-sequence Cluster Survey 2 (RCS-2) - Oral

The evolution of the cluster mass function can in principle place strong constraints on cosmology. A number of future and current large optical surveys (such as the 1000 sq. deg. RCS-2) will produce samples of more than of order 10,000 galaxy clusters. The primary challenge in using such samples to derive cosmological parameters is to understand how well observationally-inexpensive measures, such as optical richness, trace cluster mass. I will present recent results of ongoing follow-up work from the first Red-sequence Cluster Survey (RCS-1) aimed at quantifying the mass – richness relation and its scatter out to redshift one. I will also discuss factors which might affect the measurement of optical richness, such as the evolution of red-sequence cluster galaxies, over half the age of the universe.

Jimmy Hutasoit, Carnegie Mellon University
Non-linear Dynamics in Axionic Inflation - Oral

Type IIB superstring theory compactified on Calabi-Yau manifolds with $h^(1,1) = $2 can lead to a low energy effective theory with a single scalar field. At first glance, due to the restriction from the non-perturbative effects used to stabilize the moduli, it is hard to achieve enough e-folds to consider this as a realization of natural inflation in string theory. However, this problem can be solved by including the non-linear dynamics of the quantum corrections. We will also discuss the possibility of getting non-Gaussian signatures from this non-linear dynamics.

Rishi Khatri, University of Chicago at Urbana-Champaign
Fundamental Physics from the Cosmological 21 cm Radiation - Oral

New low frequency radio telescopes currently being built open up the possibility of observing the 21 cm radiation before the Epoch of Reionization in the future, in particular at redshifts $30< z <200$, also known as the dark ages. A radio array on the far side of moon, Dark Ages Lunar Interferometer (DALI), has been proposed by Joseph Lazio et al. to observe this radiation as a part of NASA initiative to return to the moon. At these high redshifts, Cosmic Microwave Background (CMB) radiation is absorbed by neutral hydrogen at its 21 cm hyperfine transition. This redshsifted 21 cm signal thus carries information about the state of the early Universe and can be used to test fundamental physics. We study two types of new physics which such observations can constrain. 1) We show that the 21 cm radiation is very sensitive to the variations in the fine structure constant and can in principle place constraints comparable to or better than the other astrophysical experiments. 2) Cosmic strings, if they exist, contribute to the anisotropies in the primordial gas leaving an imprint on the 21 cm radiation. We show that the 21 cm radiation can potentially probe strings of mass per unit length ~10e-12 assuming intercommutation probility of 1. Making such observations will require radio telescopes of collecting area 10-16e6 square km compared to ~1 square km of current telescopes.

Charles Kirkpatrick, University of waterloo
Cooling Flow Driven Starburse During Minimal AGN Activity in Abell 1664 - Poster

We present an analysis of a Chandra 37 ks observation of the Abell 1664 cluster. The central dominant galaxy (cD) in A1664 is unusually blue and is forming stars at a rate of approximately 23 solar masses per year. The hot gas in the central region has a cooling time of 3.5e8 yr and entropy of 10.4 keV cm-squared, which are consistent with other star-forming cD galaxies in cooling flow clusters. The center of A1664 has a bar-like X-ray structure. The mass of the 'bar' is comparable to the mass of molecular hydrogen about 1e10 solar masses in the cD galaxy, which further suggests that the hot gas is condensing onto the cD. The central radio source is weak, suggesting that the AGN is underpowered compared to the X-ray cooling luminosity by an order of magnitude. We suggest that A1664 is experiencing rapid cooling and star formation during a low-state of an AGN feedback cycle that regulates the rate of cooling and star formation. The metallicity profile of the cluster shows an unusual central metallicity dip with a difference between the peak metallicity (about 100 kpc from center) and the central metallicity of 0.3 solar. We show that by modeling the thermal emission as a single-phase gas, the central metallicity is underestimated. However, a multi-phase, cooling flow model yields a better fit to the X-ray emission and is able to recover a centrally-peaked metallicity profile.

Matt Kistler, Ohio State University
What's the Deal with Supernovae? - Oral

The last few years have seen a number of exciting developments concerning core-collapse supernovae and the stars that gave rise to them. In particular, over a dozen SN progenitor stars have now been discovered in pre-explosion imaging of nearby galaxies. We will discuss ongoing work and prospects for the near future in determining why massive stars explode and what can be learned when they do, focusing on the information that can be obtained from the detection of neurtrinos from SNe in the nearby universe.

Tsz Yan Lam, University of Pennsylvania
The Probability Distribution Function of Dark Matter in Real and Redshift Space - Oral

The ellipsoidal collapse model is a modification of the Zeldovich Approximation which specifies how an initial fluctuation field can be mapped to a final one, even when the mapping is rather nonlinear. I show how this allows an accurate prediction of the real and redshift space smoothed dark matter probability distribution functions. This mapping also motivates a method for reconstructing the initial field from the nonlinear one. Application of this method to the highly non-Gaussian non-linear density field in a numerical simulation yields an accurate estimate of the initial Gaussian field from which it evolved.

Zhaoming Ma, University of Pennsylvania
Effect of Source Clustering on Weak Lensing - Oral

I will show some results on the effect of source clustering on weak lensing.

Felipe Marin, University of Chicago

Galaxy Bias from the LRG 3-Point Correlation Function - Poster

We present updated and new measurements of the redshift space three-point correlation function (3PCF) of the luminous Red Galaxies (LRG) sample from the Sloan Digital Sky Survey (SDSS). Using an improved binning scheme, we can study the 3PCF in scales from 0.5 up to 80 Mpc/h. On large scales we measure galaxy biasing and are able to reject the zero non-linear bias hypothesis and study the prospects of using the 3PCF to put constrains on cosmological parameters. On small scales, we show that the 3PCF can help on constraining and improving HOD models.

Cameron McBride, University of Pittsburgh
Our Non-Gaussian Universe: Higher Order Clustering in Galaxy Surveys - Oral

Higher order clustering statistics, such as the 3-point correlation function (3PCF), are necessary to study the non-Gaussianity of the galaxy distribution and non-spherical nature of large scale structure. In the hierarchy of correlation functions, the 3PCF is the lowest order statistic to provide information on shape. This enables investigation of the triaxial nature of haloes and extended filaments within the "cosmic web". The higher order information allows both the linear and quadratic bias terms to be constrained to better address whether galaxies are unbiased tracers of mass. In addition, the 3PCF yields crucial data to break degeneracies between cosmological parameters that exist in interpreting the 2PCF or power spectrum.

Galaxy redshift surveys, such as the Sloan Digital sky Survey (SDSS), have brought about a new era in accuracy for understanding large scale structure. The wealth of observational data in these and future surveys poses interesting challenges; new statistical methods and efficient means of computation are required to mine their scientific content.

I will discuss our measurements of the 3PCF in the SDSS main galaxy sample focusing on the projected 3PCF, a complement to bispectrum and redshift-space analyses. I will present our fits of galaxy-mass bias parameters, highlighting the importance of error resolution. Finally, I will discuss a context for future analysis that measurements of the 3PCF can impact and address ongoing work.

Jorge Moreno, University of Pennsylvania
The Creation of Dark Matter Haloes - Oral

In hierarchical clustering models, self-bound dark matter haloes increase their mass by merging with other haloes. These mergers are expected to affect the galaxy populations hosted by the merging haloes, possibly triggering star formation or AGN activity. As a result, there has been some interest, both analytic and numerical, in estimating when such mergers happen. We provide Monte Carlo and analytic estimates of the distribution of times when haloes of a given mass get created. We use two variants of the excursion set approach: constant barriers (spherical collapse) and moving barriers (ellipsoidal collapse). These are compared against measurements in N-body simulations. The creation times distribution of m-haloes conditioned to belong to an M-halo today is also presented.

Jeffrey Newman, University of Pittsburgh

Calibrating Photometric Redshifts for Dark Energy Experiments with Cross-Correlation Techniques- Oral

In this talk I describe a new method for measuring the true redshift
distribution of any set of objects studied only photometrically. The
angular
cross-correlation between objects in a photometric sample with objects in
some spectroscopic sample as a function of the spectroscopic z, in
combination with standard correlation measurements, provides sufficient
information to reconstruct the true redshift distribution
of the photometric sample. This technique enables the robust calibration of
photometric redshifts even beyond spectroscopic limits.
The spectroscopic sample need not resemble the photometric one in galaxy
properties, but must overlap in sky coverage and redshift
range. With this method, the true redshift distributions of even
arbitrarily faint photometric redshift samples may be determined to the
precision required by Stage IV dark energy experiments (errors in mean and
sigma below 3x10^(-3) at z~1) using expected extensions of current
spectroscopic samples.

Brian Nord, University of Michigan
Calibration of Upcoming Surveys in the Laboratory and in Silicon: Filter Testing for the Dark Energy Survey and AAS - oral

The DES science goals require high uniformity for the survey's unprecedentedly large interference filters. The specification, design and construction of these filters represent a technological advancement. The full survey calibration scheme will account for non-uniformities across the focal plane, including the filters, to the percent-level. This effort will incorporate novel analysis tools and may integrate on-sky calibration with off-sky calibration. The Filter Testing and Calibration System (FTCS), designed and constructed at the University of Michigan, will allow full-aperture, high-precision measurement of filter transmission 1) to check the manufacturer's compliance and 2) to independently measure filter non-uniformities.

Sky surveys, like DES and the South Pole Telescope (SPT), have potential to provide a holistic view of galaxy cluster populations; however, to properly "weigh the universe," we must precisely match observable features with masses, which are provided by the underlying dark matter halo. N-body cosmological simulations of dark matter and realistic baryonic components (e.g., hydrodynamics, AGN, star formation, etc.) offer rich, state-of-the-art venues for mock observations of cluster populations.

We use re-simulations of the Millennium Run that include gas physics and preheating to create lightcones and then mock surveys, incorporating selection effects and survey limitations. With these mock skies, we may help to calibrate upcoming surveys (like DES and SPT), as well as to draw robust links between observable cluster properties and the underlying mass. Here, we present the recent work in construction and analysis of these mock, multi-wavelength cluster surveys.

Chris Orban, Ohio State University
Delving Deeper into the Tumultuous Lives of Galactic Dwarfs: Modeling Star Formation Histories - Oral

The paucity of observed dwarf galaxies in the Local group and the relative overabundance of predicted dark matter halos remains one of the greatest puzzles of the Lambda CDM paradigm. Resolving this puzzle now requires not only matching the numbers of objects but also understanding the details of their star formation histories (SFHs). We extend the phenomenological star formation model of Kravtsov, Gnedin and Klypin (2004) which is based on the mass assembly histories of dark matter halos in cosmological simulation and the Kennicutt-Schmidt law of star formation. The dwarf SFHs from this semi-analytic model are compared to a full suite of SFHs for most of the luminous dwarf galaxies in the Local Group inferred from HST observations. We find that adding stochastic variation in the minimum density threshold for star formation leads to a dramatic improvement of model predictions for the amount of recent star formation in the last 1 and 2 Gyr. The model predictions for the radial distributions of dIrr and, separately, dSph galaxy types, the fractions of stars formed in the last 2, 5 and 10 Gyr, and the mean ages of stellar populations are all now statistically consistent with the observations. These results are not sensitive to late gas accretion, the slope of the Schmidt low, or the details of cosmic reionization. Implications for the population of ultra-faint dwarfs discovered in recent years by SDSS and the MegaCam survey of M31 will be discussed.

Elena Rasia, University of Michigan
The M-Yx Relation for Clusters During Extreme Mergers - Oral

In the next few years large sky surveys will b e underway with the aim of identifying and characterizing galaxy clusters over large portions of the sky. The astronomical community will deal with tens of thousands of clusters observed in optical, millimetric or X-ray. With this ambitious and promising expectation in mind, now it is the right time to investigate the systematics that could affect the analysis of real data and provide a concrete framework for the statistical studies we will perform. To address questions both of cosmology and the smaller scale astrophysics, we are deciphering the various connections among observable cluster properties, the intrinsic quantities, and the underlying mass distribution including this evolution with redshift. I will present some first result based on two merging clusters and on a large cosmological sample.

Darren Reed, Los Alamos National Laboratory
The Clustering of the First Galaxies - Oral

We explore the clustering properties of high redshift dark matter haloes, focusing on haloes massive enough to host early generations of stars or galaxies at redshift 10 and greater. H aloes are extracted from an array of dark matter simulations able to resolve down to the “mini-halo” mass scale at redshifts as high as 30, thus encompassing the expected full mass range of haloes capable of hosting luminous objects and sources of reionization. Halo clustering on large-scales agrees with the Sheth, Mo and Tormen halo bias relation within all our simulations, greatly extending the regime where large-scale clustering is confirmed to be “universal” at the 10-20% level (which means, for example, that 3 sigma haloes of cluster mass at z=0 have the same large-scale bias with respect to the mass distribution as 3 sigma haloes of galaxy mass at z=10). However, on small scales, the clustering of our massive haloes (>~10^9Msun/h) at these high redshifts is stronger than expected from comparisons with small scale halo clustering extrapolated from lower redshifts. This implies “non-universality” in the scale-dependence of halo clustering, at least for the commonly used parameterizations of the scale-dependence of bias that we consider. We provide a fit for the scale-dependence of bias in our results. This study provides a basis for using extraordinarily high redshift galaxies (z ~ 10) as a probe of cosmology and galaxy formation at its earliest stages. We show also that mass and halo kinematics are strongly affected by finite simulation volumes. This suggests the potential for adverse affects on gas dynamics I n hydrodynamic simulations of limited volumes, such as is typical in simulations of the formation of the “first starts”, though further study is warranted.

Joseph Richards, Carnegie Mellon University
Dimensionality reduction and Efficient Inferences for Astronomical Spectra - Oral/Poster ???

Novel methods of dimension reduction hold great promise for inference in cosmology. We describe the diffusion map framework for dimensionality reduction in high-dimensional data sets that are complex and non-linear. We then introduce an adaptive framework for regression that exploits the learned low-dimensional geometry of a data set. Our proposed techniques provide an elegant, unified framework for statistical inference for high-dimensional data sets. We apply these techniques to problems of redshift prediction and age and metallicity estimation for galaxies using SDSS spectra.

Paul Ricker, University of Illinois
Expected Counts of Galaxy Cluster Radio Halos in Low-Frequency Radio Surveys -Poster

We present a first estimate based on a cosmological gasdynamics simulation of galaxy cluster radio halo counts to be expected in forthcoming low-frequency radio surveys. Our estimate is based on a FLASH simulation of the LCDM model for which we have generated mock radio sky maps by using the observed X-ray-radio correlation for clusters to normalize projections of the turbulent gas pressure <rv2>. Under the assumption that acceleration of the cosmic rays responsible for radio halos takes place due to intracluster turbulence, the radio surface brightness distribution should trace this quantity. Appropriate observational scatter and cold-core corrections are included.

Megan Roscioli, University of Chicago
Radio Sources in Galaxy Clusters - Poster

We present a statistical study of radio sources in galaxy clusters over wise redshift ($0.3 < z < 1.0$) and mass ranges. We match optically-selected galaxy clusters from the RCS1 and part of the RCS2 catalog with the FIRST and NVSS catalogs of 1.4 GHz radio sources over several hundred square degrees of sky. We investigate the radial distribution of radio sources around cluster centers and observe how the probability that a cluster hosts a radio source depends on the cluster’s mass. Our data suggest that the number of radio sources in a cluster scales linearly with the number of galaxies in the cluster’s center.

Graziano Rossi, University of Pennsylvania
Peak Statistics in the WMAP Sky: Non-Gaussianity? - Oral

In a Gaussian sky, the shape of the correlation function of peaks depends only on the underlying power spectrum. It is predicted to have a wealth of structure and oscillatory features, much more than does the correlation function of all pixels, and to depend in a precisely quantified way on peak height. Therefore, the peak correlation function oscillations allow a high precision test of the Gaussian hypothesis. Moreover, has been shown to distinguish easily between a Gaussian sky and a non-Gaussian one even when the bispectra of the two maps were not statistically different. Recent claims on non-Gaussianity of the CMB may open a new window into the inflationary scenario. However, these claims need to be further investigated. I will present and discuss accurate measurements of the peak correlation function and its dependence on peak height from the WMAP3 data (WMAP5 if time permits), and comparisons between hot and cold spots. I will explain the effect of a positive f NL parameter on the clustering of the peaks.

Regina Schulte-Ladbeck, University of Pittsburgh
The Dwarf Galaxies Crisis of Cosmology Continues - Poster

Cosmological simulations predict a much larger number of dwarf galaxies in the Local Group than have been confirmed observationally. We report on our search for additional local dwarf galaxies toward Compact High Velocity Clouds (none were found), and provide an update on other results, especially those obtained with the Sloan Digital Sky Survey (several new dwarfs have been discovered). Despite much observational and theoretical effort, the dwarf galaxy crisis continues.

Sijing Shen, McMaster University
Probing Metals in the Intergalactic Medium - Poster

We present a study of the process of metal enrichment by investigating the metal absorption lines in simulated Lyman-alpha spectra and comparing them with observations. Using Tree SPH code Gasoline, we perform a cosmological simulation down to redshift zero which takes into account both metal cooling and the ultraviolet background in a self-consistent way. Metals are generated in the star-forming regions in our simulation and transported to the IGM by diffusion. Cooling rates from 17 metal elements as functions of temperature, density, redshift, and metalicity were calculated using CLOUDY assuming ionization equilibrium under the UV background adopted from Haart & Madau (2005). We compute the absorption due to various metal species (e.g. CIII, CIV, OVI, SiIII) and compare them with observational data from the Lyman-alpha forest in higher redshift ($z \sim 3$) to the X-ray spectra due to the warm-hot intergalactic medium (WHIM) observed in the nearby universe.

Greg Stinson, McMaster University
SPH Simulations of Galaxy Formation with Supernova Feedback - Oral

Forming realistic disk galaxies remains one of the primary challenges facing the current standard cosmological model. We have used smoothed particle hydrodynamics (SPH) to follow the evolution of several typical initial density perturbations into galaxies. Using the highest resolution possible on today's computers and a simple recipe for supernova feedback, the resulting galaxies match observations well (Governato et al 2007). High resolution is critical because the n-body nature of SPH introduces numerical two body heating that artificially removes angular momentum when there are few particles. Our high resolution simulations show less angular momentum losses (Governato et al 2004). Even our highest resolution models cannot resolve the shocks associated with supernova feedback. Our simulations incorporate a sub-resolution model for star formation and supernova feedback (Stinson et al 2006). The blastwave model provides pressure to support gas disks, limits the amount of stars that form, and reduces the star formation in small, satellite galaxies. Thus, less collisionless stars that form unrealistically large spherical halos are accreted. Instead, galaxies accrete gas that collapses into a disk where there is active star formation to create disk galaxies similar to those observed.

Matthew Szydagis, University of Chicago
Spin-Dependence WIMP Limits From a Bubble Chamber - Oral

Bubble Chambers provided the dominant particle detection technology in accelerator experiments for several decades, eventually falling into disuse with the advent of other techniques. We report here on a new application for these devices by operating an ultra-clean, room-temperature bubble chamber containing 1.5 kg of superheated CF3I, a target maximally sensitive to spin-dependent and

-independent Weakly Interacting Massive Particle (WIMP) couplings. An extreme intrinsic insensitivity to th e backgrounds commonly limiting direct searches for dark matter has been measured in operating conditions leading to the detection of low-energy nuclear recoils like those expected from WIMPs. Improved limits on the spin-dependent WIMP-proton scattering cross section are extracted, excluding this type of coupling as a possible explanation for a recent claim of particle dark matter detection.

Alexander van Engelen, McGill University
Cosmological Parameters and the Primordial Power Spectrum - Poster

Eli Visbal, Harvard-Smithsonian CfA
Constraining Cosmological Parameters with 21cm Surveys

Measurements of 21cm line emission can in principle produce a 3-D map of neutral hydrogen at a wide range of redshifts. These maps will provide access to the 3-D matter power spectrum which can be used to constrain cosmological parameters. Because of its 3-D nature, this power spectrum contains many more independent modes than the 2-D power spectrum obtained from CMB measurements, and thus may eventually become a much more powerful probe of fundamental physics. Current work has focused on the 21cm signal during the epoch of reionization ($6<z<20$). We forecast cosmological constraints of 21cm surveys designed for post-reionization redshifts, where residual neutral hydrogen traces the matter power spectrum in damped Lyman-alpha galaxies.

Tonia Venters, University of Chicago
The Extragalactic Gamma-ray Background: Modeling Blazars to Constrain Dark Matter
Oral

The study of the diffuse extra-galactic gamma-ray background (EGRB) provides insight into the high-energy processes of the universe. It has been suggested that the diffuse EGRB could contain signatures of dark matter annihilation. However, in order to determine what fraction of the EGRB might be due to dark matter annihilation, it is necessary to first understand the contribution of known astrophysical gamma-ray emitters, particularly blazers, the class of gamma-ray emitters with the largest number of identified members. A critical input in determining the spectral shape of the unresolved blazer contribution to the EGRB is the intrinsic distribution of blazer spectral indices in GeV energies. Therefore, in recognizing its importance, we develop a maximum-likelihood method of determining the intrinsic spectral index distribution (ISID) for EGRET confident blazers, which accounts for error in measurement of individual spectral indices. We then employ the resulting ISID in determining the spectral shape of the unresolved blazer emission. We find that even if blazers can account for the lower energy component of the diffuse EGRB< they are not likely to be sufficient to explain the higher energy component, though the uncertainties are considerable. As GLAST data become available, it will be possible to better determine the contribution of unresolved blazers to the EGRB and thereby constrain the possible contribution of gamma-ray emission from dark matter annihilation.

James Wadsley, McMaster University
Stellar Feedback in Dwarf Galaxy Formation and the Structure of Dark Matter Halos - Oral

Dwarf galaxies pose significant challenges for cosmological models. In particular, N-body models predict a central dark matter distribution that is cuspy (highly concentrated at the center). In contrast, observations indicate a roughly constant central density core. Energetic feedback from supernova explosions and stellar winds is already assumed to be a major factor shaping the evolution of dwarf galaxies and we have shown that it can strongly affect the dark matter as well. We present detailed cosmological simulations with sufficient resolution to model clustered star formation and the impact of stellar feedback on the observable properties of dwarf galaxies. Feedback drives large-scale, bulk motions of the interstellar gas resulting in significant gravitational potential fluctuations and a consequent reduction in the central matter density, bringing the theoretical predictions in agreement with observations. Our results have implications for the formation of globular clusters and the distribution of stars in dwarf galaxies.

Niraj Welikala, University of Pittsburgh
Spatially Resolved Galaxy Star Formation and its Environmental Dependence - Oral

We use the photometric information contained in individual pixels of 44,964 (0.019z<0.125 and $-23.5<M_r<-20.5$) galaxies in the Fourth Data Release (DR4) of the Sloan Digital Sky Survey to investigate the effects of environment on galaxy star formation (SF). We use the pixel-z technique, which combines stellar populations synthesis models with photometric redshift template fitting on the scale of individual pixels in galaxy images. Spectral energy distributions are constructed, sampling a wide range of properties such as age, star formation rate (SFR), dust obscuration and metallicity. By summing the SFRs in the pixels, we demonstrate that the distribution of total galaxy SFR shifts to lower values as the local density of surrounding galaxies increases, as found in other studies. The effect is most prominent in the galaxies with the highest star formation, and we see the break in the SFR-density relation at a local galaxy density of approximately 0.05 Mpc/h^-3. Since our method allows us to spatially resolve the SF distribution within galaxies, we can calculate the mean SFR of each galaxy as a function of radius. We find that on average the mean SFR is dominated by SF in the central regions of galaxies, and that the trend for suppression of SFR in high density environments is driven by a reduction in this nuclear SF. We also find that the mean SFR in the outskirts is largely independent of environmental effects. This trend in the mean SFR is shared by galaxies which are highly star forming, while those which are weakly star forming show no statistically significant correlation between their environment and the mean SFR at any radius.

Michael Wood-Vasey, Harvard University/University of Pittsburgh

Supernova Cosmology from Today and Tomorrow to the Future, Infinity, and Beyond

Solving the mystery of the dark energy accelerating the expansion of our Universe is quite arguably the greatest challenge facing the astronomical and physics communities today. Since Type Ia supernovae had a significant hand in starting the problem, it is only responsible for them to remain involved in the solution. Current supernova surveys have found no evidence to contradict the standard LCDM model of the Universe. Future observational surveys have the potential to verify or detect deviations from LCDM to new precision and to explore the homogeneity and isotropy of the Universe and dark energy. I will summarize the current results from ongoing surveys such as ESSENCE, SNLS, and several low-z efforts, and then detail the challenges we will face in maximizing the cosmological power of supernovae in the next generation of large surveys such as Pan-STARRS, SkyMapper, and LSST, as well as discuss possibilities for the planned NASA/DOE Joint Dark Energy Mission.

Hasan Yuksel, Ohio State University
Revealing the High-Redshift Star Formation Rate with Gamma-Ray Bursts - Oral

While the high-z frontier of star formation rate (SFR) studies has advanced rapidly, direct measurements beyond z ~ 4 remain difficult, as shown by significant disagreements among different results. Gamma-ray bursts, owing to their brightness and association with massive stars, offer hope of clarifying this situation, provided that the GRB rate can be properly related to the SFR. The Swift GRB data reveal an increasing evolution in the GRB rate relative to the SFR at intermediate z; taking this into account, we use the highest-z GRB data to make a new determination of the SFR at z = 4-7. Our results exceed the lowest direct SFR measurements, and imply that no steep drop exists in the SFR up to at least z ~ 6.5. We discuss the implications of our result for cosmic reionization, the efficiency of the universe in producing stellar-mass black holes, and “GRB feedback” in star-forming hosts.

Xinghai Zhao, University of Notre Dame
Effects of Structure Formation on the Apparent Expansion Rate of the Universe - Oral

There are recent claims that back-reaction terms arise when the effective Friedmann equation is averaged over a spatial volume in a locally inhomogeneous cosmology. These terms are claimed to lead to a new average expansion rate of the universe. Many analytical methods for this averaging procedure have been proposed and investigated. In this talk, we discuss a numerical simulation approach in which we have derived a scheme to include general relativistic corrections for general three dimensional inhomogeneities in space. The volume averaged expansion rate is quantitatively calculated with an N-body simulation code for a matter dominated, structure forming era. We discuss current limits on the corrections to the standard expansion rate. The possible physical nature of the corrections and the impacts of this averaging on the cosmological observables will also be addressed.