ABSTRAT BOOKLET

2016 ANNUAL SCIENTIFIC CONFERENCE

Diving into the Dark:

Bridging Cosmological Theory and Observation

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Cairns, QLD, Australia

Ixandra Achitouv
Swinburne University of Technology

Improving Reconstruction of the Baryon Acoustic Peak: The Effect of Local Environment

Precise measurements of the baryon acoustic oscillation (BAO) scale in the clustering pattern is a central goal of current and future galaxy surveys. The BAO peak may be sharpened using the technique of density-field reconstruction, in which the bulk displacements of galaxies are estimated using a Zeldovitch approximation. We use numerical simulations to demonstrate how the accuracy of this approximation depends strongly on local environment, and how this information may be used to construct an improved BAO measurement through environmental re-weighting and using higher-order perturbation theory. We outline further applications of the displacement field for testing cosmological models.

Caitlin Adams
Swinburne University of Technology

Testing modified gravity beyond the cosmic variance limit

Observations at low-redshift can be used to distinguish between two promising explanations of the Universe's accelerating expansion: dark energy and modified gravity. Specifically, modified gravity theories introduce scale-dependence in the growth rate of structure, which is encoded in the distribution of galaxies and their peculiar velocities. The small sample size associated with these observations makes them limited by cosmic variance, preventing precision tests of cosmological models. To overcome this issue, we have developed a new maximum-likelihood approach for simultaneously fitting the observed density and peculiar velocity fields including the effects of correlated sample variance, marginalizing over key model systematics with full error propagation. Our methodology naturally allows the measurement of the growth rate as a function of scale, and we present first results from the 6-degree Field Galaxy Survey. Finally, we discuss prospects for how

these constraints will be improved by the Taipan Galaxy Survey starting later this year, which will increase the available density and velocity samples by an order of magnitude.

Eromanga Adermann
The University of Sydney

Unveiling the Signatures of Alternative Cosmologies

Using state of the art numerical simulations, I have unravelled observational signatures of several alternative cosmological models in the large scale structure of the cosmic web. The key observational probe under study is evolution of cosmological voids, to provide us with clues to the underlying cosmology of the Universe. While the ultimate goal will be to include galaxy formation recipes to determine the true efficacy of using cosmic voids in realistic future surveys with the next generation of ground- and space-based telescopes, in this presentation I will reveal how the size, shapes and density of voids, and their evolution through cosmic time, depend on the underlying cosmology of the Universe, showing that universes with an evolving and decaying dark sector leave a significant imprint on the void structure when compared to the standard Lambda Cold Dark Matter cosmology.

Adam Amara
ETH Zurich

Through the Dark with Gravitational Lenses

It is now well established that gravitational lensing can offer us powerful insights into dark matter and dark energy. Furthermore, the current generation of wide field imaging surveys are in the process of delivering substantial improvements in measured precision. In this talk, I plan to give an overview of the latest lensing results with successive zooms to smaller scales. These include weak lensing power spectrum [1], mass mapping [2, 3, 4, 5], lensing peak statistics [6], strong lensing of the peaks and ways of finding new strong lenses in imaging surveys [7]. My aim will be to highlight the connections and complementarity in the science reach of these studies, as well as to highlight some of the common challenges that they share -- namely photo-z [8] and PSF correction. The main focus of my talk will be the Dark Energy Survey, which has been the focus of my work recently. Nonetheless, the ideas and themes of my talk are relevant for other state-of-the-art imaging surveys.

[1] The Dark Energy Survey Collaboration, ''Cosmology from Cosmic Shear with DES Science Verification Data', PRD 2015
[2] Chang, C. et al, ''Wide-Field Lensing Mass Maps from Dark Energy Survey Science Verification Data', PRL 2015
[3] Vikram, V. et al, 'Wide-field lensing mass maps from Dark Energy Survey science verification data: Methodology and detailed analysis', PRD 2015
[4] Pujol, A. et al, 'A new method to measure galaxy bias by combining the density and weak lensing fields',
[5] Chang, C. et al, 'Galaxy bias from the DES Science Verification Data: combining galaxy density maps and weak lensing maps',
[6] Kacprzak, T et al, 'Cosmology constraints from shear peak statistics in Dark Energy Survey Science Verification data', arXiv:1603.05040 (2016)
[7] Nord, B., et al, 'Observation and Confirmation of Six Strong Lensing Systems in The Dark Energy Survey Science Verification Data', arXiv:1512.03062 (2016)
[8] Bonnett et al , 'Redshift distributions of galaxies in the DES Science Verification shear catalogue and implications for weak lensing', arXiv:1507.05909 (2015)

Per Andersen
Dark Cosmology Centre

Cosmology with Peculiar Velocities: Observational Effects

The discovery of the accelerated expansion of the universe caused a flood of studies into the origin and nature of dark energy, the term in the concordance Lambda-CDM cosmology responsible for this accelerated expansion. One avenue to learn more about dark energy is to measure the cosmological bulk flow, the bulk flow of our local galactic neighbourhood with respect to the dipole subtracted CMB frame. The cosmological bulk flow is a strong tracer of large scale structure formation, and probing how large scale structure has formed allows us to constrain cosmological models and determine whether dark energy really is a cosmological constant or has a more complex evolution with redshift.

Constraints on cosmology from cosmological bulk flows have historically been plagued by poor observations and systematic. However, the increasing number of precise measurements of distances and peculiar velocities from type Ia SNe provide an opportunity to revisit whether bulk flows are a useful tool to constrain cosmology and dark energy.

In this presentation I will present the current status of our work, where we use the Horizon Run 2 simulation to perform a statistical analysis of how well we can measure the cosmological bulk flow using observations of type Ia SNe, and investigate whether observational or systematic effects bias the already published results. I will start by reviewing the linear theory necessary to compare measured bulk flows to predictions from theory, and expand the theory to hold for arbitrary geometries. Then we will see that the results of this expanded theory agree well with bulk flows calculated for a number of spherical cone surveys drawn from the Horizon Run 2 simulation. Using results from this expanded theory and the Horizon Run 2 simulation as a baseline we test if the Maximum Likelihood and Minimum Variance bulk flow estimators can reproduce the actual underlying bulk flow for a number of spherical cone geometries. We find that sampling and geometry effects can strongly bias both the Maximum Likelihood and Minimum Variance estimators, with an increasingly adverse bias for poorer sampling and less spherical survey geometries. Finally I will propose a method to best avoid this bias from sampling and geometry, and briefly discuss some general challenges of using bulk flows for cosmology that still exist.

Luke Barnes
The University of Sydney

How the Cosmological Constant Ends Accretion

Theories of cosmological inflation often predict that cosmic conditions will vary from place to place in the universe as a whole. In particular, the value of the cosmological constant can plausibly explained by a combination of environmental variation and its effect on galaxy formation. In such models, it is crucial that we understand how quickly and efficiently the onset of accelerating expansion shuts down accretion of matter into dark matter haloes and galaxies. I will show simulations, based on the cosmological galaxy formation code of the Eagles collaboration that investigates this effect.

Chris Blake
Swinburne University of Technology

What can peculiar velocities do for cosmology?

I will review tests of the cosmological model using direct peculiar velocity observations, focussing in particular on the unique constraints on gravitational physics they enable on large scales that are difficult to probe using redshift-space distortion. Peculiar velocity measurements are independent of galaxy bias, and joint analyses with the density field allow further tests featuring reduced sample variance. I will summarize results from existing samples, and describe the advances expected from the Taipan Galaxy Survey, starting shortly at the UK Schmidt Telescope, which will increase the existing peculiar velocity sample by up to an order of magnitude.

Krzysztof Bolejko
The University of Sydney

Anisotropy of the HubbleFflow

One of the major cosmological discoveries of the previous century was that the Universe expands. The simplest description of this phenomenon assumes a homogeneous and isotropic expansion. However, this is merely a first approximation, for the real Hubble flow is not uniform. With increasing precision and amount of data we are now entering a stage when we can measure departures from the uniform Hubble expansion. This is similar to what happened in 1990s when cosmologists started to measure the anisotropies of the cosmic microwave background radiation (CMB). Since then we have been able to use the CMB anisotropies to put tight constraints of values of the cosmological parameters. In my talk I will discuss how the anisotropies of the Hubble flow could be used to learn more about the properties of our Universe, which goes beyond a basic set of cosmological parameters. I will present results derived from N-body simulations as well as galaxy redshift surveys.

Margot Brouwer
Leiden Observatory

Galaxy Halo Masses in the Cosmic Web

Galaxies and their dark matter haloes are part of a complex network of mass structures, collectively called the cosmic web. These structures, which can be classified into voids, sheets, filaments and knots, may influence the formation and evolution of the galaxies and haloes they host. To study the influence of the cosmic web topology on the average halo mass of galaxies, we measure the galaxy-galaxy lensing signal of ~113,000 galaxies from the spectroscopic Galaxy and Mass Assembly (GAMA) survey, using the overlapping lensing data from the Kilo-Degree Survey (KiDS). In increasingly dense cosmic environments we find a slight increase in the average halo mass and a significant increase in the average contribution of neighbouring groups, although we show that the observed effects can be entirely attributed to the local density (within 4 Mpc/h), which is correlated with the density of the cosmic environments. Within our current uncertainties we find no direct dependence of galaxy halo mass on the cosmic web topology.

Claudio Bruderer
ETH Zurich

Monte Carlo Control Loops Weak Lensing Measurements Applied to DES data

Several Stage III wide-field imaging survey are now taking data and systematically mapping the sky. Thus, large datasets, well-suited to study our Universe using weak lensing and other cosmological probes, are available and currently being analysed. However, in order to fully exploit the potential of these surveys, systematics in the measurement process need to be controlled.

The focus of my talk will be the Dark Energy Survey (DES) and a novel shape measurement approach that we are developing called MCCL (Monte Carlo Control Loops). This approach heavily relies on forward-modelling the measurement process. It has required us to develop a new image simulation tool called UFig and to implement a new statistical inference method known as Approximate Bayesian Computation (ABC), which allows us to go beyond standard Bayesian MCMC methods and compute posterior distributions even when the likelihood cannot be calculated. With these tools and the control loop aspects of our MCCL framework we can then calibrate the measurements and systematically test their robustness.

I will present the latest status of our methods and discuss the connection with other developments in shape measurements. In particular, there is a big advantage when making precision cosmology measurements to using independent complimentary methods.

Caroline Caldwell
Astrophysics Research Institute, Liverpool JMU

Velocity Dispersions of Groups: An Alternative Method of Estimating Cosmological Parameters

Velocity dispersions of galaxy groups can be used instead of mass to estimate cosmological parameters. One advantage to this approach is that velocity dispersions are directly observable and do not suffer from the same systematic biases as masses. As new large spectroscopic surveys come online, this method will become even more powerful. I present the application of the velocity dispersion method, and an analysis of sources of scatter in the mass-velocity dispersion relation, by comparing a large cosmological hydrodynamical simulation, BAHAMAS, to the GAMA survey to determine an estimate of sigma 8.

Raffaella Capasso
Ludwig Maximilian Universität

Dynamical Analysis of SPT-Selected Galaxy Clusters

The phase-space distribution of tracers in galaxy clusters is a powerful tool that can be used to test the mass distribution of dark matter haloes as predicted in large-scale structure cosmological simulations, as well as to provide information about the formation and evolution of cluster member galaxies. I will present a dynamical study of a sample of ~100 Sunyaev-Zel'dovich effect (SZE) selected galaxy clusters from SPT that have redshifts extending to z~1.3. The total spectroscopic sample is made of ~3787 passive, non-emission cluster galaxies.

We adopt parametric models to solve the Jeans equation for hydrostatic equilibrium and to break the degeneracy between the mass and velocity dispersion anisotropy profiles. Due to the limited number of spectra per cluster, we stack our sample in 5 bins of redshift, where each bin includes ~600 passive cluster members. We compute the evidence of each model and use Bayesian model averaging to combine statistics from different models.

We find that the mass profile in every bin is well fit by a NFW model. We compare the resulting masses and concentrations to theoretical expectations, and we examine the bias between the dynamical and SZE-inferred masses.

We find that the velocity anisotropy profiles of the cluster members are close to isotropic near the center and increasingly radial outside. Moreover, we find no evidence for redshift evolution.

Finally, we study the pseudo-phase-space density profile, gaining further insights into the dynamical processes underway in galaxy clusters.

Ami Choi
Institute for Astronomy, University of Edinburgh

Cosmology with the RCS Lensing Survey

I will highlight recent results from the RCS Lensing Survey (RCSLenS), an 800 square degree survey of multi-colour imaging 1-2 magnitudes deeper than SDSS. RCSLenS is a particularly powerful data set due to its spatial overlap with the BOSS and WiggleZ spectroscopic surveys in addition to Planck lensing and Sunyaev-Zeldovich maps. This synergy enables many interesting cross-correlation studies, including tests of gravity on cosmological scales and verification of photometric redshift distributions for cosmic shear tomography.

Joseph Clampitt
University of Pennsylvania

Lensing Measurements of Halo Ellipticity and Voids in SDSS

Lensing measurements of voids and the shapes of dark matter halos can provide tests of gravity theories and possible dark matter interactions. We measure weak lensing mass profiles of voids identified from a volume-limited sample of SDSS Luminous Red Galaxies (LRGs). We perform a stacked shear measurement on voids with radii between 15-55 Mpc/h. We measure the characteristic radial shear signal of voids with a signal-to-noise of 7 and find a best-fit central underdensity of delta ~ -0.5.

We measure the quadrupole weak lensing signal from the elliptical halos of LRGs and redMaPPer clusters in SDSS. We use new estimators that null the spherical halo lensing signal, isolating the shear due to anisotropy in the dark matter distribution. One estimator is insensitive to an important systematic, a spurious alignment of lens and source ellipticities, allowing us to make robust measurements of halo ellipticity. We obtain best-fit projected axis ratios of ~0.8 for both LRGs and clusters. We rule out the hypothesis of no ellipticity at the ~ 4-sigma confidence level for LRGs, and at the ~5-sigma level for clusters. We estimate the misalignment of mass and light assuming the halos are CDM-like, and also explore the alignments of disk vs elliptical galaxies.

Hamish Clark
The University of Sydney

The Dark Matter Interpretation of the Gamma-Ray Excess at the Galactic Centre

An excess of gamma rays has been observed at the centre of the Galaxy. While dark matter annihilation within the Milky Way's halo has been shown to provide a good fit to the observed excess, evidence has recently arisen to suggest that the excess is emitted by a large number of point sources, such as millisecond pulsars. In this talk I present recent results that investigate gamma rays arising from annihilation within small-scale dark matter substructure, as a compromise between these two seemingly contradictory interpretations.

Andrej Dvornik
Leiden Observatory

Detecting Assembly Bias Using Galaxy-Galaxy Lensing with the KiDS and GAMA Survey.

We investigate the signatures of galaxy halo assembly bias for spectroscopically selected galaxies from the GAMA survey using weak lensing measurements performed with the spatially overlapping regions (240 square degrees) of the deeper, high imaging quality photometric KiDS survey. We interpret the measured signal armed with a highly flexible halo model. Selecting central galaxies in rich GAMA groups (with richness between 5 and 20), we identify samples with comparable mean host halo masses but with significantly different halo properties, such as the radial distribution of satellite galaxies and the average colour of the satellite population. As those are proxies for the formation time of the haloes, we interpret those differences as imprints of assembly bias. To guide our interpretation, we show preliminary comparisons with mock group catalogues and with the predictions from the state-of-the-art hydro-cosmological simulation EAGLE. Our measurements refer to galaxy groups with typical masses of 10^13 Msun/h, naturally complementing the study of Miyatake et al.[1], who reported the first direct detection of assembly bias on galaxy cluster scales (masses ~ 2*10^14 Msun/h). As in their case, our findings undermine the main ansatz behind the standard halo model paradigm, thus reinforcing the message that in the era of precision cosmology assembly bias effects must be included in the modelling of the gravitational lensing signal from galaxies.

[1] Phys. Rev. Lett. 116, 041301 (2016)

Josh Frieman
Fermilab Center for Particle Astrophysics

Title

Mike Hudson
University of Waterloo Canada

Cosmology from the Comparison of Large-Scale Structure and Peculiar Velocities in the Nearby Universe

Peculiar velocities are the only probe of the mass distribution on very large scales in the low redshift Universe, where dark energy dominates. I will review recent results on bulk flows and the determination of cosmological parameters from the peculiar velocities, primarily from classical or direct measurements (as opposed to redshift-space distortions). Specifically, maps of the mass density field can be used to predict peculiar velocities point-by-point. The comparison of these predictions to peculiar velocity data can be used to determine the cosmological parameter combination $f(\Omega m)\sigma 8$, and to infer the contributions to the flow on very large scales. I will focus on recent results from the 2M++ reconstruction of large-scale structure.

Dragan Huterer
University of Michigan

Banana Split: Geometry Versus Growth and the Role of LSS

One very effective way to sharply test and try to "break" the currently dominant LCDM paradigm is to isolate and separately constrain the growth of structure in cosmological measurements and compare to constraints from the purely geometrical measures. Key to the success of these geometry-growth split efforts -- as well as many other cosmological tests with large-scale structure -- is exquisite control of the calibration errors, and I will describe a general formalism to account for these pervasive systematics.

Nikolas Iwanus
The University of Sydney

Dark Matter Annihilation in N-Body Simulations

The 'standard model' for the evolution of the universe is the Lambda cold dark matter (Λ-CDM) model. It's wide spread acceptance is due to its simplicity and agreement with a whole host of different astronomical observations. However much is still unknown about the Dark sector (Dark matter and Dark energy) and while Λ-CDM successfully predicts the large scale properties of the universe very well, there are some discrepancies on the smaller scale such as a larger than expected number of dwarf galaxies orbiting around their parent galaxies and an overabundance of dark matter in the cores of galaxies.

For these reasons, Cosmologists consider adding extensions to Λ-CDM. Many extensions to the Standard Model of particles physics, predict the existence of weakly interacting massive particles (WIMPs) which are promising dark matter candidates. However direct detection experiments have so far not yielded any detections considered strong enough to build a consensus.

I will present simulations of dark matter halos produced by a modified version of cosmological n-body code Gadget2, containing new physics wherein dark matter can undergo WIMP like self-annihilation into more familiar forms of matter (baryons) and radiation. The energies of these interactions will feeds into the surrounding gas affecting the matter distribution and growth of galaxies. In this way we extract indirect clues into the dark sector.

Tesla Jeltema
University of California, Santa Cruz

Clusters of Galaxies in the Dark Energy Survey

The growth rate of clusters of galaxies is highly sensitive to the underlying cosmology. In fact, clusters will provide one of the most precise methods of constraining dark energy with large-area optical surveys like the Dark Energy Survey (DES). However, extracting precision cosmology from cluster surveys necessarily depends on having a well-understood method of selecting clusters and accurately translating their observed properties to underlying mass. I will discuss the status of the DES cluster survey as well as efforts to calibrate the cluster richness-mass relation.

Austin Joyce
Kavli Institute for Cosmological Physics

Exploring Beyond the Standard Cosmological Model

We have a remarkably successful phenomenological model of the Universe on the largest scales. However, this model—Lambda CDM—possesses naturalness problems similar to those of the Standard Model Higgs. Similar to the situation in particle physics, this naturalness problem motivates searching for physics “beyond the standard model of cosmology.” In particular, this puzzle has catalyzed a reconsideration of gravitational physics in the infrared. I will discuss some of these approaches to new physics in the gravitational sector, highlighting difficulties and promising features.

Young-Lo Kim
Yonsei University

The Dependence of Type Ia Supernova Luminosity on Star Formation Rate of Host Galaxies from a Sample without the Local-Global Environmental Bias

Recent studies suggest that the difference between global and local properties of galaxies (the local-global environmental (LoG) bias) might be important in the Type Ia supernova (SN Ia) host galaxy studies. Obtaining local spectroscopic properties of hosts at high redshift, however, is challenging. Here we will introduce a more efficient way to conduct this study by only using photometric data. We find that when we restrict a sample to the hosts whose stellar mass is less than 10^10 M⨀, a sample without LoG bias is efficiently selected. From the sample without LoG bias, we confirm that SNe Ia in locally star-forming environment are 0.103 ± 0.010 mag and 0.085 ± 0.012 mag fainter than those in locally passive region, for MLCS2k2 and SALT2, respectively. Because of ~6 times larger sample that covers much wider redshift range, our results are far more significant statistically, 10.3σ for MLCS2k2 and 7.1σ for SALT2, than previous results. Considering the significant difference in the

mean population age between these morphological types, this result would imply a possible look-back time evolution of SNe Ia luminosity.

Kyler Kuehn
Australian Astronomical Observatory

Current and Future Instruments Enabling Progress in Cosmology

While much of the focus in current cosmology is on its theoretical underpinnings and/or the observations necessary to select from among competing theories, massive efforts in instrumentation are also underway that enable the current (and will enable) future progress in the field. I will describe two such instruments, and a sampling of their scientific aims:

First, the Dark Energy Camera (DECam), a 570 megapixel extremely red-sensitive instrument installed on the Blanco 4m telescope at Cerro Tololo Interamerican Observatory in Chile, is used for the Dark Energy Survey, which seeks to constrain the equation of state of dark energy with unprecedented precision using four independent cosmological probes: supernovae, weak lensing, large scale structure, and galaxy clusters. A wide variety of additional science is also facilitated by DECam, some of which also has an impact on our understanding of cosmology (e.g., the detection of numerous new Milky Way dwarf satellites is directly relevant for "near field cosmology" as well as galaxy formation more generally).

Second, TAIPAN, a massively-multiplexed fibre-fed spectrographic instrument soon to be installed on the UK Schmidt Telescope at Siding Spring Observatory, will be used to engage in the TAIPAN galaxy survey along with the FunnelWeb stellar survey. The Starbug fibre-positioner technology at the heart of TAIPAN repositions hundreds of optical fibre payloads in ~5 minutes, thereby allowing much faster reconfiguration of observing fields than conventional (i.e. serial) fibre-positioners, and opening an array of new observational possibilities. I will describe the current status of the TAIPAN instrument, highlighting the role that Starbugs will play in its success. I will briefly describe the cosmological science goals of the TAIPAN survey, and conclude with a look ahead to the MANIFEST facility, which will join the Starbugs technology with the unprecedented observing power of the Giant Magellan Telescope currently under construction in Chile.

Konrad Kuijken
Leiden Observatory

KiDS and Cosmology

The Kilo-Degree Survey (KiDS) is a 4-band imaging survey on the VLT Survey Telescope. Its main aim is to measure the large-scale distribution of matter through weak gravitational lensing and photometric redshift measurements. I will describe the current status of KiDS, highlight cosmology results obtained with the survey, and discuss synergies with other surveys such as GAMA, VIKING, 2dfLenS and WAVES.

Amandine Le Brun
CEA Saclay Service d\'Astrophysique

Simulating the Evolution of the Most Massive Galaxy Clusters since Redshift 1

The evolution of the dark matter profiles of high-mass galaxy clusters from z~1 to the present day remains poorly constrained and is a powerful test of the LambdaCDM model. Such a test requires systematic confrontations of observations of a representative sample of the Universe's most massive clusters, preferably in several redshift bins, with tailor-made numerical simulations. To date, there exist no cosmological numerical simulations with the exceptionally large volume (required to simulate the rarest, most massive clusters) and the resolution (required to resolve their structure) necessary to undertake such a project. We will present the first results from a simulation campaign aimed at producing large cosmological simulations that are 1 Gpc/h on a side and have a medium mass and spatial resolution. They are being complemented with very-high resolution zoom simulations which are progressively including the non-gravitational physics of galaxy formation such as star formation, supernova and AGN feedback. The simulations are produced using the AMR code RAMSES.

Jounghun Lee
Seoul National University

The Constant Growth Rate of the Bound-Zone Peculiar Velocity Profile

We present a numerical evidence that the amplitude and slope of the bound-zone peculiar velocity profile grow at the constant rates in a LambdaCDM universe. Analysing the friends-of-friends halo catalogues from the Millennium-II simulations at various redshifts, we measure the average peculiar velocity profile of the objects located in the bound zone around massive group-size halos and compare it to an analytic formula characterized by the amplitude and slope parameters. It is shown that the amplitude and slope of the bound-zone peculiar velocity profile remain constant in the dark matter dominated epoch but begin to grow linearly with redshift after the onset of the Lambda-domination. Our explanation for this phenomenon is that as the balance between the gravitational attraction of the massive groups and the repulsive force of the Hubble expansion cracks up in the Lambda-dominated epoch, the gravitational influence on the bound-zone halos diminishes more rapidly with the increment of the radial distances. Speculating that the constant growth rate of the amplitude and slope of the bound-zone peculiar velocity profile is a unique feature of a Lambda-dominated universe, we suggest that the redshift evolution of the amplitude and slope of the bound-zone peculiar velocity profile should be a powerful local discriminator of dark energy candidates.

Geraint Lewis
The University of Sydney

Cold vs Warm: Gravitational Lensing as a Probe of Dark Matter

Gravitational lensing is a powerful probe of the distribution of dark matter. Here I present a recent analysis of the strong and weak gravitational lensing signatures for cold and warm dark matter clusters, finding subtle differences between the two, and revealing the mass distribution of warm

dark matter to be at odds with simple expectations. These results offer a potential observational avenue to distinguish the two models of dark matter.

Chris Lidman
Australian Astronomical Observatory

OzDES Reaches the Half Way Mark

In collaboration with the Dark Energy Survey, OzDES is using the AAT to derive what will be the tightest constraints yet on the dark energy equation-of-state parameter. While probing dark energy is the prime aim of the survey, the observing strategy enables us to conduct a number of other investigations, such as the mapping the growth rate of black holes from 12 billion years ago to the present day. OzDES is now halfway through its allocation of 100 AAT nights. In this talk I will describe the OzDES project, its scientific aims, and present some preliminary results.

Ed Macaulay
University of Queensland

Measuring Sigma 8 with Supernovae

Supernovae are one of the key observable probes in establishing the dark energy dominated model of the accelerating universe. Beyond measuring the equation of state of dark energy to increasing precision, in order to understand the dark universe we must also measure the growth rate of cosmological density fluctuations. In this talk, I'll focus on constraining density fluctuations with supernovae, by modelling the effects of peculiar velocities and lensing magnification on moments of the magnitude residuals. I'll present current limits on sigma eight from the JLA supernova catalogue, and also present forecasts for the Dark Energy Survey supernova program.

Hayley Macpherson
Monash University

Formation of Structures in the Universe: A Full General Relativistic Treatment

The underlying assumptions of modern cosmology are homogeneity and isotropy of the universe. Under these assumptions we require the existence of dark energy, a mysterious negative pressure forcing the expansion of the universe to accelerate at late times. While these assumptions are valid on large scales, small scale inhomogeneities and anisotropies can have significant general relativistic effects on observations. In order to quantify these effects we need to move towards a fully general relativistic treatment of cosmological simulations. We test Cactus, an open source code used for numerical relativity, on general relativistic perturbation theory and the growth of linear structures. This is the first essential step in moving towards a fully realistic cosmological model of our universe.

Anais Möller
Australian National University

Photometric Classification of Type Ia Supernovae in SNLS with Supervised Learning

In the era of large surveys, photometric classification of supernovae (SNe) has become an important research field due to limited spectroscopic resources for candidate follow-up and classification. In this work, we present a new photometric classification of type Ia supernovae using redshifts obtained directly from SN light-curves and machine learning techniques. This method is implemented on real data from the SNLS deferred pipeline, a purely photometric pipeline that contains SNe Ia at high-redshifts ($0.2 < z < 1.1$).

Our method consists of two stages: feature extraction (obtaining SN redshift and other features from a general light-curve fitter) and machine learning classification. We study the performance of different algorithms such as Random Forest and Boosted Decision Trees. We evaluate the performance using SNe simulations and data from SNLS 3-year processing which contains large spectroscopically and photometrically selected type Ia samples. With our methods, we are able to classify a large type Ia sample with estimated contamination below 5%. This work demonstrates the feasibility of applying a machine learning classification to real high-z SN data and explores differences between real and synthetic SN classification.

Jessica Muir
University of Michigan

Integrated Sachs-Wolfe Map Reconstruction with Galaxy Surveys

The Integrated Sachs-Wolfe (ISW) effect is a large-angle modulation of the cosmic microwave background (CMB), generated when CMB photons traverse evolving potential wells associated with large scale structure (LSS). Recent efforts have been made to reconstruct maps of the ISW signal using information from galaxy distributions and other LSS tracers, but investigation into how survey systematics affect their reliability has so far been limited. Using simulated ISW and LSS maps, we study the impact of galaxy survey properties and systematic errors on the accuracy of reconstructed ISW signal. We find that systematics associated with modelling the distribution of galaxies along the line of sight have a relatively minor impact on reconstruction quality, but that direction-dependent calibration errors can be very harmful. Specifically, we find that in order to avoid significant de-gradation of our reconstruction quality statistics, direction-dependent number density fluctuations due to systematics must be controlled so that their variance is smaller than $1e{-6}$ (which corresponds to a 0.1% calibration). Additionally, we explore the implications of our results for attempts to use reconstructed ISW maps to comment on the origins of large-angle CMB alignments. Analysing our simulations, we find that there is only a weak correlation between the true and reconstructed angular momentum dispersion, which quantifies alignment, even for reconstructed ISW maps which are fairly accurate overall.

Steven Murray
ICRAR, Curtin

A Simple Halo Mass Function Distribution

One of the most fundamental properties of a dark-matter-dominated Universe is the distribution of the masses of its virialised nodes, namely dark matter halos. This distribution, known as the Halo Mass Function (HMF), has been used both directly to constrain cosmological parameters via group/cluster abundance studies, and as an ingredient in more involved analyses of cosmic structure, such as the halo model.

The standard procedure for producing theoretical mass functions is to use quasi-analytic fits based on the Press-Schechter formalism. We identify several key weaknesses of this approach, especially in the context of realistic group catalogues and associated mass uncertainties. We propose an alternate analytical distribution, called the MRP, which is numerically efficient, and allows the incorporation of arbitrary per-object uncertainties into the analysis. We find that using novel hierarchical Bayesian modelling can accurately reproduce the intrinsic HMF even when individual mass errors visually render the observed distribution as a featureless log-normal.

We envision that using the MRP in conjunction with hierarchical Bayesian modelling will improve cosmological constraints from future group catalogues such as those from the GAMA survey, as well as providing a simple and consistent framework for interpreting and disseminating such results.

Andrina Nicola
ETH Zuerich

A Joint Analysis of the CMB, Galaxy Clustering and Weak Lensing

Current and future cosmological surveys are becoming both wide and deep and different surveys are starting to overlap in redshift as well as in sky coverage. In order to place tighter constraints on our cosmological model and investigate the nature of the dark sector, we need to investigate novel methods for extracting information from these surveys. Since different cosmological probes are correlated with one another, integrated analyses present an interesting possibility. These types of analyses allow us to not only exploit each cosmological probe separately but also the information contained in the cross correlation between cosmological probes. In this talk, I will present a first attempt of a joint analysis of data coming from the CMB, galaxy clustering and weak lensing. I will focus on the methodology as well as the results and discuss the applicability of such analyses to upcoming cosmological surveys.

David Parkinson
University of Queensland

Cosmology from the EMU survey

The large area and number of galaxies that will be surveyed by the Evolutionary Map of the Universe (EMU) survey will provide a new and powerful dataset for doing cosmological tests of fundamental physics. We plan to measure the angular power spectrum of EMU galaxies, the Integrated Sachs-Wolfe Effect (by cross-correlating EMU with the cosmic microwave background) and cosmic magnification (by cross-correlating EMU with low-redshift optical surveys). These data products can in turn be used to constrain the mysterious dark energy, which is driving the late-time acceleration of the Universe, test alternative theories of gravity, and probe the details of the initial conditions of the Big Bang. I present current forecasts for the effectiveness of these cosmological probes, and progress with our data analysis pipeline.

Christian Reichardt
University of Melbourne

New Measurements of CMB Polarisation from SPTpol

The South Pole Telescope (SPT) is a 10-meter telescope designed to survey the millimetre-wave sky, taking advantage of the exceptional observing conditions at the Amundsen-Scott South Pole Station. The telescope and its ground-breaking 960-element bolometric camera finished surveying 2500 square degrees at 95. 150, and 220 GHz in November 2011. We have discovered hundreds of galaxy clusters in the SPT-SZ survey through the Sunyaev-Zel'dovich (SZ) effect. The formation of galaxy clusters – the largest bound objects in the universe – is highly sensitive to dark energy and the history of structure formation. I will discuss the recent cosmological constraints from the full SPT-SZ galaxy cluster sample as well as future prospects with the soon to-be-installed SPT-3G camera.

Alessandro Rettura

Caltech/IPAC

Mass-Richness Relations for Xray- and SZE-selected clusters at $0.4 < z <2$

We study the Mass-Richness relation of 116 spectroscopically confirmed massive clusters at $0.4 < z < 2$. We homogenously measure IRAC [4.5] um galaxy richness for our cluster sample within a fixed aperture of 2 arcmin radius. We have two subsamples, based on a) literature X-ray masses or b) literature Sunyaev-Zeldovich Effect masses. We find the associated errors in mass at fixed richness to be 0.2 dex for both subsamples, and the scatter to be independent of cluster redshift. We study the dependence of these relations with central galaxy concentration. We find that at fixed aperture radius the scatter increases for clusters with higher central concentration. We study the dependence of our richness estimates with IRAC depth and find that reaching an image depth of at least [4.5] = 21.5 AB is sufficient to derive robust mass estimates, which can be attained with just 90s exposure. As Spitzer continues it’s Warm Mission, these results make robust richness-based cluster mass estimates available for large samples at a very low observational cost, playing a crucial synergic role to the upcoming Euclid and WFIRST large scale surveys.

Graziano Rossi
Sejong University

Neutrino and Dark Radiation Bounds from the Latest Cosmological Probes

Pinpointing the total neutrino mass and the number of effective neutrino species are among the greatest challenges in science today, at the cross-road between particle physics, astrophysics, and cosmology. I will present a novel method based on a combination of analytic techniques and state-of-the-art hydrodynamical simulations, which allows one to obtain competitive constraints on the number of effective neutrino species and the sum of neutrino masses from cosmology - in synergy with data from the SDSS and additional CMB probes. I will also discuss the complementarity with particle physics experiments, along with possible interdisciplinary efforts.

Alex Saro
LMU

Optically Selected Object from DES Science Verification Data and their SPT-SZE Signature

We present results on the South Pole Telescope (SPT) Sunyaev-Zeldovich Effect (SZE) signatures of redMaPPer (RM) clusters extracted from ~130deg^2 of Dark Energy Survey science verification data (DES-SV) based on Saro et al. (2015) and Saro et al.(2016, in preparation). First, we cross-match SPT-selected galaxy cluster candidates with RM optically identified clusters, identifying 25 clusters between $0.1<z<0.8$ in the union of the SPT and RM samples. From the union sample, we then calibrate the associated RM richness λ-mass relation. We also model the optical-SZE cluster positional offset distribution with the sum of two Gaussians, showing that it is consistent with a dominant, centrally peaked population and a sub-dominant population characterized by larger offsets. Secondly, we test the consistency of the above model, calibrated starting from the SPT-selected sample, by studying the SZE signature associated to 719 RM-optically selected clusters in the DES-SV footprint. We detect the stacked SZE observables associated with RM-selected clusters down to $\lambda\sim20$. We show that at low λ all the tested models over-predict the SZE signal associated with the RM sample, while for the richest clusters, the SPT-derived SZE observables are consistent with the adopted model, a result consistent with previous works obtained using Planck and ACT data in combination with SDSS catalogs. We study the required bias corrections needed to account for the difference between the derived observables and the model by splitting our sample in richness bins and find that the measurements can be explained by a richness-dependent bias. We discuss possible biases, including SZE signal contamination or RM catalog contamination that would be more severe for lower mass clusters.

Daniel Scolnic
KICP at University of Chicago

Recent Measurements of W and H0

I will present new analysis of the Pan-STARRS spectroscopic Type Ia Supernova sample to measure dark energy as well as measurements by the SHOES team of the current rate of expansion (H0) of the universe from HST observations of Cepheid variables in host galaxies of Type Ia Supernovae. These measurements are significant improvement from past measurements, and reduces many systematic uncertainties in past analyses. I will discuss the tension of local measurements of H0 with measurements of H0 from the CMB and the impact of new constraints on dark energy.

Douglas Scott
University of British Columbia

Microwave Background Constraints

Tracey Slatyer
MIT School of Science

Mathew Smith
University of Southampton

The Dark Energy Survey Supernova Program: The First Three Years

The Dark Energy Survey (DES) supernova program has completed the first 3 of its 5 years of observations. This multi-colour, cadenced search for high redshift supernova has already discovered over 1500 likely type Ia supernova (SNIa) candidates, with over 200 spectroscopically confirmed SNe Ia out to z~0.9. The ancillary data available to DES provides a unique opportunity to study and improve the standardization of SNIa. With NIR light-curves, high S/N spectroscopy and deep stacks providing photometric redshifts and detailed environmental information for every transient, the DES dataset will be unrivalled for studying the diversity and evolution of SNIa through cosmic time. I will present highlights from these projects and the survey to date: complete from superluminous SNe at z>1 through to the first DES Hubble diagram.

Lister Staveley-Smith
ICRAR/UWA

Cosmic Flows: 2MTF and Future Surveys

The 2MASS Tully-Fisher (2MTF) survey is a new, homogeneous survey of peculiar velocities of spiral galaxies in the local Universe. Observations with the Parkes, GBT and Arecibo telescopes (ALFALFA) are complete, and new studies have been made of the local bulk flow (Hong et al. 2014) and the peculiar velocity field (Springob et al. 2016). I will report on initial findings from 2MTF, including preliminary measurements of the growth rate of structure from the combination of the 2MTF and 6dFGSv surveys. The full combination of next-generation surveys, WALLABY and TAIPAN has the potential to more accurately measure the growth of structure at z=0, and place tight limits on possible extensions to General Relativity.

Rita Tojeiro
University of St Andrews

Review of Large Scale Structure as a Cosmological Probe

Over the last 30 years we have spent massive amounts of human effort and money on mapping out the large-scale structure of the Universe - and the progress has been astonishing. With a particular focus on baryonic acoustic oscillations, I will review the motivation behind this effort, our achievements thus far, and take a good look into what the future will bring.

Erik Tollerud
Space Telescope Science Institute

Local Dwarfs in HI, the Optical, and Simulations

I will describe work comparing the results of the local blind HI survey GALFA-HI and simulations of the Local Group. These reveal a clear disagreement between the simulations and observations, separate and distinct from the optical "missing satellites problem". This suggests either reionization has a strong influence on the gas content of dwarf galaxies, even far from bright L* galaxies, or a conflict between the LCDM cosmology and observations.

Brad Tucker
Mt. Stromlo Observatory, the Australian National University

6-Year Results from ESSENCE

The Equation of State: SupErNovae trace Cosmic Expansion' (ESSENCE) discovered 228 Type Ia Supernovae (SN Ia) between $0.2 < z < 0.8$, to characterize the dark energy equation-of-state, w. However, the influences of the host galaxies on SN Ia distances and the photometric calibrations of the survey, the measurements are only accurate to ~10%. To solve some of these issues, we developed a new method for determining the spectral energy distribution and rest-frame magnitudes of the host galaxies from the ultraviolet (UV) to the infrared and use empirical relations to derive stellar mass and star-formation rate (SFR) measurements of the host galaxies. We find a 4 sigma correlation of the rest-frame FUV-V host-galaxy colour and SN distances. We also find that SN Ia at > 3 effective radius of the host galaxy occur in low-extinction environments, subsequently producing a uniform sample of SN Ia which can be used to measure cosmological parameters with lower systematic errors. SN Ia at these distances have noticeable offsets in SN colour and Hubble residual from the entire sample, suggesting an improper treatment of SN Ia colour and dust, both of which have the potential to bias SN Ia cosmological measurements

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Syed Uddin
Purple Mountain Observatory, Chinese Academy of Sciences

Host Galaxy Effects in Supernova Cosmology

The properties of Type Ia Supernovae (SNe Ia) is found to be correlated with their host galaxies. Whether these correlations bias cosmological results, is a question to answer. I will present a detail study from a compilation of ~1300 SNe Ia on this topic.

Massimo Viola
Leiden University

The Kilo Degree Survey: Cosmic Shear Results from 450 Square Degree

The Kilo Degree Survey (KiDS) is an ongoing ESO survey aiming at studying the growth of structures and the expansion history of the Universe using weak gravitational lensing. I will present in this talk the first constraints on cosmological parameters from a tomographic cosmic shear analysis of 450 square degree. I will discuss how uncertainties in the photometric redshift distribution are accounted for in the analysis as well as uncertainties in the shear estimation. Furthermore I will show how we model astrophysical effects such as intrinsic galaxy alignment and AGN feedbacks in order to derive unbiased cosmological parameters. Finally I will discuss the level of agreement of our measurements with other cosmological probes and in particular with the Planck results.

Branislav Vlahovic

North Carolina Central University

Uniformity of Cosmic Microwave Background as a Non-Inflationary Geometrical Effect

The conventional ΛCDM cosmological model supplemented by the inflation concept describes the Universe very well. However, there are still a few concerns: new Planck data impose constraints on the shape of the inflation potential, which excludes a lot of inflationary models; dark matter is not detected directly, and dark energy is not understood theoretically on a satisfactory level.

We will argue that the observed uniformity in the CMB does not mean that space was uniform at the time of decoupling. We propose a cosmological model that allows for a different interpretation of the CMB data and for inhomogeneity of the Universe at the early stage. A large scale homogeneity and isotropy is not required by classical GR theory. It is well known that in the BB models homogeneity of space cannot be explained, it is simply assumed in initial conditions.

We will demonstrate explicitly that in the framework of the ΛCDM model supplemented in the spherical space with an additional perfect fluid (namely, quintessence with the constant parameter $w = -1/3$ in the linear equation of state) there is an elegant solution [1] of the horizon problem without inflation: under the proper choice of the parameters light travels between the antipodal points during the age of the Universe. Consequently, one may suppose that the observed CMB radiation originates from a very limited space region, which explains its uniformity. In our positive curvature closed Universe model, the CMB is always coming from a very small vicinity of the antipodal point. Therefore, measuring the same CMB by looking in the opposite directions of the Universe does not represent or reflect the uniformity of the Universe at the time of decoupling, because we always measure CMB originating from approximately the same antipodal point regardless of the direction of observation. For that reason, we always must obtain the same result. Small variations for the CMB are possible and observed, but these variations are the result of measuring CMB from a small region and not exactly from a single point, and because of the interaction between matter and light during its travel. For instance, depending on the direction we choose to measure the CMB, light will travel through different galaxies and will interact with different amounts of matter, which will result in small observed variations of the CMB at large angular scales (as the photons pass through large scale structures) by the integrated Sachs — Wolfe effect. Then there seems no need for various inflation scenarios. This removes any constraints on the uniformity of the universe at the early stage and opens a possibility that the universe was not uniform and that creation of galaxies and large structures is due to the inhomogeneities that originated in the BB.

In addition, in the constructed model the gravitational potential of any single mass is convergent at any point except for the point of its location, and agreement with the supernovae data is reached at the same level of accuracy as within the ΛCDM model. There are certain serious difficulties when one tries to adjust the proposed concept to the CMB anisotropy arriving at the necessity to change the amplitude of the initial power spectrum. However, the changes that should be done are well inside experimentally allowed constrains.

[1] B. Vlahovic, M. Eingorn, C. Ilie, Modern Physics Letters A, Vol. 30, No. 35 (2015) 1530026.

Andrew Watts
The University of Sydney

Topological Properties of the Dark Matter Distribution in Alternative Cosmologies

We compare the topological properties of the dark matter distribution in a number of cosmological models using hydrodynamical simulations and the cosmological genus statistic. Genus curves are computed from z=11 to z=0 for Lambda-CDM, Quintessence and Warm Dark Matter models, over a scale range of 1 to 20 h^-1 Mpc. The curves are analysed in terms of their Hermite spectra to describe the power contained in non-Gaussian deformations to the cosmological density field. We find that the LCDM and WDM models produce nearly identical genus curves indicating no topological differences in structure formation. The quintessence model, which differs solely in its expansion history, produces differences in the strength and redshift evolution of non-Gaussian modes associated with weakly non-linear gravitational evolution. We also use the genus curves to track a highly scale-dependent feature in the high-order modes we identify with void formation. We again find a different scale and redshift dependence for the quintessence model.

Andrew Wetzel
Caltech & Carnegie Observatories

Reconciling Dwarf Galaxies with LCDM Cosmology

Low-mass "dwarf" galaxies trace structure formation on the smallest cosmological scales and represent the most significant challenges to the cold dark matter (CDM) model. Because these faintest galaxies are (best) observed only within the Local Group of the Milky Way (MW) and Andromeda (M31), it is critical to understand and model their formation within the environment of a MW-mass host. I will introduce the Latte Project, a new suite of cosmological zoom-in baryonic

simulations that model the formation of Milky Way-mass galaxies at parsec-scale resolution, using the FIRE (Feedback in Realistic Environments) model for star formation and stellar feedback. These simulations self-consistently resolve the satellite dwarf galaxy populations that forms around the Milky Way-mass hosts, including the relevant physics to model their stellar populations. I will present first results from Latte, emphasizing the impacts of (internal) stellar feedback and (external) environment on the stellar masses, stellar kinematics, star formation histories, and chemical enrichment of dwarf galaxies. In particular, I will emphasize the impact of stellar feedback and environment on dark-matter subhalos and their connection to dwarf galaxies, demonstrating progress in addressing the long-standing "missing satellites", "too-big-to-fail", and "core-cusp" problems of CDM cosmology.

Martin White
University of Adelaide

The Global and Modular BSM Inference Tool

I will present a new tool (GAMBIT) for performing global statistical fits of beyond-Standard Model particle physics theories and/or astrophysical models. The tool provides the best current way of investigating WIMP models based on particle physics and astrophysics data, but could also be used for purely astrophysical or cosmological applications. I will present first physics results from the tool, and will also present work related to the growing Australian involvement in the Cherenkov Telescope Array experiment.

Hans Arnold Winther
University of Oxford

Simulations of Structure Formation in Gravity Theories beyond General Relativity

I will review the current status of numerical simulations of cosmological structure formation in gravity theories beyond General Relativity: what kinds of theories can we do, how do we perform such simulations, what are the main challenges and what can such simulations be used for. I will also briefly report results from a recent code comparison project of N-body codes that simulate non-standard gravity theories.

Laura Wolz
University of Melbourne

Going Beyond Cosmology: Hydrogen Measurements Using Intensity Mapping Cross-Correlations

Intensity mapping surveys of neutral hydrogen (HI) are a novel way to measure the large scale matter distribution of our Universe and thus constrain parameters describing the Universal expansion. The next generation of radio telescopes and interferometers are being designed and built to optimise the detection of the HI line at low spatial resolution allowing efficient mapping of large volumes. The impact of instrumental systematics of radio observations on cosmological measurements can be significantly reduced by cross-correlating the HI signal with galaxy surveys. We demonstrated with simulations, that the cross-correlation coefficient of HI maps and optical galaxies is scale-dependent and reveals the relation between the HI and the optical selection. Specifically this implies that the shape and amplitude of the cross-correlation coefficient indicates the HI mass of the optically-selected galaxies. This is a revolutionary way to measure the Hydrogen content of galaxies at high redshifts which is impossible to detect with existing radio telescopes. This probe can maximise the outcome of existing and future galaxy surveys beyond standard cosmological tests. In my talk, I will present our realistic simulation for the expected cross-correlation signature from semi-analytic models and noise estimates from radio observations such as the Green Bank telescope (GBT). We use this simulation to improve the cosmological interpretation of the cross-correlation of GBT intensity maps in combination with the WiggleZ Dark Energy survey at medium redshift 0.8. Furthermore, I will demonstrate how our model allows the measurement of the HI masses of the optically-selected galaxies as well as testing different star formation recipes.

Bonnie Zhang
Australian National University

Constraining the Cosmic Distance Scale with Type Ia Supernovae

We review the present landscape of cosmology with Type Ia supernovae (SNe Ia) and outline new directions with a focus on two vital Australian-led projects: OzDES and SkyMapper. OzDES is the spectroscopic counterpart to the Dark Energy Survey, expected to secure ~3000 redshifts of SNe Ia host galaxies up to z~1.2. The SkyMapper Supernova Survey is a non-targeted all southern sky search at low redshift (z < 0.1).

Our efforts in combining these complementary samples builds on progress made over the past decade, with the present gold standard SN Ia sample and analysis, the Joint Lightcurve Analysis (JLA) of the Supernova Legacy Survey and SDSS SN Survey, constraining the dark energy equation-of-state w to ~5%. We also draw on lessons learned, particularly the importance of having a uniform, well sampled and precisely calibrated low redshift anchor, and the significant contribution of calibration uncertainties to the error budget. The challenges we face in reducing and estimating uncertainties include rigorous cross-calibration of these surveys, quantifying statistical contributions from the lightcurve fitting SALT2, and performing accurate corrections for peculiar motion at low redshift.

In this talk I will give an overview of current work in using SNe Ia to unify the cosmic distance scale, with a focus on these challenges. From measuring the present expansion rate and anchoring the SN Ia magnitude zero point using nearby supernovae, to tracing the universe's expansion history and the evolution of dark energy, precision and attention to detail are of the utmost importance.
