'Transients as Probes of Host Galaxy Environments (TransProbes)' Abstracts

Talks

Location, Location, Location: The Role of Local Environments in Cosmology with Type Ia Supernovae

Authors

Lisa Kelsey (1)

(1) Institute of Astronomy and Kavli Institute for Cosmology, University of Cambridge

Abstract

The precision of Type Ia Supernova (SN Ia) cosmology is becoming limited not by statistics but by incomplete understanding of their astrophysics, including the role of their environments. SNe Ia in high mass galaxies are systematically brighter than those in lower mass galaxies, for example, but the cause of this is still unclear. While global host galaxy properties are now commonly factored into cosmological analyses, it may be that local environments in the immediate stellar neighbourhood of the explosion provide a more informative picture. In this talk, I will discuss how characterising these local environments improves our ability to standardise SNe Ia and what this means for cosmological inference. Drawing on analyses of local star formation histories, stellar populations, and supernova siblings (groups of SNe Ia sharing a common host), I will show that a locally-informed view of SN Ia standardisation is more physically motivated. This will have direct implications for our understanding of the Hubble Tension, and how we approach the upcoming flood of data from next generation surveys.

Bridging gaps between fast radio burst signals and their host galaxies

Authors

Marcin Glowacki (1)

(1) University of Edinburgh

Abstract

Fast radio bursts (FRBs) are intense pulses of radio emission occurring on timescales of milliseconds with yet unknown progenitors. To help solve their mysterious origin, as well as better use FRBs as powerful tools for the study of cosmology and galaxy gas dynamics, effective localisation of FRBs to their host galaxies and follow-up observations are necessary. I present recent results from the Commensal Real-time ASKAP Fast Transients (CRAFT) survey, where with the Australian Square Kilometre Array Pathfinder (ASKAP) telescope several tens of FRBs have been localised and observed in optical and neutral hydrogen (HI) studies. In particular, I will present the first statistically significant sample of HI follow-up of FRBs, and correlation results for newly measured scattering timescales from the CRAFT survey with their host galaxy global properties. In the latter study, we find a strong positive correlation for the scattering time of the FRB with the stellar surface density or compactness, and also the stellar mass-weighted age and the gas-phase metallicity, potentially attributed to cooler and clumpier metal-rich gas in the interstellar medium increasing FRB scattering times. A strong correlation is also seen for the FRB absolute rotation measure and the inclination of the host galaxy (higher RMs for edge-on galaxies). I will also present results from recent work into the use of FRBs to probe the ionised medium surrounding galaxies through hydrodynamical galaxy simulations.

What drives a TDE? Insights from galaxy structure and evolution in IllustrisTNG

Authors

Charlotte Angus (1)

(1) Queen's University Belfast

Abstract

Tidal disruption events (TDEs), luminous flares which occur when a star wanders too close to a massive black hole, can in principle, arise within any galaxy that hosts a central massive black hole. However, observed TDE populations are strongly overrepresented in post-starburst and green-valley galaxies, suggesting that TDE rates are linked to specific phases of galaxy evolution, potentially connected to recent merger activity.

In this talk, I explore the physical drivers of this enhancement using the IllustrisTNG simulations. We construct forward models of local (z~0-0.2) TDE host populations to investigate how galaxy properties (including velocity dispersion, central concentration, recent star formation history, and merger history) affect the likelihood of producing a TDE. Combining these dependencies with realistic observational selection effects, we reproduce observed TDE host populations to identify the key drivers of TDE rate enhancement. Finally, I will examine how these evolutionary pathways and selection effects propagate into inferred black hole–galaxy scaling relations. As TDEs offer a promising probe of black holes at low masses, understanding these dependencies is crucial, as host-driven rate enhancements may systematically influence the slopes inferred from TDE-selected samples.

Old Universe, Young SNe Ia: A Statistical Analysis of Type Ia Supernova Progenitor Age from 6,983 TITAN Host Galaxies and Implications for Cosmology

Authors

Jack Tweddle (1)

(1) University of Oxford

Abstract

Correlations between standardized Type Ia supernova (SN~Ia) luminosities and host-galaxy properties highlight the importance of environment in shaping transient observables. A recent hypothesis links these trends to progenitor-age variations, predicting strong ($\sim$5-6~Gyr) evolution between low- and high-redshift populations and a potentially significant impact on cosmological inference.

In this talk, I will test this scenario using the host galaxies of TITAN DR1 - the largest low-redshift SN~Ia host sample to date (6,983 hosts; $0 \lesssim z \lesssim 0.15$). By combining host-galaxy star formation histories with empirical delay-time distributions, I derive new constraints on SN~Ia progenitor ages, where the star formation histories are inferred from UV-to-mid-IR spectral energy distribution fitting.

The TITAN sample is dominated by a young progenitor component associated with star-forming hosts (mean ~2.2~Gyr), with a smaller contribution from older, quiescent systems (mean ~6.0~Gyr), yielding an overall mean age of 3.5~Gyr. The observed age difference between environments implies a luminosity offset that is inconsistent with current data if a strong age dependence is assumed.

Instead, I find only ~1.4~Gyr of progenitor-age evolution over cosmic time. When combined with observed age--Hubble-residual relations, this corresponds to a redshift-dependent bias consistent with zero ($\Delta\mathrm{HR}=0.007_{-0.014}^{+0.012}$~mag). These results suggest that environmental dependencies of SN~Ia properties are already well captured by standard host-mass corrections, with no evidence for a large, unmodeled progenitor-age systematic.

More broadly, this work demonstrates how large, homogeneous transient samples like TITAN enable precise mapping between transient properties and galaxy environments—an essential step toward interpreting the next generation of time-domain surveys.

Dependence of Type Ia Supernova standardisation on distance from host galaxy centre in ZTF

Authors

Melzie Ghendrih (1)

(1) Lancaster University

Abstract

Type Ia Supernovae are luminous, abundant, and relatively uniform transient events, making them good distance indicators. Their peak magnitudes show a ~0.4 mag scatter. For cosmological use, their magnitudes are corrected for correlations with their light-curve shape, specifically for colour and decay rate.

After these corrections, SN Ia standardised magnitudes still depend on their environment: more massive, redder and more passive galaxies host brighter SNe Ia on average. Cosmological analyses now standardise SNe through a three-parameter correction, with the environmental correlation typically corrected by a step function. Although the origin of this relation is contentious, other SN Ia properties may provide clues to its underlying cause. Results from DES have revealed that the dependence of SN Ia magnitudes on their environment is reduced for SNe located further away from their host galaxy centres. These results provide insight into the origin of the environmental step, and suggest that outer SNe Ia could form a more homogeneous subsample. Understanding whether this is also true at low redshift could then reveal a more complex redshift dependence of environmental correlations, and could uncover unaccounted-for selection effects between surveys. Here, we investigate the dependence of the environmental step on distance in the nearby universe with SNe observed with ZTF. We also extend the analysis to the other parameters used to standardise SN Ia light-curve properties. Better understanding of these dependencies provides insights into the physical origin of SN Ia diversity.

Using gamma-ray bursts to probe the faint, distant galaxy population; consistency between metallicities measured using different techniques.

Authors

Anne Inkenhaag (1), Patricia Schady (1), Phil Wiseman (2), Robert Yates (3)

(1) University of Bath
(2) University of Southampton
(3) University of Hertfordshire

Abstract

Gamma-ray bursts (GRBs) are the most energetic explosions in the universe, often outshining their host galaxies. They have been discovered out to redshifts of ~9, revealing their host galaxies, which can go undetected in galaxy surveys due to their faintness and distance. We can therefore use GRBs to probe the faintest, most distant galaxies in the universe, and use their imprint on the GRB afterglow to measure their properties such as metallicity. Due to the connection between GRBs and massive stars, these measurements are used to expand the star forming galaxy population measured in emission to lower masses and metallicities.

However, in this process, two assumptions are made that are highly uncertain. Firstly, much remains uncertain about whether the GRB host galaxy sample follows the same fundamental relations as general star forming galaxies and therefore if these two populations are actually the same. And secondly, it is currently unknown whether the line of sight metallicities obtained through the afterglow spectra of GRBs are probing the same component of galaxies as the emission line metallicities of galaxy samples obtained through integrated spectra, and therefore if we can even use the metallicity obtained from the GRB afterglow to compare to emission spectra obtained metallicites.

In this talk I will tackle the second of these issues, by investigating the host galaxy of GRB050505 at z=4.28. For this galaxy, we detect the temperature sensitive [OIII]4363 auroral line, allowing for a measurement of the electron temperature based metallicity, a less model dependent measure than the strong line metallicity measurement, and compare this to the absorption metallicity obtained from the GRB afterglow. This allows, for the first time, to compare the electron temperature based metallicity and the absorption based metallicity of a GRB host and can give us insight into whether we can indeed use the emission and absorption metallicities interchangeably.

Posters

The progenitors and circumstellar environments of stripped-envelope interaction supernovae from BPASS

Authors

Ben Warwick (1)

(1) University of Warwick

Abstract

Stripped envelope interacting supernovae (SEISNe) are SN strongly interacting with dense, H-poor circumstellar material (CSM). They are an uncommon class of SNe that arise when a star has lost its outer hydrogen, and in the case of Icn helium, envelope and then upon explosion the SN's ejecta interacts with surrounding CSM. The nature of the progenitors of these SNe is still an open question, with implications on the final stages of stellar evolution. The first proposed progenitors were Wolf-Rayet stars that have lost their outer envelopes due to line driven wind at the end of their lives, with the resulting SN's ejecta catching up and interacting with the slower moving winds. However, over recent years more and more SEISNe have been found in environments with low star formation rates and metallicities, such as PS1-12sk and SN 2023tsz challenging the WR progenitor model. With the lack of observational constraints and progenitor detections on SEISNe we must turn to modelling to help uncover the systems, and the environments that lead to these explosive events. Using the Binary Population and Spectral Synthesis stellar evolution models, 30,153 stellar models that result in hydrogen-poor core-collapse supernovae (SN) includes both binary and single stars, spanning 13 metallicities ($Z = 10^{-5}$ to 0.04) were selected. CSM formation during their last 100 kyr is reconstructed from line-driven and Roche lobe overflow (RLOF) mass loss using three scenarios for the CSM, one looking at a wind only distribution for the CSM, and two involving the formation of a circum-binary disc (CBD). Light curve parameters from each scenario are calculated using an analytical model and fiducial SN explosion parameters. We find only the two CBD scenarios, and consequently no single star models, reproduce the luminosities and rise times of observed SEISNe. The inferred rates are comparable to observations. Expected progenitors were only found in models with ZAMS masses of 14--$40\,M_\odot$ at $\geq Z_\odot$ and 30--$40\,M_\odot$ at $< Z_\odot$. Modelling the radio emissions shows that early (≤ 8 days) and high frequency (≥ 70 GHz) observations are required to constrain the nature of CBDs in these systems. These results indicate that, without phenomena such as eruptive mass loss, SEISNe require massive stars in binary systems in order to produce sufficient masses of CSM and confine them close to the progenitor.

The hot, blue progenitors of stellar black-hole formation

Authors
Avishai Gilkis (1)

(1) University of Cambridge

Abstract
While the connection between massive stars and supernovae is well established observationally, the formation of stellar-mass black holes remains poorly constrained, with some massive stars theorised to collapse without a luminous transient. We investigate the observable properties of such “disappearing” stars by combining detailed single and binary stellar-evolution models with atmosphere calculations to produce synthetic photometry from the ultraviolet to the infrared. We find that black-hole progenitors occupy a distinct region of colour–magnitude space: they are predominantly hot, compact, and blue, with many in Wolf–Rayet phases and luminous at ultraviolet wavelengths, while only a minority are red supergiants. In contrast, core-collapse supernova progenitors span a broader range of colours and include a significant population of optically bright cool stars. This difference implies that current observational strategies, which are most sensitive to luminous red supergiants in optical bands, are likely to miss a substantial fraction of black-hole formation events. Our results provide a predictive framework for interpreting disappearing-star searches and highlight the importance of ultraviolet-sensitive monitoring of nearby galaxies. In the era of large transient surveys, identifying these missing events is essential for connecting massive-star evolution to the formation of compact remnants.

Effect of spatial resolution on parameters measured at transient environments

Authors
Berk Topcu (1)

(1) University of Bath

Abstract
Studying the environmental properties near a transient event is a powerful method for inferring the characteristics of progenitor stars. While this approach works well for high resolution observations (~100pc or less) where we are able to resolve individual star forming regions or stellar populations, beyond z > ~0.1 resolution drops to kpc scales. This drop in resolution makes it difficult to distinguish between multiple neighbouring stellar populations or to separate them from contamination by diffuse ionised gas (DIG) regions. Therefore, measurements at higher redshifts may lead to inaccurate conclusions about the local properties of a transient event. It is thus crucial to quantify how measurements obtained at lower spatial resolution deviate from the true local environmental values. In this study, we use IFU observations of nearby (z < 0.01) star-forming galaxies from the MUSE Atlas of Disks (MAD) survey to measure gas-phase metallicities and H-alpha EWs of HII regions at pc scale resolution. We then degrade the spatial resolution of these data to simulate observations at increasingly higher redshifts and repeat the measurements at each step. This approach allows us to observe how inferred environmental parameters evolve as a function of spatial resolution. Finally, we investigate whether the observed changes are due to intrinsic properties like galaxy metallicity gradients or indeed by contamination from neighbouring regions.

Exploring Photometric Subpopulations of Stripped-Envelope Supernovae with ZTF

Authors

Yogesh Wagh (1), Daniel Perley (1)

(1) Astrophysics Research Institute, LJMU

Abstract

Type Ib and Ic supernovae result from massive stars that have shed most or all of their hydrogen envelopes prior to explosion. While several mechanisms have been proposed, line-driven stellar winds, binary stripping, or common-envelope interactions, the relative contributions of these channels remain poorly constrained. We cannot yet determine from observations alone whether a given SN Ib/c progenitor was a binary-stripped star or a massive single star. Distinguishing between these channels has direct implications for our understanding of massive star evolution, binary population statistics, and the initial mass function.

We present an ongoing study of the SNe Ib/c population using uniformly selected light curves and spectra from the ZTF Bright Transient Survey. Prior work (Perley et al. 2020) revealed that in the timescale-luminosity parameter space, SNe Ib/c do not form an isolated cluster, a core population is accompanied by a tail toward higher luminosities and longer timescales, with a gap near 30 days and -19 absolute magnitude. We now have roughly four times the original sample, which we use to revisit and extend this analysis. Our work involves sample cleaning and light curve classification to improve completeness, followed by exploration of the photometric parameter space and model fitting to extract physical parameters such as ejecta mass. Where possible, we apply machine learning tools to identify and confirm distinct photometric subgroups. We aim to test whether these subgroups reflect distinct progenitor channels, binary versus single star.

We also plan to incorporate constraints from host galaxy properties and, in the longer term, leverage the increased sample size from Rubin/LSST to better resolve overlapping subpopulations such as SNe Ic-BL and SLSNe-I.