Contributed Abstracts

Midwest Workshop on Supernovae and Transients
Columbus, OH, 26-27 Septermber, 2019

Physics Research Building – 1080 (Smith Seminar Room)

Thursday 26 September, 2019

Session 1

Andre Sieverding (University of Minnesota)
Nucleosynthesis based on a 3D supernova simulation of an $11.8\,M_\odot$ progenitor model

We study the nucleosynthesis based on tracer particles from a self-consistent, three-dimensional simulation of a $11.8\,M_\odot$ stellar model. We find, that the innermost supernova ejecta contribute significant amounts of ^{45}Sc and ^{64}Zn. The production of heavier isotopes, however, remains highly uncertain within the current setup. The results from the tracer particles representative for the innermost $0.168\,M_\odot$ of ejecta is combined with a suitable explosion model in spherical symmetry for the outer layers to obtain the total yields. We study the production of the short-lived radioactive isotopes in the context of a supernova trigger for solar system formation. We find that ^{53}Mn and ^{60}Fe are over-produced with respect to the inferred ratios in the early solar system, while the yield of ^{10}Be is highly uncertain due to the $^{10}\mathrm{Be}(p,\alpha)^7\mathrm{Li}$ reaction and the neutrino emission spectra.

Michael A Pajkos (Michigan State University)
The Final Heartbeat from Core-collapse Supernovae: Gravitational Waves

The era of gravitational wave (GW) astronomy has begun. The LIGO/Virgo Collaboration is now routinely making detections of compact object mergers, and gravitational wave (GW) astronomers are poised to observe another potential GW transient: core collapse supernovae (CCSNe). GWs encode a vast amount of physical information, such as core rotational properties, protoneutron star activity, and even explosion characteristics; however, there is still much to learn about translating GW signals to the physics within a supernova. In this effort, theoretical modeling of GW signals for CCSNe is critical. In this talk, I will discuss work by our research group on making predictions for GW emission from high-fidelity simulations of CCSNe and our efforts to improve physical parameter estimation from a potential detection.

Matthias J. Raives (Ohio State University)
The Antesonic Condition: Understanding the Critical Explosion Criterion

In the model problem of steady spherically-symmetric pressure-less free-fall onto a standing shockwave around an accreting central mass, the "antesonic" condition limits the regime of stable accretion to $c_T^2/v_{\rm esc}^2 \leq 3/16$, where c_T is the isothermal sound speed in the subsonic post-shock flow, and $v_{\rm esc}$ is the escape velocity at the shock radius. Above this limit, it is impossible to simultaneously satisfy the time-steady Euler equation and the strong shock jump conditions, and the system undergoes a time-dependent transition to a thermal wind. This physics has been shown to explain the existence of a critical neutrino luminosity in steady-state models proto-neutron star accretion in the context of core-collapse supernovae. We extend the antesonic condition to flows with rotation and turbulence using a simple one-dimensional formalism that highlights the basic physics of the antesonic condition and its generalizations to more complicated flows. The analysis suggests a framework to better understand its applicability to 3D simulations.

Shiv K. Subedi (Ohio University)
Nuclear Reaction Rate Sensitivities of Ti-44 Synthesis in Core Collapse Supernovae Using MESA

Recent observational advances have enabled high resolution mapping of Ti-44 in core-collapse supernova (CCSN) remnants. Comparisons between observations and models provide stringent constraints on the CCSN mechanism. However, recent works with post-processing models have identified several uncertain nuclear reaction rates that influence Ti-44 and Ni-56 production in model calculations. We evolved one dimensional models of 15M, 18M, 22M and 25M stars from ZAMS through CCSN in MESA (Modules for Experiments in Stellar Astrophysics) and investigated the previously identified sensitivities of Ti-44 and Ni-56 production in CCSN to varied reaction rates for a variety of assumptions about the explosion energy and mass-cut. In my talk I will present our final results of the sensitivity study.

Dan Milisavljevic (Purdue University)
Probing Progenitors and Explosion Mechanisms of Core-collapse Supernovae With Late-time Observations

I will review how radio-through-X-ray investigations of supernovae at late times (years to centuries after explosion) are helping to reverse engineer solutions to key open questions in stellar evolution and core collapse explosion dynamics. Particular focus will be placed on recent work that is providing firm observational tests for state-of-the-art simulations attempting to predict and interpret the multi-messenger signals from the next Galactic supernova. I will also highlight how late-time observations made possible by Extremely Large Telescopes will facilitate transformational science opportunities and rapidly accelerate the community towards a complete understanding of supernova explosions.

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Session 2

Patrick Kelly (University of Minnesota)
The Multiply Imaged Supernova Refsdal

In 1964, Sjur Refsdal first considered the possibility that the light from a background supernova could traverse multiple paths around a strong gravitational lens towards us. He showed that the arrival times of the supernovas light would depend on the cosmic expansion rate, as well as the distribution of matter in the lens. I will discuss detailed analysis of the first such multiply imaged supernova, which exploded behind the MACS J1149.6+2223 galaxy cluster. We have used Hubble Space Telescope to measure the relative time delay of its fifth reappearance within $\sim 1.6\%$, and constructed a high-cadence light curve of the Supernova (SN) 1987A-like SN by combining photometry of the five observed images. I will also describe a microlensing analysis using a simulated SN 1987A-like SN photosphere. Finally, I will talk about a connection between the blue supergiant progenitor of SN Refsdal and a highly magnified individual star in the same host galaxy at redshift z=1.49.

Daniel Perrefort (University of Pittsburgh)
Photometric 91bg Classification with Lightcurve Morphology

The upcoming Large Synoptic Survey Telescope (LSST) is expected to observe hundreds of thousands of new SNe. With such a large number of observed targets, it will be impossible to provide spectroscopic classifications for more than a small percentage of new SNe. The ability to provide accurate, photometric classifications will thus be an increasingly important necessity in the coming years. One approach to this challenge is the development of machine learning classifiers designed to reproduce existing classification schemes. However, machine learning classifiers obscure the underlying physics that lead to a classification and are extremely sensitive to the quality and diversity of the initial training sample. We instead demonstrate an extension of the classification technique presented by Gonzalez-Gaitan et al. 2014 where 91bg-like SNe are identified based on their light-curve properties. This approach is not only transparent in how a classification is determined but simultaneously provides physically motivated values such as standardized peak luminosities. We discuss ongoing work to apply this classify technique to approximately 2,000 SNe Ia targets from the SDSS-II SN data release.

Deep Chatterjee (University of Wisconsin – Milwaukee)
Toward Rate Estimation for Transient Surveys

The past couple of decades have seen an emergence of transient detection facilities in various avenues of time-domain astronomy that have provided us with a rich data set of transients. The rates of these transients have implications in star formation, progenitor models, evolution channels, and cosmology measurements. The crucial component of any rate calculation is the detectability and spacetime volume sensitivity of a survey to a particular transient type as a function of many intrinsic and extrinsic parameters. Fully sampling that multidimensional parameter space is challenging. Instead, we present a scheme to assess the detectability of transients using supervised machine learning. The data product is a classifier that determines the detection likelihood of sources resulting from an image subtraction pipeline associated with time-domain survey telescopes, taking into consideration the intrinsic properties of the transients and the observing conditions. We apply our method to assess the spacetime volume sensitivity of type Ia supernovae (SNe Ia) in the intermediate Palomar Transient Factory (iPTF) and obtain the result, $\langle VT \rangle_{\mathrm{Ia}} = (2.93 \pm 0.21) \times 10^{-2}\,\mathrm{Gpc}^3\,\mathrm{yr}$. With rate estimates in the literature, this volume sensitivity gives a count of 6801160 SNe Ia detectable by iPTF, which is consistent with the archival data. With a view toward wider applicability of this technique we do a preliminary computation for long-duration type IIp supernovae (SNe IIp) and find $\langle VT \rangle_{\mathrm{IIp}} = (7.80 \pm 0.76) \times 10^{-4}\,\mathrm{Gpc}^3\,\mathrm{yr}$. This classifier can be used for computationally fast spacetime volume sensitivity calculation of any generic transient type using their light-curve properties. Hence, it can be used as a tool to facilitate calculation of transient rates in a range of time-domain surveys, given suitable training sets.

Timothée Grégoire (Penn State University)
The Astrophysical Multimessenger Observatory Network (AMON)

Presentation of the Astrophysical Multimessenger Observatory Network (AMON) which seeks to perform a real-time correlation analysis of the high-energy signals across all known astronomical messengers photons, neutrinos, cosmic rays, and gravitational waves. The results of these analyses are distributed as AMON alerts to the community. Several online analyses will be presented.

Robert Morgan (University of Wisconsin – Madison)
Recent Results from Multimessenger Follow-up Programs by the Dark Energy Survey

The Dark Energy Survey Collaboration has performed several multimessenger follow-ups using the using the Dark Energy Camera mounted on the 4 m Blanco Telescope at Cerro Tololo Inter-American Observatory in Chile. I report on recent searches for explosive optical counterparts to TeV-PeV neutrino alerts from the IceCube Collaboration and to gravitational wave alerts from the LIGO and Virgo Collaborations. For neutrino alerts, we search for core-collapse supernovae as potential progenitors. Using extensively validated supernovae simulations, we develop a candidate selection pipeline and quantity the sensitivity of our and other optical follow-up programs. For gravitational wave alerts, I report on results from multiple follow-ups from the third LIGO/VIRGO observing run.

Troy Raen (University of Pittsburgh)
Setting up an LSST alert broker

I will give a brief overview of LSST alerts and discuss ongoing efforts to develop an alert broker, focusing on two use cases: supernovae and novae. The University of Pittsburgh and Google are collaborating to set up a cloud-based broker capable of ingesting, classifying, storing, and serving up alerts at LSST scales. Google technology and expertise will allow us to process the full alert stream as well as other LSST data products and our own value added products, thereby enabling science by the community at large. My work has focused on combining LSST data with data from other catalogs to produce photometric classifications for a wide range of objects, photo-z's, and other value added products. Users will be able to connect through a variety of channels including alert streams (both the full stream and flexibly filtered subsets), APIs, and a web-based UI. The Pitt-Google Broker project is in the early stages and we welcome collaboration and input to hone our use cases and better serve the community.

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Session 3

John Beacom (Ohio State University)
Diffuse Supernova Neutrino Background

The diffuse supernova neutrino background (DSNB) is the weak glow of neutrinos from all past core-collapse supernovae. Though the massive stars that precede core collapses are rare, and the neutrino emission lasts only tens of seconds, the cosmic energy density of the DSNB is as large as that of the extragalactic background light made by all stars ever, over their complete lifetimes. The DSNB is now near first detection.

Ermal Rrapaj (UC Berkeley University of Minnesota)
Exact solution of multi-angle quantum many-body collective neutrino flavor oscillations

I study the flavor evolution of a dense neutrino gas by considering vacuum contributions, matter effects and neutrino self-interactions. Assuming a system of two flavors in a uniform matter background, the time evolution of the many-body system in discretized momentum space is computed. The multi-angle neutrino-neutrino interactions are treated exactly and compared to both the single-angle approximation and mean field calculations. The mono-energetic two neutrino beam scenario is solved analytically. I proceed to solve flavor oscillations for mono-energetic cubic lattices and quadratic lattices of two energy levels. In addition I study various configurations of twelve, sixteen, and twenty neutrinos. I find that when all neutrinos are initially of the same flavor, all methods agree. When both flavors are present, I find fast collective oscillations and rapid flavor equilibration develop both for mono-energetic scenarios and when neutrinos have different momentum magnitudes. However, this is not seen in the mean field treatment. The difference can be ascribed to non-negligible flavor polarization correlations being present. Even in dense matter environments I find rapid flavor equilibration from the many-body treatment while the mean field approximation shows no flavor oscillation at all. Entanglement entropy is significant in all such cases. The relevance for supernovae or neutron stars mergers is contingent upon the value of the normalization volume V and the large N dependence of the timescale associated with oscillations.

Spencer Griswold (University of Rochester, NY)
Galactic Supernova Detection at the IceCube Neutrino Observatory

The IceCube Neutrino Observatory is a cornerstone of Galactic supernova detection. IceCube is comprised of 5160 digital optical modules (DOMs) instrumenting 1 km of ice deep below the surface of the geographic South Pole. This large volume makes it sensitive to neutrinos generated by core-collapse supernovae (CCSNe) in the Milky Way at $> 10\sigma$ for all progenitor models, and sensitive to neutrinos from CCSNe in the Magellanic Clouds at the 5 level. The sub-millisecond time resolution of the detector will enable detailed measurements of the onset of the neutrino burst, and makes IceCube useful for triangulation with other neutrino experiments. IceCubes supernova trigger continuously searches for a collective rise in hit rates across the DOMs in a sliding window of several seconds. This trigger is affected by substantial correlated and uncorrelated background hits in each DOM, limiting its sensitivity to CCSNe far outside the Galaxy. However, the high detector uptime ($> 99.5\%$) provides continuous coverage of the Milky Way. We will summarize the fundamental neutrino physics and astrophysics accessible to IceCube from a Galactic CCSN. We will also discuss the role of IceCube in multi-messenger event reporting via the Supernova Early Warning System. Finally, we describe potential IceCube-Gen2 hardware upgrades that will improve IceCubes CCSN detection horizon and neutrino energy resolution.

Zidu Lin (Arizona State University)
Detectability of SASI activity of supernova neutrino fluxes

In this work, we study the detectability of the SASI signatures in the neutrino luminosity and capability to estimate some of its physical defining parameters. The methodology can also be applied to quantify the scientific potential of other SASI scenarios identified by present and future numerical simulations.

Joshua Wood (NASA / MSFC)
Fermi-GBM in the era of multimessenger transients

The Fermi Gamma-ray Burst Monitor (GBM) is an all sky monitoring instrument sensitive to photon energies from 8 keV to 40 MeV. Its capabilities allow it to observe around 240 gamma-ray bursts (GRBs) each year through on-board triggers alone, making it ideal for providing simultaneous gamma-ray observations of multimessenger transients. This fact was proven through the on-board detection of GRB 170817A and the associated binary neutron star merger event GW170817 which was a major milestone in multimessenger astronomy. Fermi-GBM continues to look for similar multimessenger detections through on-board triggers as well subthreshold searches for weak transients, performed both in high-time-resolution continuous data as well as in targeted follow-ups of gravitational wave and high energy neutrino events. I will provide an overview of these searches and their recent results.

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Session 4

Dimitrios Giannios (Purdue University)
Neutron star mergers: gravitational waves and jet structure

The first-ever neutron star merger observed through its gravitational wave emission, GW170817, was followed by a short duration gamma-ray burst (GRB). At longer time scales the source exhibited thermal and non-thermal optical, radio and X-ray emission related to matter ejected during and after the merger and its subsequent interaction with ambient gas. This groundbreaking discovery, not only proves that short-duration GRBs originate from the merger of neutron stars but also allows us, for the first time, to directly probe the structure of the GRB jet. I will present the work of my group in predicting the detection of GRBs in a significant number of gravitational wave neutron star mergers as well as our simulations on the jet structure and the jet interactions with the ambient gas. I finish with a discussion on a possible surprise that GW170817 may have in store for us in the near future.

Aprajita Hajela (Northwestern University)
Two years of non-thermal emission from GW170817

We present a new method to constrain the density of the environment of GW170817 based on diffuse X-ray emission from hot ionized gas around the host galaxy. I will further discuss the updated broadband modeling after applying the new density constraint.

Adam Kawash (Michigan State University)
The Galactic Nova Rate with ASAS-SN

The Galactic classical novae rate has been estimated to be somewhere between 20 and 260, but over the last decade, the discovery rate has been 9.8 per year. This suggests that most novae in the Galaxy go undetected. Since 2017, the All-Sky Automated Survey for Supernovae (ASAS-SN) has been monitoring the entire sky nightly down to a V-band magnitude of 17, and is the premier survey to discover novae in the Galaxy. However, the discovery rate still remains inconsistent with theoretical expectations. To investigate this, we have analyzed ASAS-SN observations of novae and other CVs to explore the possibility that novae go unidentified. Dwarf nova outbursts are the most significant contaminant in our nova survey, so we carry out a systematic comparison of the outburst properties of classical novae and dwarf novae to optimize characterization of white dwarf transients. In this talk, I will discuss the previous estimates of the Galactic nova rate, the ability of ASAS-SN to constrain the Galactic nova rate, and our initial work investigating the large sample of ASAS-SN discovered CVs.

Patrick Vallely (Ohio State University)
TESS as a transient exploration mission: Synergies with ASAS-SN and other ground-based supernovae surveys

While the Transiting Exoplanet Survey Satellite (TESS) was designed to survey bright nearby stars for planets, its high-precision and rapid cadence observations are proving to be a powerful resource for studying astronomical transients. Building off of our experience working with ASAS-SN data, we have developed an image subtraction pipeline optimized for studying these TESS transients. Here I present the early results of this work, including a TESS light curve probing the early-time behavior of ASASSN-18tb, the first normal Type Ia supernova to show H-alpha emission signatures in its spectra.

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Session 5

C. S. Kochanek (Ohio State University)
Why the RSG mass limit exists?

We examine the mass limits on red supergiant progenitors to Type II supernovae by Davies & Beasor (2018). In Monte Carlo simulations, we find that their statistical method systematically and significantly overestimates, rather than underestimates, the upper mass limit. The red supergiant problem is alive and well.

Roberta Humphreys (University of Minnesota)
The Red Supergiant Problem – Warm Hypergiants and Post-Red Supergiant Evolution

Several evolved yellow supergiants near the upper luminosity boundary, often called yellow hypergiants, with evidence for instabilities and a history of high mass loss episodes have long been considered to be post -RSGs, such as IRC +10420 and the peculiar Var A in M33. But what about the other yellow supergiants which populate the center of the HR Diagram? From our survey of luminous and variable stars in M31 and M33, we selected a samples of yellow and red supergiants. Based on spectroscopic evidence for mass loss and stellar winds, and the presence of circumstellar dust in their SEDs, 30 - 40% are candidates for post RSG evolution. Comparison with tracks suggest initial masses of 20 - 40 Msun. Red supergiant problem? – they evolve to warmer temperatures where they may become type IIL, IIb or Ib, Ic SNe or maybe they become black holes.

Kris Davidson (University of Minnesota)
Eta Carinae is nearing completion of its change of state

Giant eruptions or SN impostors, along with the largest LBV events, arguably pose the biggest mystery in massive-star physics, ejecting enough mass to threaten the validity of evolution models. The only giant eruption survivor that can be observed well is Eta Carinae. But only HST can do this job reliably, because Eta's slow ejecta strongly contaminate all ground-based spectroscopy. The star's Great Eruption of 1830-1860 obviously left it far from thermal equilibrium, and perhaps rotationally deranged as well. Recovery has been remarkably slow and unsteady. Observable trends greatly accelerated in the 1990's, so today the spectrum looks like a different star compared to 1999. Diverse photometric and spectroscopic changes appear consistent with a major decrease of the mass-loss rate. Recent HST data strongly suggest that those developments have slackened since 2010, very likely leaving the star in a new state that may or may not resemble what Halley observed 342 years ago. A periastron event early next year may provide decisive evidence.

Rachel Patton (Ohio State University)
An improved Explosion Landscape for Binary Population Synthesis

Binary population synthesis studies play important roles in understanding the evolution of massive binary systems, supernova rates, and compact object mass distributions. However, these studies are computationally expensive and often assume an arbitrary explosion landscape to avoid evolving each massive star through to core collapse, instead, terminating evolution at helium depletion or carbon ignition. It is a well established fact that the structure of a massive stars presupernova core, its iron-core and the surrounding silicon and oxygen shells, is strongly correlated with the stars final fate. We propose a solution to this problem by taking advantage of two key properties of carbon-oxygen (CO) cores in massive stars: (1) CO core evolves largely independently from the rest of the star; (2) CO core evolution is principally determined by its starting mass and composition. Through an extensive library of calculations describing the entire evolution of the CO core, we compile a table that maps stellar final fates, explosion or implosion, to basic CO core properties. Using two codes, KEPLER and MESA, we evolve thousands of bare CO cores with masses ranging between 2.5 10 Msun, and with initial compositions ranging from 5% C and 95% O to 50% C and O, from carbon ignition through core collapse. For each model, we determine its final fate based on its presupernova properties. Though not suitable for individual models, the resulting table of initial core properties and their final fates provides a more realistic explosion landscape for use by population synthesis studies.

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Session 6

David Khatami (UC Berkeley)
Diversity and Classification of Light Curves from CSM Interaction SNe

The presence of a dense circumstellar medium surrounding a supernova will dramatically alter the evolution and overall shape of the light curve (LC). The efficient conversion of kinetic to radiative energy from the ejecta-CSM shock interaction is capable of powering some of the brightest observable transients and is a leading explanation for superluminous supernovae, as well as a recently-observed class known as fast blue optical transient (FBOTs). Using radiation hydrodynamics simulations with CASTRO, I explain the physical picture of CSM interaction with supernova ejecta, which can be described by five stages in the LC. I show how CSM interaction LCs can be divided into three distinct classes depending on the location of the shock when the light curve becomes visible, and show how each class has its own unique peak scalings with the CSM properties, such as the total mass and radius. Finally, I apply the CSM model LCs to a pair of recently observed FBOTs.

Subhash Bose (Ohio State University)
A Strongly Bipolar core in the dust forming ejecta of a normal IIP supernova

Few core-collapse supernovae shows asymmetric Halpha emission in the nebular phase indicating asymmetry in the 56Ni distribution and/or in the line-emitting region of the inner ejecta. Here I will discuss nebular phase observations of the supernova ASASSN-16at, which shows strong bifurcation in late nebular phase (¿200 days) Halpha and Hbeta emissions, which has not been observed in any other core-collapse supernovae. Such distinct double-peaked profile indicates strong bipolarity in the inner ejecta of the supernova ASASSN-16at, which otherwise showed a normal SNe IIP like evolution until 200 days. Interestingly each component of the double-peaked nebular HI emission is seen to be evolving, where the red peak progressively weakens relatively to the blue peak. This evolution may be explained by differential extinction due to the formation of dust in the ejecta, which is also supported by the NIR color excess during late times.

Niharika Sravan (Purdue University)
A comprehensive population-scale modeling of Type IIb supernova progenitors

The mechanisms driving removal of envelopes of stripped-envelope supernova (SE SN) progenitors is a key challenge to our understanding of massive star evolution. Type IIb SNe are particularly valuable for addressing this challenge because of the wide variety of observational constraints available for them, most notably, direct progenitor/companion identifications in several cases. We undertake an unprecedented population-scale modeling effort using MESA to test our ability to reproduce all observational constraints for Type IIb SNe. Our comprehensive grid of 150,000 models span the full parameter space occupied by single and binary SN IIb (in progenitor mass, mass ratio, orbital separation, and mass transfer efficiency) at solar and low metallicities. As already widely suggested, we find that Type IIb SN fractions imply that binaries comprise of the vast majority of Type IIb SNe. However, the models require significantly lower wind mass loss rates at solar metallicity and highly inefficient mass transfer. We find observational parameter spaces that are currently unprobed but highly constraining for mass loss rates due to stellar winds and eruptions. In particular, our models indicate the presence of a population of highly-compact nearly-fully-stripped progenitors and episodic mass loss in progenitors in the years leading up to core-collapse.

Tuguldur Sukhbold (Ohio State University)
What really powers the light curves of ordinary Type Ib/c supernovae?

The wealth of observational data on light curves, compact objects, and chemical abundances hold critical clues on how massive stars live and die. However, the utility of these observables are severely hampered due to our limited understanding of the explosion mechanism in core-collapse supernovae. We address this problem using a novel and efficient method of simulating supernovae through calibrated neutrino-driven explosions. Recently we have applied this approach to a population of single stars and found a possible physical explanation for the "Red Supergiant Problem". In this talk, I will present new results from its application to massive stars in binary systems that have lost their envelope to its companion. Surprisingly, it turns out the explosions of stripped stars do not make enough ^{56}Ni to explain the observed Type Ib/c light curves, which flies in the face of current convention that states their optical displays are powered by radioactivity.

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Session 7

Abigail Polin (UC Berkeley)
Modeling sub-Chandrasekhar mass explosions as Type Ia supernovae

Type Ia supernovae are some of the most common cosmic transients, yet their progenitors are still not known. I will discuss my thesis research on a specific pathway to these explosions, known as the double detonation scenario. I will first describe the hydrodynamic techniques I use to simulate these explosions and to calculate the composition of the outflow. I will also describe the radiation transport methods I use to translate the hydrodynamical output into synthetic light curves and spectra. Using these methods, I have calculated some distinct observational signatures that should be exhibited by any double-detonation explosion in both the photospheric and nebular phase. I will discuss the populations of Type Ias which are consistent with these features. Lastly, I will present the first observed supernova, SN2018byg, that exhibits some "smoking gun" signatures I predicted, and which therefore strongly supports the idea that some Ias are triggered by double detonations.

Wynn Jacobson-Galan (Northwestern University)
Calcium-Rich Transients from Helium-Shell Detonations on White Dwarfs

Calcium-rich (Ca-rich) transients are a rapidly growing class of thermonuclear explosions whose progenitor system remains ill-constrained. Ca-rich SNe are often found far (¿30 kpc) from their host galaxies and in dense galactic environments. A large fraction have elliptical host galaxies, indicating a long-lived progenitor. Here I will present observations of SN 2016hnk, a new Ca-rich object in a barred-spiral host galaxy with a peak absolute magnitude of -15.4 and rise-time of 15 days. Photospheric spectra of SN 2016hnk show prominent, high-velocity Ca II features and significant line blanketing amongst Fe-group elements from 4000-5000 Angstroms. These properties are in contrast with typical Ca-rich objects that do not exhibit suppressed blue-wards flux or such high calcium velocities. In the nebular phase, the SN 2016hnk spectra are Fe- and O-poor, with nearly all of the optical flux from [Ca II]. We show that, despite its likeness to Ca-rich objects and 91bg-like SNe Ia, SN 2016hnk is most similar to that of SN 2018byg, the first object to show a consistency with a helium shell double detonation. SN 2016hnk is strikingly similar to a He-shell double-detonation model with helium shell and WD masses of 0.02 and 0.85 solar masses, respectively. I will elaborate on how peculiar objects such as SNe 2016hnk and 2018byg contribute to the diversity of both Ca-rich and 91bg-like SN classes. Finally, I will discuss the observational variety and inferred frequency of helium shell detonations as it relates to the progenitor system of Ca-rich SNe.

Poster Abtracts:

John Banovetz (Purdue University)
The Center of Expansion and Explosion Age of the Oxygen-Rich Supernova Remnant 1E0102.2-7219

We present new proper motion measurements of oxygen-rich knots of supernova remnant 1E0102.2-7219 yielding new estimates of its center of expansion and age. We utilize four epochs of high resolution optical images obtained with the Hubble Space Telescope, spanning 18.9 years and following 96 knots. We find asymmetry in the proper motions of the knots as a function of position angle, leading us to believe that the free expansion model cannot be used to estimate the supernova remnant's center of expansion. We employ a method that does not depend on proper motion velocity to determine the center of expansion and we only use the fastest filaments across all baselines to calculate the remnant's age. Constraining these explosion parameters for 1E0102.2-7219 has become increasingly important in light of the discovery of a possible central compact object (CCO). Our results imply that the candidate CCO has an unusually high transverse kick velocity, which may provide important insight into the original supernova's explosion dynamics.

Kirby Hermansen (Michigan State University)
Reaction Rate Sensitivity Studies for Nucleosynthesis in Core-Collapse Supernovae

Explosive nucleosynthesis in core collapse supernovae makes important contributions to the origin of the elements, and directly observable gamma-ray emitters such as 44Ti are ideally suited to constrain supernova models. We utilize SkyNet, an open source, modular reaction network, to model the isotopic abundance evolution during the explosion, and to systematically explore the impact of reaction rate uncertainties.

Jayasinghe Tharindu (Ohio State University)
Constructing an all-sky catalog of bright variable stars with ASAS-SN

The All-Sky Automated Survey for SuperNovae (ASAS-SN, Shappee et al. 2014; Kochanek et al. 2017) has monitored the entire visible sky to a depth of 17 mag in the V-band since 2014. In addition to the detection of transients in real-time, ASAS-SN data are well suited for the discovery and characterization of variable stars (Jayasinghe et al. 2018ab; Shields et al. 2018). In Jayasinghe et al. (2018a), we reported the discovery of 66,000 new variable stars in ASAS-SN V-band data. In Jayasinghe et al. (2018b), we uniformly analyzed the ASAS-SN light curves of 412,000 known variables from the AAVSO's VSX catalog (Watson et al. 2006), providing the first all-sky, homogeneously classified catalog of variable stars. We have also systematically characterized the variability of ¿31 million sources in the southern hemisphere and have discovered 95,000 new variables (Jayasinghe et al. 2019a/b). All the light curves for these sources are made available to the public. We are currently finalizing our catalog of variable sources in the northern hemisphere using ASAS-SN V-band data.

Charlotte Wood (University of Notre Dame)
The light echo around Supernova 2009ig

The light echo around Supernova 2009ig (SN2009ig) is the sixth known and most luminous around a type Ia supernova. Light echoes can provide information on the local environment around supernovae, which is particularly important for type Ias since they are used as standard candles. The presence of gas and dust in the local environment of a type Ia can affect the observed luminosity and could impact measurements of the Hubble constant. Using photometric data from the Large Binocular Telescope between 2010 and 2018, we present new observations of the SN2009ig light echo that confirm a slow fading of the echo over the past 6 years since its discovery in 2013. The fading is similar to that seen in the light echo of SN1991T and suggests that some of dust producing the echo may be local to the event.