and better ways. These efforts almost always involve the rarest and most exotic of recycled binary systems, including those which formed in unusual ways, or those whose orbits or companions were altered later, as often happens in globular clusters. We report recent results, using timing and search observations from the GBT and Arecibo, on several of these exotic systems. We have new and potentially exciting neutron star mass measurements and new tests of general relativity. And we suggest that it is well worth the efforts involved to uncover and examine these "1%" pulsar systems.

Author(s): Scott M. Ransom, Bridget Andersen, H. Thankful Cromartie, Jason Hessels, Ryan S Lynch, Nicholas Clifford, Emmanuel Fonseca, Ingrid Stairs, Paulo Freire, Megan E. DeCesar, Paul Demorest
Institution(s): NRAO, McGill University, University of Virginia, MPIfRA, Lafayette College, ASTRON, University of Amsterdam, University of British Columbia, Green Bank Observatory

228.03 - Testing General Relativity Using a Pulsar in a Triple System(Anne Archibald)

The millisecond pulsar PSR J0337+1715 is in a 1.6-day orbit with an inner white dwarf companion, and the pair is in a 327-day orbit with an outer white dwarf companion. This hierarchical triple provides an excellent laboratory to test a key idea of Einstein's theory of gravity, the strong equivalence principle (SEP): do all objects, even those with strong gravity like neutron stars, fall the same way in the same gravitational field? Almost all alternative theories of gravity predict violations of the SEP at some level. We have carried out an intensive program of timing this pulsar, and we are able to perform a very sensitive test of the SEP. I will discuss our methods, our result, and its theoretical implications.

Author(s): Anne Archibald, Duncan Lorimer, Jason Hessels, Ryan S Lynch, Scott M. Ransom, Adam Deller, David Kaplan, Ingrid Stairs, Nina Gusinskaia
Institution(s): Universiteit van Amsterdam, NRAO, University of British Columbia, University of Wisconsin-Milwaukee, University of West Virginia, Swinburne University of Technology,, ASTRON

228.04 - The NANOGrav 11-year Data Set: New Insights into Galaxy Growth and Evolution(Maura McLaughlin)

The NANOGrav collaboration monitors an array of over 70 precisely timed millisecond pulsars with the Green Bank Telescope and Arecibo Observatory in order to detect perturbations due to gravitational waves at nanohertz frequencies. These gravitational waves will most likely result from an ensemble of supermassive black hole binaries. I will present the most recent upper limits on various types of gravitational wave sources and will demonstrate that these limits are already constraining models for galaxy formation and evolution. I will then describe the dramatic gains in sensitivity that are expected from discoveries of millisecond pulsars, more sensitive instrumentation, improved detection algorithms, and international collaboration and show that detection is possible before the end of the decade.

Author(s): Maura McLaughlin
Institution(s): West Virginia University Contributing Team(s): NANOGrav Physics Frontiers Center

228.05 - Current results and future prospects from PSR J1757-1854, a highly-relativistic double neutron star binary.(Andrew David Cameron)

Pulsars, rapidly-rotating highly-magnetised neutron stars, can serve as useful laboratories for probing aspects of fundamental physics. Binary pulsars, especially those in tight binary systems with massive, compact companions, are useful in testing different theories of gravity, the current paradigm being General Relativity (GR). Additionally, binary pulsars can also be utilised to explore other areas of fundamental physics, such as the behaviour of matter at ultra-high densities and the neutron star moment of inertia.A standout example is PSR J1757-1854, a 21.5-ms pulsar in a highly-eccentric (e=0.61), 4.4-hr orbit around a neutron star companion. This pulsar exhibits some of the most extreme relativistic parameters ever observed in a binary pulsar, reaching a maximum line-of-sight acceleration of close to 700 m/s/s and displaying among the strongest relativistic effects due to gravitational wave damping. To date, five post-Keplerian parameters have been measured in PSR J1757-1854, allowing for three independent tests of gravity to be conducted (of which GR passes all three) and for the component neutron star masses to be separated. The extreme properties of this system (particularly its high eccentricity) are expected to allow for future measurements of Lense-Thirring precession effects (allow for a measurement of the neutron star moment of inertia) and the relativistic deformation of the orbit, both of which remain almost completely unexplored by other binary systems.Although first discovered by the Parkes Radio Telescope in 2016 as part of the High Time Resolution Universe Southern Galactic Plane survey, it is ongoing observations with the Green Bank Telescope (GBT) which have provided the backbone of PSR J1757-1854's continuing study. The large-bandwidth, high-precision observations afforded by the GBT played a fundamental role in delivering the science derived from the pulsar so far, and will be critical in allowing it to reach its full scientific potential going forward. In this talk I will provide a progress report on the ongoing timing of the system, including a review of the latest mass measurements and gravity tests, with an emphasis towards the future science which this pulsar will make possible.

Author(s): Duncan Lorimer, Sarah Burke-Spolaor, 0, Thomas Tauris, David Champion, Shivani Bhandari, Nihan Pol, Cherry Ng, Willem van Straten, Andrew Jameson, Chris Flynn, Caterina Tiburzi, Michael Keith, Norbert Wex, Maura McLaughlin, Andrew Lyne, Ramesh Karup
Institution(s): Dunlap Institute, University of Toronto, 0Center for Gravitational Waves and Cosmology, West Virginia University, Argelander-Institut fuer Astronomie, Universitaet

Bonn, Institute for Radio Astronomy & Space Research, Auckland University of Technology,

228.06 - New Wide-bandwidth Technologies for Studying Radio Pulsars with the Green Bank Telescope(Ryan S Lynch)

The Green Bank Telescope (GBT) is a premier instrument for the study of pulsars, enabling advances in a wide range of fundamental physics and astronomy. The GBT has discovered and characterized the fastest spinning and most massive known neutron stars, placing important constraints on the equation of state of ultra-dense matter. The sensitivity and world-leading instrumentation of the GBT has led to precise tests of general relativity and alternative theories of gravity through observations of exotic binary pulsars. The broad radio frequency coverage of the GBT has also made it an excellent complement to pulsar observatories operating in different wavelength regimes, leading to the discovery of dozens of millisecond pulsars. The GBT plays a crucial role in on-going efforts to detect and explore the low-frequency gravitational wave universe via pulsar timing, and in the coming decade it will join other gravitational observatories to study supermassive binary black holes and exotic physics. One of the great strengths of the GBT is its cutting edge radio frequency and digital technology, and new advances in both areas promise to further enhance the GBT's capabilities for pulsar observations. I will discuss two such closely related projects currently underway at the Green Bank Observatory. The first is a new ultrawideband radio receiver that will cover the 0.7-4 GHz band. The detector is being optimized for wide-band, high precision timing of millisecond pulsars for gravitational wave detection, and has the potential to improve timing precision for such experiments by a factor of two. The second project uses new high-speed analog to digital converters and system-on-chip technology to directly sample the radio frequency provided by the ultrawideband receiver, while directly incorporating active identification and removal of man-made interference. Together, these projects will continue to make the GBT one of the best telescopes in the world for the study of radio pulsars.
Author(s): Ryan S Lynch
Institution(s): Green Bank Observatory Contributing Team(s): Green Bank Observatory

229 - First Results from the Kepler/K2 Supernova Experiment

229.01 - Overview of the Kepler/K2 Supernova Experiment(Jessie Dotson)

The Kepler space telescope was launched in 2009 and spent more than 9 years taking high-precision, high-cadence, uninterrupted light curves of a variety of astrophysical targets - including a large sample of galaxies. Over the first 8.5 years of operation, over 20 supernovae were observed by Kepler/K2 - providing data on novel supernovae including shock breakout and fast evolving luminous transients. The Kepler/K2 supernova experiment was executed during K2's 16th and 17th campaigns (December 2017 - May 2018). The fields of view of these two campaigns were chosen to include a large number of galaxies - which resulted in K2 data of an additional ~ 40 supernovae. In addition, the spacecraft was operated in its "forward facing" orientation - which permitted simultaneous observations of these fields from the ground. I will provide an overview of the Kepler/K2 supernovae dataset as well as discuss complementary observations taken by PanSTARRS1.
Author(s): Jessie Dotson
Institution(s): NASA Ames Research Center

229.02 - Type II Supernovae with K2/Kepler(Peter Garnavich)

We discovered two transient events in the original Kepler field with light curves that strongly suggest they are type II-P supernovae. A handful of additional candidate type II-P events have been detected in the K2 data, although none are as spectacular as the two observed during the Kepler mission. The original Kepler events, KSN2011a and KSN2011d, provided high-quality light curves from their initial rise and were followed to the end of their plateau phase. The well-sampled rise was used to estimate the size of the progenitor star and idealized analytic models allowed us to constraint their explosion energies. The early light curves of the two events were significantly different. KSN2011d displayed an inital brightening that is well-matched by predictions of a shock breakout in a red supergiant star. In contrast, KSN2011a did not show evidence for a shock break out, but its early rise was faster than expected possibly due to the supernova shockwave moving into pre-existing wind or mass-loss from the RSG.
Author(s): Robert Olling, Peter Garnavich, Edward Shaya, Armin Rest, Ashley Villar, Brad Tucker, Dan Kasen
Institution(s): University of Notre Dame, Space Telescope Science Institute, Australian National University, University of California, Berkeley, University of Maryland, Center for Astrophysics Contributing Team(s): Kepler ExtraGalactic Survey

229.03 - A Fast-Evolving, Luminous Transient Discovered by K2/Kepler(Armin Rest)

For decades optical time-domain searches have been tuned to find ordinary supernovae, which rise and fall in brightness over a period of weeks. Recently, supernova searches have improved their cadences and a handful of fast-evolving luminous transients (FELTs) have been identified. FELTs have peak luminosities comparable to type Ia supernovae, but rise to maximum in <10 days and fade from view in <30 days. Here we present the most extreme example of this class thus far, KSN2015K, with a rise time of only 2.2 days and a time above half-maximum of only 6.8 days. Possible energy sources for are the decay of radioactive elements, a central engine powered by accretion/magnetic fields, or hydrodynamic shock. We show