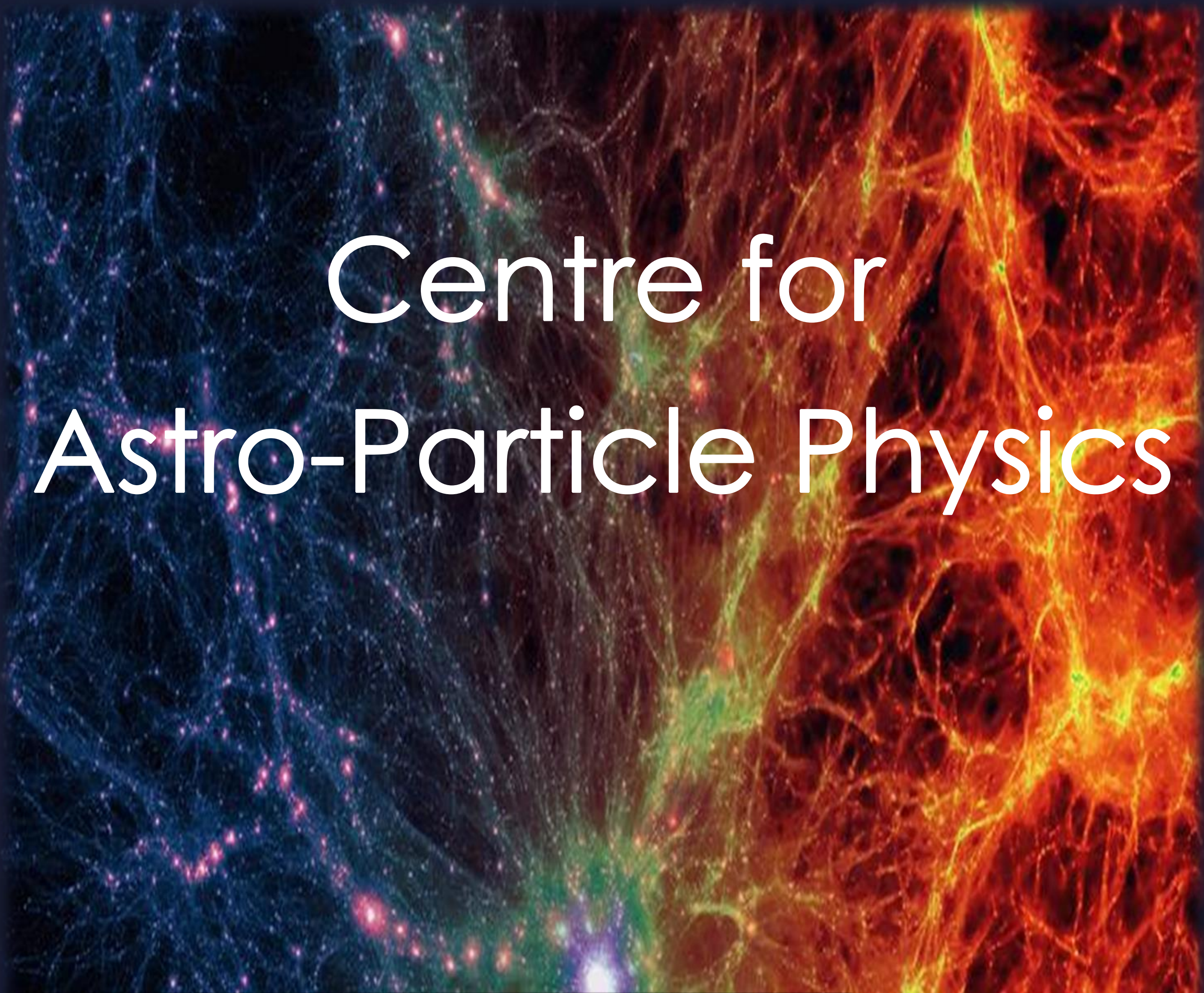


Centre for Astro-Particle Physics

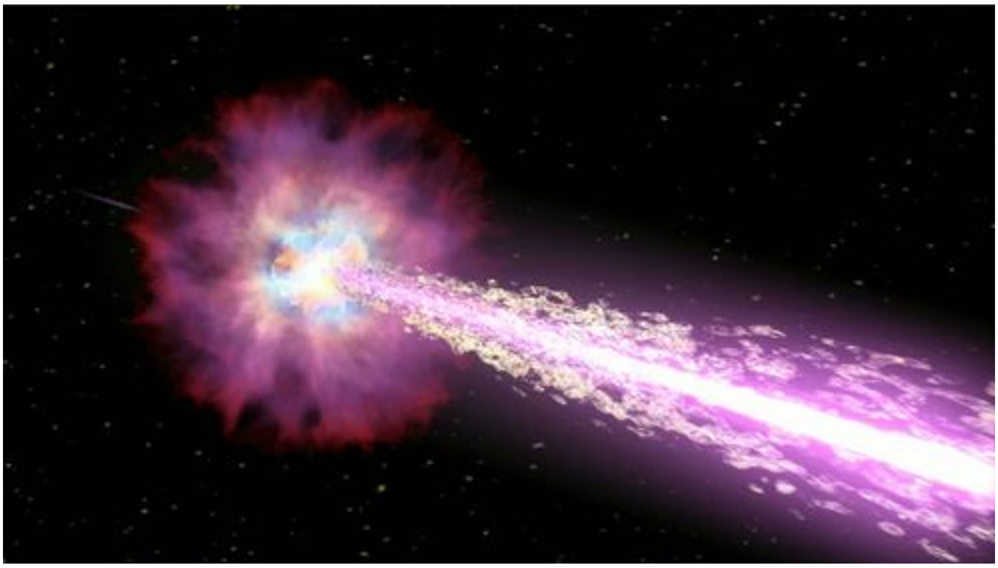
Newsletter of the Centre for Astro-Particle Physics

University of Johannesburg

Date: 25-09-2018

MESSAGE FROM THE DIRECTOR

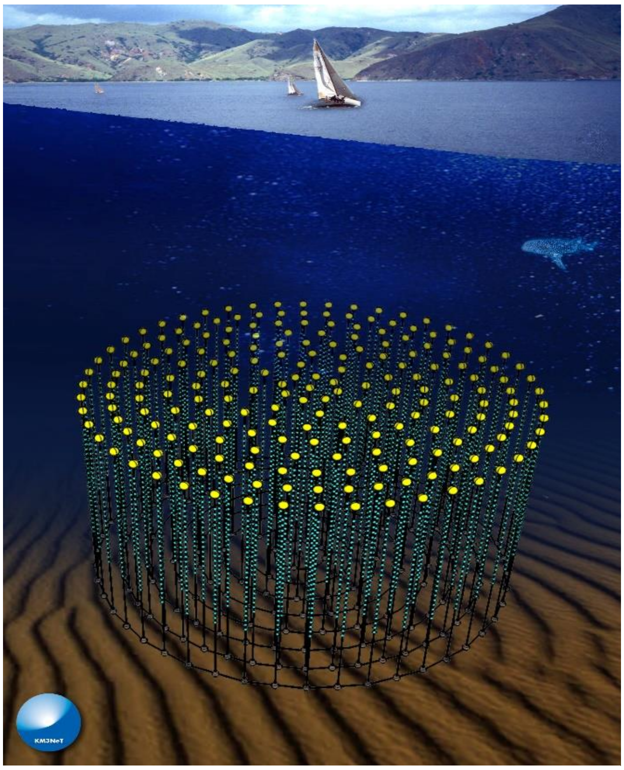
It is a pleasure to introduce the newly established Centre for Astro-Particle Physics (CAPP) at the University of Johannesburg to you. As the name suggests the Centre is focused on cross-disciplinary research with topics from Astrophysics and Particle Physics. Information from various corners of the universe reaches us in the form of light, which behaves like a particle at high energies and called gamma rays, and in the form of other elementary particles such as cosmic rays and neutrinos. These particles are produced in the fantastic laboratories in the universe, such as black holes of various masses, neutron stars, exploding stars, etc., which far exceed the efficiencies of even the largest man-made laboratories. The research at CAPP is aimed at studying these particles from nature and advance our understanding of various astrophysical sources of these particles as well as to use these particles to answer some of the most fundamental physics questions.



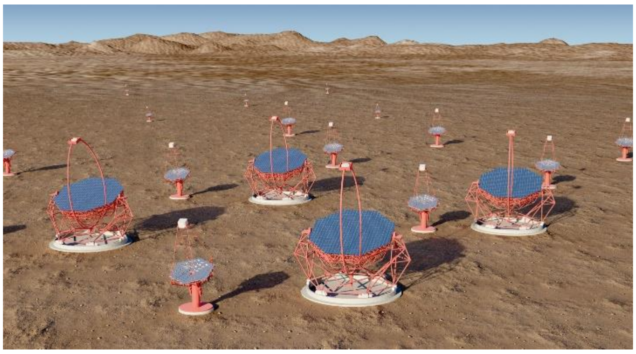
Artist's concept of a GRB (Credit: NASA / Swift / Cruz deWilde)

Researchers at CAPP are involved in theoretical modelling, computation and data analysis. Some of the astrophysical sources that are studied closely are Gamma-ray bursts (GRBs) and Active-galactic nuclei (AGNs). Gamma-ray bursts are the most luminous explosions in the universe, arising either from the death of a rare type of massive star or from the mergers of binary systems (neutron star-neutron star or neutron star-black hole). GRBs can be detected in galaxies out to the edge of the visible universe. Active-galactic nuclei are a subclass of galaxies with a supermassive black hole (with 10 to over 100 million times the mass of the Sun) at its centre that is devouring materials from its surrounding and throwing them in narrow jets with speed close to the speed of light. Gamma rays from AGNs have been detected that have energies exceeding the maximum energy achievable at the Large Hadron Collider (LHC), the most powerful man-made particle accelerator.

The most energetic particles in nature are cosmic rays, detected with energies up to billions of trillion (10^{21}) electron Volt. It is a mystery how and where exactly these particles are created in nature. Cosmic rays are charged particles and they interact with other particles and radiation fields to produce secondary particles including very high energy gamma rays and neutrinos. These gamma rays are now routinely detected on the earth and from space. Cosmic rays hitting the atmosphere of the earth produce neutrinos that have been measured with good accuracy. Questions in fundamental Physics such as neutrino mass, charge-parity violation and extra species are being addressed using these atmospheric neutrinos. Recently Peta (10^{15}) electron Volt neutrinos have been detected directly from astrophysical sources. Researchers at CAPP model acceleration, interactions and propagation of energetic cosmic rays, neutrinos and gamma rays from various plausible astrophysical sources in our Galaxy and in other galaxies. Very recently gravitational waves, predicted by Einstein, have been detected from merging of binary black holes and neutron stars. Members of CAPP are embarking on research in this area as well.



Artist's concept of the KM3NeT Neutrino Observatory in the Mediterranean Sea



Artist's concept of the Cherenkov Telescope Array (CTA) in Chile and Canary Island

Fermi Gamma-Ray Space Telescope

Over 400 years ago Galileo looked through his telescope and started modern Astronomy. Visible light was the only way to study the universe for the next 300 or so years until cosmic rays were discovered in 1912 by Victor Hess. We are now in an era of true multi-messenger Astronomy with discovery of high-energy cosmic neutrinos and gravitational waves only during this decade. This certainly means that researchers at CAPP will be busy studying the universe with these cosmic messengers in foreseeable future.

Soebur Razzaque, PhD
Professor of Physics and Director of CAPP

Members of CAPP are involved in Fermi, CTA and KM3NeT Collaborations

MESSAGE FROM THE EDITOR

Welcome to the CAPP newsletter

COMING SOON!

Once our website is up and running you can go and view upcoming events, the latest news, images, and the research our group members are doing to find out more.

https://www.uj.ac.za/faculties/science/capp/
or
www.uj.ac.za/capp

You can also contact us at capp@uj.ac.za

Jessica-Sheay Verrall~

Creator and editor of newsletter and website for CAPP.

THE GROUP MEMBERS

"I am the Director of the Centre for Astro-Particle Physics (CAPP). The Centre has been approved in June of this year, and it is the first Research Centre hosted by the Physics Department to date. My primary research areas are Neutrino Physics and Astrophysics, Multi-messenger Astronomy, Gamma-ray and Cosmic-ray Astrophysics."- Soebur Razzaque (Professor)

"The SBL (Short Baseline), reactor and reaction experiment results show an anomaly with respect to the tree active neutrinos. One possible solution is the proposal of an extra sterile neutrino that affects the neutrino oscillations. My job is to study the neutrino oscillations including the extra neutrino on different schemes to find constraints on the particle."- Salvador Miranda-Palacios (Postdoctoral Research Fellow)

"I am working on the radiative processes in the expected astrophysical sources of cosmic rays. The aim of this study is to use multi-wavelength observations in the modelling. Currently at the University of Johannesburg, I am modelling the afterglow emission from Gamma ray bursts. Alongside, I am interested in the propagation of cosmic rays in the interstellar medium."- Jagdish Joshi (Postdoctoral Research Fellow)

"My thesis project is to model photons from the Gamma-Ray Bursts (GRBs) and standardize these objects as cosmological standard candles, like Type Ia supernovae. Since GRBs have been detected to higher redshift (> 9) than any other astrophysical objects, they can probe evolution of cosmological model parameters at an early Universe."- Feraol F. Dirirsa (Doctoral Student)

"In my project I study the effects of the region near the accretion disk of active galactic nuclei (AGN). These particular AGNs are focussed on blazars, and I am modelling the gamma rays emitted by blazars as well the spectrum of the broad line region (BLR) by considering the possible interaction of the gamma rays in the jets with the low energy target photons in the BLR." -Mfuphi Ntshatsha (Masters Student)

"In my project I study the evolution of massive binary objects emitting gravitational waves, such as two black holes or two neutron stars in close binary orbit, and astrophysical phenomena which includes the collision of binary black holes or binary neutron stars."-Lutendo Nyadzani (Master's Student)

"I am doing research under Prof. CA Engelbrecht's supervision. My project involves probing stellar structure using asteroseismology to determine physical parameters, as well as study the effects of rotation on pulsating β Cep stars."-Jessica-Sheay Verrall (Honours Student and Student Assistant)

"I study in detail the synchrotron radiation by relativistic electrons in a magnetic field, synchrotron self-absorption and free-free absorption. Using a solution to the radiative transfer equation, the intensity of radio emissions from normal galaxies will be calculated and computational models used to fit radio data from normal galaxies."-Nomthendeleko Motha (Honours Student)

LATEST NEWS AND DISCOVERIES

Discovery of a born-again star after explosion may give clues to the fate of the Sun

A star found to have about the same mass as our Sun, had died and began life again as a star surrounded by a planetary nebula cloud of dust and gas.

PAGE 8

A mass eruption from another star

Devastating solar flares ejected from another star.

PAGE 9

IceCube: Unlocking the secrets of cosmic rays

Prof S Razzaque is a co-author of the IceCube neutrino source discovery paper published in the Science magazine (Aartsen et al., "Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A," Science, Vol.361, Issue 6398, eaat1378, 2018).

PAGE 10

New discovery of the largest solar system may shed light our place in the universe.

44 Planets have been discovered in a solar system beyond our own.

PAGE 11

DISCOVERY OF A BORN-AGAIN STAR AFTER EXPLOSION MAY GIVE CLUES TO THE FATE OF THE SUN

A hot nebula surrounding an apparently cooler star hides its explosive past

Courtesy of Martin A Guerrero/Nordic Optical

A team of astronomers (Guerrero et al., 2018) recently found that a star called HuBi1, with about the same mass as the Sun had died in an explosion and began life again as a star surrounded by a planetary nebula cloud of dust and gas.

Studies of this planetary nebula revealed that the clouds centre was cooler than the edge that was furthest from the star. When archival data was examined in 1971, it was found that the star's central brightness had dropped by a factor of 10,000 since then.

The team of astronomers realised that the star is now getting hot enough to fuse helium into carbon and then expel it in a wave at high speeds. This wave of carbon which hurled through space heated up the area in front of it as it went. The nebula was only observed after the wave had passed through the innermost area, therefore the outer part of the shell beyond the wave was hotter.

As time went on and the carbon streamed further away from the star, it cooled down and condensed into dust grains that would therefore, block some of the stars light which was being emitted. This is the reason why the star looks cooler and dimmer, and therefore younger.

It may be possible that our Sun could someday share the same fate, after evolving over billions of years and then be born again.

Guerrero, M., Fang, X., Miller Bertolami, et al. (2018), "The inside-out planetary nebula around a born-again star."

Nature Astronomy, Advanced Online Publication

A MASS ERUPTION FROM ANOTHER STAR

Astronomers saw the first mass eruption from a star that's not the Sun

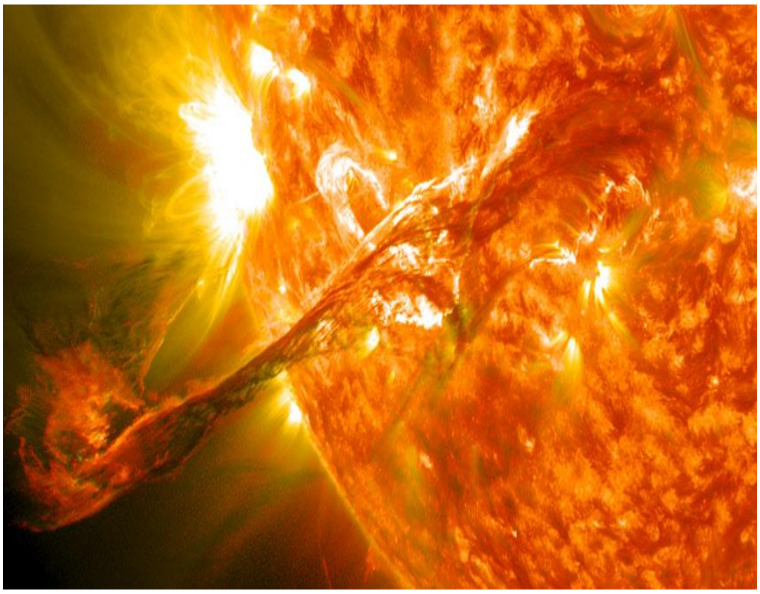
For the first time, a corresponding coronal mass ejection (CME) of plasma and charged particles, otherwise known as a solar flare, has been spotted fleeing a distant star.

These solar flares are well-known on the sun (Grossman, 2018). This discovery is leading scientists to explore the prospects for life in other solar systems.

The detection in question relates to a flare that was ejected 10 years ago, from a giant star called HR 9024 about 450 light-years from Earth. The star is assumed to be about three solar masses (three times the size of our Sun).

The ejection contained about 1 billion trillion grams of material, which is approximately what scientists expected based on their estimates extrapolated from the sun's CMEs, however, the outburst's kinetic energy, measured by the escaping material's speed, was much lower than expected.

It is suggested that the lower than expected kinetic energy may be due to the star's strong magnetic field, which may have held the eruption back.



A strong magnetic field can sometimes act as a cage that keeps a CME tethered to the star or could slow the progress of ejections that make it out, this could also be one of the reasons why this star's solar flare took so long to reach our planet.

This could also explain why scientists hadn't detected a CME from another star before. Scientists have been baffled with this because strong stellar magnetic fields are associated with more flares, which should cause more ejections.

The energy and matter released in both flares and CMEs could wreak havoc in our own solar system. Luckily Earth is mostly protected from the Sun's flares and radiation by its own magnetic field. This lead scientists to conclude that any exoplanets within the vicinity of this star could not sustain life.

Grossman, L. (2018). <u>Astronomers saw the first mass eruption from a star that's not the Sun</u>. [online] Science News. Available at: https://www.sciencenews.org/article/astronomers-saw-the-first-mass-eruption-star-thats-not-sun?tgt=nr [Accessed 13 August 2018].

ICECUBE: UNLOCKING THE SECRETS OF COSMIC RAYS

Incredible Science

Between May 2010 and May 2012, IceCube observed 28 very high-energy particles.

In April 2012, a pair of high energy neutrino's Bert and Ernie named after the child show "Sesame street", were detected, having energies above 1 petaelectronvolt (PeV). The pair were the first definitively detected neutrinos from outside the solar system since the 1987 supernova. IceCube were therefore, awarded the Physics World 2013 Breakthrough of the Year. Another major detection was on December 4th, 2012, the neutrino was ranked as the 2nd highest-energy neutrino, as of 2018. Thanks to NASA's Fermi Gamma-ray Space telescope, the neutrino which came from an event named "Big Bird" (also from "Sesame street"), was tied to the highly energetic outburst of a blazar known as PKS B1424-418.

Blazars are powered by supermassive black holes at the center of a galaxy. As the black hole gobbles down material, some of the material is deflected into jets carrying so much energy they outshine the stars in the galaxy. The jets accelerate matter, creating neutrinos and the fragments of atoms that create some cosmic rays. In July of this year, IceCube announced that, for the first time, it had tracked neutrinos back to their source blazar. This allowed for the presence of active blazars, such as TXS-0506+056, to be detected.

IceCube isn't finished yet. The new alert system, which allowed for these detections, will keep astronomers on their toes in future years.

Aartsen et al (2018). IceCube:Unlocking the secrets of Cosmic Rays. [Online] Space.com. Available at: https://www.space.com/41170-icecube-neutrino-observatory.html[Accessed Sep. 2018].

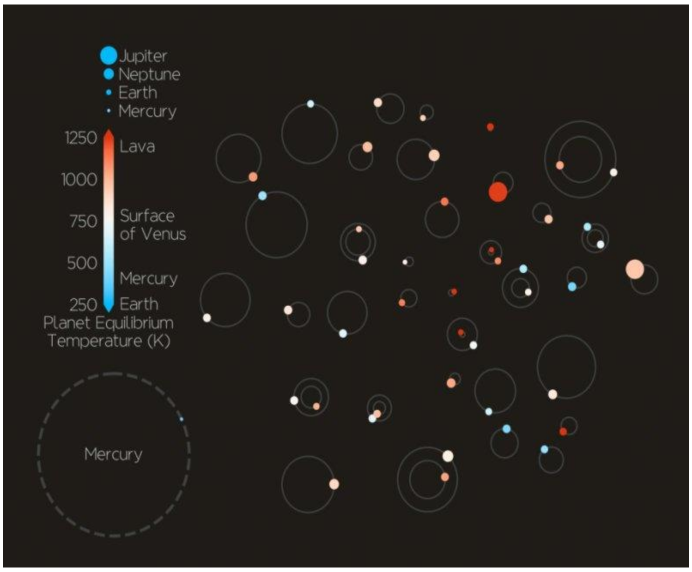
NEW DISCOVERY OF THE LARGEST SOLAR SYSTEM MAY SHED LIGHT OUR PLACE IN THE UNIVERSE

44 Validated Planets from K2 Campaign 10

In a solar system beyond our own, forty-four planets have been discovered. These findings will allow for future research into exoplanet atmospheres.

The detailed analyses of data obtained from ground-based telescopes, namely, K2 and Gaia enabled precise determination of these planets' sizes and temperatures. The team found 27 additional candidates which are likely to be real planets.

The addition of many new planets, therefore, leads directly to a better theoretical understanding of solar-system formation, where knowledge of other planets will allow for better understanding of our own (Livingston, 2018).



The end goal will be to come across a planet which is able to sustain life, just like Earth.

John H. Livingston, Michael Endl, Fei Dai, et al. 44 Validated Planets from K2 Campaign 10. The Astronomical Journal, 2018; 156 (2): 78 DOI: 10.3847/1538-3881/aaccde