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CENTRE FOR ASTRO-PARTICLE PHYSICS

THE OFFICIAL NEWSLETTER OF THE CENTRE FOR ASTRO-PARTICLE PHYSICS

A limited number of top-up bursaries are available for MSc and PhD students from the CAPP.

Interested students should contact Ms Anna Samara Larmuth (**capp@uj.ac.za**) with their academic transcripts.

Further Your Studies

CUTTING EDGE RESEARCH BY CAPP GROUP MEMBERS

Scientists and students at the Centre for Astro-Particle Physics focus on research in Gamma-ray Astrophysics, Neutrino Astrophysics, Neutrino Physics and Gravitational Wave Physics.

We perform theoretical studies as well as data analysis and modelling. All three experimental facilities that we are involved in, namely the Fermi Gamma-ray Space Telescope; the Cherenkov Telescope Array and the KM3NeT Neutrino Telescope, perform cutting edge research.

Thus, working at CAPP can provide students and postdoctoral fellows opportunities to get involved in the science of these state of the art experiments, learn the latest techniques and interpret data collected with various instruments.

Research in Astro-Particle Physics requires strong background in Physics, Mathematics and computer programming.

Although some theoretical studies are still done on papers with pencils, numerical computations and simulations on computers are the main tools to make theoretical predictions these days. Data analysis and modeling also require significant computer skills and learning specialised software.

Students who would like to pursue postgraduate studies in AstroParticle Physics should choose Physics and Mathematics for their BSc degree.

The BSc Honours programme at the Department of Physics offer a wide range of advanced courses, including Astrophysics courses, that can prepare students for future MSc and PhD research in Astro-Particle Physics.

Honours students also get a taste of research by doing a project that helps them to prepare for MSc and PhD studies.

LATEST NEWS FROM OUR CENTRE

Recent Conference Presentations

SAIP 2021

Three of our very own CAPP members have presented at the SAIP 2021 conference. The conference took place during the 22-30 July 2021, and was completely virtual.

View the conference's page here: **https://events.saip.org.za/event/206/**

Read more about what Mfuphi Ntshasha, Dr. Ushak Rahaman, and Nomthendeleko Motha presented at the conference in the pages to come or on our website using the link **https://www.uj.ac.za/faculties/science/capp/Pages/Latest-news-and-events.aspx**

Nomthendeleko Motha

The diffuse extragalactic radio background and the implications for gamma-ray astrophysics

For the SAIP 2021 virtual conference, Thendi will present a poster based on her MSc research where she updates the Protheroe and Biermann (1996) model and introduce a new model for the diffuse extragalactic radio background (ERB) by using radio survey data. In this presentation, she revises the synchrotron spectra and radio luminosity function for normal galaxies and radio galaxies. She also addresses the uncertainties in the new ERB estimate by introducing the Yuan et al.(2017) evolution models for the source density and source luminosity. As a result, the distribution of extragalactic radio sources remains consistent with radio data. Finally, she suggests applications for this ERB study, including the opacity analysis of ultrahigh-energy gamma-rays in the universe. In addition to the SAIP conference, Thendi will also be attending the SAIP winter school.

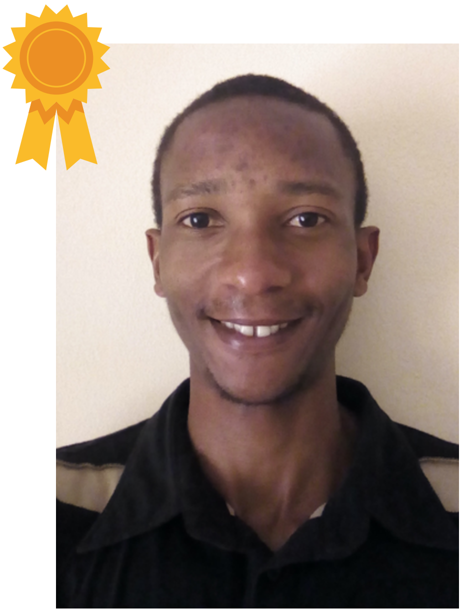
LATEST NEWS FROM OUR CENTRE

Dr. Ushak Rahaman

Looking for Lorentz invariance violation (LIV) in the latest long baseline accelerator neutrino oscillation data

Ushak presented what he has analysed with the latest data from NOvA and T2K with the Lorentz invariance violation along with the standard oscillation hypothesis at the SAIP 2021 conference. He has found that the NOvA data cannot distinguish between the two hypotheses at 1-sigma confidence level. T2K data and the combined data analysis excludes standard oscillation at 1-sigma. All three cases do not have any hierarchy sensitivity when analysed with LIV. There is a mild tension between the two experiments, when analysed with LIV, as theta23 at NOvA best-fit is at higher octant but the same for T2K is at lower octant. The present data from accelerator neutrino long baseline experiments lose octant determination sensitivity when analysed with LIV. The tension between the two experiments is also reduced when the data are analysed with LIV.

Well done to one of our very own CAPP students, Mfuphi Ntshasha, for receiving the Encouragement Award at the SAIP 2021 Conference.



Mfuphi Ntshasha

Effects of emission by electron-positron pairs from gamma-ray absorption in the BLR of gammaray blazars on the broadband SED

Mfuphi presented his MSc work on spectral energy distributions (SED) of some blazars which have dips in the gamma-ray range ~10-100 GeV at the SAIP 2021 conference. His work presents the broad-line region (BLR) model of the blazar 3C 279 which plays a major role in his calculations. It shows the opacity calculation of gamma rays traversing through the BLR of 3C 279, as well as the subsequent spectrum of electron-positron pairs resulting from those gamma rays which are absorbed. Mfuphi shows fits to the gamma-ray spectrum (GRS) of 3C 279, using log-parabola function in his work. He also incorporates the opacity calculation in the GRS fit. These pairs emit gamma rays by inverse-Compton scattering of synchrotron radiation, the so-called synchrotron self-Compton (SSC) emission. Mfuphi presents this calculation in his work as well. He then goes on to discuss the results by comparing the sum of the SSC emission from pairs and absorbed GRS to the unabsorbed GRS.

LATEST NEWS FROM OUR CENTRE

Recent Conference Presentations

ICRC 2021

One of our very own CAPP members, Dr. Monica Barnard, has presented at the ICRC 2021 conference. The conference took place during the 12-23 July 2021, and was completely virtual.

View the conference's page here: **https://icrc2021.desy.de/**

Read more about what Dr. Monica Barnard presented at the conference in the pages to come or on our website using the link **https://www.uj.ac.za/faculties/science/capp/Pages/Latest-news-and-events.aspx**

Dr. Monica Barnard

Modelling Phase-resolved Spectra and Energy-dependent Light Curves of the Vela Pulsar to Scrutinize its GeV Emission Mechanism

Monica and her team presented a talk at the ICRC 2021 on the recent detection of the Vela pulsar in the GeV band up to ~100 GeV by both H.E.S.S. and the 100 GeV by both H.E.S.S. and the Fermi Large Area Telescope provides evidence for a curved spectral component in this band, distinct from the TeV pulsed emission seen by H.E.S.S. up to ~100 GeV by both H.E.S.S. and the 7 TeV. They predict energy-dependent light curves and phase resolved spectra using an extended slot gap and current sheet model in a force-free magnetosphere, invoking a step function for the accelerating electric field as motivated by kinetic simulations. Their refined calculation of the curvature radius of particle trajectories in the lab frame impacts the particle transport and resulting light curves and spectra. As a result their model reproduces the decrease of flux of the first peak versus the second one (P1/P2 effect), evolution of the bridge emission, near constant phase positions of peaks, and narrowing of pulses with increasing energy.

LATEST NEWS FROM OUR CENTRE

A Warm Welcome to Our Newest CAPP Members

Ms Tamador Aldowma has just been awarded the prestigious OWSD PhD fellowship. The Organization for Women in Science for the Developing World (OWSD) is a UNESCO organization (**www.owsd.net**).

Tamador Khalil Mansoor Aldowma, from Omdurman-Sudan, Lecturer at Omdurman Islamic University, Faculty of Science and Technology, Department Of Astronomy and Meteorology.

Ph.D. candidate for first-year 2021, under supervision of Prof. Soebur Razzaque.

Her research will be analyzing and modeling (Gamma Ray Burst) GRBs prompt and afterglow data in order to use GRBs as standard cosmological candles.

Thabo Msiza is a 25 year old aspiring Astrophysicist from a small town of Ekangala (about 53km from Pretoria), Gauteng.

Astrophysics has always been at the very core of his curiosity from the early stages of his life, being pulled in by the wonderful on screen work of Carl Sagan and Neil deGrasse Tyson.

He is in the first year of his Masters in a physics degree, doing research in Neutrino Physics, particularly, attempting to Prope high energy Neutrino Physics with a new beyond the standard model Physics.

Neutrinos prove to be a significant case study, promising new and improved ways of studying Astrophyisical sources.

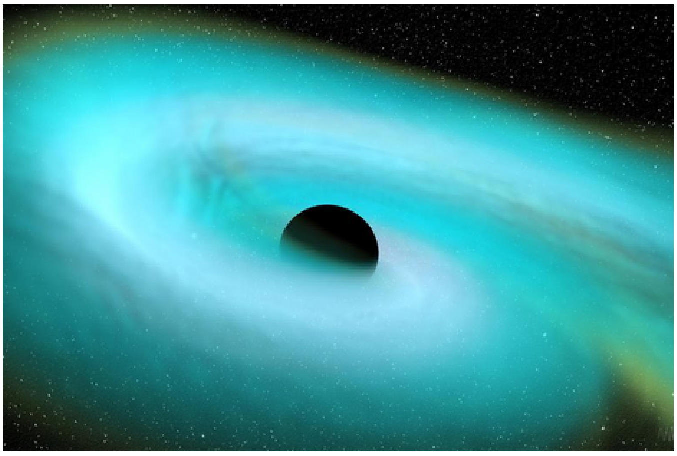
Luyanda Mazwi is 23 and born and raised in Johannesburg, Gauteng.

He did his undergraduate studies in Maths and Physics at the University of Johannesburg in 2017 and completed them in 2019. He then completed his Honours in Physics at UJ in 2020.

He is currently registered for his Masters in Physics at UJ. His research is focused on finding a connection or link between gravitational wave radiation (GWs) and short Gamma-ray bursts (sGRBs) from binary neutron star mergers in order to possibly estimate how many dual observations events (the act of observing both GWs and sGRBs from the same source) will occur and how often.

LATEST NEWS AND DISCOVERIES

Rare Mergers of Black Holes With Neutron Stars are detected by Gravitational-Wave Observatories for the First Time



Numerical relativity simulation of an NSBH binary merger by the MAYA collaboration, showing the disruption of the Neutron Star. Credit: Deborah Ferguson (UT Austin), Bhavesh Khamesra (Georgia Tech), and Karen Jani (Vanderbilt)

WRITTEN BY ANNA SAMARA LARMUTH

According to physicist Salvatore Vitale, gravitational-wave signals suggest black holes devoured their neutron star companions.

An international team of scientists, including MIT researchers, recently announced the discovery of a new type of astrophysical system: a collision between a black hole and a neutron star, which happen to be two of the densest and most exotic objects in the universe to date.

There have been reports of colliding black holes and colliding neutron stars, however, as of now no evidence had been found of a black hole merging with a neutron star.

In January 2020, just 10 days apart, scientists observed not just one, but two such rare events. Both produced gravitational waves that echoed across a wide area of the universe before reaching Earth.

Virgo in Italy and the Laser Interferometer Gravitational-Wave Observatory (LIGO) of the National Science Foundation detected gravitational waves from both collisions. As a result of the date on which each gravitational wave was observed, the events have been named GW200105 and GW200115, respectively. The two signals represent the final seconds of a black hole merging with a neutron star.

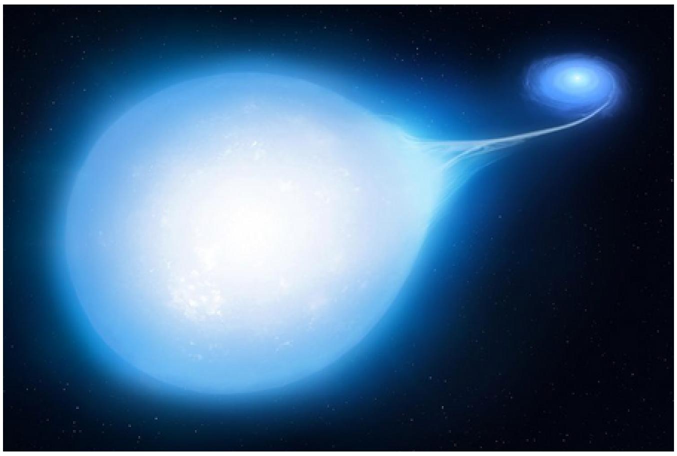
GW200105 is estimated to be around 9 times larger than the sun, together with an accompanying neutron star of approximately 1.9 solar masses. According to estimates, the two objects merged about 900 million years ago. It is thought that GW200115 formed when a 6-solar-mass black hole collided with a neutron star around 1 billion years ago. Black holes in both events were so large that they likely devoured their neutron stars completely, leaving very little to no light as a result.

SciTechDaily. 2021. Gravitational-Wave Observatories Detect Rare Mergers of Black Holes With Neutron Stars for the First Time. [online] Available at: <https://scitechdaily.com/gravitational-wave-observatories-detect-rare-mergers-of-black-holes-with-neutron-stars-for-the-first-time/> [Accessed 27 July 2021].

LATEST NEWS AND DISCOVERIES

Supernova Doom Revealed in Tragic Teardrop Star

WRITTEN BY ANNA SAMARA LARMUTH



Here is a visual representation of the HD265435 system, perhaps 30 million years in the future, where the smaller white dwarf will cause the hot subdwarf to appear in a teardrop shape. Credit: University of Warwick/Mark Garlick

The tell-tale signs of a teardrop-shaped star allowed astronomers to spot two stars spiralling to their demise.

White dwarfs nearby distort the star with their intense gravity, creating the tragic shape and eventually triggering an eventual supernova that will consume both stars. The star system is one of the very few in which a white dwarf star will one day re-ignite at its core.

A new astronomical study shows the two stars are in the process of spiralling in the direction of a Type Ia supernova - the type that helps astronomers determine how fast the universe is expanding.

A binary star system, known as HD265435, is located approximately 1,500 light-years away, with a hot subdwarf star and a white dwarf star orbiting closely each other at an astonishing rate of around 100 minutes.

Although researchers have knowledge that these supernovae can explode, they aren't exactly sure how they do. Researchers only know that these supernovae can explode because they have been seeing them in other parts of the universe.

Data used from NASA's Transiting Exoplanet Survey Satellite (TESS), allowed researchers to observe the hot subdwarf. However, they were unable to pick up on any sign of the white dwarf. The researchers were able to monitor the brightness of the hot subdwarf over a period of time, which further suggest that an object of a large size was indeed distorting the shape of the stare into a teardrop.

A key piece of data from the Keck telescope was determining that HD265435 was one of the very few supernova Ia progenitor systems that exceeded the Chandrasekhar limit.

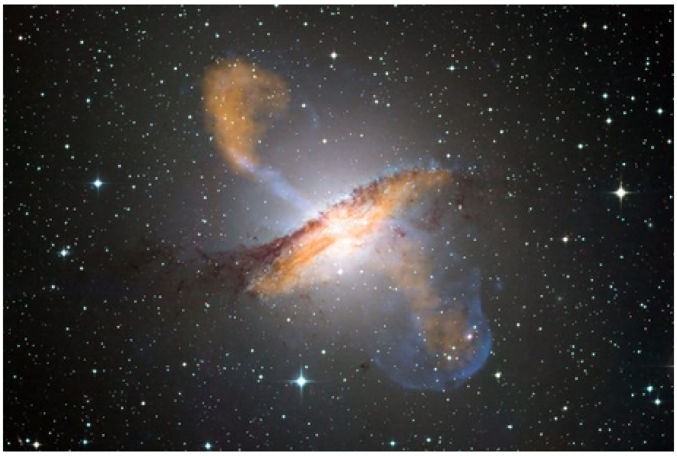
Having already spiralled sufficiently close to each other, the white dwarf will inevitably burst into a supernova in around 70 million years. Furthermore, based on this study, theoretical models predict that the hot subdwarf will contract and merge with its companion after a period of time.

SciTechDaily. 2021. Tragic Teardrop Star Reveals Hidden Supernova Doom. [online] Available at: <https://scitechdaily.com/tragic-teardrop-star-reveals-hidden-supernova-doom/>
[Accessed 27 July 2021].

LATEST NEWS AND DISCOVERIES

A Gigantic Jet Captured in Ground-Breaking Detail in the Heart of the Nearest Radio Galaxy

WRITTEN BY ANNA SAMARA LARMUTH

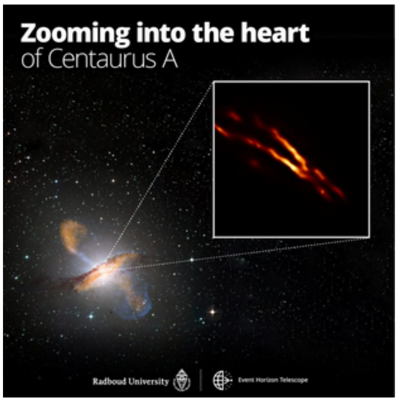


Known as Centaurus A, this galaxy is merging with its neighbour. Credits: ESO/WFI (Optical), MpIfR/ESO/Apex/ A.Weiss et al. (submillimeter); NASA/CXC/CfA/R. Kraft et al. (X-rays)

An international team of researchers have recently captured a gigantic jet in the heart of the nearest radio galaxy in ground-breaking detail. Researchers were able to precisely locate the position of a gigantic jet being created at the centre of a supermassive black hole. Most notably, the jet only seems to emit radiation at its outer edges, which challenges theory-based models of jets.

When considering radio wavelengths, Centaurus A is considered to be one of the largest and brightest objects in the night sky to date. A variety of radio, infrared, optical, X-ray, and gamma-ray telescopes have studied Centaurus A extensively since it was identified in 1949 as one of the first known extragalactic radio sources.

Capturing Centaurus A in such detail, allows researchers to study an extragalactic radio jet on a smaller scale than that of a day's travel of light for the first time. Researchers are able to see first-hand how a gigantic jet is born within a supermassive black hole.



This high-resolution observation of Centaurus A is ten times more frequent and sixteen times closer than previous high-resolution observations. Due to the capabilities of the Event Horizon Telescope (EHT), we can now link the huge scales of the source, which are 16 times the angular diameter of the Moon on the sky, to their origin near the black hole which spans only the width of an apple on the Moon!

The highest-resolution version of Centaurus A seen with the Event Horizon Telescope, combined with a composite color image of the entire galaxy. Credit: Radboud University; ESO/WFI; MPIfR/ESO/APEX/A. Weiss et al.; NASA/CXC/CfA/R. Kraft et al.; EHT/M. Janssen et al.

SciTechDaily. 2021. Gigantic Jet in Dark Heart of the Nearest Radio Galaxy Imaged in Unprecedented Detail. [online] Available at: <https://scitechdaily.com/dark-heart-of-the-nearest-radio-galaxy-pinpointed-by-event-horizon-telescope/> [Accessed 27 July 2021].

LATEST NEWS AND DISCOVERIES

Thousand-Year-Old Astronomical Mystery Solved by Massive Stellar Explosion

WRITTEN BY ANNA SAMARA LARMUTH

An electron-capture supernova 2018zd and a starburst galaxy NGC 2146 as seen through the Hubble Space Telescope. Credit: NASA/STScI/J. DePasquale; Las Cumbres Observatory

During a recent study, researchers have identified an electron-capture supernova, as a new kind of stellar explosion. An example of this type of explosion has been hard to come across in real life, as they have been speculated for 40 years by researchers. Supernovas of this type form when stars 8-9 times the mass of the sun explode. The researchers also shed a new light on the thousand-year mystery of the Crab Nebula, which was observed by ancient astronomers 1,000 years ago and evolved later into the supernova that we see today.

There are two kinds of supernovas – one being thermonuclear supernovas, which are those caused by white dwarf stars gaining matter after they form binary star systems. The other being core-collapse supernovas, where a black hole or neutron star is created when a massive star, 10 times the mass of the sun, runs out of fuel which further collapses its core. Theoretically, electron-capture supernovae may occur between the two types.

Over the years, researchers have developed models to predict what to look for in electron-capture supernovas. A recent study focuses on the supernova SN2018zd, as it meets the predictions of a star that should explode as an electron-capture supernovae. Not only does it meet the predictions of a star that should explode as an electron-capture supernovae, but it meets all six of the predictions, unlike other electron-capture supernovae which only meet a few of the predictions. SN2018zd meets the predictions; having a progenitor star that fits within the expected mass range, strong pre-supernova mass loss, an unusual chemical composition, a weak explosion, little radioactivity, and neutron-rich material.

The closest candidate for an electron-capture supernova was the Crab Nebula, which had an unusual composition. Unfortunately, researchers are unsure whether it would've been classified as an electron-capture supernova, as it happened close to 1000 years ago. However, the recent discovery of the supernova SN2018zd, gives researchers certainty that the 1000-year-old explosion could've been an electron-capture supernova.

SciTechDaily. 2021. Massive Stellar Explosion Illuminates Thousand-Year-Old Astronomical Mystery. [online] Available at: <https://scitechdaily.com/massive-stellar-explosion-illuminates-thousand-year-old-astronomical-mystery/>
[Accessed 27 July 2021].

You can view our website to see events, the latest news, images, and info regarding the research of our group members as they happen and when they happen.

www.uj.ac.za/capp

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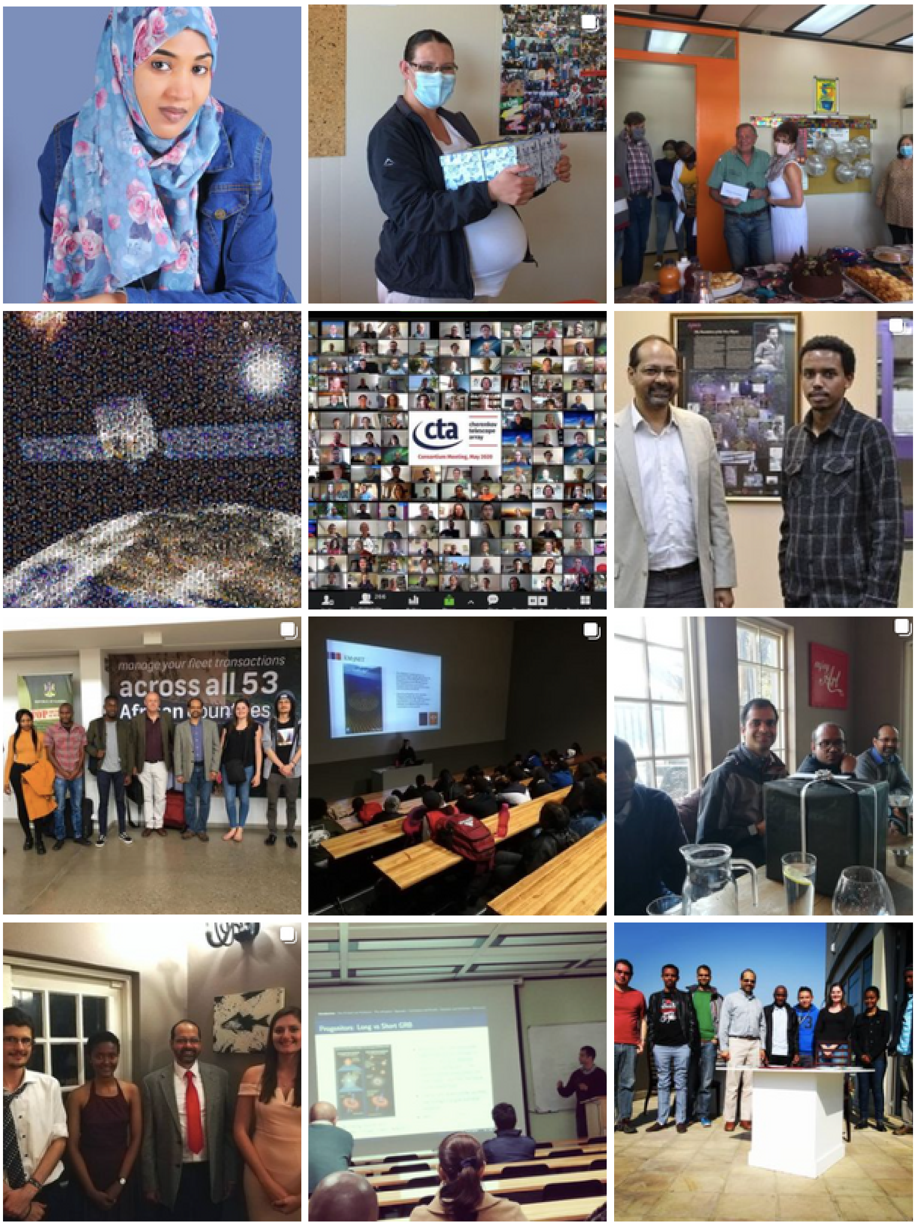
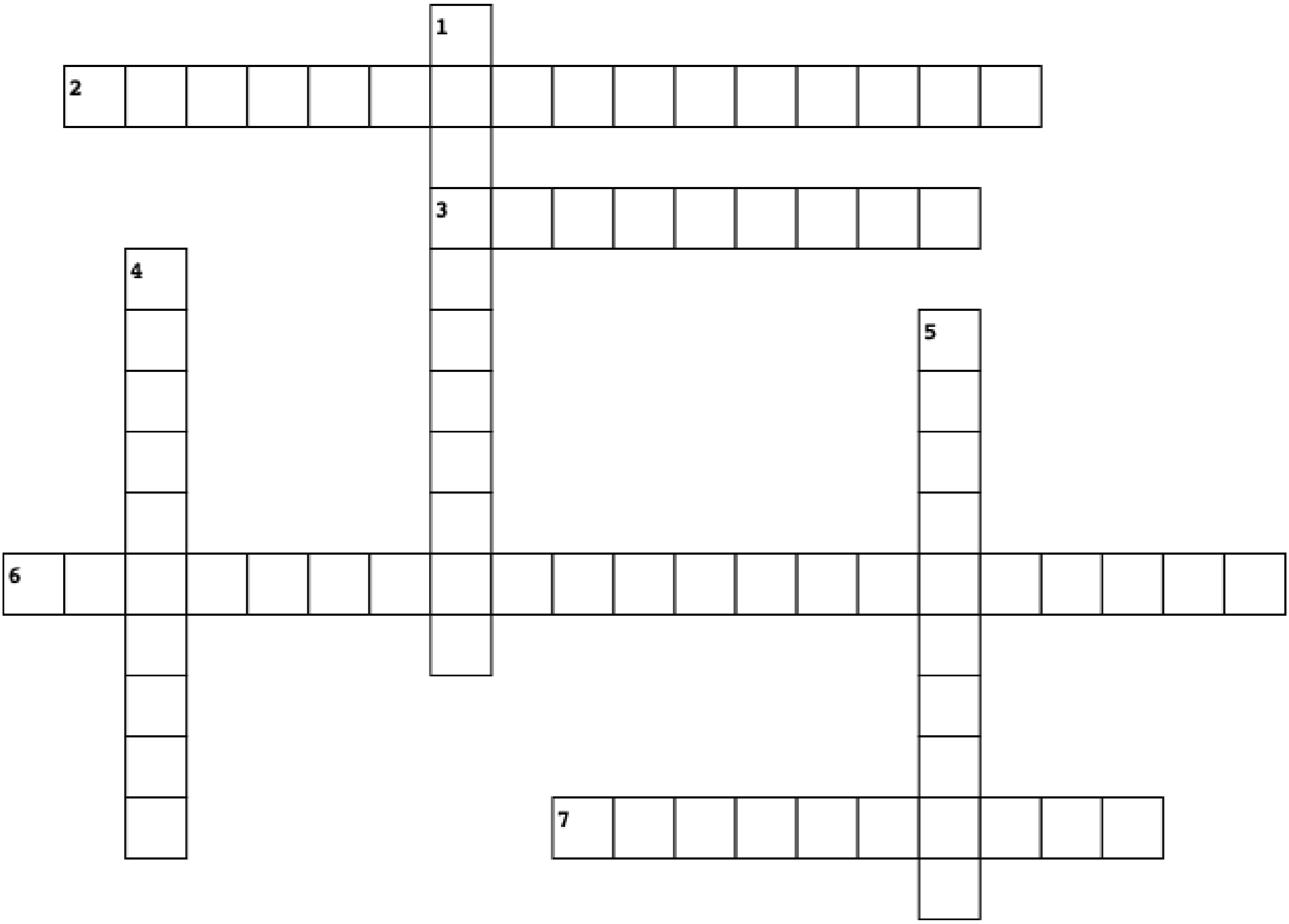


Astro-Physics Themed Crossword



Crossword Clues

Across

2. A type of stellar explosion ignited when atomic nuclei sop up electrons within a star's core
3. A powerful and luminous stellar explosion
6. The meaning of the acronym 'EHT'
7. Also known as NGC 5128 or Caldwell 77

Down

1. Core helium-burning stars at the blue end of the horizontal branch or have evolved even beyond that stage
4. A supernova remnant and pulsar wind nebula in the constellation of Taurus
5. Stars which are hot, dense remnants of long-dead stars

- **Hint:** Find clues to the answers by reading the '**Latest News and Discoveries**' articles