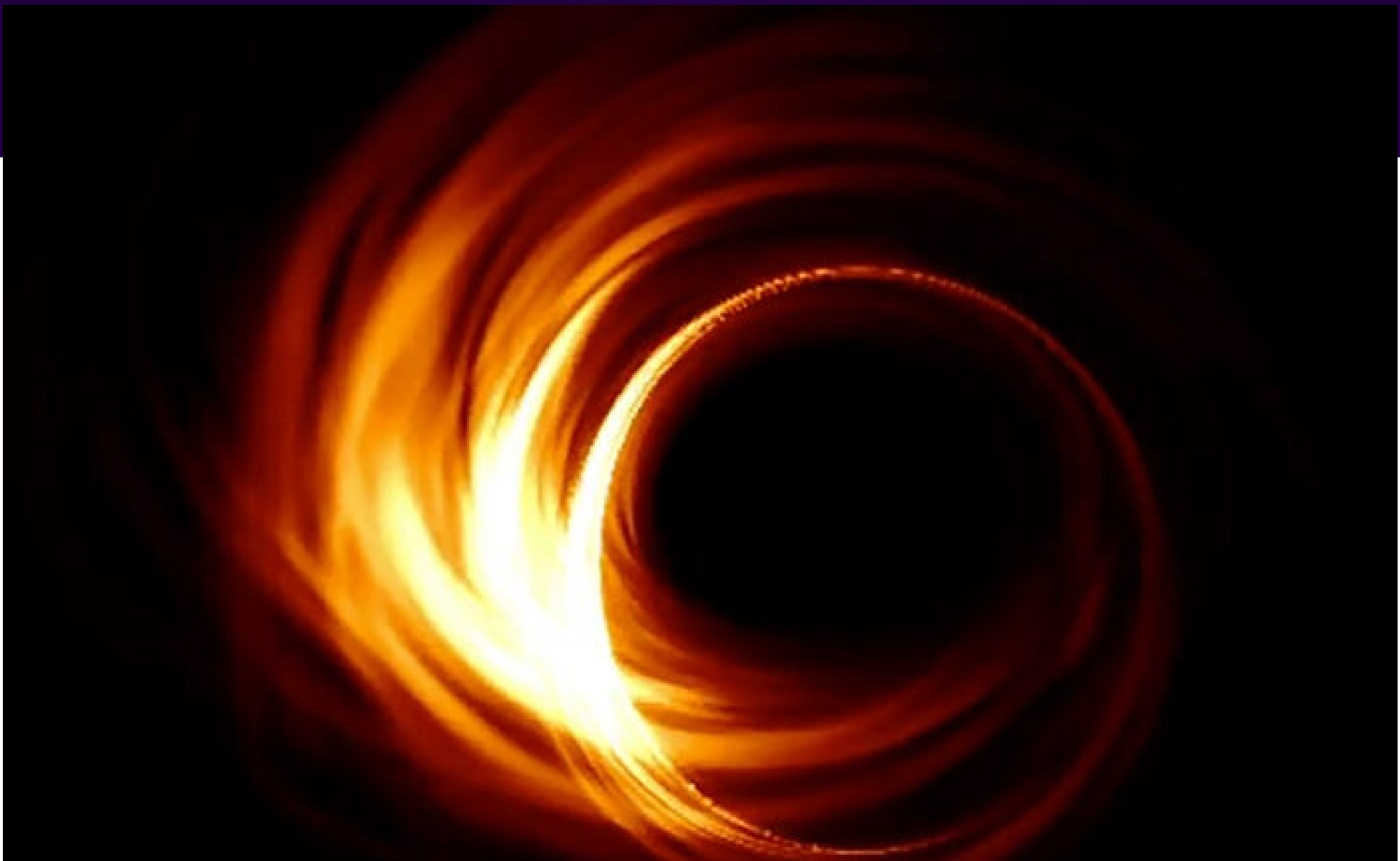
DECEMBER 2019 | VOL6

CENTRE FOR ASTRO-PARTICLE PHYSICS



(A computer simulation of how a supermassive black hole. Event Horizon Telescope/Hotaka Shiokawa, 2019)

NEWSLETTER OF THE CENTRE FOR ASTRO-PARTICLE PHYSICS
UNIVERSITY OF JOHANNESBURG
SIXTH EDITION
DATE: 11-12-2019

Designed by Jessica-Sheay Verrall

Centre for Astro-Particle Physics UJ CAPP

UNIVERSITY OF JOHANNESBURG

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 Astro-Particle 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.

A limited number of top-up bursaries are available for Honours, MSc and PhD students from the CAPP. Interested students should contact Ms Jessica-Sheay Verrall (capp@uj.ac.za) with their academic transcripts.

FOLLOW US

We now have a Facebook and Instagram page. Please help us grow by following us and sharing the news.

WEBSITE

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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Centre for Astro-Particle Physics

EMAIL

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LINKEDIN

UJ CAPP. Centre for Astro-Particle Physics

FOR MORE INFORMATION

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OBSERVATION OF INVERSE COMPTON EMISSION FROM A LONG GAMMA-RAY BURST

UJ Physics featuring in Nature

We are extremely proud to have Prof. Razzaque (director of CAPP) and Dr. Dirirsa (research fellow) featuring on this article that was published in the latest issue of the top journal Nature;

Caught in afterglow: The first detection of gargantuan light energy - tera-electron volts - from a dying star's gamma-ray burst named GRB 190114C, validates Inverse Compton emission theory.After about 20 years, scientists finally observe the elusive light they'd been waiting for.

More about the making of afterglow in the extreme environment of a gamma ray burst, at
https://www.eurekalert.org/pub_re…/2019-11/uoj-cia112219.php

The full article is under the latest news below.

#GammaRayBurst
#Astrophysics
#UJCAPP

Draw me a neutrino

KM3NET CHALLENGE: DRAW ME A NEUTRINO

Drawing contest for KM3Net

KM3NeT (Cubic Kilometre Neutrino Telescope) is a new generation water based Cherenkov neutrino detector, which is located at the bottom of Mediterranean Sea. This telescope has been distributed over three locations in the Mediterranean: one part in France, Italy and Greece coasts respectively. https://www.km3net.org/

ARCA stands for Astroparticle Research with Cosmics in the Abyss, and it will be installed at the KM3NeT-It site, about 100 kilometre off-shore the small town of Portopalo di Capo Passero on Sicily, Italy. This part of the telescope detects neutrinos in the 100 to 10^8 GeV (Giga electronvolts) energy range.
Neutrino flavor could be of three types: electron, muon and tau ones.

The University of Johannesburg (UJ) is full member of the collaboration since february 2018. The UJ group led by Professor Soebur Razzaque.

KM3NeT is having a contest for young children. The challenge: drawing the most creative, expressive, and original representation of a neutrino!

The contest ;
The KM3NeT Collaboration is organizing its first international challenge: a drawing contest. The Collaboration will provide information about what a neutrino is, its intrinsic properties, and its production in our atmosphere or in the vastness of our Universe. This information will help the participants to get to know the neutrino, its role in astrophysics and particle physics, and the work of our Collaboration to detect it.

KM3NET CHALLENGE: DRAW ME A NEUTRINO

Drawing contest for KM3Net

With this project, we aim at:· creating awareness of particle physics and astronomy to a young community that may become interested in science in the future· engaging and informing the families and teachers· introducing research and science in schools using an original approach· creating/reinforcing the link between the participating universities and research agencies with the schools and the public· promoting the science carried out by KM3NeT around the World.

In short:
Who?
Everyone! There are three different groups of participants:
- Group 'electron neutrino':pre-school and primary school
- Group 'muon neutrino': secondary school
- Group 'tau neutrino': adults

When?
The drawings should be submitted by March 15th 2020 and the winners will be announced in April 2020.

How?
Any format and technique is allowed as long as the project can be submitted as a PDF, PNG,or JPEG file on the contest website. The drawings can also be sent by mail to the hosting labs.

Detailed rules can be found on: http://wos.ba.infn.it

Contact for the national contest:
Jessica-Sheay Verrall
capp@uj.ac.za

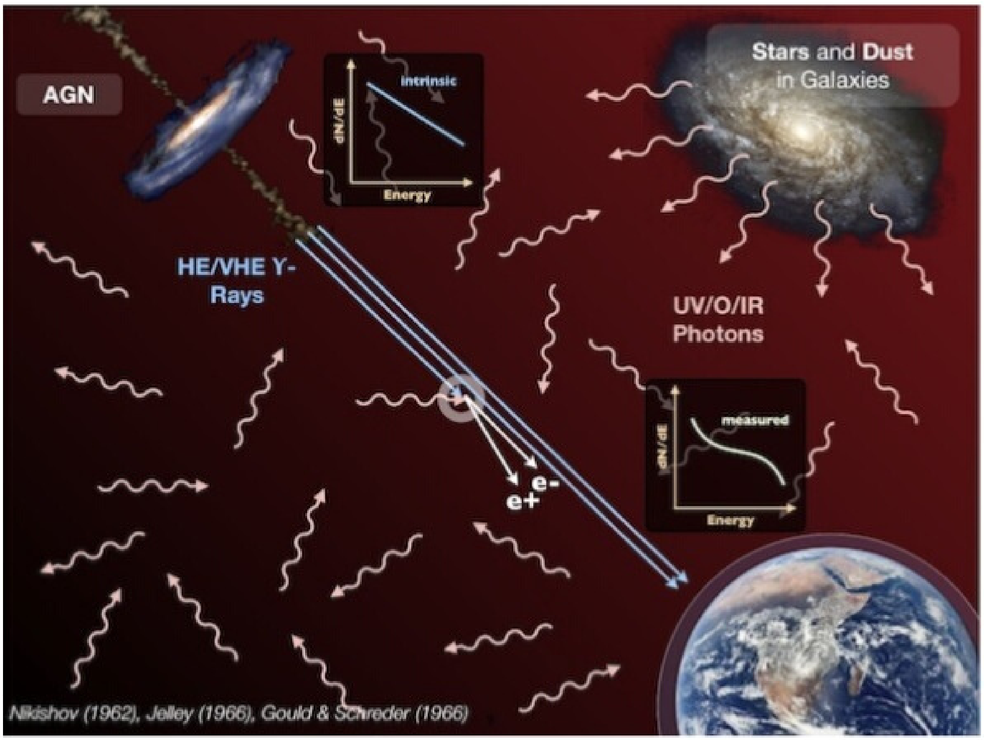
Dr. Feraol Dirirsa

COMPLETION OF DOCTORAL DEGREE

We are delighted announce the successful completion of another postgraduate degree in the Physics Department. Please join us in congratulating Dr Feraol Dirirsa and his supervisor Professor Soeb Razzaque on the completion of Feraol's doctoral degree.

We wish him all of the very best for his future scientific career!

Feraol's doctoral degree will be officially conferred at one of the Faculty of Science graduation ceremonies in March/April next year. The date of the ceremony will be communicated in due course.



Credit: Martin Raue 2011

Seminar given by Hassan Abdalla

PROBING FUNDAMENTAL PHYSICS AND COSMOLOGY USING GAMMA RAY OBSERVATIONS

Hassan Abdalla from the University of North-West's Centre for Space Research gave a seminar in the physics department.

Date: Thu 21 November

Time: 13h00-13h50

Abstract: Gamma-ray photons from distant astronomical objects with energies greater than the threshold energy for electron-positron pair creation are expected to be annihilated due to their absorption by Extragalactic Background Light (EBL).The talk consisted of particular challenges of gamma-ray observations compared to other electromagnetic wave-bands, the sources of gamma ray photons, and how the EBL gamma-gamma absorption may be exploited to probe fundamental physics and cosmology.

The latest news and discoveries

NEWS

Caught in afterglow: 1st detection of Inverse Compton emission from dying gamma-ray burst

EurekAlert!. (2019). Caught in afterglow: 1st detection of Inverse Compton emission from dying gamma-ray burst. [online] Available at: https://www.eurekalert.org/pub_releases/2019-11/uoj-cia112219.php [Accessed 4 Dec. 2019].

Credit to Ms Therese Van Wyk and Dr Feraol Dirirsa as the writers of this news story.

Galaxies lacking some Dark Matter?

Science News. (2019). 19 more galaxies mysteriously missing dark matter have been found. [online] Available at: https://www.sciencenews.org/article/19-more-galaxies-mysteriously-missing-dark-matter-found [Accessed 9 Dec. 2019].

Shine bright like a neutron star

ScienceDaily. (2019). A new theory for how black holes and neutron stars shine bright. [online] Available at: https://www.sciencedaily.com/releases/2019/11/191127161255.htm [Accessed 9 Dec. 2019].

Caught in afterglow: 1st detection of Inverse Compton emission from dying gamma-ray burst

A dying star emits intense flashes of light called a gamma-ray burst. Most days, the Fermi gamma-ray space telescope detects these flashes. About 20 years ago, scientists predicted that a gargantuan energy level - tera-electron volts - would be detected in burst afterglow.In January, the MAGIC telescopes on the Canary Islands observed light at this energy level for the first time. The theories predicting how such light would be produced, are now validated.Burst mechanicsWhen a star dies, its core collapses. While it collapses, the core shoots out hot plasma material at nearly the speed of light. Intense flashes of light called gamma-ray bursts result from these hot plasma jets.When telescopes on satellites observe an area of the night sky, they use two ways to recognise the bursts coming from dying stars.First, if the bursts last relatively long, from a few seconds to a few minutes, then they are called long-duration bursts. Second, such a burst starts with a 'bang' of very bright gamma-ray emission that pulses brighter and dimmer before it fades away. This is called the variable phase of its emission.The making of afterglowWhile the star's core is collapsing, the star is still rotating on its axis. At the same time, the core starts spewing the fast-moving jet of super-heated ionized matter, which radiates along the star's axis of rotation. It is this jet of ionized star matter that causes the gamma-ray burst from the dying star.As the jet radiates away from the star, it encounters resistance, even though this is happening in outer space. Pressure builds up and slows down the jet - and then starts producing shock waves. The shock waves are just like the sonic boom from a supersonic jet plane.The shock waves heat up electrons in the space environment around the jet. The heated electrons then start spiralling in the magnetic medium surrounding the jet. At the same time, the electrons emit light in all wavelengths of the electromagnetic spectrum.The electrons' light is called the afterglow radiation from the gamma-ray burst. It can last from days to months and is relatively easy to observe. It is explained by the synchrotron radiation model in physics.

Scientists routinely detect afterglow radiation at radio, optical, X-ray and gamma-ray wavelengths. The Fermi Gamma-Ray Space Telescope (FGST) can even detect afterglow light at giga-electron volt energies. A giga-electron volt is 10 to the power 9 electron volts.Elusive lightUntil January 2019 something had been missing from the afterglow picture, however. It was the light energy that scientists had been expecting to see for about 20 years.Researchers, including Prof Soebur Razzaque, predicted that afterglow from gamma-ray bursts would include far more powerful light. They said there would be light generated at the tera-electron volt level. Which is ten to the power 12, at least a thousand times more powerful than what the FGST had detected up to then.Prof Razzaque is the Director of the Centre for Astro-Particle Physics (CAPP) within the Department of Physics at the University of Johannesburg (UJ)."We said that the heated, spiralling electrons around the jet should be undergoing another process. This additional process is called inverse-Compton radiation. Also, this process would generate light with an energy level of a tera-electron volts."But it was not possible to validate this theory, because we had not detected light at that energy level yet," says Razzaque."Also, if we could detect such light, we hoped for a new window to study the extreme environment that gamma-ray burst afterglow is produced in," he adds.Caught in space and terra firmaOn 14 January 2019, that window opened up. Several telescopes on board space missions observed a gamma ray burst, which was named GRB 190114C. One of these telescopes was the Fermi Gamma-ray Space Telescope, another the Swift Space Observatory.Within hours, scientists realised GRB 190114C was out of the ordinary. They could see extremely high-energy photons, or light particles. The established synchrotron radiation model could not readily explain these photons.In fact, about a minute after the gamma-ray bursts' light got to Earth, the MAGIC telescope on the Canary Islands found what researchers had hoped for. The telescope had detected radiation of 1 tera-electron volt or more, lasting as long as predicted for a dying star.Later, the Fermi and SWIFT satellites also observed the burst's long-lasting afterglow radiation. For the first 10 days after the burst, many telescopes on Earth could detect the afterglow also. The radiation ranged from radio frequencies up to very high energy gamma-rays.Extreme environmentIn South Africa, Dr Feraol Fana Dirirsa started analysing gamma-ray data from the Fermi space telescope soon after the burst. He is a research fellow at the Centre for Astro-Particle Physics at UJ.Meanwhile, Prof. Razzaque worked with several other scientists from the Fermi, Swift and MAGIC telescope teams. They investigated modelling of multi-wavelength afterglow emission from GRB 190114C.It soon became clear that the high-energy light that MAGIC detected, had validated their predictions. This light was the tera-electron volt radiation from inverse Compton emission, identified for the first time.

"We observed a huge range of frequencies in the electromagnetic radiation afterglow of GRB 190114C. It is the most extensive to date for a gamma-ray burst," says Razzaque."We're elated that the theories around inverse-Compton emission are now validated. However, we need more observations from bursts like this. More data will help us to better understand the extreme environment that gamma-ray burst afterglow is produced in. Meanwhile, other theoretical models about gamma rays and stars are still waiting for direct observation," he adds.

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Prof Soebur Razzaque and Dr. Feraol F. Dirirsa from the University of Johannesburg's (UJ) Centre for Astro-Particle Physics (CAPP) contributed to this global research project.

CAPP within the UJ Department of Physics is a member of the Fermi Large Area Telescope Collaboration.

Prof Razzaque was partially supported by The South African Gamma-ray Astronomy Programme (SA-GAMMA), which is funded by the Department of Science and Technology / National Research Foundation, South Africa.

The University of Johannesburg provided fellowship support to Dr Dirirsa.

For email or broadcast interviews, contact Prof Soebur Razzaque, PhD, Professor of Physics and Director, UJ Centre for Astro-Particle Physics (CAPP) at srazzaque@uj.ac.za

Thanks to ESO/A. Roquette for the image of a gamma-ray burst at https://commons.wikimedia.org/wiki/File:Most_distant_Gamma-ray_burst.jpg.

Galaxies lacking some Dark Matter?

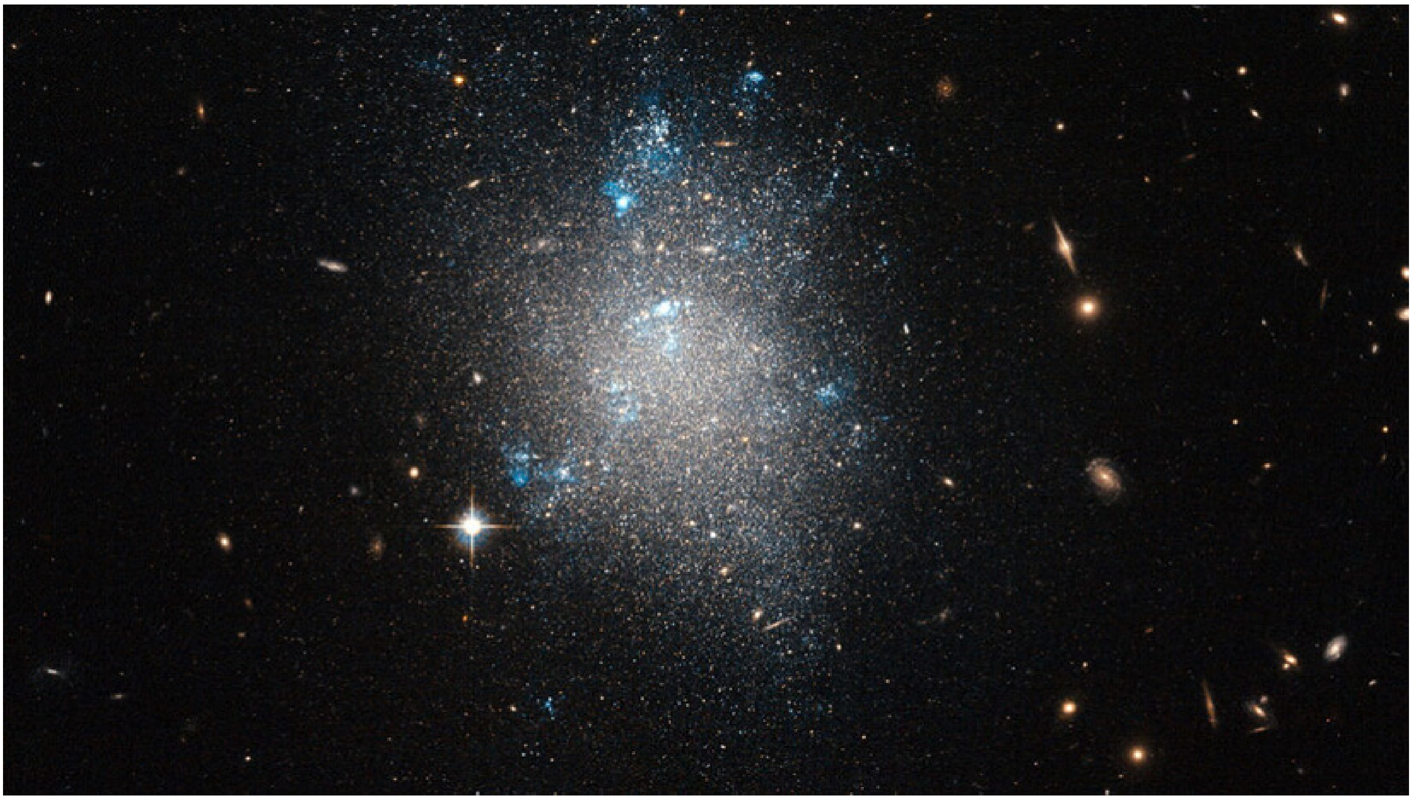
As we know, most of the galaxies in our universe are invisible. These galaxies have what's known as Dark Matter, which is an elusive mass that is key for holding together the gas and stars in a galaxy.

It has recently been found that 19 of the 324 dwarf galaxies studied, have much less dark matter than expected. These dwarf galaxies all being much smaller than the Milky Way. In previous studies it has been found that a dwarf galaxy would actually concentrate dark matter far more than their larger cousins. The smaller size of the dwarf galaxy would result in a weaker gravity, which has trouble holding on to tenuous clouds of gas in the galaxy. This would result in a shift of the balance of mass away from normal matter to dark matter.

The scientists calculated an estimate of how much of each galaxies mass is made up of normal matter and for every galaxy the total mass added up to more than the mass of the gas and stars. About 6 percent of the cases, there wasn't as much extra mass as expected.

All of the 19 dwarf galaxies lacking dark matter are about 500 million light-years away and five are in or near other groups of galaxies. Scientists are noting that perhaps their galactic neighbors have somehow siphoned off their dark matter, however the other 14 are far from other galaxies. Either these galaxies were born different, or some internal machinations such as exploding stars have upset their balance of dark matter and everyday matter or baryons.

It may also not be a case of missing dark matter, but maybe the dwarf galaxies have clung to their normal matter or may even have stolen some.



HUBBLE/ESA AND NASA

Shine bright like a neutron star

High-energy radiation is what makes neutron stars and black holes shine bright. Scientists believe that this high-energy radiation is generated by electrons that move at nearly the speed of light, but the process that accelerates these particles has remained a mystery.

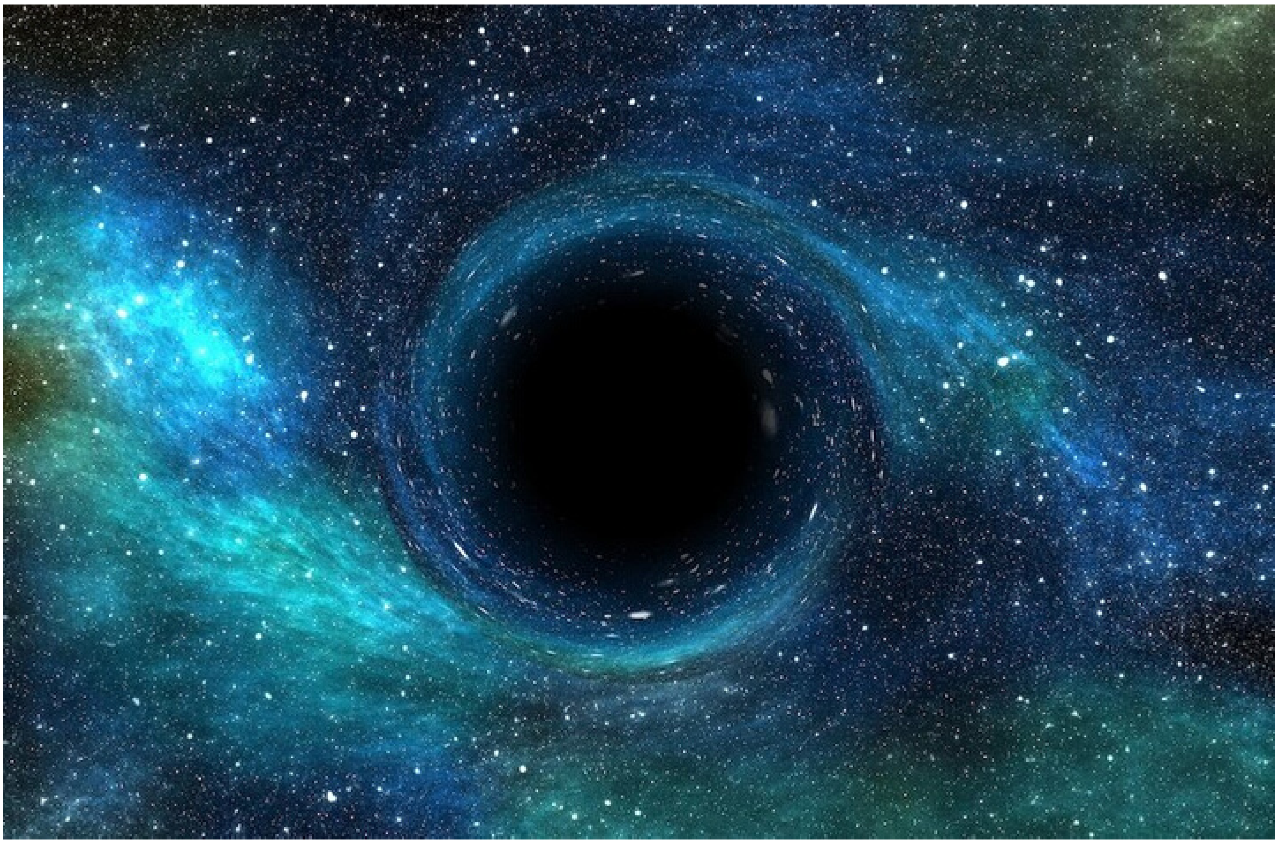
In a published study, in the December issue of The Astrophysical Journal, it was concluded that their energization is a result of the interaction between chaotic motion and reconnection of super-strong magnetic fields. A process in which the magnetic field lines tear and rapidly reconnect, known as turbulence and magnetic reconnection, conspire together to accelerate the particles, boosting them to velocities that approach the speed of light.

The region that hosts black holes and neutron stars is permeated by an extremely hot gas of charged particles. The magnetic field lines are then dragged by the chaotic motions of the gas resulting in the drive of vigorous magnetic reconnection.

Unfortunately scientists cannot predict the chaotic motion precisely. So the crucial point of the study was to identify the role the magnetic reconnection plays within the turbulent environment. Stimulations were conducted and showed that reconnection is they key mechanism that selects the particles that will be subsequently accelerated by the turbulent magnetic fields up to the highest energies.

These stimulations also showed that the particles gained most of their energy by bouncing randomly at an extremely high speed off the turbulence fluctuations. This means that when the magnetic field is strong, then the acceleration mechanism is very rapid.

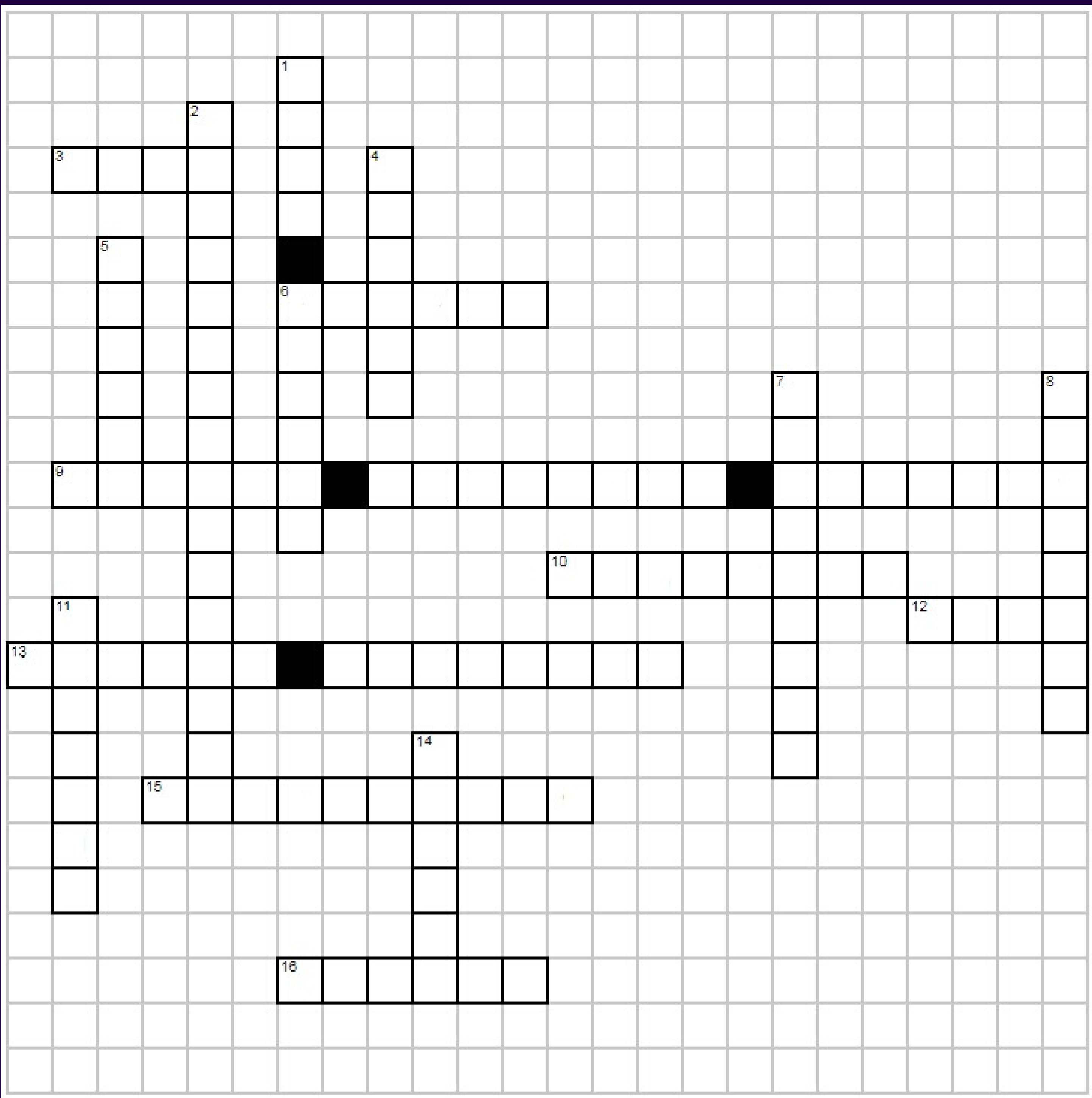
Being able to one day understand the extreme environment surrounding black holes and neutron stars could shed some additional light on fundamental physics as well as the functioning of our Universe.



Credit: © vchalup / Adobe Stock

ASTROPHYSICS CROSSWORD PUZZLE

Have a go at our new astrophysics themed crossword puzzle. Answers will be given on the last page our of newsletter.



Across:

3. An antiparticle has the same ... but different charge of a particle. (4)

6**.** If the atom were a football stadium, the nucleus would be a .... (6)

9. A compact region at the center of a galaxy that has a much higher than normal luminosity. (6, 8, 7)

10. E=mc^2 relates to which scientists? (8)

12. Who developed the modern idea of an atom, which has a nucleus at the center with electrons revolving round it. (4)

13. The name of the rate at which the universe is expanding, from the primordial "Big Bang". (6, 8)

15. Complete the quote by Einstein:" The most beautiful experience we can have is the ...." (10)

16.Co-inventor of calculus, a major contributor to the science of optics and a gifted mathematician. (6)

Down:

1. A form of matter thought to account for approximately 85% of the matter in the universe and about a quarter of its total energy density. (4, 6)

2. The study of oscillations in stars. (16)

4. The higher the photon's frequency, the higher its .... (6)

5. The astronomical unit used to measure the length or distance of an object in space. (6)

7. Father of the periodic table. (9)

8. The antiparticle of the electron. (8)

11. Where is the proton found? (7)

14. What colour in the visible light spectrum has the highest frequency? (6)

Crosswordhobbyist.com. (2019). Crossword Puzzle Maker | Make Your Own Crossword Puzzle. [online] Available at: https://crosswordhobbyist.com/create_crossword/659887 [Accessed 03. 2019].

Solutions for crossword puzzle

Across:

3. MASS
6.MARBLE
9. ACTIVE GALACTIC NUCLEUS
10. EINSTEIN
12. BOHR
13. HUBBLE CONSTANT
15. MYSTERIOUS
16. NEWTON

Down:

1.DARK MATTER
2. ASTEROSEISMOLOGY
4. ENERGY
5. PARSEC
7. MENDELEEV
8. POSITRON
11. NUCLEUS
14. VIOLET