A mystery everyone wants to solve

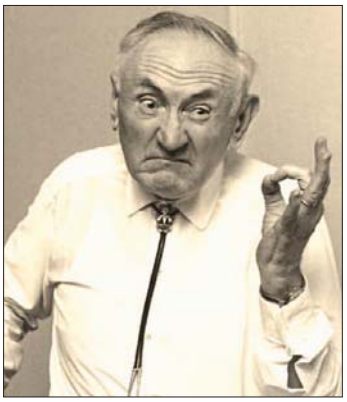
The quest for dark matter has drawn together the far ends of physics, says s ananthanarayanan

SCIENTISTS propose that there is a thing called dark matter, an invisible substance that dominates the universe because of what has been observed by astronomers and cosmologists. But what dark matter could consist of is still unanswered and has become the concern of particle physicists and String theorists and answers may come from the results of the Large Hadron Collider!

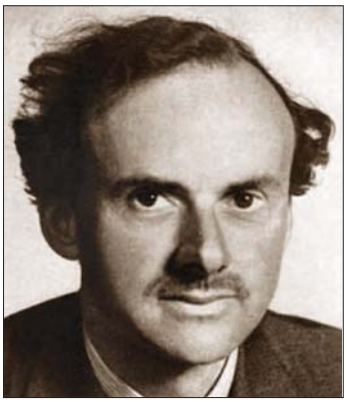
It was Fritz Zwicky, a Swiss-American, who discovered that not all the mass of the universe was visible. In 1933, he was studying the *Coma Cluster*, a group of more than 1,000 galaxies at a distance of 321 million light years. The light that comes from opposite ends of the cluster have differences of frequency, which shows that one end is moving towards us and the other end away from us, which is to say that the cluster is rotating like a spinning disk.

Now, things that are spinning will fly apart and in the case of a cluster of galaxies it is gravity that is keeping it together. Except that Zwicky found that the Coma Cluster was spinning so fast that the mass of the 1,000-odd visible galaxies could not account for the necessary force of gravity. He worked it out that at least 400 times the visible mass should be there as *dunkle materie*, or *dark matter*, to explain the gravity needed to allow the observed speed of rotation.

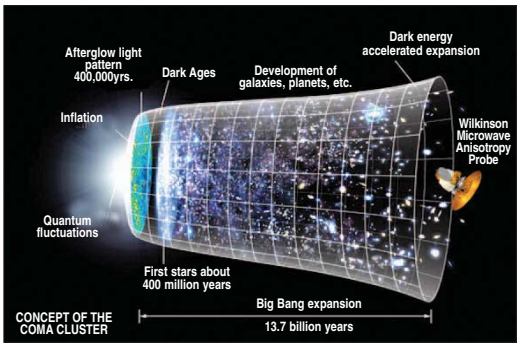
Apart from the speed of rotation of galaxies and clusters, there is other evidence, such as *gravitational lensing*, which calls for the presence of more matter than is visible or has been detected. The temperature distribution of hot gases within galaxies or clusters, again, calls from more mass to be present than is visible. The estimate of the quantity of dark matter in the universe is placed at about five times more than ordinary matter and a great question is about "what dark matter could consists of ".



Fritz Zwicky.



Paul Dirac.



Colour of darkness

One suggestion has been that it could be remnants of stars that have burnt out all their nuclear fuel and are no longer luminous. Or there could be the mass of gas that is yet to warm by coming together in the process of star formation. But these suggestions get eliminated because the generally successful theory of how the universe formed, the *Big Bang Theory*, makes an estimate of the total mass of the universe, which is in keeping with the mass of the visible universe. The age of the universe, which has been otherwise determined, and the intensity of background radiation that persists are also in agreement with the Big Bang. The existence of any more ordinary matter, like stars or gas, would thus overturn the current and soundly based theory. Dark matter must hence consist of some other form of matter, which has escaped detection for so long.

The candidate material for dark matter is the *Weakly Interacting Massive Particle* – something that has the mass for the gravitational effect that has been seen but still interacts very feebly with ordinary matter, which is why it has not been detected so far in nuclear reactions or in particle accelerators, or even in cosmic rays, which are the products of nuclear reactions in the sun or in far-off supernovae. Another property that dark matter material must have is that it should be stable, as it has been around for so long.

Many different particles are created in reactions in particle accelerators, but most of these are unstable and decay into *electrons* and *protons*, of which atoms are made, or *photons*, the particles of light, or *neutrinos*, which are very light, uncharged and weakly-interacting particles. Huge quantities of neutrinos were produced during the processes in early part of the Big Bang and are still being produced in energetic reactions in the sun and in supernovae. But neutrinos, despite being weakly interacting and abundant in number, have such little mass that they cannot explain the effect we are trying to understand. The quest for the nature of dark matter has become multidisciplinary and the Kavli Institute for Cosmological Physics at the University of Chicago, with the National Academy of Sciences recently organised a conference where cosmologists, particle physicists and observational astrophysicists came together to review where we stand.

The currently accepted framework of the nature of matter is the *Standard Model*, which explains the different nuclear and atomic interactions with the help of a set of basic elementary particles. Particles all have an intrinsic spin, or angular momentum, and are classified in two groups based on the nature of spin. Particles with spin measured in whole numbers, like 0, 1, 2 are one category, called *Bosons*, and the those which have spin in fractions like 1/2, 3/2, 5/2, are the other category, called *Fermions*.

The Standard Model is incredibly successful in describing atoms and nuclei, but it has this deficiency — it does not deal with the nature of mass and General Relativity. A sequel to the Standard Model, to overcome limitations, is the *String Theory*, which conceives not separate constituents of matter but one, multidimensional entity known as the *String*, which shows different properties, based on frequencies of vibration, and can account for everything that the Standard Model can explain and also goes further to propose solutions to areas that are beyond the Standard Model.

Supersymmetry

Scientists think physical laws are elegant and symmetric, like being the same from different viewpoints, or even when reflected in a mirror. One remarkable symmetry, proposed in 1928 by Paul Dirac, is the existence of an *anti-particle* for every *elementary particle*. Anti-particles are the same as the corresponding particle in all respects, except the charge. For instance, the *positron* is in all ways like the *electron*, except that it has a positive charge. So also the *anti-proton*, also called the *negatron*, is like the *proton* except for the charge. And the anti-proton and the positron can also form an atom, which should be like hydrogen in all respects. Anti-particles had been predicted by Paul Dirac, based on solutions of the *Dirac equation*, and their subsequent discovery in experiments consolidated the belief in theory and symmetry.

Supersymmetry is that every Boson must have a corresponding Fermion. The suggestion that supersymmetric partners should have the same mass is clearly not valid, as no such partners have been discovered so far. But there are bases to hold that the lightest supersymmetric particles, which may be Wimpy things we are seeking, would be 100 to 1,000 times as heavy as the proton. The LHC is an arrangement to attain very high energies where such particles may be found. The latest results show that supersymmetric particles would be heavier than the Higgs Boson. A similar symmetry that arises from String Theory, as this is called, and it is believed that they may be about 10 times heavier.

The writer can be contacted at simplescience@gmail.com

By accident

NGC 6872 is the biggest spiral galaxy yet discovered – five times the size of the Milky Way, writes rob williams

A SPIRAL galaxy system that spans more than 522,000 light years has been identified by a team of astronomers. The spectacular spiral galaxy, NGC 6872, is the biggest yet seen and astronomers earmarked it using archival data taken from the National Aeronautics and Space Administration's Galaxy Evolution Explorer (Galex) satellite.

NGC 6872 ranked among the biggest stellar systems for decades, but the new analysis has now crowned it the largest known spiral. The discovery indicates it is five times the size of the Milky Way galaxy.

The team of astronomers say a comparatively recent collision with another galaxy could be causing one of the outer arms of the spiral to spawn fresh stars that may eventually create a new galaxy. With astronomers from Brazil, Chile and the USA, the team was led by lead scientist Rafael Eufrasio who presented the findings recently at the American Astronomical Society meeting in Long Beach, California. "It's been known to be among the largest for two decades, but it's much larger than we thought," he explained.

"The galaxy that collided with the (central disc of NGC 6872) splashed stars all over the place — 500,000 light years away." He told the BBC that

the team had made the discovery by accident. "I was not looking for the largest spiral — it just came as a gift."

The Galex space telescope was designed to search for ultraviolet light that newly born stars put out and it was that feature that hinted that NGC 6872 was made much larger in size by a collision. The two galaxies are located around 212 million light years from earth.

The Independent London

Getting a grip on technology

A recent fair hosted by the Birla Industrial and Technological Museum turned out to be quite the infotainment package, writes debameeta bhattacharya

WHILE most beleaguered parents across the country prodded their upcoming Board-exam children to complete their academic obligations, some saw reason in sending their wards off to participate in a science fair hosted by the Birla Industrial and Technological Museum — a constituent unit of the National Council of Science Museums — for school and college students — between 8-12 January. There weren't any of the basic tabletop volcanoes or potted sunflower entries; instead, what was on view was from what one might imagine graces the pages of prestigious scientific journals — inventions developed for use in the wider world. And, mind you, their creators are still in high school or college, but would-be engineers all.

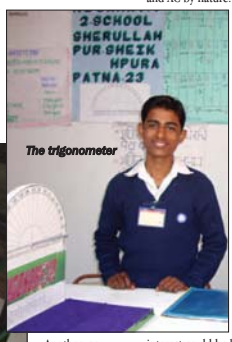
The Eastern India Science Fair is by far the biggest show about innovative models/exhibits by students in the region, providing a unique platform for showcasing the creative potential of youth. Participants represented Arunachal Pradesh, Assam, Andaman and Nicobar Islands, Bihar, Jharkhand, Manipur, Nagaland, Odhisa, Sikkim and West Bengal.

Various camps were organised on mechanics, gravitation, light, electromagnetic waves, electronics, life science, mask and pattern making, involving 195 schools (with 320 students with 78 guides) and 11 science/engineering colleges (63 students). The eye-catching charts, working models and other presentation techniques made the experience enthralling.

If one were to critically evaluate the projects from a layman's point of view, the result would be a tough ask. Nevertheless, there were a shortlisted few. Two projects by the Calcutta Institute of Engineering Management – one, an automatic submarine and the other high-performance solar cells. The submarine, being small in size, can used for both defence and attack and the concept of solar cells with photocatalytic coating, which increases cell durability by 20 years, is eco-friendly and possesses the quality of self-cleaning, is chemical-esistant and anti-reflectant. The concept was well-explained by Rishov Das, Ananya Chakrabarty and Laboni Saha.

Another project, by the Bengal College of Engineering, drew attention. It concerned the conservation of time and energy — the design and implementation of a microcontroller-based home and office appliance control system using GSM. The model was demonstated by Manashi Kumari Mitra, Anjana Roy and Sayanti Ghosh.

The footstep project



The trigonometer

Another, an experiment on power generated by footsteps by Aditee, Sana Zahra, Rumi Bandhopadhyay and Jaya Rani, involved a device reliant on bodyweight that moves an iron plate upwards and down, drove a crankshaft that further powered gear arrangements. This crankshaft then oscillated into a coil and a magnet moved into the hollow section of the coil, thanks to Faraday's Law of electromagnetic induction, current flowing through copper wires and AC by nature. A rectifier circuit used to convert it to DC and, finally, the battery being fed to store generated power proved to be non-conventional, renewable, eco-friendly, pollution-free and cost-efficient.

Some of the school projects were innovative, one interesting one being that put up by Md Zakiullah, a Class X student of KB Sahay+2 School, Patna. His project was a trigonometer that helps one calculate tedious problems in seconds.

Manohar Kumar, a Class X student of High School Dhamedha, Bihar, explained the concept of disaster management with a self-regulatory fire-management model. Unfortunately for many, the word "science" itself was enough to make eyes glaze over. Then again, lack of interest could be blamed on teachers because at the end it really boils down to one word — "presentation".

Overall, the projects and presentations were interesting and colourful, with inquisitive visiting school students across the eastern zone flooded the camp on all three days. From naming their models after political icons like Anna Hazare to taking tips from *3 idiots* and coming up with urine mobile chargers – the show had it all. The complete infotainment package.