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From the Big Bang, to Rings of Fire

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by

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What does the phrase '*big-bang*' conjure up in your mind?

The term unfortunately suggests to many that all matter once existed somewhere as a superdense ball of matter which suddenly exploded, scattering debris throughout space like an exploding bomb. But this picture is too simple and is plainly incorrect. Any presupposition that space already existed before the explosion and that the big bang was merely the mechanism that flung the stars and galaxies out into space is wrong. Many popular articles suggest that before the bang there was empty space, like an empty room, with a highly concentrated dot of matter at its centre. Not true!

The big bang is also concerned with the formation of space itself! There was no 'room' within which the explosion could occur. Analogies are inadequate but it is something like representing the early universe as bread dough expanding as it is baked. But note that in this analogy the dough is not 'matter' and the oven in which it is baking 'space', for the dough represents both space and matter. Initially the dough is concentrated together, but as the bread rises the dough expands and becomes less dense. If you could run the baking process backwards then every part of the bread would contract. Yet at every stage the bread is bread; it is only the density at all points which varies. If the universe is open (saddle shaped) and infinite now, it has always been infinite.

The big bang models will not permit us to do what Augustine forbade, namely, to ask what God was doing 'before He made heaven and earth'. The big bang epoch marks the beginning of *time* as well as of matter. Augustine argued that, like matter, time was God-created, and that before heaven and earth were made there was no time. The question, 'What was God doing *then*?' is without meaning. If there was not any time, there was not any *then*. Now to the punch-line. We should not be surprised to find that the observable universe is so large. No astronomer could exist in one that was any smaller!

Violent collisions often demarcate the appearance of galaxies in our early universe. Photons of light, traveling for over 10 billion years, often reveal myriads of galaxies with a tempestuous past: colliding galaxies in the formative stages of our Universe often appear to be the norm, rather than the exception.

What a grand sight to behold our own Galaxy, the Milky Way, with its hundred thousand million stars. To see those rivers of stars, with dark lanes or rifts which almost seem to split the lengthwise band of our Galaxy in two, is an unforgettable experience. These dark rifts emphasise an important point. It is not that they are empty patches out there; those rifts and patches are invariably vast clouds of dust which absorb any background starlight so dramatically that *all we see* is apparent emptiness. The effect is much the same as thick fog obscuring a traffic light.

For over 30 years, astronomers had debated on just how much matter between the stars was in the form of cosmic dust. One may think that dust simply reddens background light - as viewing the sun in a dust-storm - but tracing the presence, distribution and amount of dust grains in our Cosmos can be very frustrating: any reddening caused by the dust absorbing light can largely be compensated by the bluing caused by dust scattering!

Let me explain. Firstly, cosmic dust is very effective in scattering starlight. A simple analogy is in order. Our daytime sky appears blue through a process called Rayleigh scattering: the dispersal of sunlight by gas molecules in the earth's atmosphere. Rayleigh scattering discriminates very strongly among colours, blue light being scattered very efficiently. But the grains also absorb and redden starlight.

The space between stars is often filled with cosmic dust, whose temperatures may be as low as minus 253 C. These dust grains are tiny - with typical diameters less than a millionth of one meter, or equivalently a thousandth of a one millimetre. Cosmic dust may perhaps seem to be rather far removed from our everyday existence. But, on the contrary it is the very stuff of life! Are we not carbon-based beings, formed from the dust of our Earth? How did our solar system come into existence 4,5 million years ago?

Our Sun, obviously the most famous star in our skies, is a ball of gas where temperatures in the centre are estimated to be approximately 16 million degrees Centigrade. It was formed by the contraction, under gravity, of a giant interstellar cloud of gas ... and dust. The Earth and our Solar System's other planets are also great geoids formed of the same elements, but in different combinations. The study of interstellar gas and dust is, therefore, of immense importance.

The marriage of dust and gas is, in fact, a very firm one. As a consequence of the dust being so cold, the late Professor Mayo Greenberg of the Netherlands had predicted that the gas atoms and molecules in interstellar clouds would condense out on the dust like frost on a window in winter. This frost is bombarded by energetic light photons from distant stars and, by simulating the space conditions in his laboratory, Greenberg was able to demonstrate that the interstellar particles were extremely efficient factories for manufacturing very complex organic molecules which, when analysed, showed that interstellar dust contained just the kind of prebiotic molecules which were needed as the primeval building blocks for the origin of life on earth.

Enter the world's grandest infrared space telescope, the Spitzer Space Telescope, named after one of Princeton's foremost astrophysicists, the late Lyman Spitzer, Jr. The Spitzer Space Telescope is the last in NASA's **Great Observatories** Program; the first is *Hubble Space Telescope*, deployed by a NASA Space Shuttle in 1990. The second Great Observatory was launched and deployed by a Shuttle in 1991 and is known as the *Compton Gamma-Ray Observatory*. This mission continues to collect data on some of the most violent physical processes in the Universe, characterized by their extremely high energies. The third member of the Great Observatory family, the *Chandra X-Ray Observatory* (CXO), was deployed from a Shuttle and boosted into a high-Earth orbit, in July 1999. This observatory is observing such objects as black holes, quasars, and high-temperature gases throughout the x-ray portion of the spectrum. Finally, the *Spitzer Space Telescope*, launched in 2003.

The marvel of the Spitzer Space Telescope is that astronomers can actually see the radiation emitted from tiny molecules and minute grains of dust – instead of dark dust rifts and patches, one majestically views glowing curtains of dust! Herein the marvel: masks of cosmic dust clouds are unveiled using the Spitzer Space Telescope, often revealing the most intricate structure and detail.

Turn the eyes of the Spitzer Space Telescope toward our closest spiral galaxy, the majestic Andromeda Spiral - located at a distance of about 2.5 million light years from us. Our Milky Way Galaxy actually belongs to the 'Local Group of Galaxies', boasting some thirty members. The Local Group spans about 10 million light years across, and the largest spiral galaxy in it is Andromeda, with an estimated diameter of 140 000 light years.

The great American astronomer E.E. Barnard had photographed the Andromeda Spiral Galaxy in the late 1800s. In the photographs by Barnard, Edwin Hubble and many others, the Empress Andromeda, looked so quiescent; so tranquil – so calm. However, appearances can be so deceiving.

Images secured with the orbiting Spitzer Space Telescope reveal **two glowing rings of fire**. One ring - an outer ring - has a diameter of approximately 65 000 light years. The second ring immediately beckoned our attention; it betrayed a crucial secret. A secret kept *secret* for over 200 million years. The dimensions of this ring are some 4900 light years by 3300 light years. Why had it never been discovered before? This amazing inner ring is completely hidden, in optical light, by the luminous stars in the central bulge of the Andromeda Galaxy.

The results are contained in today's edition (October 19, 2006) of NATURE, the world's most prestigious scientific journal. Announcing the discovery are a team of astronomers from South Africa, France and the United States: David Block and Robert Groess (South Africa), Frederic Bournaud and Françoise Combes (France) and, from the Harvard-Smithsonian Center for Astrophysics in the USA, Pauline Barmby, Matt Ashby, Giovanni Fazio, Mike Pahre and Steve Willner.

What event could have caused these remarkable set of rings, whose centres do not coincide with the centre of the Andromeda Galaxy?

The penny dropped.

A *head-on galaxy collision* of the Andromeda Spiral Galaxy with its companion galaxy Messier 32! The Andromeda Galaxy has over two dozen companion galaxies, one of which was catalogued by the French astronomer Charles Messier as number 32 in his list (hence the name, Messier 32). The culprit in this awesome galactic “hit and run” is M32 colliding with the Andromeda Spiral! Think of a simple analogy - that of tossing a stone into a pond of water. Rings or ripples are created, travelling outward with time.

French team members Frederic Bournaud and Francoise Combes began to simulate the history of the Andromeda Spiral. Using highly sophisticated computer codes, it was discovered that Messier 32 has indeed collided almost head-on with the Andromeda Galaxy, creating the remarkable set of off-centered rings observed by the Spitzer Space Telescope.

Messier 32 had impacted the disk at over 250 km/s, creating two rings of fire, whose outward expansion velocities are about 50 km/s and 18 km/s respectively. In cosmological terms, the time of collision is remarkably short: only 200 million years ago. On Earth, the continents had not yet separated but dinosaurs indeed roamed freely.

It was an astronomical task – in the truest sense of the word – to capture the Andromeda Spiral Galaxy with the Infrared Array Camera (IRAC) on-board the Spitzer Space Telescope. That galaxy covers such a huge angular size in the sky: over 6 full moons. The field of view with the infrared camera IRAC is reasonably small, and so the telescope was moved in 700 different directions to cover the entire galaxy! The discovery image published in NATURE contains 3000 individual frames secured during the 700 different pointings, with a total exposure time not of 1 second, or 2 seconds, but over 50 hours!

From the stunning photographs or snapshots of our universe showing our once very hot (now very cold) radiation which had been travelling for more than 14 thousand million years, astronomers can study photons of light emitted only 300 000 years after the Creation Event. The coldest radiation detected in our cosmos is at minus 270 C. I well recall front-page newspaper headlines, such as: “What we have found is evidence for the birth of the universe. It is like looking at God.” Those unique snapshots led to John Mather and George Smoot winning the Nobel Prize in Physics for 2006.

But not only can astronomers study the glow from the Big Bang. There are other glows.... through the eyes of the Spitzer Space Telescope, dust grains in our Milky Way and other galaxies can be studied in emission – grains glowing in all their brilliance and splendour. The inner ring of dust and gas in the Andromeda Galaxy *majestically glows* through the eyes of the Spitzer Space Telescope.

One of the world’s foremost experts on galaxies, Professor Kenneth Freeman (Fellow of the Royal Society), has this to say about the Block et al. discovery published on October 19 in NATURE:

“The findings, through the eyes of the Spitzer Space Telescope, of a head-on collision in the Andromeda Galaxy ranks as one of the most important discoveries yet made concerning that galaxy’s history, ever since Charles Messier catalogued it as a diffuse object on August 3, 1764.”

The hidden inner ring of fire, hidden by millions of stars in the bulge of the Andromeda Galaxy, was unveiled to the world today, October 19, through the infrared eyes of one of the world's greatest space telescopes, the Spitzer Space Telescope.

NOTE: On the day of publication of NATURE on October 19, a public lecture will be held in Johannesburg at the Wits Theatre on the WITS University campus at 7pm.

Title: ASTRONOMERS SOLVE A 200 MILLION YEAR OLD RIDDLE.

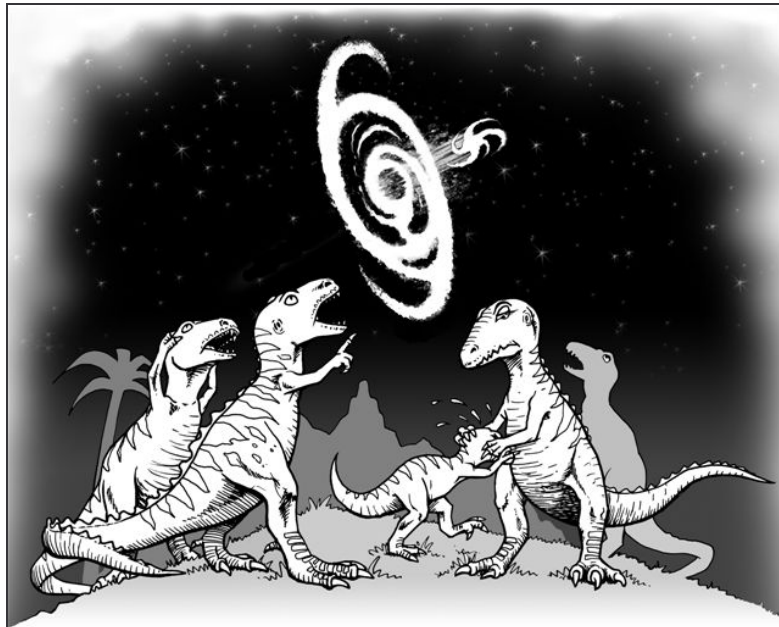
Present at the lecture to elucidate the discovery to the public will be Dr. Giovanni Fazio (Harvard) and Professor David Block (WITS).

Booking at computicket is essential, to secure a seat.

David Block's Webpage:

www.davidblock.com

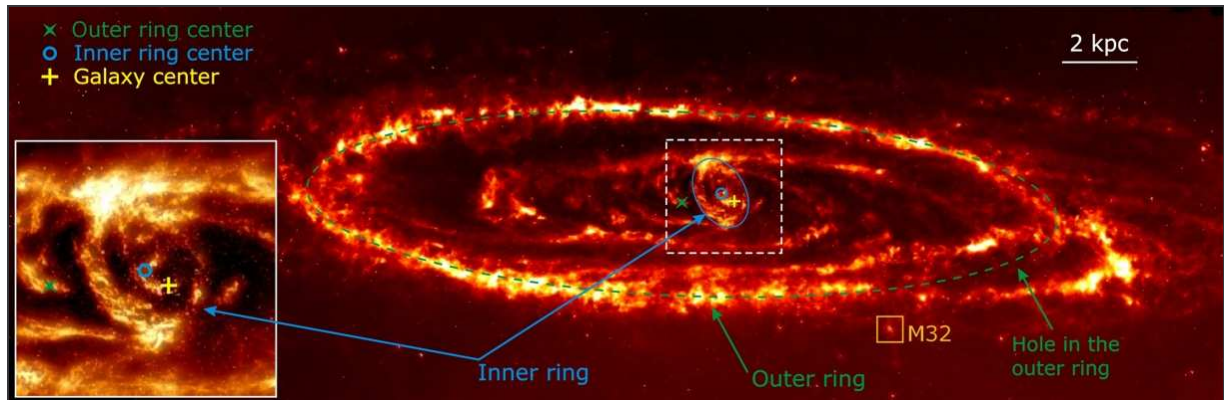
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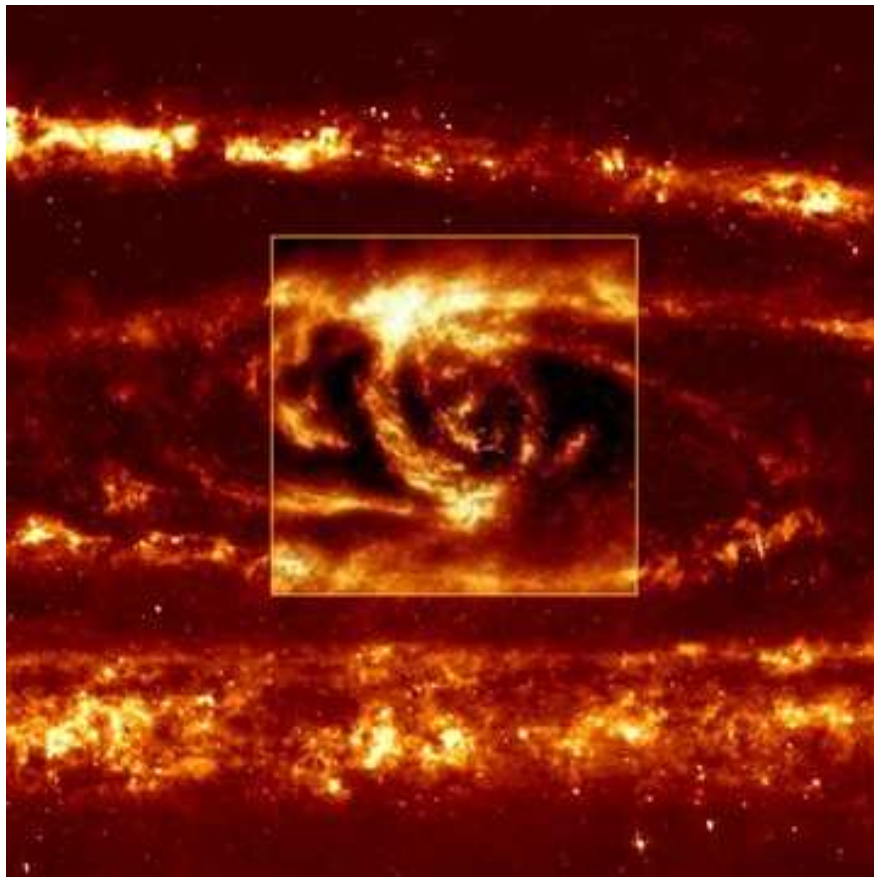
A schematic of an almost "head-on" collision in the Andromeda Spiral Galaxy, 210 million years ago. Courtesy Cobus Prinsloo.



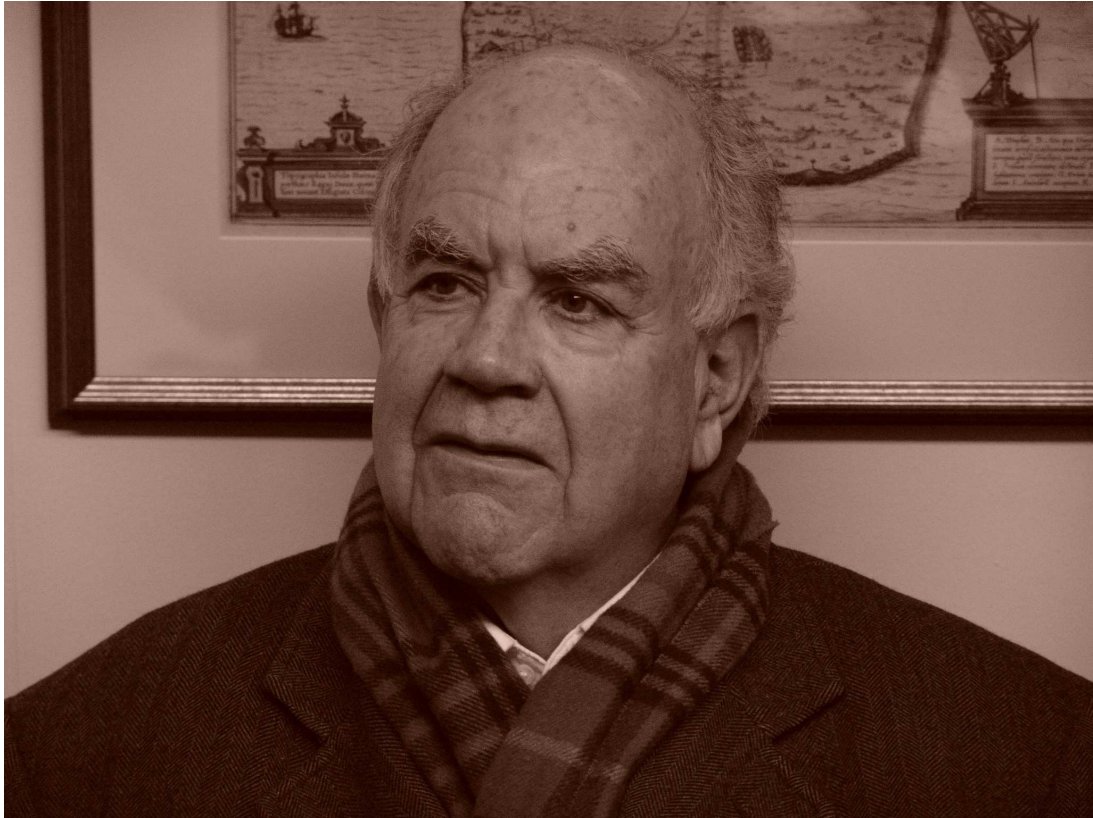
An optical photograph of the Empress, or the Andromeda Spiral Galaxy. The galaxy lies 2.5 million light years distant, and is about 140 000 light years in diameter. A team of South African, French and US astronomers report in the October 19 edition of NATURE that this galaxy was involved in an awesome, near 'head-on' collision. The culprit: a companion galaxy (seen below centre) plunged almost through the disk centre of the Andromeda Galaxy, creating two glowing rings of fire, which cannot be detected in optical photographs. Image copyright: DAVID MALIN/CALTECH.



Glowing rings of fire observed in the Andromeda Spiral Galaxy. The outer ring has a diameter of 65 000 light years. The newly discovered inner ring betrays the signature of a violent head-on collision, as the companion galaxy M32 plunged almost “head-on” near the centre of the disk of the Andromeda Galaxy. The Spitzer Space Telescope was pointed in 700 different directions to secure this image, which contains 3000 individual data frames. Image courtesy: NATURE



The inner ring of fire, discovered in the Andromeda Spiral Galaxy by a team of South African, French and US astronomers using the Spitzer Space Telescope, betrays the signature of a head-on collision. The violent, near head-on collision is estimated to have occurred about 200 million years ago, whilst dinosaurs roamed the Earth. Image credit: Courtesy: R. Groess and NATURE.



Professor Giovanni Fazio, Principal Investigator of IRAC (the camera on board the Spitzer Space Telescope which was used to make the discovery published in NATURE - October 19, 2006), is personally flying to South Africa to address an International Astronomy Press Conference at WITS, as well as to deliver a public lecture in Johannesburg. The public lecture will take place at the WITS THEATRE on the WITS CAMPUS on October 19 at 7pm. The title of the lecture will be: "Astronomers solve a 200 million year old Riddle." Bookings at computicket are essential to secure a seat.