

# Getting gooey in the middle

**A neutron star, the densest known form of matter, is found to have a superfluid core, writes ananthanarayanan**

**CRAIG** Heinke and others at the University of Alberta and Wynn Ho and team at the University of Southampton have taken a peek into the interior of *Cassiopeia A*, the remains of a supernova that was seen 300 years ago. The peck confirms a bizarre conjecture, that the centre of such massive and super-dense remnants of *supernovae* harbour a *superfluid* core, as they are about to report in the *Monthly Notices of the Royal Astronomical Society*. The same results will also appear shortly in *Physical Review Letters*, reported by Dany Page at the National Autonomous University of Mexico and colleagues in the USA and were also arrived at by a group headed by Dima Yakovlev from the Ioffe Physical Technical Institute in St Petersburg.

The end of the lifetime of a star is when it runs out of fuel for its nuclear fires and it collapses under its own weight. A similar collapse happens several times in the star's lifetime, when it superheats and expands, to cool by expansion and then collapse. The collapse heats the star and again ignites the nuclei of atoms in its core to fuse, or merge to form atoms of other elements, emitting fabulous energy in the process. The heating causes expansion, which results in cooling and collapse. But when the atoms have all fused and formed metals that can no longer form stable combinations, usually after the final explosion as a supernova, there can be no expansion phase and the collapse continues.

If the star was massive enough to start with, the collapse can strip atoms of their electron exterior to create a gas of charged particles and, with even greater pressures, the positively charged protons in the nuclei of atoms combine with electrons to become neutrons. Neutrons, which are uncharged and do not mutually repel, can be crushed further together till the matter of the star is tightly packed and cannot get any smaller only because of other effects which prevent matter from getting completely closer together.

This core of neutrons, which is then at a tremendous temperature, also expresses any

rotation momentum of the original star, in the form of extremely rapid rotation. We may have seen circus artistes — once set spinning with their arms outstretched, they begin to spin suddenly faster just by drawing their arms inwards. The reason is that momentum of rotation depends on how far apart the parts of the rotating body are. If the same momentum has

maelstrom in the neutron star's vicinity which flashes like a lighthouse, due to the rotation of the core.

**Superfluids**  
There is friction or resistance to relative motion in the case of all matter in contact. This is because of electrical and other forces that act at the atomic level, which is where, finally, all contact between objects, or even atoms and molecules, takes place. There is thus some viscosity or resistance, in the case of fluids, which is a burden when driving liquids through pipelines or even our blood through our veins and arteries. Still, at extremely low temperatures, it has been seen that substances like liquid

the temperature of the material. But as the material is cooled, the bulk of the particles comes down to the lowest energy levels, with very few at higher levels. Now, there is a fundamental law of physics that in the case of nuclear particles, which have a quality called spin, of  $\frac{1}{2}$ , no two particles in a system can occupy the same energy level. But if the spin is 1 or 2, in place of  $\frac{3}{2}$ ,  $\frac{5}{2}$ , etc, which are odd multiples of  $\frac{1}{2}$ , there is no restriction.

When such a material is cooled then, although the particles take the lowest energy levels, only one can be at each level and the particles, in principle, are *distinct*. This is unlike a material where the rule does not apply and all the particles can bunk down at the same energy level and become *identical*. When this happens, the mass of identical particles, by the rules of mechanics for very small particles, begins not to interact but to behave in cohesion, as if they were all one extended particle.

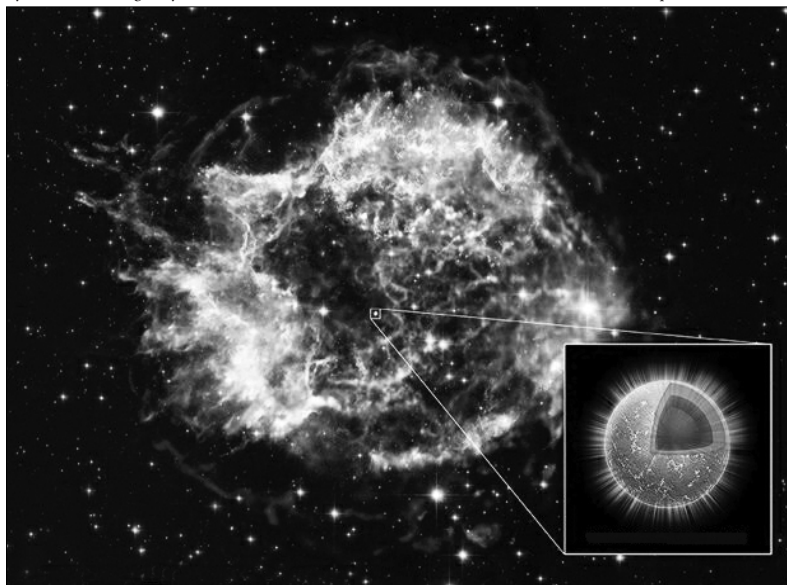
Now neutrons and protons have a spin of  $\frac{1}{2}$  each and cannot form superfluids. This is also true of most materials which are unable to be superfluids for a variety of reasons that prevent them. But the helium nucleus, which has two protons and two neutrons, has spin of  $4 \times \frac{1}{2} = 2$ , and such particles in a group are allowed to occupy the same energy level, and it is in helium that superfluidity was first observed.

**Neutron stars & superfluids**

The idea has been around since 1959 that at the pressures in the core of neutron stars, helium nucleus-like particles of whole number spin and, hence, superfluidity can arise. "We knew that it was there, our models had it all included before, but we did not have the data to actually hang our coats on," said Madappa Prakash of Ohio University, a co-author of the paper in *Physical Review Letters*.

But last year, Craig Heinke and Wynn Ho noticed something surprising about *Cassiopeia A*, a neutron star in the *Cassiopeia* constellation and 11,000 light years from the earth. At over two million degrees Centigrade, data from the Chandra X-ray telescope showed that the neutron star was cooling a whole four per cent in just 10 years, which was faster than it should have been. The theory of how neutron stars cool is that the neutrons decay into protons and electrons, giving off nearly massless particles and very weakly interacting with what are called *neutrinos*, which escape and carry energy away. But neutron decay is a slow process and cannot account for so much heat loss.

But if the neutrons formed a superfluid, then there were conditions that allowed massive neutrino



The neutron star at the core of X-ray activity.

to show in parts that are closer together, then the body needs to spin faster. A star consists mainly of gasses spread across hundreds of light years of space. Even if the star were to have the slightest rotation, when all its mass is compressed within a few kilometres, in a neutron star we can imagine that the speed of rotation would become rapid! With rapid rotation, charged particles in its insides and tremendous heat, there is a raging X-ray

helium, which are normally regular liquids, seem to lose all viscosity or resistance to flow. Helium set swirling in a vessel will, thus, continue to swirl forever and a fountain, once set going, will keep going.

The reason for this effect, *superfluidity*, is now understood because of the helium nucleus consisting of four nuclear particles, two protons and two neutrons. In any material, the particles are distributed at various energies, according to

production and sizeable energy drain. The observation of rapid cooling is then a pointer to the presence of superfluids in neutron stars and the different groups started working on the idea. If *Cassiopeia A* continues to cool at this rate for the next 10 years, this will confirm the presence of superfluids in its core.

The writer can be contacted at simple-science@gmail.com

# We're all aliens...

**The mystery of how the building blocks of biology came to be on earth may finally have been solved, says steve connor**

AS scientific mysteries go, this is the big one. How did life on earth begin? Not how did life evolve, but how did it start in the first place? What was the initial spark that lit the fire of evolution? Charles Darwin solved the mystery of life's wondrous diversity with his theory of natural selection, but even he was flummoxed by the ultimate mystery of mysteries: what led to the origin of life itself?

In trying to answer the problem, scientists have turned to the stars, or at least the "builders' rubble" of meteorites and comets left over from the formation of our solar system some five billion years ago. These space rocks, they believe, could help to explain why life began here on earth.

In fact, a growing body of evidence is now pointing to deep space as the possible source of the raw materials that formed the building blocks of life. The latest study, which focused on a class of meteorites that fell on to the Antarctic ice sheet, also suggests that life's origins may have been extraterrestrial. An analysis of the meteorites has revealed that these rocks can be induced, under high pressures and temperatures, to emit nitrogen-containing ammonia, a vital ingredient for the first self-replicating molecules that eventually led to DNA, the molecule at the heart of all life.

"These particular meteorites have been preserved in the ice and are found pristine — that is, they show less terrestrial contamination," said Professor Sandra Pizzarello of

Arizona State University, who led the meteorite study published in the *Proceedings of the National Academy of Sciences*. "What is important is the finding of abundant ammonia. Nitrogen is an indispensable ingredient for the formation of the biopolymers, such as DNA, RNA and proteins, on which life depends, and any theory that tries to explain life's origin has to account for a supply of 'usable' nitrogen. Therefore, its direct delivery as ammonia and in relatively large amounts from the nearby asteroids could have found a 'prebiotic venue' on the early earth."

"Tests have also shown that the nitrogen in the ammonia released by the meteorite is composed of unusual isotopes, indicating an extraterrestrial origin rather than contamination from a terrestrial source.

Professor Pizzarello and her colleagues believe similar meteorites falling to earth about four billion years ago could have produced a constant and replenishable supply of ammonia, and hence nitrogen, which was so necessary for the formation of the first self-replicating molecules.



An artist's impression of the heavy bombardment period.

bombardment period" from 4.5 billion to 3.8 billion years ago. However, this bombardment of meteorites may have actually come with a silver lining, given that many of these space rocks would have carried the relatively delicate organic molecules necessary for life to get started.

Earlier studies have already confirmed that meteorites contain many different kinds of organic molecules, such as the amino acids

with the building blocks needed for life. It adds a further piece to the jigsaw puzzle."

**Making an impact**

Scientists estimate between 40,000 and 60,000 tonnes of meteorites and other cosmic debris land on earth each year. About four billion years ago, during the period of the "heavy bombardment", the amount would have been much higher. Scientists study meteorites

to understand the evolution of the solar system, but these lumps of space rock may also tell them something about the origin of life here on earth, and possibly on other planets.

**The Murchison meteorite**

This large meteorite fell to earth on 28 September 1969 near the town of Murchison in Victoria, Australia. It is one of the most studied meteorites and its value lies in the fact that it was found immediately after it landed, thus limiting the risks of terrestrial contamination that could confuse any chemical analysis. Exhaustive tests on the rock have revealed that it contains a rich variety of organic molecules, such as amino acids, which are the building blocks of proteins, and nucleobases, found in DNA, the vital molecule of inheritance. Many scientists believe that the meteorite provides strong evidence of an extraterrestrial origin of life's building blocks.

**The ALH 84001 meteorite**

This meteorite was found in 1984 in a region of Antarctica called Allan Hills. There is no dispute that it came from Mars and that it landed on earth many thousands of years ago, but there is great controversy over claims made in 1996 by National Aeronautics and Space Administration scientists that the meteorite showed evidence of fossilised life forms that may have originated on the Red Planet. The potato-sized rock contains traces of "microfossils" that could have come from extraterrestrial microbes, they claimed. Others, however, question whether these traces of life exist.

The Independent, London

## TENDER

**SHORT TENDER NOTICE NO. 57-58/2010-2011**

Sealed Tenders are invited by the Managing Director, West Bengal Agro Industries Corporation Limited, 23B, Netaji Subhas Road, 3rd Floor, Kolkata-700001 for civil works at different blocks of Jalpaiguri District. The Tender documents may be obtained from the above address on any working day between 12.00 hours to 16.00 hours from 02.03.2011 to 11.03.2011 against cash payment of Rs. 500/- only. Details may be obtained from the above address.

Sealed Tender will be received upto 14.00 hours on 15.03.2011 and will be opened on 15.03.2011 at 14.30 hours.

Sd/-  
(ASOKE BANERJEE)  
MANAGING DIRECTOR

**Indian Rare Earths Limited**

(A Government of India Undertaking)  
Plot No.1207, Veer Savarkar Marg, ECIL Building, Prabhadevi, Mumbai - 400 028. Tel.24220230/24382042 Fax : 24220236  
IREL Website : http://irel.gov.in Govt. website : http://tenders.gov.in

**Tender No.IREL/HO/PT/HLPB/11-12/017**

Sealed offers invited from Indian parties for procurement of following material, Hessian Laminated Polythene (HLP) bags - 7,75,000 Nos. approx. Tender documents available from 02.03.2011 to 14.03.2011 between 1400 Hrs. & 16.30 Hrs. Submission of Tender : 16.03.2011 upto 1400 Hrs. Opening of Tender : 16.03.2011 at 1500 Hrs. Tender forms available for Rs.562.50 (inclusive of Taxes) at above address. For further enquiry please contact at above address or visit our above website. Sr.Officer (Purchase)

**DELHI TRANSCO LIMITED**

**NOTICE INVITING TENDERS**

Name of Work : 3rd party inspection of electrical equipment/material, civil works, electrical works and technical audit of Sub-stations & lines by Govt./semi Govt. agencies for the year 2011-2012  
Tender No. : DGM (QA&I)/202/10-11/F-6/T-1  
Estimated Cost : Rs. 43,80,000/-  
Date of release of Tender : 28.02.2011 or 01.03.2011  
Last Date/Time for receipt of Tenders : 23.03.2011 upto 10.30 Hrs.  
Further details can be seen at DTL website www.dtl.gov.in (Unique No. DTL-2558-240211) PR/10-11/121  
Visit us at : www.dtl.gov.in

**KOLKATA METROPOLITAN DEVELOPMENT AUTHORITY**

**Abridged NIT No. 12/SE/EC-II/E&M/KMDA of 2010-2011**

Superintending Engineer, Electrical Circle-II, for and on behalf of Kolkata Metropolitan Development Authority (KMDA) invites sealed bids in two envelope systems from the eligible intending bidders for the following packaged work under the NRCD project and will be received by him up to the date and time specified here in below: "Providing design, manufacturing, shop testing, supply and delivery at site, erection, commissioning, trial run including six (6) months comprehensive O&M of the one combined Pollution Control Unit for two existing electrical cremation furnaces, presently one operative and another inoperative and making inoperative furnace ready for operation by replacement of requisite defective spares at Salkia, Howrah, West Bengal under NRCD project". Cost of tender documents : Rs. 1,000/-. Last date of application : 18.03.2011 up to 15.00 hours. Details may be had from the detailed NIT at the above office or from the KMDA website.

KMDA/240(3)/Headliners(23)/10-11  
Visit : www.kmdaonline.org / www.cmdaonline.com

**State Bank of India**

**Commercial Branch**

**Magma House, 24, Park Street, Kolkata - 700 016**

**TENDER NOTICE**

Two part bids are invited from established and empanelled contractors for the proposed 1. Interior, Furniture, Civil and Sanitary & Plumbing works, 2. Electrical Works, 3. Air Conditioning works and 4. Fire Alarm, Detection and Music Cum Public Address System works at Commercial Branch, Magma House, 24 Park Street, Kolkata - 700 016.

Details are available at the Bank's official website www.sbi.co.in

Bids complete in all respects and addressed to the Dy. General Manager, State Bank of India, Commercial Branch, Magma House, 24, Park Street, Kolkata - 700 016 must be submitted latest by 1 P.M. on 14.03.2011.

Deputy General Manager

**National Highways Authority of India**

(Ministry of Road Transport and Highways)

**REQUEST FOR QUALIFICATION**

(International Competitive Bidding)

NHAI hereby invites applications from eligible firms/organizations for pre-qualification from applicants interested in the following projects stretch Design, Build, Finance, Operate & Transfer (DBFOT) toll basis for a pre-agreed concession period (the "concession Period") under NHDP Phase-IV:

Name of Work	Length (in km.)	Indicative Project Cost (TPC)
4 Laning of Lucknow - Sultanpur Section from km 11.500 to km 134.700 of NH-56 in the State of Uttar Pradesh.	123.400	Rs.1079 Crores

Sale of RFQ document : Up to 14.04.11 (1000 hrs to 1700 hrs)

Cost of RFQ document : Rs1,10,000/- (Non-Refundable)

Last date of Submission : 15.04.11 (1100 hrs)

The detailed RFQ can be downloaded from NHA's website i.e. www.nhai.org. Amendments/Corrigendum, if any, would be hosted on the website only. Sealed Proposals should reach NHA at the following address.

Address for communication: General Manager (U.P.),NHAI G-5 & 6, Sector-10, Dwarka, New Delhi-110 075

Ph: 011-25074100 Extn: 1505,2469, E-mail: harihamath@nhai.org

**NOT JUST ROADS, BUILDING A NATION**

**INDIAN INSTITUTE OF TECHNOLOGY**

KHARAGPUR-721302

No: IIT/TC/ENG/UGCable/10-11/1 Date: 22-02-2011

**NOTICE INVITING TENDER**

The Engineer (Telephone), IIT, Kharagpur, invites sealed item rate tenders from the approved and eligible contractors of the Indian Institute of Technology, Kharagpur/BSNL/MES for the following works

Sl. No.	Name of work	Estimated Amount (Rs.)	Earnest Money (Rs)	Time allowed for completion
01	Dig out the UG telephone cables and relay the same with other associated works	13 lakhs	26,000.00	04 months

Cost of tender paper Rs.500.00 each (NOT REFUNDABLE) in the form of DD only in favour of IIT, Kharagpur, payable at Kharagpur to be submitted at the time of issue of Tender paper

Last Date & Time of receipt of Application : 02-03-2011 upto 2.30 PM

Date of Sale of Tender paper : 03-03-2011

Time and date of submission of tender : 07-03-2011 upto 3.30 PM

Time and date of opening of tender : 07-03-2011 at 4.30 PM

The earnest money should be deposited along with the tenders in the form of DD only in favour of IIT, Kharagpur payable at Kharagpur. Tender without EMD will be rejected. Institute have the right to reject any tender without assigning any reason

**Eligibility Criteria**

Credentialed to execute three similar works each of value 40% of estimated cost or two works each of value 50% of estimated cost or one work of value of 80% of estimated cost in the last 5 years ending last day of the month previous to the one in which the tenders are invited

Engineer(Telephone)