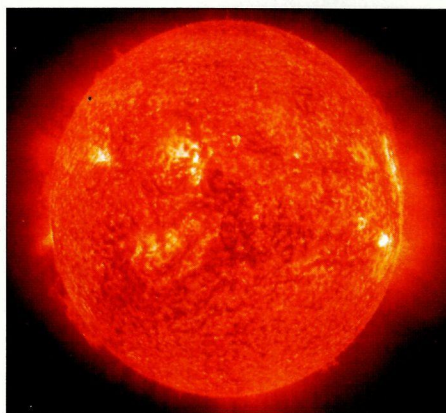


SOLAR NEUTRINOS

Neutrinos limit role of CNO cycle

The Sun burns through various nuclear reactions with the same net effect – the fusion of four protons to form a nucleus of helium, with the release of energy. The two main sets of reactions are the p - p chain, which involves the lightest nuclei, and the CNO cycle, in which the heavier nuclei of carbon, nitrogen and oxygen play a role. Calculations based on the standard solar model suggest that most of the Sun's energy comes from the p - p chain, with only 1.5% from the CNO cycle. This prediction is widely assumed to be correct, but can it be tested experimentally?

This was indeed an early goal of solar neutrino experiments. However, the solar neutrinos that proved the least difficult to detect have been the high-energy neutrinos from the ^8B decays in a variant of the p - p chain. The low-energy neutrinos from ^{13}N and ^{15}O decays in the CNO cycle are much more problematic. Moreover, electron-neutrinos emitted by the Sun are now known to escape detection in many experiments through



Neutrinos have shed light on element building in the Sun. (SOHO/EIT/ESA/NASA.)

oscillation to another variety. Indeed, before the data from the Sudbury Neutrino Observatory (SNO) and SuperKamiokande became available, calculations in which the CNO cycle contributed as much as 99.95% of the solar energy would fit the data.

Now John Bahcall and Carlos Peña-Garay of

the Institute of Advanced Study, Princeton, and M C Gonzalez-Garcia of CERN, SUNY and IFIC Valencia, have revisited the problem using all existing solar neutrino data, including that from SNO and SuperKamiokande, as well as the recent reactor data from KamLAND (*CERN Courier* March 2003 p7). Their extensive analysis involves 10 free parameters, which include neutrino oscillation parameters as well as various solar neutrino fluxes – including ^{13}N and ^{15}O decays. Their best fit indicates that the energy from the CNO cycle must be less than 7.3% at the 3σ level. To improve the limits to the 1.5% level of the solar model predictions will be very challenging, but would, say Bahcall and colleagues, provide a stringent test of the theory of stellar evolution.

Further reading

J N Bahcall, M C Gonzalez-Garcia and C Peña-Garay 2003 *Phys. Rev. Lett.* **90** 131301–1.

SYNCHROTRON RADIATION

BESSY shines bright in the far-infrared

The BESSY synchrotron light source in Berlin has developed a technique to provide intense, steady-state, broadband coherent radiation in the far-infrared – or terahertz (THz) – spectral range. This region of the spectrum, close to the microwave region, has so far been difficult to use because the available sources were very weak, but there are many potential applications, for example in medical imaging and chemical “fingerprinting”. The breakthrough follows recent advances at the Jefferson Laboratory, where high-average-power broadband emission in the far-infrared was produced by synchrotron radiation from electron bunches in the free-electron laser (*CERN Courier* January 2003 p6).

Coherent far-infrared radiation can be produced as synchrotron radiation when the length of the electron bunches is comparable to that of the wavelength of the radiation. To produce these conditions the BESSY



BESSY can now produce terahertz radiation. (BESSY/Luftbild und Pressefoto Grahn, Berlin.)

synchrotron must be run in a “low alpha” optics mode in which the length of the bunches and the shape are specially tuned. In this mode the bunches are typically 1 mm long, with up to 400 bunches stored in the ring at 2 ns bunch spacing. Measurements of the intensity of the coherent far-infrared radiation produced are 1000 times greater

than a standard spectrometer mercury arc lamp, illustrating the advantage of the synchrotron source over a more standard thermal source.

Further reading

M Abo-Bakr et al. *Phys. Rev. Lett.* **90** 094801–1

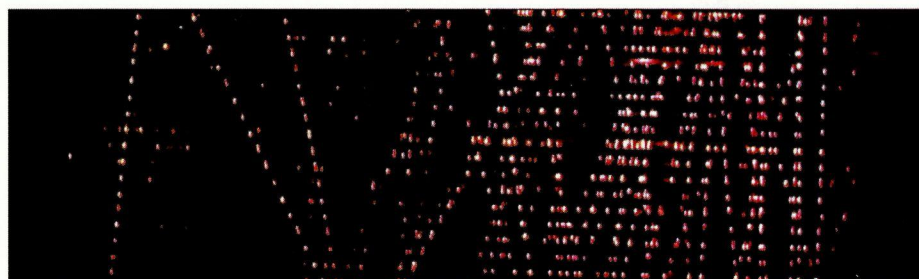
Edited by Archana Sharma

Muons bend to beat the smuggler

Physicists and astrophysicists at the Los Alamos National Laboratory, US, believe that cosmic-ray muons could join the armoury of cross-border surveillance techniques, because of their ability to create images of dense objects. The technique would be relatively inexpensive and harmless as it involves only natural background radiation, and the team says that it could be used to detect, for example, "a block of uranium concealed inside a truck full of sheep".

The process relies on the slight deflection in the paths of cosmic-ray muons as they pass through an object. By measuring the amount of deflection, the object's density can be reconstructed, rather as X-rays reveal varying density through differing amounts of absorption.

To investigate the potential of muon radiography, the team at Los Alamos placed



Cosmic rays in a spark chamber: could these muons help to catch smugglers?

pairs of drift chambers with an active area of $60 \times 60 \text{ cm}^2$ above and below a test object of tungsten on steel supports. The reconstructed image clearly shows the tungsten, with some evidence for the steel. While one disadvantage of the technique is the relatively low flux of cosmic-ray muons, the team's simulations show that within only a minute

they could detect a 10 cm cube of uranium in a large metal container full of sheep. The researchers conclude that the technique offers promise for the surveillance of commercial vehicles, cars and sea containers.

Further reading

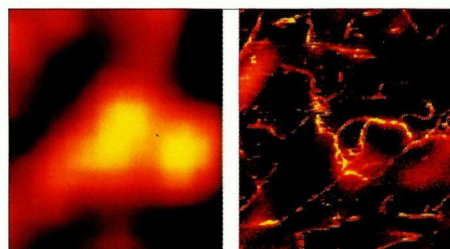
KN Borozdin *et al.* 2003 *Nature* **422** 277.

New nano technique boosts microscopy

Single-walled nanotubes have become the focus of much interest thanks to their potential for nanotechnological applications. Now they have demonstrated the effectiveness of a new technique in high-resolution microscopy. Measuring below 50 nm with optical techniques has been a challenge, but researchers at Rochester, Portland State and Harvard have achieved just that with images of single-walled carbon nanotubes with a resolution of around 25 nm.

The team has extended the concept of "near-field optical microscopy" to develop "near-field Raman spectroscopy" in which a small probe – in this case a sharp 10–15 nm radius silver tip – is placed very close to a surface to enhance the Raman effect (the inelastic scattering of photons by molecules in the sample). The technique thus overcomes the diffraction limit, which in normal optical methods prevents details smaller than half the light's wavelength being clearly seen.

In the near-field Raman technique the researchers focus laser light on the sample close to the tip, which is kept only a few nanometres away from the surface. The field established at the tip increases the Raman



Two $2 \mu\text{m}$ square views of a carbon nanotube on a glass surface. One (left) was recorded using conventional optical microscopy, while the other was recorded with the near-field Raman technique, improving the resolution tenfold. (AIP Physics News Update.)

scattering, and the scattered light can be collected to form an image as the tip is raster-scanned across the sample. The frequencies of the light also provide information on chemical composition and molecular structure.

The team has successfully produced images of individual carbon nanotubes with walls only a single atom thick. They now plan to determine structural details of carbon nanotubes, and hope to develop the technique to produce detailed pictures of proteins in cell membranes. Such images could offer hints for designing better drugs.

Further reading

A Hartschuh *et al.* 2003 *Phys. Rev. Lett.* **90** 095503-1.

Researchers reveal prime predictability

An interesting discovery may be imminent regarding whether prime numbers appear randomly in the sequence of whole numbers. It has not yet been shown that the occurrence of prime numbers – 2, 3, 5, 7, 11, 13, etc – follows a pattern, or that there is definitely no pattern. Now Pradeep Kumar and colleagues at Boston University have found that the increments in the distances between consecutive primes are not random, but have some rudimentary predictability. For the first few primes the distances are 1, 2, 2, 4 and 2 and the increments are +1, 0, +2 and –2.

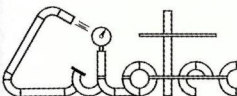
The researchers find for example that positive values are almost every time followed by corresponding negative values. These studies, the researchers say, may have consequences for understanding patterns in nature that depend on prime numbers.

Further reading

Nature Science Update www.nature.com/nsu/030317/030317-13.html.

P Kumar, P C Ivanov and H E Stanley
Information entropy and correlations in prime numbers <http://xxx.lanl.gov/abs/cond-mat/0303110> (2003).

LIST OF EXHIBITORS AT ITALY

 AERIMPIANTI s.p.a.	AERIMPIANTI Spa Via Barberini, 11, I – 00187 Roma Tel: +39 06 4203011. Fax: +39 06 42030140. E-mail: direzione@aerimpianti.it www.aerimpianti.it
 società di Aerimpianti	AERSAT Spa Via Barberini, 11, I – 00187 Roma Tel: +39 06 42030135. Fax: +39 06 42030140. E-mail: info@aersat.it www.aersat.it
 Andalò Gianni srl Imola LAVORAZIONI CERAMICHE TECNICHE E NUOVI MATERIALI	ANDALO' GIANNI Srl Via Serraglio, 46, I – 40026 Imola (BO) Tel: +39 0542 640387. Fax: +39 0542 640654. E-mail: info@andalogianni.com www.andalogianni.com
 Ansaldo Superconduttori	ANSALDO SUPERCONDUTTORI Spa Via Nicola Lorenzi, 8, I – 16152 Genova Tel: +39 010 6489205. Fax: +39 010 6489275. E-mail: info@as-g.it www.as-g.it
	CAEN Spa Via Vetraia, 11, I – 55049 Viareggio (LU) Tel: +39 0584 388398. Fax: +39 0584 388959. E-mail: info@caen.it www.caen.it
 CAMERA DI COMMERCIO ITALIANA PER LA SVIZZERA Fondata nel 1909	CAMERA DI COMMERCIO ITALIANA PER LA SVIZZERA Seestrasse 123 – Postfach, CH – 8027 Zürich. Tel: +41 1 289 23 23. Fax: +41 1 201 53 57. E-mail: info@ccis.ch. www.ccis.ch. Rue du Cendrier 12-14 – Case Postale, CH – 1211 Genève 11. Tel: +41 22 906 85 95. Fax: +41 22 906 85 99. E-mail: infogva@ccis.ch
	CARPENTERIA SAN ANTONIO Via Enrico Fermi, 14, I – 24050 Zanica (BG) Tel: +39 035 670620. Fax: +39 035 670631.
 Cecom snc Costruzioni Meccaniche di Precisione Sistemi e Componenti da Vuoto - UHV Apparelli per la Ricerca Scientifica Via Tiburtina km. 18,700 - 00012 Guidonia Montecelio (RM) - Pagine Gialle Partecipazioni n°235 - Pagine Gialle Partecipazioni n°237 - C.C.I.A.A. 20012 Roma Codice Fiscale 00734072580 Partita IVA 0079981058 Tel. 0774-355777 3 linee R.A. Fax 0774-355860 cecom@fbnet.it - www.cecocom-net.it	C.E.C.O.M. Snc Via Tiburtina, km. 18,700, I – 00012 Guidonia Montecelio (RM) Tel: +39 0774 355777. Fax: +39 0774 355778. E-mail: cecom@fbnet.it www.cecocom-net.it
 IMPIANTI S.r.l.	CRIOTEC IMPIANTI Srl Via F. Parigi 4/A – Z. I. CHIND, I – 10034 Chivasso (TO) Tel: +39 011 919 52 00. Fax: +39 011 919 58 85. E-mail: criotec@criotec.com www.criotec.com
	C.S.C Spa Via Lago Maggiore, 7, I – 36015 Schio (VI) Tel: +39 0445 575989. Fax: +39 0445 575750. E-mail: info@csc-schio.com www.csc-schio.com
	CTE SISTEMI Srl Via Galeazzo Alessi, 5/1, I – 16128 Genova Tel: +39 010 5761629. Fax: 39 010 5530345. E-mail: info@ctesistemi.com
	EEI – Equipaggiamenti Elettronici Industriali Srl Via dell'Artigianato, 9, I – 36100 Vicenza Tel: +39 0444 562988. Fax: +39 0444 562373. E-mail: staff@eei.it www.eei.it
	ELECA Spa Via Como, 214/216, I – 22063 Cantù (CO) Tel: +39 031 7070100. Fax: +39 031 710077. E-mail: eleca@eleca.it www.eleca.it

AT CERN, 23-26 JUNE 2003



EUROPA METALLI Spa

Via della Repubblica 257, I – 55052 Fornaci di Barga
Tel: +39 0583 701473. Fax: +39 0583 701471. E-mail: guglielmo.donati@kme.com
www.kme.com



FBMICOSS Srl

Via Valtrighe, 5, I-24030 Terno D'Isola (BG)
Tel: +39 035 4941511. Fax: +39 035 4941512. E-mail: infoicoss@icoss.it
www.fbmicoss.it



FINSYSTEM Srl

Via Risorgimento, 532, I – 51015 Monsummano Terme (PT)
Tel: +39 0572 250222. Fax: +39 0572 250111. E-mail: info@finsystem.it
www.finsystem.it



LABEN Spa

Strada Padana Superiore, 290, I – 20090 Vimodrone
Tel: +39 02 250751. Fax: +39 02 2505515. E-mail: info@laben.it
www.laben.it



MARA Srl IMPIANTI

Via delle Primule, 12, I – 20146 Milano
Tel: +39 02 42290638. Fax: +39 02 48951666.



O.C.E.M. S.p.A.

Via 2 Agosto 1980, 11,
40016 - S. GIORGIO DI PIANO - BOLOGNA (ITALY)
tel: +39 051 6656611 - fax: +39 051 6650099
e-mail: ocem@ocem.com - web: www.ocem.com

OCEM Spa

Via 2 Agosto 1980, 11, I – 40016 San Giorgio di Piano (BO)
Tel: +39 051 6656611. Fax: +39 051 6656677. E-mail: ocem@ocem.com
www.ocem.com



RENCO Spa

Viale Venezia, 53, I – 61100 Pesaro
Tel: +39 0721 43331. Fax: +39 0721 400924. E-mail: rencospa@renco.it
www.renco.it



REVEN.GE Srl

Via Luigi Einaudi, 14, I – 10024 Moncalieri (TO)
Tel: +39 011 642103. Fax: +36 011 645393. E-mail: info@revenge.it
www.revenge.it



RIAL VACUUM Spa

Via Tito E. Manzini, 7/a, I – 43100 Parma
Tel: +39 0521 949311. Fax: +39 0521 949300. E-mail: sales@rialvacuum.com
www.rialvacuum.com



SAES GETTERS Spa

Viale Italia, 77, I – 20020 Lainate (MI)
Tel: +39 02 93178 286. Fax: +39 02 93178 320. E-mail: marina_perino@saes-group.com. www.saesgetters.com



SIMIC Spa

Via Vittorio Veneto, 24, I – 12072 Camerana (CN)
Tel: +39 0174 906611. Fax: +39 0174 906609. E-mail: info@simic.it
www.simic.it



SIMPRO Spa

Via Torino, 446/A, I – 10032 Brandizzo (TO)
Tel: +39 011 9179329. Fax: +39 011 9179398. E-mail: simpro@simpro.it
www.simpro.it



Banca Popolare di Sondrio (suisse)

BANCA POPOLARE DI SONDRIO (SUISSE) SA

Ufficio di Rappresentanza di Ginevra, Rue du Cendrier 12-14, CH – 1211 Genève 1
Tel: +41 22 731 15 75. Fax: +41 22 906 85 99. E-mail: popso@popso.it
www.popso.it

All you need...

- for particle accelerators

- Magnet Technology
- Magnet Power Supplies
- Current Transducers
- Electron Accelerators
- Ion Accelerators
- Electrostatics
- Beam Diagnostics



Meet us at
**PAC
2003**

From source to target



DANFYSIK A/S · Møllehaven 31 · DK-4040 Jyllinge
Tel.: +45 46 79 00 00 · Fax: +45 46 79 00 01
e-mail: danfysik@danfysik.dk · www.danfysik.dk