Compiled by Steve Reucroft and John Swain, Northeastern University

# Eggshells demonstrate the onset of fragmentation

A high-energy physicist contemplating fragmentation is likely to be thinking about quarks and gluons, but other things fragment too, as in the oft-cited example of eggshells. Now Ferenc Kun of the University of Debrecen and Falk Wittel and colleagues at the University of Stuttgart have considered how shell-shaped objects break into pieces. In a delightful paper they explain how they took ordinary eggs – both brown and white – made small holes in them, blew out the contents, and either catapulted them to the ground or filled them with hydrogen and blew them up.

The team found that the size of the pieces followed a power law with an exponent of 1.35 regardless of which way the eggshells are broken. This is much smaller than the known value of 2.5 obtained when solid objects break, but is in good agreement with computer models. All this means that one can make sensible estimates for how hollow objects break up. This finding has important applications for the current pressing problem of figuring out how debris in space is distributed, as well as in explosives engineering and perhaps even in understanding supernovae.

**Further reading**

F Wittel *et al.* 2004 *Phys. Rev. Lett.* **93** 035504.

# The spin behind a transformer's hum

Sometimes the title of a paper hides the fact that it contains some fascinating physics. Take for example the article: "Origin of higher order magnetic exchange: evidence for local dimer exchange striction in $CsMn_{0.28}Mg_{0.72}Br_3$ probed by inelastic neutron scattering". If you dig deep enough in this one you'll find that it's about magnetostriction – the contraction of materials in a magnetic field which, among other things, leads to the hum of transformers whose metal cores contract and expand as the current in their coils changes with time.

Thierry Strässle and colleagues from ETH Zurich and the University of Bern have used neutron scattering to track down the effect at the microscopic level. They have found that it depends on the spin exchange interaction between pairs of manganese atoms (known as dimers), which tends to pull the magnetic moments together. These measurements on microscopic magnetostriction go beyond predictions of the traditional Heisenberg single exchange interaction model, although that still works well at macroscopic scales.

**Further reading**

T Strässle *et al.* 2004 *Phys. Rev. Lett.* **92** 257202.

# Synchronization may underlie migraines

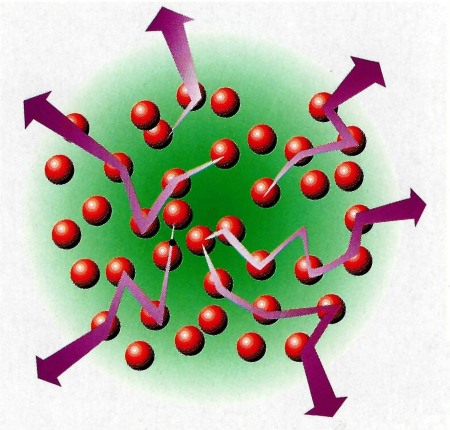
A typical physicist's approach to studying almost any system is to excite it in some way and see how it responds, and it seems this is paying off in the study of migraines. Sebino Stramaglia of the University of Bari and colleagues have flashed repeating visual patterns both at healthy people and at those suffering from migraines, and then looked at the electrical activity that their brains produced.

By decomposing this activity into various frequencies, Stramaglia's team could look at the "alpha rhythms", which correspond to 8 to 12.5 Hz and are associated with quiet alertness with closed eyes. The researchers found that in migraine sufferers these rhythms are much more synchronized across the brain than in healthy people. Of course the brain is a very complex system so it is still not clear what this means, but it does suggest that one might look for treatments that would interfere with this "hypersynchronization".

**Further reading**

L Angelini *et al.* 2004 *Phys. Rev. Lett.* **93** 038103.

# The mysterious power of the long-distance photon



*In a random laser, light scatters in the disordered material many times, keeping it trapped long enough for amplification and for laser light to emerge in random directions (Wiersma 2000).*

Random lasers, which are made without conventional cavities formed by mirrors, relying instead on repeated bouncing of light in a disordered medium, have always had some mysterious features. One of these is that despite their randomness they often exhibit sharp, narrow emission lines. Now Diederik Wiersma and his colleagues at the European Laboratory for Non-Linear Spectroscopy and the Italian National Institute for the Physics of Matter, in Florence, have realized why.

The key insight is that some photons bounce around with very long path lengths, and while one might naively imagine that these rare long-distance runners would not be of much importance, this is far from the truth. A long path in an amplifying medium leads to a large gain, and this in turn means that these rare photons can be amplified by enormous amounts, picking up companions by stimulated emission at an incredible rate. So, in the end they play a role far larger than might have been expected.

**Further reading**

S Mujumdar *et al.* 2004 *Phys. Rev. Lett.* **93** 053903.

D Wiersma 2000 *Nature* **406** 132.

# METALS & ALLOYS

# ADVENT

Standard Catalogue Items

Element Name
Atomic No. Symbol
Atomic weight
Density
M.pt./B.pt.(°C)

← Solids & **Liquids** (g/cm³) Gases(g/l)
← Melting point (Solids & **Liquids**) • Boiling point (Gases)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrogen<br>1 H<br>1.0079<br>0.090<br>-252.87 | | | | | | | | | | | | | | | | | Helium<br>2 He<br>4.0026<br>0.177<br>-268.93 |
| Lithium<br>3 Li<br>6.941<br>0.54<br>180.5 | Beryllium<br>4 Be<br>9.0122<br>1.85<br>1287 | | | | | | | | | | | Boron<br>5 B<br>10.811<br>2.46<br>2076 | Carbon<br>6 C<br>12.011<br>2.27<br>3900 | Nitrogen<br>7 N<br>14.007<br>1.251<br>-195.79 | Oxygen<br>8 O<br>15.999<br>1.429<br>-182.95 | Fluorine<br>9 F<br>18.998<br>1.696<br>-188.12 | Neon<br>10 Ne<br>20.180<br>0.900<br>-246.08 |
| Sodium<br>11 Na<br>22.990<br>0.97<br>97.7 | Magnesium<br>12 Mg<br>24.305<br>1.74<br>650 | | | | | | | | | | | Aluminium<br>13 Al<br>26.982<br>2.70<br>660.3 | Silicon<br>14 Si<br>28.086<br>2.33<br>1414 | Phosphorus<br>15 P<br>30.974<br>1.82<br>44.2 | Sulphur<br>16 S<br>32.065<br>1.96<br>115.2 | Chlorine<br>17 Cl<br>35.453<br>3.214<br>-34.04 | Argon<br>18 Ar<br>39.948<br>1.784<br>-185.85 |
| Potassium<br>19 K<br>39.098<br>0.86<br>63.4 | Calcium<br>20 Ca<br>40.078<br>1.55<br>842 | Scandium<br>21 Sc<br>44.956<br>2.99<br>1541 | Titanium<br>22 Ti<br>47.867<br>4.51<br>1668 | Vanadium<br>23 V<br>50.942<br>6.11<br>1910 | Chromium<br>24 Cr<br>51.996<br>7.14<br>1907 | Manganese<br>25 Mn<br>54.938<br>7.47<br>1246 | Iron<br>26 Fe<br>55.845<br>7.87<br>1538 | Cobalt<br>27 Co<br>58.933<br>8.90<br>1495 | Nickel<br>28 Ni<br>58.693<br>8.91<br>1455 | Copper<br>29 Cu<br>63.546<br>8.92<br>1084.6 | Zinc<br>30 Zn<br>65.39<br>7.14<br>419.5 | Gallium<br>31 Ga<br>69.723<br>5.90<br>29.8 | Germanium<br>32 Ge<br>72.64<br>5.32<br>938.3 | Arsenic<br>33 As<br>74.922<br>5.73<br>816.9 | Selenium<br>34 Se<br>78.96<br>4.82<br>221 | Bromine<br>35 Br<br>79.904<br>3.12<br>-7.3 | Krypton<br>36 Kr<br>83.80<br>3.733<br>-153.22 |
| Rubidium<br>37 Rb<br>85.468<br>1.53<br>39.3 | Strontium<br>38 Sr<br>87.62<br>2.63<br>777 | Yttrium<br>39 Y<br>88.906<br>4.47<br>1526 | Zirconium<br>40 Zr<br>91.224<br>6.51<br>1855 | Niobium<br>41 Nb<br>92.906<br>8.57<br>2477 | Molybdenum<br>42 Mo<br>95.94<br>10.28<br>2623 | Technetium<br>43 Tc<br>[98]<br>11.5<br>2157 | Ruthenium<br>44 Ru<br>101.07<br>12.37<br>2334 | Rhodium<br>45 Rh<br>102.91<br>12.45<br>1964 | Palladium<br>46 Pd<br>106.42<br>12.02<br>1554.9 | Silver<br>47 Ag<br>107.87<br>10.49<br>961.8 | Cadmium<br>48 Cd<br>112.41<br>8.65<br>321.1 | Indium<br>49 In<br>114.82<br>7.31<br>156.6 | Tin<br>50 Sn<br>118.71<br>7.31<br>231.9 | Antimony<br>51 Sb<br>121.76<br>6.70<br>630.6 | Tellurium<br>52 Te<br>127.60<br>6.24<br>449.5 | Iodine<br>53 I<br>126.90<br>4.94<br>113.7 | Xenon<br>54 Xe<br>131.29<br>5.887<br>-108.05 |
| Caesium<br>55 Cs<br>132.91<br>1.88<br>28.4 | Barium<br>56 Ba<br>137.33<br>3.51<br>727 | 57-70<br>* | Lutetium<br>71 Lu<br>174.97<br>9.84<br>1652 | Hafnium<br>72 Hf<br>178.49<br>13.31<br>2233 | Tantalum<br>73 Ta<br>180.95<br>16.65<br>3017 | Tungsten<br>74 W<br>183.84<br>19.25<br>3422 | Rhenium<br>75 Re<br>186.21<br>21.02<br>3186 | Osmium<br>76 Os<br>190.23<br>22.61<br>3033 | Iridium<br>77 Ir<br>192.22<br>22.65<br>2466 | Platinum<br>78 Pt<br>195.08<br>21.09<br>1768.3 | Gold<br>79 Au<br>196.97<br>19.30<br>1064.2 | Mercury<br>80 Hg<br>200.59<br>13.55<br>-38.83 | Thallium<br>81 Tl<br>204.38<br>11.85<br>304 | Lead<br>82 Pb<br>207.2<br>11.34<br>327.5 | Bismuth<br>83 Bi<br>208.98<br>9.78<br>271.3 | Polonium<br>84 Po<br>[209]<br>9.20<br>254 | Astatine<br>85 At<br>[210]<br>-<br>302 | Radon<br>86 Rn<br>[222]<br>9.73<br>-61.85 |
| Francium<br>87 Fr<br>[223]<br>--<br>-- | Radium<br>88 Ra<br>[226]<br>5.0<br>700 | 89-102<br>** | Lawrencium<br>103 Lr<br>[262]<br>--<br>1627 | Rutherfordium<br>104 Rf<br>[262]<br>--<br>-- | Dubnium<br>105 Db<br>[262]<br>--<br>-- | Seaborgium<br>106 Sg<br>[266]<br>--<br>-- | Bohrium<br>107 Bh<br>[264]<br>--<br>-- | Hassium<br>108 Hs<br>[277]<br>--<br>-- | Meitnerium<br>109 Mt<br>[268]<br>--<br>-- | Darmstadtium<br>110 Ds<br>[281]<br>--<br>-- | Ununnunium<br>111 Uuu<br>[272]<br>--<br>-- | Ununbium<br>112 Uub<br>[285]<br>--<br>-- | | Ununquadium<br>114 Uuq<br>[289]<br>--<br>-- | | | | |

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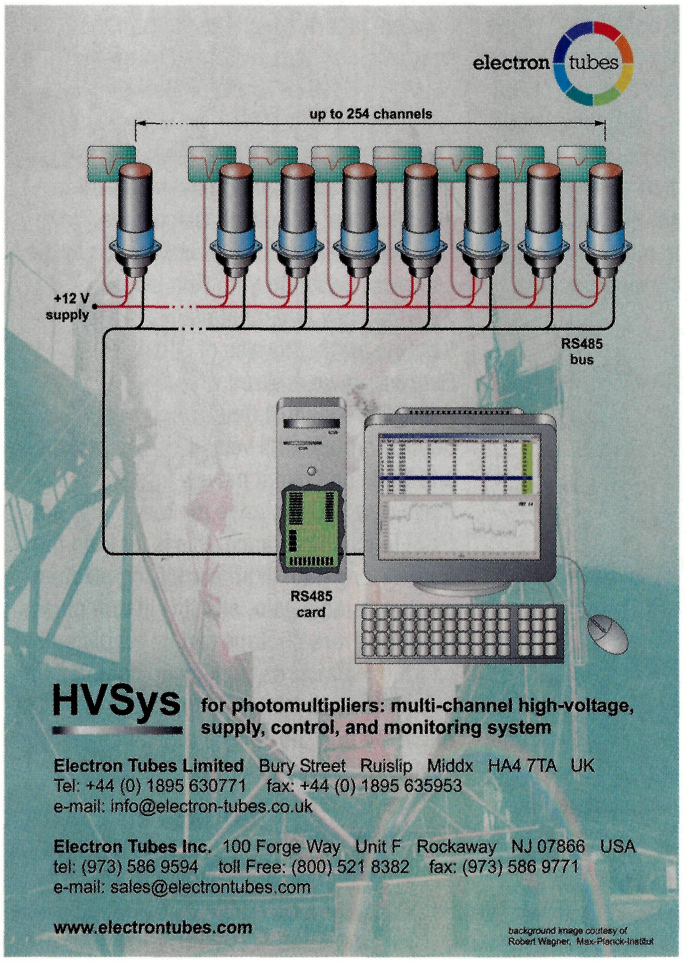
| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lanthanoids | Lanthanum<br>57 La<br>138.91<br>6.146<br>920 | Cerium<br>58 Ce<br>140.12<br>6.689<br>795 | Praseodymium<br>59 Pr<br>140.91<br>6.64<br>935 | Neodymium<br>60 Nd<br>144.24<br>6.80<br>1024 | Promethium<br>61 Pm<br>[145]<br>7.264<br>1100 | Samarium<br>62 Sm<br>150.36<br>7.353<br>1072 | Europium<br>63 Eu<br>151.96<br>5.244<br>826 | Gadolinium<br>64 Gd<br>157.25<br>7.901<br>1312 | Terbium<br>65 Tb<br>158.93<br>8.219<br>1356 | Dysprosium<br>66 Dy<br>162.50<br>8.551<br>1407 | Holmium<br>67 Ho<br>164.93<br>8.795<br>1461 | Erbium<br>68 Er<br>167.26<br>9.066<br>1497 | Thulium<br>69 Tm<br>168.93<br>9.321<br>1545 | Ytterbium<br>70 Yb<br>173.04<br>6.57<br>824 |
| **Actinoids | Actinium<br>89 Ac<br>[227]<br>10.07<br>1050 | Thorium<br>90 Th<br>232.04<br>11.72<br>1842 | Protactinium<br>91 Pa<br>231.04<br>15.37<br>1568 | Uranium<br>92 U<br>238.03<br>19.05<br>1132 | Neptunium<br>93 Np<br>[237]<br>20.45<br>637 | Plutonium<br>94 Pu<br>[244]<br>19.816<br>639 | Americium<br>95 Am<br>[243]<br>--<br>1176 | Curium<br>96 Cm<br>[247]<br>13.51<br>1340 | Berkelium<br>97 Bk<br>[247]<br>14.78<br>986 | Californium<br>98 Cf<br>[251]<br>15.1<br>900 | Einsteinium<br>99 Es<br>[252]<br>-<br>860 | Fermium<br>100 Fm<br>[257]<br>-<br>1527 | Mendelevium<br>101 Md<br>[258]<br>-<br>827 | Nobelium<br>102 No<br>[259]<br>-<br>827 |

**Metals – Alloys • Foils • Sheets • Wires • Mesh • Rods • Tubes • for Research/Development and Industry**

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