luminosity of the 5 March burst, which released energy at a million times the rate of the Crab pulsar; and by the enormous energy of ~ 3 × 10^{44} erg that was confined close to the neutron star over the 200-second duration of the burst[12]. But these arguments, although compelling and consistent, are indirect.

By contrast, the evidence now presented by Kouveliotou *et al.*[1] is direct. Using the Rossi X-ray Timing Explorer, they have discovered 7.47-second pulsations in the X-ray counterpart[6] of SGR1806–20. The authors go further in providing two independent measurements of an increasing period, both of which imply a magnetic dipole field somewhat stronger than 10^{14} gauss. They also make cogent arguments against accretion as an energy source for the quiescent X-ray emission, leaving magnetic-field decay as the most likely alternative. The rotational energy of the neutron star with its present period is far too small to power the X-ray and particle emissions.

The important caveat here, raised by the authors, is that if the star seen near SGR1806–20 is its binary companion, then the measured period increase could be modified by the gravitational acceleration of the companion. In addition, a neutron star of this long period, if as hot internally as its quiescent X-ray emissions imply, will undergo sudden decreases in period[13] (glitches) by perhaps one part in 10,000.

The two SGR sources 0525–66 and 1806–20 are not the end of the story. As we go to press, a possible discovery of 89-second pulsations from SGR1900+14 has been announced[14]. The long period may seem puzzling, but it fits in very well with our theoretical expectations. Unlike pulsars, magnetars should have two distinct phases of spindown: the standard pulsar mechanism and a particle-aided spindown. The spin period increases exponentially during the latter phase. The long period of SGR1900+14 is therefore consistent with its low activity — it need only be older than the other two SGRs. Another wrinkle is the identification[15,16] of a nearby candidate magnetar, RX J0720.4–3125, which is consistent with the inference that magnetars may constitute a sizeable fraction of neutron stars, about 10%.

What does the future hold? First, we must measure changes in period for SGR0525–66 and RX J0720.4–3125. Another important target is the 12-second X-ray pulsar 1E 1841–0.45 in the very young supernova remnant[17] Kes73, one of several anomalous, low-luminosity X-ray pulsars that bear some resemblance to SGR0525–66 in quiescence.

More generally, observations of neutron stars that are slowly rotating but have warm interiors should provide valuable new information on the physics of their interiors, in particular the superfluid component in their crusts. Measurement of low-frequency noise in their spindown is a promising discriminant between accreting and non-accreting behaviour. In the radio regime, observations of long-period, isolated neutron stars will also provide important constraints on emission models.

As the evidence for magnetars grows, it becomes more plausible that our failure to detect radio pulsars with magnetic fields greater than 2 × 10^{13} gauss is because, at such high fields, quantum electrodynamic effects help to damp the radio emission. Detailed X-ray spectra obtained by the AXAF satellite will probe radiative transport in strong magnetic fields, and allow neutron stars to expand their roles as laboratories for physics in extreme conditions. ☐

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Neurobiology

Knowing where you're going

In terms of mental processes, how do you get from A to B? This question of navigation has been tackled by Eleanor A. Maguire and colleagues, who report their latest findings in the 8 May issue of *Science* (280, 921–924; 1998). Using positron emission tomography they have mapped brain activity as people find their way through a familiar, yet complex, virtual-reality town.

Subjects were allowed to get their bearings in the virtual town (pictured), and they were then asked to head directly towards a goal. Increased blood flow was found in the right hippocampus and inferior parietal cortex of people who successfully completed this task, indicating that these two regions allow navigation to an unseen goal.

Activity was also seen in these areas of the brain when some of the routes to the goal were blocked, forcing the subjects to make a detour. In this case, the left frontal cortex was activated as well, and the authors infer that this region is involved in planning and making decisions. They also studied average speed, measured in virtual metres per second, and found that it correlates with activity in the right caudate nucleus. So this region probably helps people to get where they're going quickly.

E. MAGUIRE ET AL.

What Maguire and colleagues now have is a map of the areas in the brain that support navigation. These findings agree with results from monkeys and rats, and also with studies of London taxi drivers asked to recall complex routes around the city — all of which goes to show that some experiments on rodents really do bear directly on the human rat race.

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