magnetic field compare with other burst sources? The X-ray photons it emits are higher in energy than those emitted by the Rapid Burster, which leads Kouveliotou *et al.* to suggest that GROJ1744–28 has a stronger magnetic field. Support for this inference comes from the detection of coherently pulsed, persistent X-ray emission[8-10]. The 0.467-second pulse period is almost certainly the rotation period of the star.

Conventional wisdom holds that neutron stars — including the Rapid Burster — that emit type-I (thermonuclear) flashes are weakly magnetized, with surface fields of the order of 10^8 to 10^9 gauss; whereas pulsating X-ray sources have stronger magnetic fields of the order of 10^{11} to 10^{13} gauss which channel the accreted material to polar hotspots, thereby raising the temperature above the threshold for stable nuclear burning[3]. The absence of coherent X-ray pulsations in type-I burst sources is ascribed to the weakness of the magnetic field. This reasoning has always been problematic in the case of the Rapid Burster, for the magnetic field of that source is apparently strong enough to trigger type-II X-ray bursts as well. Some additional ingredient may be required to suppress pulsations, such as alignment of the magnetic axis with the angular momentum of the accreting matter.

GROJ1744–28 may already be giving us some clues about that most basic of neutron-star puzzles, namely how their magnetic fields decay. The tendency of weakly magnetized radio pulsars to spin rapidly and to have binary stellar companions has led to a growing suspicion, not as yet backed by any compelling physical theory, that deposition of enough matter on the surface of a neutron star can bury its magnetic field. If the Rapid Burster is indeed weakly magnetized, then it is surprising that its most energetic bursts should occur at similar intervals (a few hundred seconds to one hour) and with similar energies to the bursts from GROJ1744–28.

But there is a loophole. The idea of field burial allows for the existence of neutron stars which have experienced only partial burial: that is, stars that are weakly magnetized over most of their surface and can emit thermonuclear flashes, but still retain a sizeable fraction of the original external dipole flux. The behaviour of type-II bursts suggests the existence of two distinct accretion channels[11] which may reflect the distribution of magnetic flux over the stellar surface.

How do the soft gamma repeaters (SGRs) fit in with these two rapid X-ray repeaters? SGRs only emit a faint glow of X-rays in between their brief, blinding outbursts, during which their X-ray output increases by a factor of a million or more. By contrast, the Rapid Burster only brightens by an order of magnitude when it bursts. This indicates that SGR bursts are probably not powered by accretion instabilities. Thermonuclear power has great difficulty accommodating the extraordinary burst emitted by SGR0526–66 on 5 March 1979, which released a million times the energy of a typical type-I X-ray burst. One possibility that has received considerable recent attention[12] is that the SGR sources are a rare subspecies of neutron stars with magnetic fields stronger than 10^{14} gauss, and that bursts are triggered when these very strong fields fracture their crusts.

This does not mean that there are no threads connecting the SGR sources with the rapid X-ray repeaters. Curiously, the spectra of SGR bursts and the Rapid Burster's type-II bursts show a number of similarities. Both are consistent, to a first approximation, with black-body emission from an area comparable to the surface of a neutron star. (SGR bursts are much more luminous and correspondingly much hotter and spectrally harder.) Their radiating surfaces appear to contract at approximately constant temperature, without the marked spectral softening (and occasional photospheric expansion) characteristic of type-I X-ray bursts. Together these observations suggest that the emitting plasma is optically thick and confined by the magnetic field of the neutron star. One explanation for this similarity of spectral behaviour in such otherwise dissimilar sources is that the free energy is absorbed by the magnetic field and converted to a trapped photon–electron–positron plasma[12].

It is not yet clear whether the bursts of GROJ1744–28 share this radiative mechanism. They are harder than the type-II bursts emitted by the Rapid Burster and much less luminous than SGR bursts. It may be that X-rays are emitted from a small patch of the star's surface. In any case, the message flashed to us from the universe of X-ray astronomy is a subtle one, of both unity and diversity. ☐

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DAEDALUS

Per aqua ad astra

GUNS of various kinds have often been proposed as space launchers, but have never gained wide acceptance. Daedalus has a new approach to the topic.

The ocean, he points out, exerts an atmosphere of pressure for every 10 m of depth, and in some places is over 10 km deep. Imagine, he says, a tube extending right to the bottom, with a free-rising piston at its base. This is a gun with an initial barrel pressure of 1,000 atmospheres and a length of 10 km. A 1-m diameter tube could release enough energy to accelerate a 6 tonne payload to the escape velocity of 11 km s^{-1}.

Sadly, it would never do it. Tons of water would be accelerated too, wasting most of the energy; air could not be expelled fast enough from the long barrel, and no payload could rise through the sea-level atmosphere at 11 km s^{-1}. Daedalus sees the idea not as a replacement for a complete space rocket, but merely for its big first stage. This accounts for about 80% of the weight and cost of a space launcher, but gives it only about 20% of its final velocity.

The oceanic catapult will consist of many short segments of steel pipe held together by O-ring seals, each with a small solid-charge actuator to separate the joint on command. As the piston rises up the long tube, each joint is separated the instant it has passed. The segment falls away, and the water rushes sideways into the upwardly disintegrating barrel. None needs to be accelerated upwards.

A cushioning slug of compressed gas above the entering water will transmit its pressure to the piston ahead of it, on which the vehicle rests. The barrel above it contains no air to be pushed out of the way. It is full of vacuum — one extra atmosphere of compressive stress hardly matters in such a design. It is sealed at the top by a lid which is blown open just before the vehicle emerges at a few times the speed of sound: just about the velocity which a conventional first stage would have given it. The second and subsequent rocket stages will then take over to complete the launch. A catapult 1 m across could launch a rocket of several hundred tonnes.

Much Shuttle hardware is already designed to be fished out of the ocean and used again, and deep-sea oil drillers are already expert at assembling pipes under water. So the oceanic launcher might not need much development. Once built, it could be used repeatedly. Its barrel segments would be retained on cables, to be hauled together and pumped out ready for the next launch. Engineers would applaud its simplicity, scientists its cheapness, and environmentalists its lack of pollution. David Jones