the ATP-binding pocket could cause a swinging motion of a long α-helical domain through as much as 5 nm (see figure). But the mean displacement measured by Finer *et al.* is 11 nm, and some motions are as large as 17 nm; such distances seem too large to correspond to a single head, as assumed. Because they are using two-headed molecules, it is possible that Finer *et al.* are actually seeing the strokes of the two heads in rapid succession. Even though the two heads can sequentially bind to one actin filament[12], the binding cannot be identical because the two heads are related by a 2-fold axis of symmetry rather than by translational symmetry. The role of the two heads must be clarified before the whole muscle or single-molecule measurements can be interpreted with an accuracy better than a factor of two.

The displacement clamp apparatus makes many new experiments possible. The possible cooperativity of the two heads can be investigated by comparing the forces of single-headed and double-headed motors. By rapidly clamping the motor to a different position it should be possible to determine whether the 10-nm force transition characteristic of whole muscle corresponds to the powerstroke. With so many techniques converging on motor proteins — molecular mechanics, enzyme kinetics, molecular engineering and crystallography — we can expect to see great progress in the next year. □

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GAMMA-RAY BURSTERS

Cosmic flasher exposed

Charles Bailyn

GAMMA-ray burst sources (hereafter GRBs) probably constitute the least well understood class of celestial object. Estimates of their intrinsic luminosity vary by over 20 orders of magnitude. The primary impediment to greater understanding has been astronomers' inability to identify radiation other than γ-rays associated with GRBs. Three papers in this issue now reveal a compelling identification of a GRB with an object emitting other kinds of radiation[1-3]. This, though, is one of a small and unusual subclass, and the observing techniques and models described in these papers will not apply to most GRBs, which remain mysterious.

The outlines of the general GRB problem have recently been reviewed in these pages[4]. Briefly, GRBs are short, intense bursts of γ-rays which occur seemingly at random across the sky. The flood of new detections by the recently launched Compton Gamma Ray Observatory has shown that their locations are consistent with an isotropic spatial distribution. Coupled with earlier indications of a relative lack of faint and hence distant GRBs (an observation confirmed by the more recent data), this result indicates that we are in the middle of a bounded distribution of bursters. This bounded distribution might represent anything from our Solar System to the Universe as a whole, but mechanisms to produce the bursts either at the outer reaches of the Solar System or at cosmological distances are speculative at best. More plausible models, associated with surface phenomena on neutron stars, are problematic because a bounded distribution of neutron stars should be concentrated towards the centre of our Galaxy, in contradiction to the observations. As the catalogue of GRBs expands, astronomers are constantly re-evaluating the statistics of the GRB distribution, with ambiguous results[4].

For some time, it has been recognized that three of the GRBs are different from the others. Their γ-rays are of relatively low energy (or 'soft', in the language of γ-ray astronomers) and, unlike the bulk of GRBs, they emit repeated bursts, characteristics which have led to these sources being dubbed 'soft gamma-ray repeaters' or SGRs. Radio observers then noted that the SGRs seem to be located within the remnants of supernova explosions[5,6], an encouraging result, as supernovae are the birthplaces of neutron stars.

Now Murakami *et al.*[1] have observed one of the SGRs with an imaging X-ray telescope, in the hope of identifying an underlying constant source of X-rays from the suspected neutron star. Not only did they succeed in this endeavour, but by good fortune they managed to catch the source in the act of bursting. These same bursts were observed by the Compton Gamma Ray Observatory, as reported by Kouveliotou *et al.*[2]. Thus the identity of the X-ray source as the SGR is beyond doubt. The much higher spatial resolution of the X-ray observations also leaves no doubt of the association between the SGR and the supernova remnant.

Detailed radio observations by Kulkarni *et al.*[3,5] reveal that the supernova remnant is itself unusual. It is one of a small class of supernova remnants called 'plerions', which are illuminated by a strong central source. But this plerion also shows features reminiscent of the radio-emitting nebulae associated with several X-ray-emitting binary systems. So Kulkarni *et al.* suggest that a complete model of SGRs may need to combine elements of an unusual class of supernovae and an even more unusual class of X-ray emitters.

The circumstances leading to the creation of an SGR must be very rare. The Compton Gamma Ray Observatory has now seen bursts from all three of the previously known SGRs, but has discovered no new ones, so the census of SGRs in and near our Galaxy may be complete[2]. The curious radio characteristics of the supernova remnant, and the high velocity of the burster implied by its off-centre location within the remnant, further suggest that something quite remarkable must be required to produce an SGR[3]. Although none of the three discovery teams propose a mechanism to produce the bursts, the identification of the main features of the source will provide theorists with a much firmer basis from which to explore the SGR phenomenon.

The sudden leap forward allowed by the discovery of counterparts in other energy regimes goes to show the power of 'multi-wavelength astronomy', which has so greatly aided our understanding of celestial objects ranging from clusters of galaxies to neutron stars only 10 kilometres across. The discovery of counterparts at other wavelengths remains the best hope of resolving the contentious claims surrounding the ordinary γ-ray bursts. Such an advance will be difficult: the likelihood of observing an X-ray, optical or radio counterpart of a non-repeating GRB is slim. But it is not zero, and rapid response networks are now being developed which may increase the odds. Perhaps then the bulk of these one-time flashers will be exposed for what they are, just as the softer repeat offenders have been. □

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