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Figure 1 | The Sculptor galaxy, NGC 253. Analyses[1–3] of a burst of γ-ray emissions from this galaxy suggest that they were produced by a giant flare from a magnetar — a highly magnetized stellar remnant.

Astronomy

Cosmic electromagnetic bombs laid bare

Christopher Thompson

Celestial eruptions known as giant magnetar flares have been seen in our cosmic backyard, but were so bright they blinded observational instruments. The discovery of a more distant flare finally reveals details of these emissions. **See p.207 & p.211**

Much astronomical research in the twenty-first century is a study of impermanence. Telescopes probing the full range of the electromagnetic spectrum, from radio waves to γ-rays, are unveiling an astonishing variety of brief, and frequently enigmatic, cataclysms. Our understanding of many types of cosmic explosion, such as supernovae and γ-ray bursts, has been limited by our inability to see their inner workings and by their rarity in our own Galaxy. Two papers[1,2] in this issue and another[3] in *Nature Astronomy* lay the foundation for the study of an extragalactic population of flaring γ-ray sources whose relatives can be found nearby and have already been well studied in quiescence. These sources might also be connected to fast radio bursts[4] — the hottest topic in astronomy.

Stellar remnants known as magnetars shine in a fundamentally different way from any other type of star. They seem to be like ordinary neutron stars, such as radio pulsars, and have densities even greater than that of an atomic nucleus. But their magnetic fields are 1,000 times stronger than those of most pulsars (reaching 10^{11} tesla)[5]. The main fuel for their radiation is not nuclear fusion (as is the case for the Sun), or the release of residual thermal energy (as in white dwarfs formed as remnants of Sun-like stars), or even stellar spin (as in a radio pulsar). Instead, the decay of the powerful electric currents that support the magnetic fields sustains a prodigious release of X-rays and γ-rays.

Even in quiescence, magnetars can be 100 times as luminous as the Sun[5]. Their strongest outbursts are about one trillion times brighter, yet, remarkably, can release more energy in a fraction of a second than was gradually emitted over the preceding decade. These giant flares have been detected a few times within the Milky Way, but their proximity makes them blindingly bright to spaceborne X-ray and γ-ray telescopes[5,6].

Svinkin *et al.*[1] (page 211) and Roberts *et al.*[2] (page 207) demonstrate a close correspondence between these Galactic events and a γ-ray pulse detected on 15 April 2020, which Svinkin *et al.* triangulated to the nearby galaxy NGC 253 (also called the Sculptor galaxy; Fig. 1) using a combination of instruments known as the Interplanetary Network. From this distance, the authors of the two papers were able to identify fine details of the γ-ray spectrum and of the time profile of the flare — which turns out to be a near copy of a previously reported extragalactic flare. Two distinct components are apparent in the γ-ray flare profile: a fast and rapidly variable component, lasting several thousandths of a second; and a slower one that decays exponentially, ten times more slowly. The slow component carries comparable or greater energy than the fast component.

Why should the output of magnetars be so spasmodic, compared with other types of star? After all, some isolated white dwarfs are also strongly magnetized[7], but none have been connected with intense electromagnetic flares.

The answer could relate to the fact that although magnetars are hotter at their surfaces than are other stars[5], they are fundamentally cryogenic objects. The outer layers of a neutron star contain heavy, neutron-rich nuclei, and begin to freeze into a solid soon after the stellar collapse that triggers the neutron star's formation[8]. This crust has peculiar properties when compared with those of Earth's outer layer. The temperature in the deep crust has dropped far below the melting point of the nuclear material from which it is made. Moreover, this material is an excellent conductor of electricity, effectively tying it to the twisting magnetic field – the magnetic field and crust must move together, either slowly during quiescence or more rapidly during an outburst.

Precisely how a magnetar flare is triggered is still being investigated. In contrast to the hot, magnetized atmosphere of the Sun, there are no swirling convective motions that actively deform the embedded magnetic field. But in a giant flare, we can be fairly certain that the crust undergoes a very large-scale disruption – imagine a tectonic event in which California and New York become interchanged. The slower component seen in the 15 April event and its siblings is consistent with what would be produced by the relaxation of a crustal deformation.

Such a disruption would twist up the exterior magnetic field of the magnetar, driving unstable electric currents one billion times stronger than those flowing through the Sun's corona[9,10]. A further consequence could be the ejection of a magnetic loop, similarly to large solar flares[11,12]. The magnetic disturbance would be strong enough to create a dense, outflowing gas of electrons, positrons and γ-rays. The interaction of such an electrically conducting gas with the magnetic field is thought to produce the subsecond-long γ-ray spectrum observed by Svinkin *et al.* and by Roberts and colleagues.

In its study[3], the Fermi LAT collaboration opens a new window on magnetar flares. It reports that the low-energy γ-rays described in the other two papers[1,2] were followed 19 seconds later by an emission of higher-energy γ-rays, which lasted for several minutes. This is the first detection of delayed, high-energy γ-rays from a magnetar flare. The proposed explanation involves the release of a cloud of fast-moving (relativistic) ions during the flare – the high-energy γ-rays are produced in a shock wave as the eruption hits the gaseous medium of NGC 253. However, it is unclear whether magnetar flares contain a substantial mass of ions. A pulse consisting of nearly pure electromagnetic radiation would also drive a shock wave, and might interact first with a relativistic nebula of particles confined around the magnetar.

Taking stock, the trio of papers reports a γ-ray flare that offers direct clues about how magnetic stresses relax in and around a neutron star. The measured energy fell short of that produced by most γ-ray bursts generated by colliding neutron stars, by a factor of 1,000 or more, although the duration was similar. Theorists modelling γ-ray bursts have so far failed to agree on the process that produces the events' signature γ-ray emissions. Understanding the similarities and differences with regard to magnetar flares will help to narrow down the possibilities. Continued monitoring of magnetars in nearby galaxies will also constrain models of the origin of fast radio bursts.

Christopher Thompson is at the Canadian Institute for Theoretical Astrophysics, University of Toronto, Toronto, Ontario M5S 3H4, Canada.
e-mail: thompson@cita.utoronto.ca

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Genetics

Repeat DNA expands our understanding of autism

Anthony J. Hannan

A link has been found between repetitive stretches of DNA called tandem repeats and autism spectrum disorder. The discovery might inform approaches to studying tandem repeats in a wide range of other human disorders. **See p.246**

Approximately half of the human genome, known as the repeatome, consists of repetitive DNA sequences. The repeatome includes more than one million tandem repeats – sections of DNA in which a sequence is replicated many times in tandem – whose biology remains largely unexplored. More than 50 diseases are known to be caused by expansion of a tandem-repeat sequence in a single gene; among them are Huntington's disease and fragile X syndrome[1]. But less-well understood is the role of tandem repeats in polygenic diseases, which have more-complex genetic underpinnings. On page 246, Mitra *et al.*[2] use a newly developed bioinformatics approach to identify tandem repeats associated with one such condition, autism spectrum disorder.

Autism spectrum disorder (ASD) is highly prevalent, affecting approximately 1–2% of children in the United States (see go.nature.com/38sqvhd), although this varies internationally. It is characterized by atypical neurodevelopment, communication deficits, atypical social functioning, restricted interests and repetitive behaviours. Although progress is being made[3] in discovering the genetic basis of ASD, it remains poorly understood. Changes in the number of copies of large segments of DNA, along with other genetic variants, have been previously implicated[3], but the capacity to systematically investigate tandem repeats genome-wide has been optimized only in the past few years, thanks to advances in DNA sequencing and bioinformatics[1].

Mitra *et al.* analysed tandem repeats in people who have ASD, and in their immediate families, using a newly developed bioinformatics tool that they named MonSTR. The tool processes DNA sequences from tandem-repeat regions across the genome to determine the likelihood that a *de novo* mutation (one that occurs only in the person who has ASD, and not in their parents) led to a change in a tandem repeat.

The analysis revealed that tandem-repeat mutations are significantly more common in people who have ASD than in their unaffected siblings, with mutations more likely to cause the repeat to expand than to contract (Fig. 1). Many of the expansions occurred in DNA regions that drive the expression of genes involved in fetal brain development. To determine the likelihood that a mutation would be deleterious, Mitra *et al.* developed another