NATURE

50 Years Ago

With the growth of telecommunications based on geostationary orbits, there is growing concern that satellites may become so closely crowded together that they interfere with each other … An article in the current issue of the *Proceedings of the Institution of Electrical Engineers* … consists of a calculation of the capacity of the equatorial orbit to accumulate geostationary communications satellites. Their chief conclusion is that the capacity of the equatorial orbit, with present arrangements, is probably limited to about 2,000 telephone circuits for each degree of the orbit. For practical purposes, this amounts to roughly one satellite in each four degrees of the orbit, which in turn implies that it may take very little further development before parts of the equatorial orbit — over the Atlantic and America, for example — may be overcrowded.
From *Nature* 16 August 1969

100 Years Ago

The war has been responsible for great developments in many branches of science … [C]lose attention has been given to the subject of marine physics … especially … submarine acoustics … The singular property which distinguishes a submarine from other ships is its capacity of rendering itself invisible when pursued or when seeking and attacking its prey. Robbed of this power, it is an extremely vulnerable craft … The acoustic method of detecting a submerged submarine … was found to be far more sensitive and to give a much longer range than all other methods. Instruments used for this purpose are called hydrophones. … [T]he improved hydrophones developed for war service should greatly reduce the dangers of collisions and shipwreck.
From *Nature* 14 August 1919

by Jiang and colleagues, indicate that GIPCs fulfil versatile sensing and signalling functions in plants. This work also points to a crucial role for membrane-lipid composition in organizing functionally important signalling domains for many key processes in plants. ■

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This article was published online on 31 July 2019.

ASTROPHYSICS

X marks the spot for fast radio bursts

Fast radio bursts are enigmatic astronomical signals that originate from deep in extragalactic space. Observations using an array of radio telescopes have identified a likely host galaxy for one of these signals. **See Letter p.352**

JASON HESSELS

In 2007, astronomers detected a flash of radio waves that was much shorter in duration than the blink of an eye[1]. Such signals, now called fast radio bursts (FRBs), are thought to have been produced billions of years ago in distant galaxies[2]. If so, the sources of FRBs must be spectacularly energetic and, quite possibly, unlike anything that has ever been observed in our Galaxy. Pinpointing the galaxies that host FRBs is the key to unlocking the mysterious origins of these signals. On page 352, Ravi *et al.*[3] report the discovery of the likely host galaxy of an FRB that travelled for 6 billion years before reaching Earth. The properties of this galaxy suggest that active star formation is not essential for making an FRB source.

The maxim 'location, location, location' applies to FRBs: knowing where these signals originate is crucial to understanding what generates them. Although astronomers have detected almost 100 FRB sources so far[2], the measured positions of these sources on the sky have typically been too inaccurate to identify their host galaxies. One exception is the first FRB source observed to produce repeat bursts[4]. This source was localized to a region of active star formation in a puny 'dwarf' galaxy[5]. The finding supported theories that ascribe the origin of FRBs to the extremely condensed remnants of powerful stellar explosions called supernovae. For example, the repeating FRBs could originate from young and hyper-magnetized neutron stars — the collapsed remnants of massive stars[6].

However, most FRB sources have not been seen to produce repeat bursts. Astronomers have therefore questioned whether these apparently one-off events have a different origin from that of the repeating FRBs[2]. From a practical point of view, one-off FRBs are much more challenging to study than repeaters. In the case of a repeating FRB, a patient observer can wait for further bursts and refine the measured position of the source. But for a one-off FRB, the position needs to be pinpointed by capturing the necessary high-resolution data at the same time as the burst is discovered.

Ravi and colleagues achieved this feat using an array of ten relatively small (4.5-metre-diameter) radio dishes spread across an area of roughly one square kilometre in Owens Valley, California. This distributed telescope network, known as the Deep Synoptic Array 10-antenna prototype (DSA-10), can scan a broad swathe of sky for FRBs (Fig. 1a). It can also provide enough spatial resolution to determine the position of a burst on the sky with high precision[7]. This precision must indeed be extremely high: unless the position is known to 1,000th of a degree, robustly associating an FRB with a specific host galaxy is impossible[8]. Even though Ravi *et al.* determined the position of their FRB to this level of precision (Fig. 1b), there is still some uncertainty as to whether or not the identified galaxy is the true host.

The authors demonstrate that this likely

IMAGES: CALTECH/OVRO/V. RAVI

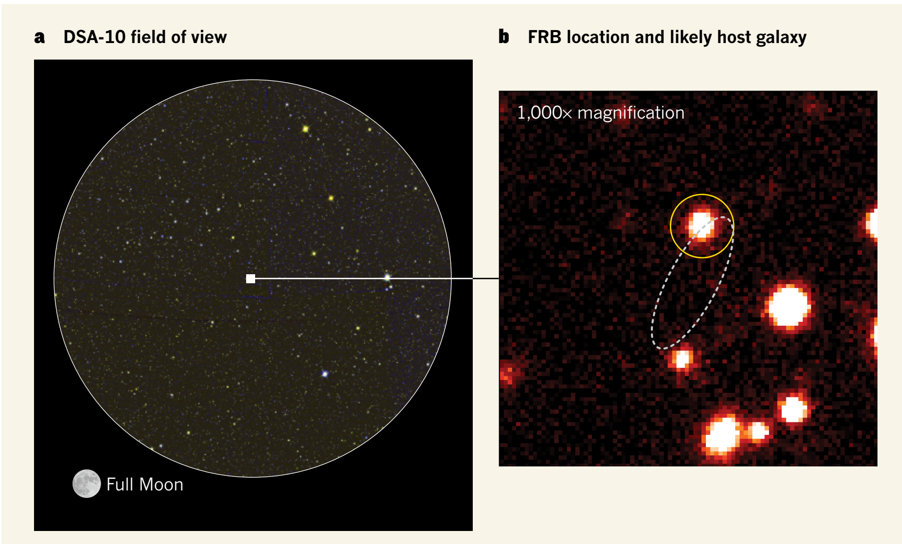

Figure 1 | Localization of a fast radio burst (FRB). **a**, Ravi *et al.*[3] report observations from an array of radio telescopes known as the Deep Synoptic Array 10-antenna prototype (DSA-10). The field of view of DSA-10 is roughly 40 square degrees[7], which is about 200 times the area on the sky that is covered by the full Moon when viewed from Earth's surface. **b**, Ravi and colleagues used DSA-10 to precisely determine the position of an FRB — a millisecond-duration flash of radio waves. The broken white ellipse shows the region in which the FRB could be located. The authors then identified a massive galaxy (indicated by the yellow circle) that is the likely host of the FRB.

host galaxy is markedly different from the host[5] of the well-localized source of the repeating FRB. It is 1,000 times more massive, and shows none of the prodigious star formation that is associated with the environment of the repeating-FRB source. Only a week before Ravi and colleagues' work was published online, a similar breakthrough was reported[9] using the Australian Square Kilometre Array Pathfinder (ASKAP) telescope. The authors of that paper achieved an even more precise localization of another one-off FRB, and also demonstrated that it originates from a massive galaxy that shows little signs of active star formation.

So, do these results mean that one-off FRBs and repeaters come from different galaxy types, and that they have physically different origins? Do astronomers have two puzzles on their hands? Perhaps, but with only three FRB host galaxies identified so far, many alternatives remain open. For instance, it is possible that all FRBs are generated by hyper-magnetized neutron stars, but that there are various ways in which such neutron stars can be produced[10]. Some might form directly through the collapse of a massive star, whereas others might be made from old neutron stars in a binary system that smash into each other as the orbital distance between them decreases. This difference could explain why some FRBs seem to originate from star-forming regions and others do not[10].

Excitingly, we will soon know a lot more. The mystery of FRBs has driven many teams worldwide to tune radio telescopes towards discovering and localizing these signals, and many thousands of FRBs are thought to happen somewhere on the sky each day[2]. The fact that fewer than 100 FRB sources have been detected is a reflection of the small fields of view of existing radio telescopes. If a sensitive radio telescope could be built that has a continuous view of the entire sky, FRBs would look like a fireworks display. However, wide-field telescopes such as the Canadian Hydrogen Intensity Mapping Experiment[11] (CHIME) are starting to change the game. It might not be long before astronomers have catalogued thousands of FRB sources and pinpointed at least dozens of them.

The precise localizations from DSA-10 and ASKAP are shedding light on the origins of FRBs, but they are also teaching us about the potential use of these signals as astronomical probes. FRBs are delayed in their arrival at Earth by the otherwise invisible material between galaxies[2]. By measuring the magnitude of this time delay, and comparing this measurement with the distance to the host galaxy, astronomers can map the density of ionized material in intergalactic space and thereby weigh the Universe in a unique way. The localizations of one-off FRBs suggest that FRB host galaxies will only slightly skew such measurements. Moreover, the results indicate that, with the detection and localization of thousands of FRBs, a 3D map of the material between galaxies could be made. ■

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TUMOUR BIOLOGY

A dynamic view of chemotherapy

Chemotherapy can halt cancer by causing cells to enter a non-dividing state called senescence, but sometimes it causes tumour cells to proliferate. It now seems that the dynamics of the protein p21 governs which of these fates occurs.

YUNPENG LIU & MICHAEL T. HEMANN

Chemotherapy usually works by inducing DNA damage that leads to cell death. However, rather than dying after chemotherapy, some tumour cells enter an inactive state, termed senescence, in which they are alive but have permanently stopped dividing[1]. Although senescence in normal cells drives ageing and tissue degeneration[2], cancer-therapy-induced senescence is associated with positive clinical outcomes[3]. Understanding the factors that drive the senescence of tumour cells might thus aid the development of new anticancer treatments. Writing in *Cell*, Hsu *et al.*[4] shed light on a previously unknown aspect of how chemotherapy-induced entry into senescence is controlled.

Although much progress has been made in uncovering factors that drive senescence, the processes that ultimately commit cells to this fate are poorly understood. A growing body