Martin Ryle (1918–1984)

Martin Ryle was one of the pioneers of the field of radio astronomy which made rapid progress in the decades immediately following the Second World War. He was awarded the Nobel Prize in Physics for developing the technique known as 'aperture synthesis'. This overcame what appeared to be a fundamental limitation of using radio waves. The smallest angle θ_{min} (in radians) at which details can be made out in an image of the sky made by a telescope depends on its diameter D and the wavelength λ. This is called the angular resolution and is given by the famous equation $\theta_{\text{min}} = \lambda/\text{D}$. Any finer detail such as the separation of two stars get blurred out. At a radio wavelength of 0.5 metres and a telescope of diameter of 50 metres, this comes out to be $\frac{1}{100}$ radian or a little more than half a degree – the size of the moon as seen from the Earth. The early pictures of the sky in radio waves were very crude compared to those made with visible light, typical wavelength 0.5 micrometres, a million times smaller. Making a radio dish of size even 100 times an optical telescope mirror would still leave radio pictures ten thousand times poorer than those made with visible light. Aperture synthesis broke this barrier, and today radio astronomy produces the sharpest images at any wavelength! The background to the emergence of radio astronomy, and this particular technique are explained in the article by Chengalur in this issue (p.165). A very detailed account of Ryle's life, personality, and work is given by Graham Smith, himself an eminent radio astronomer who worked with Ryle at Cambridge in the early 1950s. In what follows, I have drawn on this obituary (`rsbm.royalsocietypublishing.org/content/32/495`) for factual details, though any views expressed are my own.

There was no element of religion in Ryle's upbringing. In his school years he was described as quiet and thoughtful, a strong swimmer, fully capable of working with his hands, and significantly, a radio 'ham' – a term used in those days for amateurs who built their own shortwave transmitters and receivers, and used them to make contacts all over the globe. He secured a first class in physics in Oxford in 1939. His examiner was the famous Cambridge ionospheric physicist J A Ratcliffe who immediately recruited this talented young man for research. The Second World War was just beginning, and a very important role was played by radar – detecting the enemy aircrafts by the radio waves scattered by them. Ryle soon gave up his research and joined the war effort. By 1942, he was specialising in 'countermeasures' – how to detect German radar and 'jam' it – make it unusable by sending out signals at the same frequency. (Readers will note that jammers for mobile phones are in use today based on the same principle!). By 1942, a 23-year-old Ryle was the head of a group and had many achievements to his credit. A particular episode gives a feel for the pressures under which he worked in this

period. In 1944, it was vital that a particular German radar station, operating at centimetre wavelengths be 'jammed'. The proposal for a new device was made on Thursday, approved, some parts were made by Saturday, and the whole set up was flown by Tuesday! Another achievement was jamming and hence disabling the navigation system of the German V2 rockets which were targeting Britain. A very characteristic incident was his response in a meeting, to a proposal from the seniormost scientific adviser to the British government, in his presence. When asked for his opinion, Ryle burst out with "Utter bloody rubbish". Can we imagine this happening in any defence science establishment today?

After the war, Ryle returned to Cambridge and started with studies of radio waves from the Sun. He seems to have soon concluded that the future lay in improving observing techniques by the technique of interferometry, pioneered by Michelson at optical wavelengths (see *Resonance*, Vol.22, No.7, p.645, 2017 for the basic principle). This allowed him and his colleagues to make catalogues of first the brightest, and later many more sources of radio waves in the sky. Another group in Sydney, Australia was pursuing a similar goal and pointed out serious errors in the second such catalogue, called '2C'. Ryle's response was to create 3C – the third Cambridge catalogue – which has stood the test of time and is a landmark in the study of these objects. Initially, the nature of these sources of radio waves was unknown. But by the 1960s, it was clear that these resided in very distant galaxies (see the article by Saikia on Astrophysical Jets in this issue, p.147). Ryle did not take kindly to criticism and fought fiercely for his own views – whether it be with the Sydney group, or with the theoretical astronomer Fred Hoyle, also at Cambridge. Hoyle interpreted data on radio sources in terms of his own 'steady state cosmology', and in fact coined the term 'big bang cosmology' for the rival version earlier proposed by George Gamow in which the universe evolves from a hot initial state. Of course, it is the latter model which is now universally accepted. Gamow, with characteristic humour, summed up the controversy in his popular book *Mr. Tompkins in Paperback* in verse which his wife Barbara wrote, worth quoting in full.

> "Your years of toil," / Said Ryle to Hoyle, / "Are wasted years, believe me.
> The steady state / Is out of date. / Unless my eyes deceive me,
>
> My telescope / Has dashed your hope; / Your tenets are refuted.
> Let me be terse: / Our universe / Grows daily more diluted!"
>
> Said Hoyle, "You quote / Lemaître, I note, / And Gamow. Well, forget them!
> That errant gang / And their Big Bang— / Why aid them and abet them?
>
> You see, my friend, / It has no end / And there was no beginning,
> As Bondi, Gold, / And I will hold / Until our hair is thinning!"
>
> "Not so!" cried Ryle / With rising bile / And straining at the tether;

"Far galaxies / Are, as one sees, / More tightly packed together!"

"You make me boil!" / Exploded Hoyle, / His statement rearranging;
"New matter's born / Each night and morn. / The picture is unchanging!"

"Come off it, Hoyle! / I aim to foil / You yet" (The fun commences)
"And in a while" / Continued Ryle, / "I'll bring you to your senses!"

What added spice to the controversy was that both the parties were only a few hundred metres apart in Cambridge.

While all this was going on, Ryle moved step by step to his crowning achievement. His style was characterised as personal and intuitive – one of his colleagues said he was unsure whether Ryle had ever read a textbook. It was also completely hands-on. The following extract from Smith's memoir brings out this utterly unique trait.

"An astonishing aspect of these developments is that Ryle concerned himself with every detail of the construction of the aerial systems, [aerial is an old-fashioned term for what we now call a radio antenna or dish] receivers, control systems and digital recorders of the succession of interferometers and aperture synthesis telescopes. Scheuer (a student in Cambridge in those years) concludes his account of the development of aperture synthesis as follows: 'It is the story of one remarkable man, who not only provided the inspiration and the driving force but actually designed most of the bits and pieces, charmed or savaged official persons according to their deserts, wielded shovels, and sledgehammers, mended breakdowns, and kept the rest of us on our toes.'" This is all the more remarkable, given that he had his share of health problems by this time – he died at 66.

One strong principle Ryle followed was never to keep releasing details of progress piecemeal, the way most scientists do now. He would wait till there was a major result to be unveiled, and his group had little choice in the matter. This gained him a well-deserved reputation for being secretive, but there was a strong justification in his mind. Even in his wartime days, he had seen how the United States, by pouring in money and manpower, could achieve rapid results by exploring many options, while his own group had to rely on their own ideas and judgment to find the best way. He did not want his group in Cambridge to be overtaken simply because their ideas were divulged prematurely to people who had more resources. This policy earned him severe criticism when the Cambridge group published studies on three newly discovered radio pulsars but did not reveal their locations in the sky.

None of this can take away the importance of aperture synthesis which has formed the basis for almost all the discoveries in radio astronomy since his time. The Cavendish laboratory at Cambridge is renowned for its discoveries in nuclear physics led by Rutherford (*Resonance*,Vol.16,

No.11, 2011) and later in crystallography and molecular biology, led by Bragg (*Resonance*, Vol.19, No.12, 2014). The other revolution led from the Cavendish laboratory was in radio astronomy. If one had to name one towering figure in a field with many giants, it would have to be Ryle. One of Ryle's own discoveries and its aftermath is descried in Saikia's article. India's own Giant Metrewave Radio Telescope (described in Chengalur's article) is based firmly on aperture synthesis. In one respect, the modern instruments have gone beyond Ryle's vision – they utilise clever mathematical/statistical techniques to make images even with limited data. (See *Resonance*, Vol.6, No.9, 2001, p.8 for an account of this area known as 'deconvolution'). Ryle was firm that he would not publish an image till all holes in the aperture were filled. He disapproved the early attempts to do otherwise, though they were outstandingly successful.

No account of Ryle would be complete without bringing in his passion for nature and in particular for sailing – of course, he brought his powerful scientific mind to bear on sails as well and designed and built a wind operated generator. Late in his life, his wartime experiences and the cold war political climate seem to have driven him to a strong stance not just against nuclear weapons, but also nuclear energy and even against fundamental research which might lead to dangerous consequences – a view bound to be unpopular. Shortly before his death, he was asked by a conference to suggest topics on the relation of science to society. He wrote a letter to the organisers what is now regarded as his last testament. It was published after his death (*New Scientist*, 14 February 1985, available online at Google Books). His words were written at a time when the threat of nuclear war between the superpowers loomed large. Today, they would apply with equal force to the threat of climate change which, like nuclear war, is a threat to all mankind. Here is an extract from his letter.

"..... in succeeding years we developed new techniques for making very powerful radio telescopes; these techniques have been perverted for improving radar and sonar systems A sadly large proportion of the PhD students we have trained have taken the skills they have learned in these and other areas into the field of defence. I am left at the end of my scientific life with the feeling that it would have been better to have become a farmer in 1946." The last line of his letter reads, "Our cleverness has grown prodigiously, but not our wisdom."

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