50 Years Ago

Discovering the Universe by Sir Bernard and Lady Lovell — Seldom has a technical exploit aroused such widespread interest and excitement as did the launching of the first Russian *Sputnik* in 1957. It was at this time that the radio telescope at Jodrell Bank was first coming into operation … So it was natural that the quickened scientific awareness of the general public should find a focal point in Prof. Lovell and the radio telescope … In view of the joint authorship one might, perhaps, anticipate some comments of a more personal nature. What does it feel like to live under the shadow of the bowl, to partner a man whose name has become a household word? Such elements are difficult to detect save in the preface, "The life which we knew before October 1957 has never quite returned". One can well imagine that this is something of an understatement.
From *Nature* 22 February 1964

100 Years Ago

'The wearing of birds' plumage — a woman's protest' — The dealers in feathers seem to think that because they have embarked on that particular trade it must never be abolished, no matter if the most exquisite birds become extinct. It is known that many trades have suffered severely from the advent of the motor-car. Whip-makers scarcely have anything to do. Harness-makers have also suffered, yet these trades could scarcely demand that motors should not be used because such might suffer thereby … There is such an abundance of lovely ornaments to be had … and if there must be feathers, then take some which require no cruelty to procure … Of course, imitation feathers would be cheap — to some women an unpardonable fault. Well, when the adornment *must* be expensive, there are jewels and laces.
From *Nature* 19 February 1914

PLASMA PHYSICS

A promising advance in nuclear fusion

Experiments conducted at the US National Ignition Facility have cleared a hurdle on the road to nuclear fusion in the laboratory, encouraging fusion scientists around the world. SEE LETTER P.343

MARK HERRMANN

Formidable challenges face the decades-long quest to achieve nuclear fusion — the power source of stars — in the laboratory. For a plasma to undergo self-heating nuclear fusion (ignition), it must be both hot and well confined. The facilities that hope to accomplish this goal are technological marvels, but are dauntingly expensive to build and operate. Setbacks abound as nature resists human attempts to control it, and technical hurdles lead to cost increases that threaten funding support. Thus, it is not surprising that fusion scientists throughout the world are cheering the exciting advances reported by Hurricane *et al.*[1] on page 343 of this issue. For the first time, their laboratory fusion experiment achieved more energy from fusion reactions than had been invested in the fusion fuel. These results are still a long way from ignition, but they represent a significant step forward in fusion research.

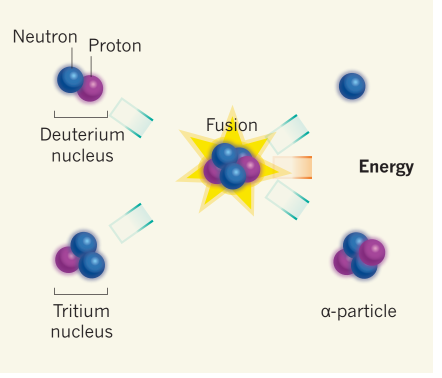

Figure 1 | Deuterium–tritium fusion reaction. When a deuterium nucleus and a tritium nucleus fuse, a neutron and an α-particle emerge and substantial energy is released. Hurricane and colleagues[1] have created a plasma of deuterium and tritium that has a fusion-energy yield greater than the energy invested in the fusion fuel.

In the most commonly used laboratory fusion reaction, the fusion fuel consists of a plasma of deuterium and tritium, and the reaction produces both an α-particle (two protons and two neutrons bound together) and a neutron (Fig. 1). The charged α-particle deposits its energy locally, whereas the neutron escapes. The local heating that results from the α-particles provides the potential for ignition if energy losses from the plasma can be overcome. For a deuterium–tritium plasma at a temperature of 50 million kelvin, the criterion for achieving ignition is known as the Lawson criterion[2,3], and can be simply written as $P\tau > 25$ atm s, where P is the pressure of the plasma; τ is the energy confinement time of the plasma (the timescale over which the plasma loses its energy); atm is atmospheres; and s is seconds. Once ignition is obtained, fusion proceeds rapidly and produces much more energy than was invested in creating the plasma.

Many approaches to achieving this criterion have been conceived, but the two main methods occupy very different regimes of pressure and energy confinement time. In magnetic confinement fusion, in which a strong magnetic field confines the hot plasma, the pressure is of the order of atmospheres and the energy confinement time of the order of seconds. In inertial confinement fusion — the approach taken by Hurricane and colleagues — it is the inertia of the deuterium–tritium plasma itself that provides the confinement. In this regime, the pressure is a few times 10^{11} atm, and the energy confinement time is about 10^{-10} s.

Achieving pressures this large, even for vanishingly short times, is no easy task. Hurricane *et al.* performed their experiments using the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory in California, which was completed in 2009 after more than a decade of construction. The NIF consists of 192 laser beams that can be focused onto a centimetre-scale target containing a capsule filled with fusion fuel. The beams are capable of delivering more than 1.8 million joules of energy to the target in a carefully controlled laser pulse lasting less than 2×10^{-8} s. As extreme as this sounds, the pressure on the target is still 1,000 times lower than that needed to meet the Lawson criterion. To achieve ignition, one must compress the fusion fuel in a nearly perfect spherical implosion at velocities of hundreds of kilometres per second, while adding as little heat as possible to the fusion fuel and avoiding numerous hydrodynamic instabilities.

Hurricane *et al.* made their advance by studying deuterium–tritium implosions that were more stable than those previously explored. This increased stability was accomplished