RAL

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RUTHERFORD APPLETON LABORATORY

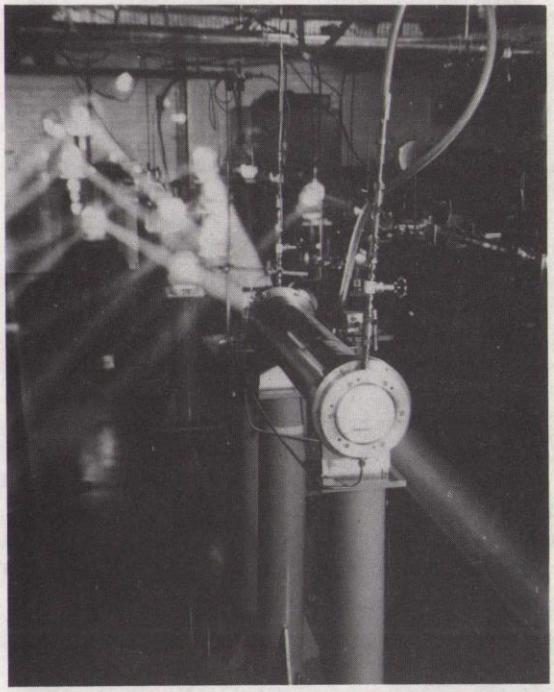
SCIENCE AND ENGINEERING RESEARCH COUNCIL

THE SPRITE LASER SYSTEM

The Sprite laser system is the most powerful laser of its kind in the world. It produces very short pulses of ultraviolet light whose peak power exceeds one hundred thousand million watts. We have focussed this light to a spot so small that 50 of them would fit onto the end of a human hair. At the focus the light is as intense as at the core of the sun !

Visiting scientists use the Sprite system to study the effects of intense light on solid matter. Practical applications of their results include x-ray laser development, the control of nuclear fusion, possible new designs for subatomic particle accelerators and the simulation, in the laboratory, of conditions otherwise found only inside stars.

The system is also being used as a test bed for the next generation of very large lasers. Schemes currently being considered include modules four times the physical size of Sprite, producing one hundred times its output energy !



The final laser in the Sprite system uses energy from seven input beams (top left) to amplify one output beam, exiting towards the bottom right.

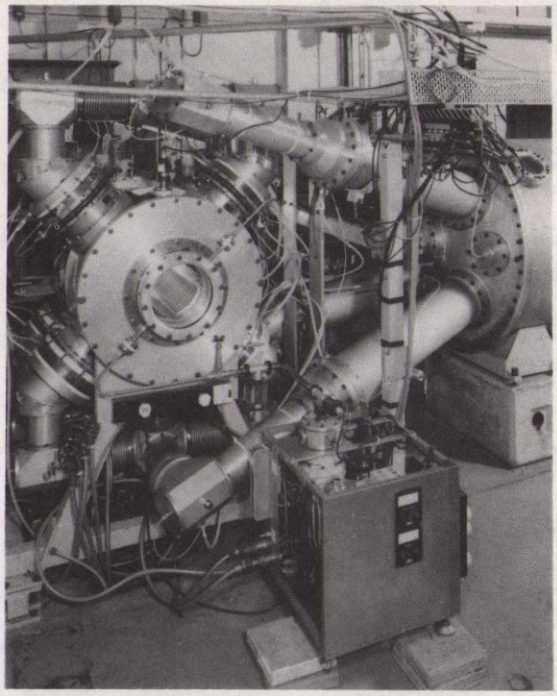
WHAT'S SO SPECIAL ABOUT LASERS ?

Laser light is different from more common forms of light (such as sunlight or electric light) in two ways. Firstly it is effectively single-coloured (strictly it spans a very narrow range of wavelengths) whereas sunlight, for instance, is made up from a continuous spread of different colours. These are revealed when raindrops or prisms separate it into the familiar rainbow spectrum. Laser light typically has a range of colours much narrower even than one band of a rainbow.

The second distinctive property of laser light is its directionality. Light from a light bulb spreads out in all directions, and even with a searchlight mirror it is difficult to produce a beam that doesn't fan out after a few hundred metres. Laser light, on the other hand, has been shone all the way from the earth to the moon ! The Sprite output beam spreads about a thousand times more slowly than a torch beam of the same size. A consequence of the laser beam's very low spread is that it can be focussed to a very small spot.

Lasers can be used in two different ways, as "oscillators", which generate beams of light, or as "amplifiers", which take an already existing weak beam and make it stronger. All of the lasers which we will discuss here are set up as amplifiers.

THE "SPRITE" KRYPTON FLUORIDE LASER



This machine, after which the whole system is named, is the largest Krypton Fluoride laser in Europe. It amplifies ultraviolet light in a mixture of gases which are themselves powered by a pulse of electrical energy. (The hardware used to generate the extremely high-voltage, high-current pulses is on display in the neighbouring building, R7.) The gas mix includes Krypton and Fluorine which form Krypton Fluoride when the machine is working. There are a number of reasons for using Krypton Fluoride lasers, among the most compelling being the relatively high efficiency. Sprite can convert more than 1% of its electrical input energy into light. The comparable figure for Vulcan, the laboratory's Neodymium-Glass laser, is one tenth of this.

Sprite is presently being used to amplify eight very short pulses of light in succession. These are then used in the Multiplexer Room to drive three Raman laser amplifiers (described below). The beams passing through Sprite are 27 centimetres in diameter, but each lasts only 10 millionths of a millionth of a second. Light travels 3 millimetres in this time so the individual pulses are only 3 millimetres long. If they could be made visible they would look like a train of eight "pancakes", 1.5 metres apart, passing through the laser.

THE MULTIPLEXER ROOM

This room contains the final three lasers in the Sprite system and nearly all of the mirrors (more than 70 of them) used to steer, subdivide and recombine the laser beams. This process, known as "multiplexing", is necessary to make most efficient use of the large Krypton Fluoride amplifiers.

The lasers in the Multiplexer Room are Raman lasers, which means that they are powered by light of one colour, called the "pump" light, and amplify light of a slightly different colour. The pump light comes from Sprite as eight separate pulses, the first of which powers the two smaller Raman lasers. The remaining seven are combined to pump the third amplifier. The Raman lasers consist simply of a tube containing methane (the laser gas) with a window at each end. The larger ones also contain a square tube with mirrored walls (a "lightguide"). This ensures that the pump beams and the beam being amplified continue to overlap for the full length of the laser. It also "mixes up" the pumps, averaging out any hot spots.

Of the total energy put into the final amplifier by its seven pumps, more than half is extracted by the single amplified beam. As well as containing more energy than any one of the pumps, the amplified beam also has a much lower beam-spread and a very low level of "prepulse" (i.e. light produced before the main pulse). These features make this system unique among the world's large laser facilities.