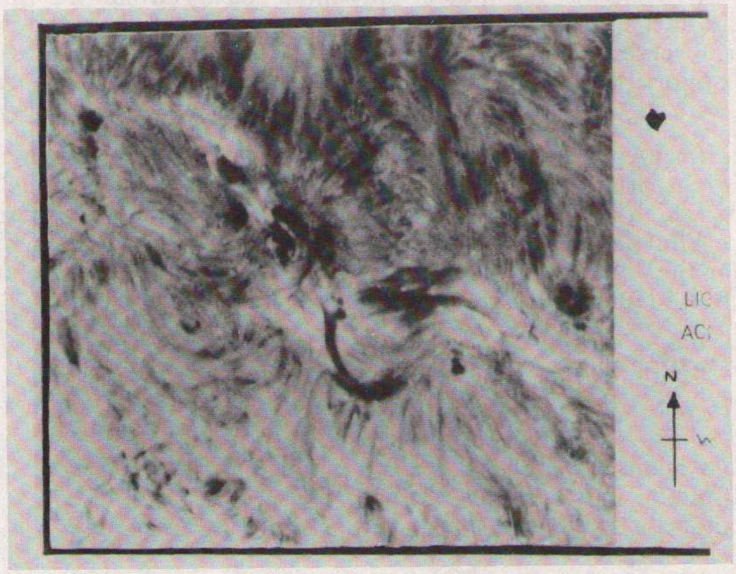
RAL
DESIGN & DISCOVERY
Open Days July 1990
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

The Sun

The Sun is a perfectly ordinary star. All life on Earth is totally dependent on the heat and light which the Sun generates, yet we know remarkably little about how such a star works. We know that thermonuclear reactions occur in the core of the Sun, where hydrogen is fused to form helium – in regions where the temperature is about 15 million degrees.

Energy radiates from the core through much of the body of the Sun, and finally escapes to the surface by setting up huge convection cells. These cells can be seen as a vast array of regular granules on the solar surface or photosphere. Since the Sun is extremely hot most atoms are stripped of most of their electrons. Thus, the motion of the solar gases or plasma, due to the convection and to the Sun's own rotation results in electric currents – the motion of charged particles. Such currents set up magnetic fields. The Sun's magnetic field structure is not like that of a bar magnet, the complex motions and flows result in an extremely tangled system of magnetic loops in continual motion. If one imagines these



An image of a portion of the Sun's disc, taken through a filter to show the complex magnetic structures. The dark patches are sunspots and the largest of these is about the size of the Earth.

field lines to be like elastic bands in motion, being twisted and pressed against one another, one would expect regions of breakdown, where the bands break. In the Sun's atmosphere, such activity and breakdown results in a variety of strange phenomena and active features.

The Sun's strange rotation – the equator rotates faster than the poles – drives a cycle of solar activity. Every 11 years the fields become very complex and much activity occurs as the structures break down.

The Sun is surrounded by an atmosphere, much as the Earth is. We call the Sun's upper atmosphere the corona. The corona is highly structured because of the magnetic fields and it is hot – typically 2 million degrees. The visible surface of the Sun has a temperature of only about 6000 degrees. Why should the Sun's atmosphere get hotter as you move away from the Sun? We have known for many years that the corona emits a continuous stream of matter known as the solar wind. This wind flows in all directions and engulfs all of the planets in the solar system. How is this wind accelerated?

The acceleration of the solar wind and the heating of the corona are two of the great mysteries of the Sun. They are probably a result of continuous activity in the solar atmosphere as the solar gases and magnetic fields interact. However, the most dramatic phenomena seen on the Sun are due to a breakdown in the magnetic structures, just as the most dramatic geological effects at the Earth's surface – volcanoes and earthquakes – are due to some breakdown at a weakness in the Earth's crust. On the Sun, these events include huge explosions, called solar flares, and occasions where millions of tonnes of matter are expelled into space at once, the so called coronal mass ejections and prominence eruptions.

Although we know that these phenomena are driven by the complexity of the Sun's magnetic fields, and that their frequency depends on the phase of the solar activity cycle, we do not fully understand how such events occur and we cannot predict their occurrence. However, since such activity can result in highly energetic particles or clouds of magnetised gas engulfing the Earth, affecting radio communications and power grids on the Earth, damaging sensitive satellite equipment and endangering human life in space, it is in our interests to find out! Finally, from the astronomer's point of view, the Sun is the only star which we can observe in detail, rather than as a mere point of light. It thus represents our only real opportunity to examine processes which undoubtedly occur throughout the universe.

The Rutherford Appleton Laboratory has taken an active role in the UK's contribution to solar physics research, and this includes, in recent years, the construction and operation of experiments which have been flown aboard NASA's Solar Maximum Mission satellite and the Space Shuttle, as well as the development of theory. Present projects include experiments for the Japanese Solar-A satellite and the NASA/ESA Solar and Heliospheric Observatory, to be launched in 1991 and 1995, respectively.

For more information please contact:

Bruce Patchett,
Head of Solar Group,
Astrophysics Division,
Rutherford Appleton Laboratory,
Chilton, Didcot
Oxfordshire OX11 0QX.
Tel: (0235) 44 6368