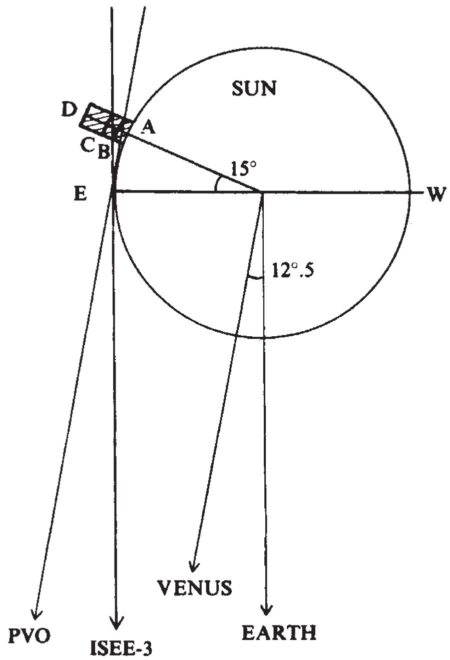
The hard X-ray Sun in stereo

from John C. Brown

VIRTUALLY on the eve of launch (14 February, 1980) of the first ever solar hard X-ray imaging telescope, aboard NASAs Solar Maximum Mission (SMM), a group of US researchers has scooped some of its expected results without the use of imaging instruments. Kane and Anderson of Berkeley and Evans, Klebesadel and Laros of Los Alamos (*Astrophys. J. Lett.* **233**, L151; 1979) have obtained quantitative information on the spatial structure of a solar hard X-ray source by simultaneous observations from two separate spacecraft. Their results provide invaluable insight into the process of electron acceleration which is central to the solar flare problem.

At the time of observation (5 October, 1978 around 0632 UT) an International Sun Earth Explorer (ISEE-3) was located near the Earth while Pioneer Venus Orbiter (PVO) was 12.5 degrees eastward as seen from the Sun (see Figure). Fortuitously, a flare occurred in an active region A some 15 degrees behind the solar limb which consequently occulted different parts of the flaring solar atmosphere from the two spacecraft. As a result (see Figure) ISEE-3 observed only X rays emanating from altitude (C–D) in the source greater than 25,000 km above the photosphere (A) while PVO observed all emissions (B–D) from above 700 km altitude. At burst peak the PVO flux above 50 keV photon energy exceeded the ISEE flux, extrapolated to the same energy range, by a factor of 600 and had a spectrum harder by about +2 in the power-law exponent. We can thus conclude that the hard X-ray source is concentrated at altitudes below 25,000 km, particularly at higher photon energies, with a factor of 600 above 50 keV. This result is a great advance on previous behind-the-limb results from single spacecraft which established the existence of a high altitude source component but gave no information on the differential height structure.

The importance of hard X-ray bursts lies not in the bremsstrahlung X rays themselves but in the energy of the electrons emitting them. These electrons represent a significant, and perhaps a large, fraction of the total energy released by magnetic field dissipation in a solar flare. How severe are the demands that this places on the electron acceleration process depends strongly on the hard X-ray source model assumed. In particular the acceleration efficiency involved is modest if the bulk of the source electrons are in a relaxed quasi-thermal state. On the other hand, if the source electrons are non-thermal they lose most of their energy by collisions to the cooler thermal plasma rather than to bremsstrahlung and a far greater total electron energy is required.



Schematic showing directions of the two spacecraft as seen from the Sun and the different heights in the X-ray source (hatched area) seen from each spacecraft.

Two possible cases of the latter situation are the descending electron beam (thick target) model (with acceleration near D in the Figure) and the trap model where fast electrons are confined in a magnetic arch after acceleration. Although these latter models pose problems for acceleration mechanisms, they provide a plausible interpretation of impulsive chromospheric emissions in flares in terms of electron bombardment. The greatest single source of ambiguity in modelling hard X-ray bursts to date has been the lack of spatial resolution.

There seems to be no ready interpretation of Kane *et al.*'s results in terms of the trap model since this predicts comparable X-ray fluxes from the trapped (coronal) electrons and those precipitating down the limbs to the chromosphere (unless by chance ISEE just glimpsed part of the arch summit at C). A thermal model just might fit the facts if quasi-thermal emission emanated from CD at energies up to around 50 keV while the high energy electron tail escaped downward. The most convincing interpretation at present, however, is the thick target model which predicts a difference of +2 in spectral index between coronal and chromospheric components, and much greater total flux at low altitudes (Brown & McClymont *Solar Phys.* **41**, 135; 1975). The PVO/ISEE flux ratio would then require an acceleration site D located at a plasma column depth of 2.5×10^{18} protons cm^{-2} above the 25,000 km level C. For quiet Sun conditions the plasma density n here is around 10^8 cm^{-2}, but such a low density could not sustain a stable reverse current to neutralise the descending beam. Reverse current stability demands $n \gtrsim 5\times10^9$ cm^{-3} which is consistent with the density enhancements typical of active regions. It will be of great interest to see whether a similar source distribution with height occurs in other bursts or if these are more consistent with one of the other source models.

In the coming months SMM will disgorge vastly more hard X-ray source spatial data than are contained in Kane *et al.*'s results. Specifically it will yield detailed information on horizontal source structure and so test whether electrons really do bombard the chromosphere. On the other hand the SMM telescope is limited to photon energies below 30 keV and, furthermore, has no spatial resolution along the line of sight. Thus the 'stereo' data of Kane *et al.* will remain unique until we are again fortunate enough to have two spacecraft and a flare in the right places at the right time. □

J.C. Brown is a Senior Lecturer in the Department of Astronomy, University of Glasgow.

Tailoring liposome structure

from Gregory Gregoriadis

THE idea that drugs entrapped in lipid envelopes (liposomes) may provide a better means of delivery to specific sites within the body has aroused wide interest. Much of the interest in the liposomal carriers has no doubt stemmed from the almost unlimited number of potential versions in terms of composition, size and other characteristics. Indeed, correct choice of these parameters has, in some instances, led to liposomal preparations best suited for optimal drug action (for reviews of various aspects of liposomes see *Liposomes and their uses in Biology and Medicine* (D. Papahadjopoulos ed.) *Ann. N.Y. Acad. Sci.* **308**, 1978; *Liposomes in Biological Systems* (eds G. Gregoriadis & A.C. Allison) John Wiley and Sons Ltd, 1980). Recently, attempts have been made to rationalise liposome development by tailoring their structure to the particular biological milieu in which they are intended to act.

The ability to control the extent to which liposomes in the blood retain their entrapped drugs is obviously important to those interested in applying them systemically. Although in many cases drugs must be transported intact to where they are needed, in others their gradual release in the circulation may be preferable, especially when membrane barriers will prevent liposomes from reaching target sites.

In the blood, drugs are released from liposomes much more rapidly than expected from normal solute diffusion

Gregory Gregoriadis is at the MRC's Clinical Research Centre, Harrow, Middlesex.

0028-0836/80/09814-02$01.00