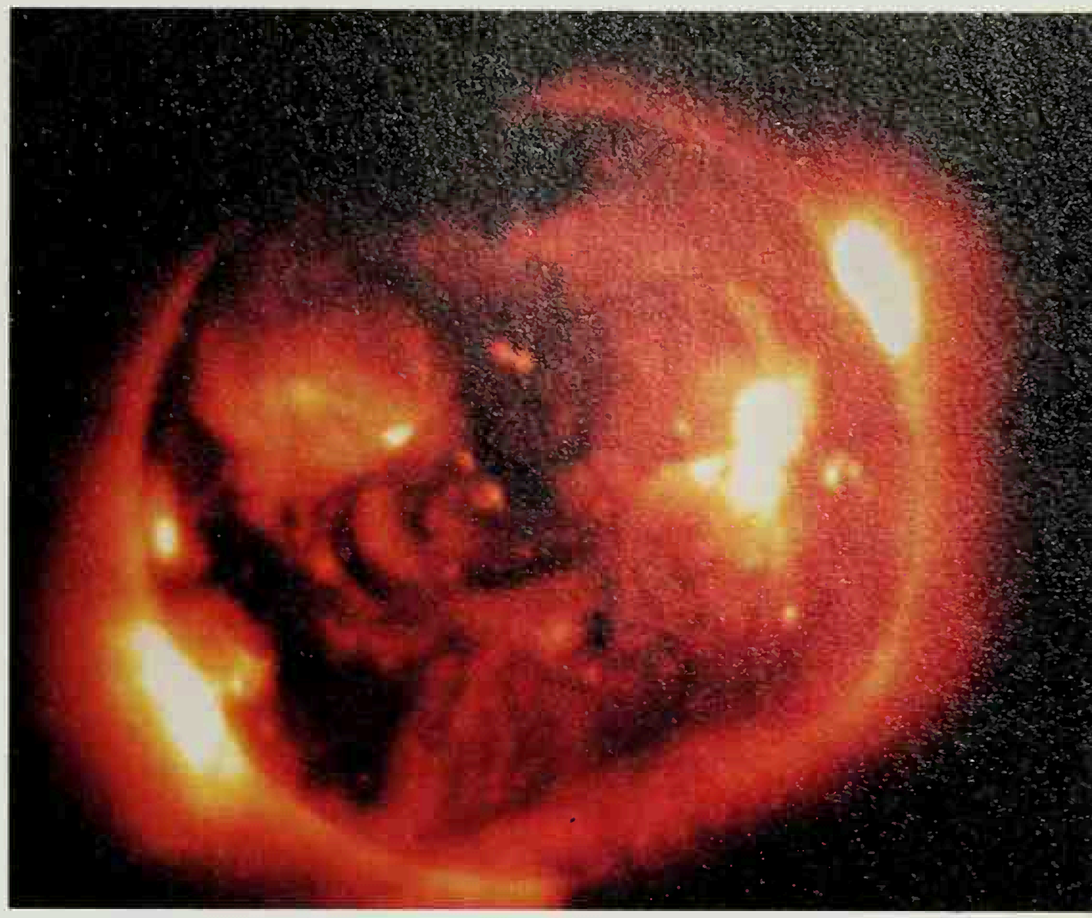
advanced. Changes in the overall diameter may be expected to occur over very long periods of time, but evidence has been presented that some shrinkage has occurred in just a few hundred years. Other discussions argue that little alteration has taken place, and only further research into historical records and careful determination of the current diameter of the Sun can settle the issue. There have been suggestions that there might be oscillations of the Sun's radius, but these are as yet unconfirmed. However, recent investigations have apparently established that the Sun is very slightly oblate. This in itself may be in accord with some recent proposals for amendments to theories of gravitation – more specifically, to Einstein's theory.

The solar neutrino problem

Solar astronomers believed they knew the temperature at the core of the Sun and the general properties of its interior. Nuclear physicists believed they understood the nuclear reaction processes and so between them they could predict the number of neutrinos emitted from a particular step of the proton-proton chain. An elaborate experiment was set up deep in a gold mine in the USA in an attempt to confirm these ideas and detect the neutrinos. Surprisingly, though, very few neutrinos have been detected and, because the apparatus did not appear to be at fault, immediate suspicion fell on our so-called knowledge of the solar interior. Speculative solutions to the problem include a cooler core so reducing the neutrino yield, a switched-off core where the Sun is 'coasting' between phases of nuclear burning, rapid core rotation, and very low heavy element abundance in the core. Yet another suggestion is that there may be a very considerable core of heavy elements such as iron, and that this core has existed from the time of the Sun's formation, the material being supplied by the initial solar nebula. Even more ingenious experiments are being mounted to try to determine both low and high-energy neutrino fluxes, and the results from these may throw some light upon this vexed question. One thing is certain; the discrepancy between theory and observation is uncomfortably large, showing that we do not even understand the details of the internal mechanics of our own Sun, let alone being in a position to solve many of the riddles the cosmos presents to us. A sobering thought, but a challenge which spurs astronomers to devise better instruments and more ingenious theories.



The Sun as it appears in X-ray light. This photograph was taken by astronauts aboard Skylab and reveals the hot bright inner corona and some flare hotspots across the disc. A new and previously unnoticed phenomenon of coronal holes was discovered. These are regions where the coronal density and temperature are reduced and appear as dark patches on X-ray pictures, but have no associated activity in visible light. It is speculated that these coronal holes may be the source of the high-speed ionized particles of the solar wind. Note: *The colours in this photograph are not real; they are computer generated to provide contrasts so that detail may be detected more easily.*

Table 4·1 **Some general properties of the Sun**

property	**value**
angular diameter in the sky	31·99 minutes of arc
mean Earth-Sun distance	$1·496 \times 10^{8}$ km
radius $R_\odot$	$6·96 \times 10^{5}$ km
mass $M_\odot$	$1·99 \times 10^{30}$ kg
mean density	$1·41 \times 10^{3}$ kg
effective surface temperature	5 800 K
spectral type	G2V
apparent magnitude m_v	−26·74
absolute magnitude M_v	+ 4·83
luminosity $L_\odot$	$3·83 \times 10^{26}$ W
equatorial rotation period	26 days

This photograph by Brian Manning taken in hydrogen-α light, shows considerable detail upon the Sun's disk, including bright faculae and dark filaments.