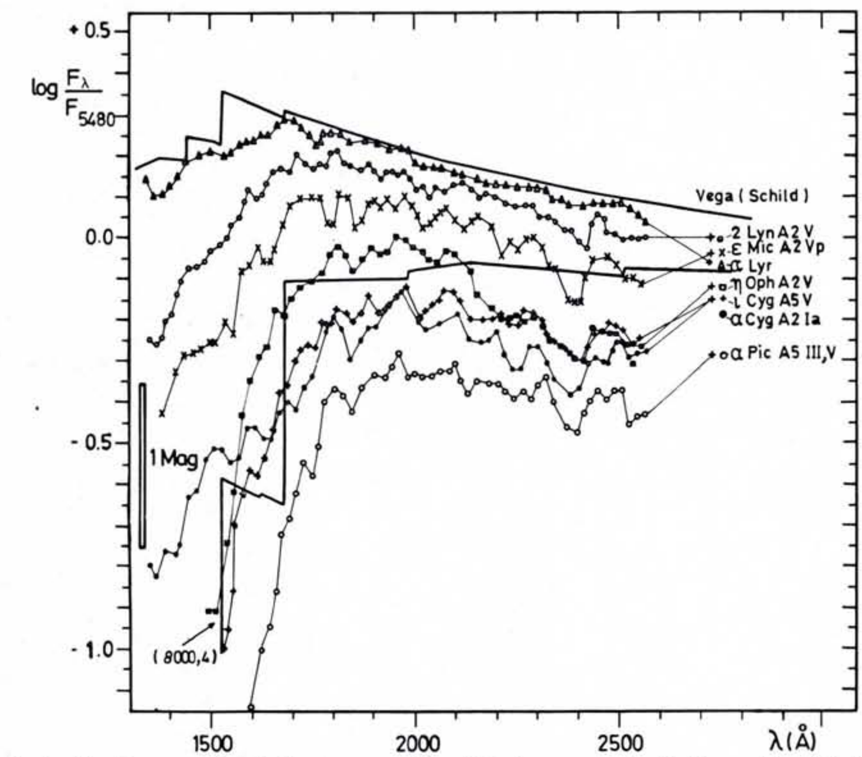

Fig. 4 *Absolute energy distribution for some A2 and A5 stars compared with Vega and predicted flux from two theoretical model atmospheres.*

sified as O9 and WC8, the O-type star was found to be well described by existing models of stellar atmospheres (built up largely on visible spectral data), but the UV flux from the WC member of the pair was much higher than expected. This could be due to a higher than expected amount of helium in its atmosphere.

Two further TD experiments produced results of significant astrophysical interest. One observed the abundance of cosmic-ray nucleii. The relative abundances of these particles tell the experimenters how long they have existed and the regions through which they have travelled on their way to the earth. The second observed solar X-ray bursts with a time resolution of just greater than 1 s. This enabled the experimenters to discover that an X-ray event on the sun was made up not of one large initial burst which then gradually decayed, but of a series of largely unrelated short-lived bursts. This result indicates that the particles producing X-rays in the solar atmosphere are not all injected then at the same time. The sun is our nearest star and detailed results like this, which we cannot hope to obtain from distant stars, will help piece together the picture of how stars in general behave.

COS-B

COS-B is the first European satellite to carry a single complex experiment developed by a collaboration of research institutes. Its primary mission is to study high-energy gamma radiation from the Galaxy, from known or postulated point sources and the diffuse background radiation. The position of gamma-ray sources is measured in order to investigate where the cosmic radiation originates and a study of the gamma energy spectrum helps decide which processes take place in the production region and en route to the earth.

The satellite was launched on 9 August 1975 and scientists have been studying a heavy flow of high-quality data since a few days after launch. Both spacecraft and experiment are operating perfectly and gamma and X-rays were measured arriving from known source positions in the sky during the early weeks of operation. Since then the satellite has carried out a comprehensive study of selected regions of the Galactic disc and has just embarked on an exploration of the relatively unknown regions outside the Galaxy.

The regions so far selected for study include several where pulsars have been seen at X-ray wavelengths. In two cases (the Crab and Vela supernova remnants) the experiment has detected enhanced emission from the direction of the pulsar and the experimenters will be searching the data for evidence of gamma-ray pulsations. Other regions studied contain binary star systems in which X-ray sources show occultations, and one contains an X-ray source which has been suggested as a possible black hole. The experimenters are monitoring the incoming data closely for any first signs of interesting effects in any of these peculiar objects. They are also watching closely for those unexplained dramatic and apparently random gamma-ray bursts detected by American satellites in the past few years.

A problem in trying to measure gamma rays from a satellite is the high background of charged particles but in COS-B the background count has been reduced to a level where we can confidently expect to make the measurements hoped for.

Part 3 Satellites under Development

GEOS

GEOS is a sophisticated and ambitious satellite which will carry seven experiments into a geostationary orbit during 1977. It will be the first purely scientific geostationary satellite and as such has been adopted as the 'reference' spacecraft for the International Magnetospheric Study (IMS). The IMS is a world-wide programme combining spacecraft, balloons, sounding rockets and ground-based observatories in an attack on the basic problems of magnetospheric physics.

ISEE

Single satellite measurements have been unable to sort out spatial from time variations and to determine, for example, wavelengths undistorted by spacecraft and wave relative velocities. ESA and NASA have put together the International Sun Earth Explorer (ISEE) mission to attack such problems. One spacecraft will monitor interplanetary phenomena while two others will, as a pair, simultaneously study the behaviour of the earth's magnetosphere in response to the interplanetary changes.

IUE

The International Ultraviolet Explorer (IUE) is a joint NASA, United Kingdom and ESA venture due for launch in late 1977. The scientific aims are to study high-resolution spectra of stars of all spectral types, to study the gas streams in and around some binary star systems, to examine with lower resolution spectra of faint stars, galaxies and quasars, to make repeated observations of objects known to show features which vary with time, and to define more precisely the way in which starlight is modified by interstellar dust and gas.

The IUE space observatory will have, by virtue of its geosynchronous position, a big advantage over previous astronomical satellites in lower orbits.

EXOSAT

The spacecraft EXOSAT, due to fly around 1980, will determine the position and examine the structure of celestial X-ray sources. In one mode it uses lunar occultation to examine source structure and the resolution thus obtained should yield information on binary stellar systems within which many cosmologists believe one of the stars to be a black hole.

Part 4

Future Scientific Projects

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The European Space Agency is presently conducting several feasibility studies. It may be recalled that such studies concern missions which have been recommended by ESA's various scientific advisory committees but which have not yet been approved by the Science Programme Committee : a project is approved on the basis of its feasibility study, which, of course, includes an evaluation of the cost.

Out-of Ecliptic and Solar Stereoscopic Mission

Proposed as a joint ESA/NASA venture, two spacecraft would be sent out of the ecliptic plane with the help of Jupiter's gravitational field. Each spacecraft would then fly over the sun almost at its North and South poles. Since all planets explored so far travel very close to the ecliptic plane, this mission would represent the first exploration of the solar system's third dimension, in a nearly symmetrical way with respect to the solar equator. Properties of particles, electric and magnetic fields would be studied, not only in the interplanetary medium but also close to Jupiter while both spacecraft swing around this planet. In addition, instruments such as a coronagraph, placed on board one of the spacecraft, would perform solar observations which, combined with terrestrial observations, would allow the study of various transient phenomena in the sun's atmosphere in a stereoscopic fashion. ESA and NASA would each build one of the spacecraft, with NASA also providing the launcher (Space Shuttle + Interim Upper Stage) and the deep space network. If the above mission were not fully accepted, a fall-back mission could consist of only one spacecraft provided by ESA, the launcher being supplied by NASA.

2.4 m Space Telescope (ST)

This is a major future project currently under study by NASA. In summary, the telescope would have a main mirror with a diameter of 2.4 m and an array of instruments including a low resolution spectrograph for faint objects, and a high spatial resolution camera. Due to the absence of atmospheric absorption, scintillation and scattering, the ST would have a unique capability to concentrate light falling on a large aperture into an image approximately 0.1 arc seconds across in the ultraviolet and the visible spectrum (and somewhat less good images in the infra-red). This would greatly benefit many areas of astronomy, including planetary, galactic and extragalactic studies, and particularly in studies in cosmology and evolution of galaxies.

Launched by the Shuttle, the ST is intended to last as long as 15 years, and replacement or refurbishment of some of its parts could be done by later Shuttle missions.

ESA has been invited by NASA to consider a possible participation in the ST project. Besides some pieces of hardware, such as the electric power system or a share in the scientific operations of the ST, ESA's possible contribution could consist of a faint object camera and a two-dimensional photon counting detector: feasibility studies have been started in these areas.

Large Infra-Red Telescope on Spacelab (LIRTS)

This is a large diameter telescope (in the range 2-3 m diameter) which is intended to observe celestial objects in the infra-red part of the spectrum in the range 20 to 300 μm : this spectral region cannot be observed from the ground because of the atmospheric absorption. Such a telescope, which would be placed on board Spacelab, would have an excellent capability to carry out high sensitivity photometric observations with high spatial resolution, as well as to measure atomic and molecular lines in the far infra-red with very high resolution. Polarimetric observations would also be performed with this instrument.

The duration of each mission is rather short, that is from 7 days up to possibly 30 days, but the possibility to refly an instrument several times, and therefore to modify or improve it, is precisely one of the unique capabilities of Spacelab.

The major problems related to this project are the thermal control of the uncooled telescope, the cryogenic system for the focal plane instrumentation, the contamination induced by Spacelab and the capabilities of the Instrument Pointing System, especially due to the weight of the LIRTS, during launching and landing.

X-Ray Spectropolarimetry on Spacelab (EXSPOS)

This mission consists of a set of instruments to be flown on Spacelab to study the spectra of cosmic X-ray sources and detect polarised X-ray emission. So far, very little emphasis has been placed on X-ray high resolution spectroscopy and polarimetry. The energy range to be studied extends from 2 to 10 keV. High sensitivity (and, therefore, good time resolution for the brighter sources) spectrometry and polarimetry, good spatial resolution, broad band spectroscopy are among the features of the various instruments. Since the proposed payload places only light demands on the Spacelab resources, it would be well suited for a great number of Spacelab missions. In about 8 missions of 7 days, this experiment could perform the desired observations of all relevant X-ray sources of the Uhuru catalogue.

Atmosphere, Magnetosphere and Plasmas in Space (AMPS)

AMPS is a programme studied by NASA, in which the capabilities of Spacelab in terms of weight, volume