As Stars Fall to Ashes

Astronomy in the extreme ultraviolet poses some questions for the theory of the last things in the life of a star

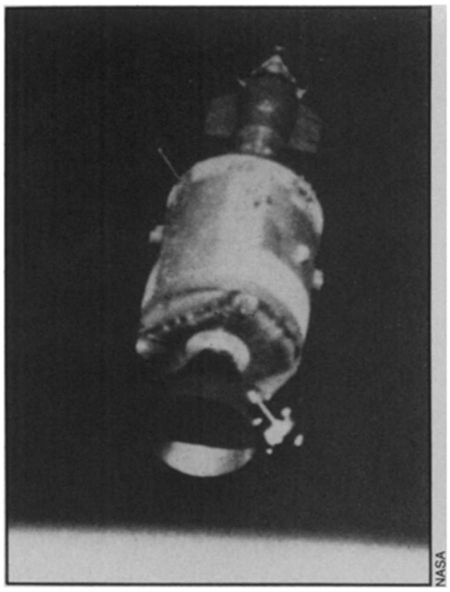
BY DIETRICK E. THOMSEN

Little by little and big by big, astronomers over the past generation have been extending their observational capabilities from the ancient medium of visible light in both directions, to the long-wave radio limits of the electromagnetic spectrum at one end to gamma rays at the other. But there are gaps, and some of them seem, or seemed, intrinsically unfillable.

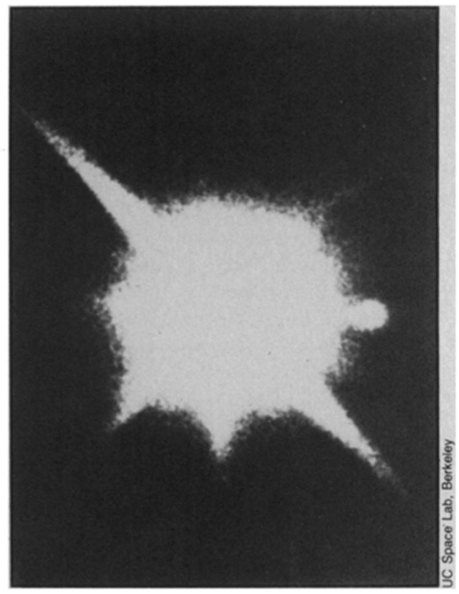
Take the extreme ultraviolet. This is a range of the spectrum with somewhat elastic boundaries, but it lies between the far ultraviolet and the soft X-ray regions. (In speaking of ultraviolet, "near," "far" and "extreme" refer to distance in wavelength size from the visible violet.) Conventional wisdom was that you could never see stars in the extreme ultraviolet because the junk in interstellar space would absorb all the radiation. The sun was all you could ever expect to see.

So they laughed, or at least smiled behind their hands, when Stuart Bowyer of the University of California at Berkeley and his associates, Michael Lampton, Francesco Paresce, Bruce Margon, Bob Stern and Jay Freeman, went down to the lab to try to figure out how to do EUV observing. Nevertheless, as Bowyer told the meeting of the American Physical Society in Washington, a small EUV telescope on the Apollo-Soyuz spacecraft found four EUV stars and a possible fifth, and a later balloon mission in the Southern Hemisphere found yet another. The data already have raised some serious questions about the end points of current models of the evolutionary history of stars. So who's laughing now?

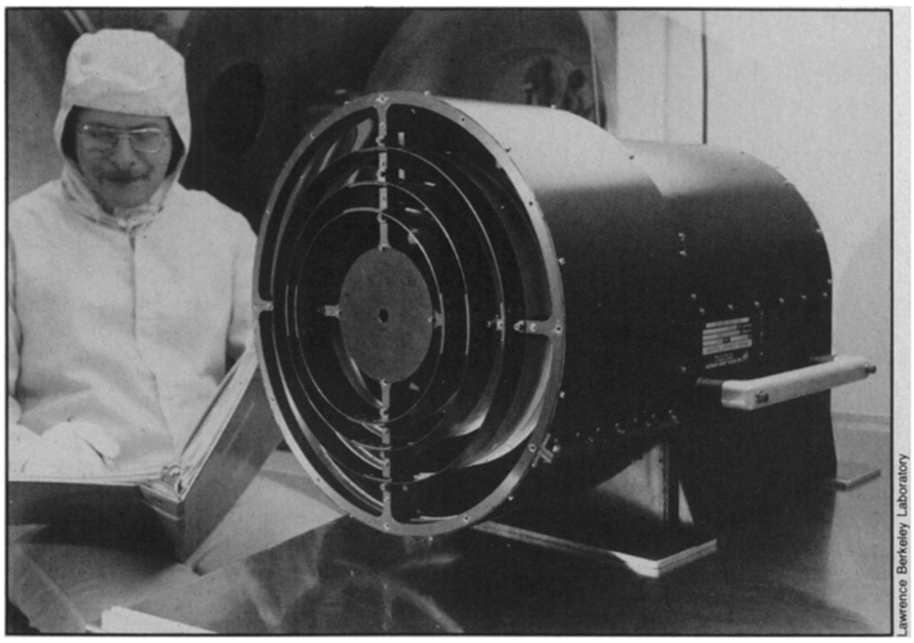
How and why the impossible took just a little longer than the really difficult is an interesting story. One thing it illustrates is the advisability of taking a close look at any argument based on average or mean values. Bowyer and his co-workers went to the laboratory to find out just what the particular absorptions of EUV by the different components of the interstellar medium were. Meanwhile, it became clear in the early seventies that the average value of the density of the interstellar medium is somewhat misleading for this purpose. The clouds are patchy, and some are small. The intercloud density is about $^{1}/_{10}$ atom per cubic centimeter, a tenth of the overall average. Between the clouds it turns out to be possible to observe at one wavelength or another.



Apollo-Soyuz carried EUV telescope.



Sirius A outshines Sirius B (at right).



Graduate student Robert Stern checks the EUV telescope in a laboratory clean room.

Bowyer sets the lower wavelength limit of the EUV at 100 angstroms. The most convenient upper cutoff is probably 912 angstroms, the ionization wavelength for hydrogen. Hydrogen is the most abundant and pervasive material in interstellar space, and when it starts to absorb, it will cover everything. Nevertheless, the group's calculations showed that even at this absorption edge it is possible to see at least 10 near stars. It's not a large number absolutely, but it may prove useful for studies of the physics of stellar chromospheres.

The group's main interest was in trying to see farther out. They calculated that at a wavelength of 300 angstroms they should be able to see about 30 light-years. In that distance are about a million stars, "enough to keep me and my co-workers busy," Bowyer says.

So they decided to fly a small telescope. An EUV telescope shares certain difficulties with an X-ray telescope. Telescopes depend on mirrors. Visible light and radio can be reflected by surfaces more or less perpendicular to the beam of radiation, but X-rays and EUV will go right through a perpendicular surface. Reflection is possible only at grazing incidence. A telescope consists of a series of ever narrower collars around the axis of the beam. Gradually, reflection off these collars narrows the beam to a focal point. The telescope built by Bowyer's group has no imaging capability, but it will determine if a given source is radiating EUV.

"The telescope was small," says Bowyer, "but the mounting was large." It was the Apollo-Soyuz spacecraft. Because of the constraints of the mission, a sky survey was impossible. The group had to look at seven objects that seemed likely candidates because of their radiations in ranges near to the EUV. The objects successfully detected were two hot white dwarfs (HZ 43 in Coma Berenices and Feige 24), a flare star (Proxima Centauri) and a periodically erupting nova (SS Cygni [SN: 8/2/75, p. 71]).

The hot white dwarfs turn out to be the most interesting sources momentarily. In the case of HZ 43, which is also an X-ray source, it becomes clear that the X-rays are the "tip of the iceberg." The big blast is in the EUV. The temperature of the star can be found from its spectrum. There is some possible difference depending on whether the spectrum is read as a blackbody, power-law or exponential relationship, but the temperature of HZ 43 seems to be a fantastic 110,000° K, give or take 10,000°. This comes to about 17 times the temperature of the sun and seems extreme even for a hot white dwarf. Another white-dwarf surprise was Sirius B. Optically, this is a small dim dwarf, generally dominated by its companion, the giant star Sirius A. In the EUV, Sirius B turns out to be 10,000 times as bright as it is optically. If its spectrum is thermal, its temperature comes to something between 30,000° and 35,000° K.

These temperatures, especially the one for HZ 43, place the stars somewhat beyond the pale for white dwarfs. If one tries to place them on the usual evolutionary scheme for stars, the Hertzsprung-Russell diagram, they fall in a region that is theoretically supposed to be excluded. Bowyer suggests this may mean a need for "some modification in the theory of the end point of the evolution of a star."

The results so far are exciting enough that Bowyer and his associates are developing a telescope with imaging capabilities that could be part of the payload of a future satellite. Bowyer's conclusion is that although EUV astronomy started off impossible, it may be potentially useful. □