COORDINATED OBSERVATIONS FOR THE EUVE ALL-SKY SURVEY

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Abstract

We present a brief summary of the EUVE mission, with particular emphasis on the all-sky survey.We expect to detect a significant number of objects of various classes in this survey, and simultaneous optical observations are extremely important in order to interpret the EUVE data of many of these objects, in particular, cataclysmic variables, flare stars, and (if detected) AGN's. We show that visual observations by amateurs will be possible and useful.

1. The EUVE Mission

The Extreme Ultraviolet Explorer (EUVE) is a NASA explorer-class satellite mission devoted entirely to observations in the wavelength range from 70 to 900 Angstroms (EUV). The scientific payload, developed at the Center for EUV Astrophysics (University of California, Berkeley) consists of three co-aligned scanning telescopes and a Deep Survey/Spectrometer (DS/S). EUVE is currently scheduled to be launched on a Delta II rocket in late 1991; after the in-orbit checkout phase, the first six months of the mission will be devoted to an all-sky survey.

By spinning the spacecraft at a rate of one rotation in approximately 30 minutes, the scanners (each having a field of view of 5° diameter) will survey a strip of sky 5° wide along an ecliptic longitude line every 30 minutes, while the DS/S will stay fixed, observing a 2.1° diameter circular area of the sky. Over the course of the six-month survey period, the spin axis will be precessed to keep the DS/S pointing towards the anti-sun direction. Thus the scanner will cover the entire sky while the DS/S will cover a 2.1° by 180° strip of the sky along the ecliptic during the survey.

For the remainder of the mission, EUVE will become a guest-observer facility and make pointed observations with the DS/S. The spectrometer covers the 70-760 Angstrom range in three channels, with a resolution of approximately 300. An introduction to EUV astronomy, including a brief description of EUVE, can be found in Welsh (1989), and a detailed description of the EUVE mission can be found in Bowyer and Malina (1990).

2. Expected EUV Sources

A temperature of about 100,000° K is required to emit a significant amount of EUV emission. In addition, interstellar absorption is particularly strong in this wavelength range, favoring nearby astronomical objects. From these considerations, we expect the EUVE all-sky survey to detect the following classes of sources, roughly in order of decreasing number:

- Hot coronae/chromospheres of nearby, late-type stars
- Hot white dwarfs
- Cataclysmic variables (CV's)
- Strong winds from early-type stars
- Active galactic nuclei (AGN's)

The detection of these latter classes will depend on the incidence of intrinsically bright sources in directions of low column density of the interstellar medium, and even then detection can be achieved only at the shortest wavelengths (<200 Angstroms). The detected sources, it is hoped, will include both previously known objects and new discoveries.

3. Coordinated Observations

EUVE survey data alone (EUV brightness in at most four bands, typically less) may not be sufficient to identify the nature of the objects or the physical mechanisms responsible for the EUV emission; we need observations with the EUVE spectrometer and/or at other wavelengths to help interpret the EUVE survey data. For objects such as white dwarfs, existing data may be sufficient, or additional observations can be obtained after the mission, since they do not vary much with time.

However, several classes of sources are known to be variable, and therefore simultaneous or near-simultaneous observations are required. These include CV's, flare stars, and AGN's. We envisage the need for optical photometry, optical spectroscopy, and IUE observations for these variable objects. Of these, optical photometry of many of the potential EUV sources may be within the capabilities of AAVSO members (in fact, many are already regularly monitored by the AAVSO) and will be extremely useful.

4. Dwarf Novae in Outburst

Dwarf novae are typically hard X-ray sources when quiescent and become strong soft X-ray sources during outbursts (Córdova and Mason 1984 and references therein). If the interstellar absorption is sufficiently small, we expect dwarf novae in outburst to be strong EUV sources; in fact, SS Cyg in outburst was one of the first EUV sources to be detected (Margon *et al.* 1978). It is therefore likely that the EUVE all-sky survey will detect those dwarf novae that happen to be in outburst at the time. It is well known that their outbursts occur at irregular (quasi-periodic at best) intervals, thus making reliable prediction impossible. Furthermore, more than 100 dwarf novae are optically bright enough to be considered potential EUV sources, although distances and the amount of interstellar absorption are not known with any accuracy in the majority of cases.

Monitoring of such a large number of sources is best accomplished via collaboration with amateur astronomers. Our current plan is to ask for regular and intensive monitoring of more than 100 dwarf novae ($V_{outburst} \leq 15.0$) for about a month around the time of the EUVE survey coverage. For the majority of sources, the results of such monitoring will be compared with the EUVE data during the analysis phase, a few months after the data are taken. However, for sources of particular interest (because of their brightness or peculiarities), we will ask for rapid communication, so that we can trigger "target of opportunity" observations by professional astronomers if the sources are in outburst at the right time.

5. AM Her Systems

AM Her systems differ from dwarf novae in that they contain strongly magnetic white dwarfs, which completely changes their accretion geometry (see Cropper 1990 for a comprehensive and up-to-date review; Liller 1977 describes the early observations of the prototype AM Her). They accrete via an accretion column rather than an accretion disc, which leads to very efficient production of soft X-ray/EUV photons. AM Her's are the strongest soft X-ray sources among various subclasses of CV's. In fact, the prototype AM Her may turn out to be among the brightest EUV sources in the entire sky.

In the past, X-ray satellites sensitive to soft X-rays (HEAO-1, Einstein, and EXOSAT) have discovered more than half the known AM Her systems. (There are currently 17 confirmed members of this class.) Extrapolation suggests that the EUVE all-sky survey will discover dozens of new AM Her stars, opening the possibility of a reliable statistical study of these objects. We also expect to obtain EUV light curves of known bright AM Her systems as well as some spectral information.

Contemporaneous monitoring is important because AM Her stars occasionally go into a low state, up to ~5 magnitudes fainter than in their normal or "high" state in the optical. Such a dramatic change can be detected by amateurs for the brightest (V<15.0) of these stars; in fact the most detailed long-term light curve of the prototype AM Her has been obtained by AAVSO observers. Such monitoring by amateurs should be possible for the five or six brightest AM Her stars. We also need monitoring of a more detailed kind by professional astronomers since these objects change the shape of their orbital light curves, in X-ray, UV, and optical, the precise cause of which is still unknown (e.g. Osborne *et al.* 1987), and we hope to obtain repeated observations with the IUE, as well as spectroscopic, photometric, and polarimetric observations from the ground.

6. Flare Stars

Flares from late-type stars have been detected in the UV and X-ray bands, and one of the first extra-solar EUV sources discovered was a flare star, Proxima Centauri (Haisch *et al.* 1977). The EUV emission from these flares arises in the hot, thin plasma of the transition region and coronae of the active regions of these stars, with the luminosity many orders of magnitude greater than the largest solar flare. In fact, it is expected that EUVE will detect flares from only the most active of the late-type stars, such as dMe and RS CVn stars.

Coordinated observations will be most effective during the long (>40,000 sec) observations of individual flare stars with the EUVE spectrometers. Because the time scales of individual flares range from seconds to hours, whereas the total integration time for any individual location is small, EUVE is not expected to detect many flares during the six-month photometric survey (Vedder *et al.* 1990). However, simultaneous observations of the most active flare stars during the time that the EUVE scanning telescopes are surveying the flare stars' location would be invaluable if a flare is detected in the EUV or optical regions of the spectrum.

7. Active Galactic Nuclei (AGN's)

AGN's are generally believed to contain a massive (millions of solar masses) accreting black hole; the studies at UV and X-ray wavelengths suggest that they are also intrinsically strong EUV sources. However, the average absorption within our own Galaxy is sufficient to absorb most EUV photons from AGN's before they ever reach Earth. Whether the EUVE survey can detect these sources depends critically on the distribution of the interstellar matter and the precise shape of the spectrum of AGN emission. Thus there are conflicting predictions as to the number of AGN's that the EUVE survey will detect. Even with such uncertainties, we believe that the optical monitoring of the brightest AGN's will be valuable.

8. Summary

Simultaneous or contemporary observations at other wavelengths will enhance the scientific returns of the EUVE survey in a variety of ways:

• CV's will benefit most from such coordinated observations. They are expected to be strong EUV sources and are variable on all time scales.

• The number of CV's that require monitoring is such that the participation of amateur astronomers is essential.

• Flare stars and AGN's are other possible objects for which coordinated observations will be important.

• For several targets, notification of an outburst may be used to trigger "target of opportunity" observations.

•A similar strategy is likely to be followed during the spectroscopy phase of the EUVE mission by some investigators.

We are planning to ask the AAVSO to coordinate amateur observations during the EUVE survey. Those who are interested in making coordinated observations are invited to contact the AAVSO or the authors of this article. [Ed. note: AAVSO will be coordinating amateur astronomers' observations throughout the EUVE mission.]

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