An Optical Study of the Field of EUVE J1027+323: Discovery of a QSO and a Hidden Hot White Dwarf

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We have carried out optical and Far UV studies of the field around the EUV source EUVE J1027+323. We find two sources which contribute to this flux which are spatially unresolvable with *EUVE*. One is a non-cataloged QSO and one is a "hidden" hot white dwarf.† Reasonable scenarios ascribe the majority of the flux to the white dwarf.

1. Introduction

The EUV source EUVE J1027+323 was detected in the course of the all-sky survey conducted from the *EUVE* satellite and has been listed as "not identified" in the First *EUVE* Source Catalog (Bowyer et al. 1994). A detailed optical study of the field reveals the presence of two objects which contribute to the EUV flux in the region: a high redshift QSO and a "hidden" hot white dwarf companion to a main-sequence star.

2. The Region Around EUVE J1027+323

The *EUVE* source J1027+323 was detected by *EUVE* within a 60″ radius circle centered at (α, δ)=($10^h27^m08^s$, +32°23′18″), a line of sight that was scanned between 15 and 21 of November, 1992.‡ The Bell Laboratories H I survey (Stark et al. 1992) show that the total neutral hydrogen column density out of the Galaxy in this direction is $\leq 2 \times 10^{20}$ cm^{-2}.

The Simbad database shows two sources within 3′ of the EUV source: RE 1027+322, located within a 39″ radius circle centered at (α, δ)=($10^h27^m11^s.7$, +32°23′24″.0), detected by the *ROSAT* satellite Wide Field Camera (WFC) and listed as "not identified" in the First *ROSAT* Catalog (Pounds et al. 1993) and in the Optical Atlas of *ROSAT* Sources (Shara et al. 1993); the second source is *IRAS* 10245+3238, detected by the *IRAS* satellite toward (α, δ)=($10^h27^m23^s.73$, +32°22′52″.09). Given the small angular separation between the *ROSAT*, *IRAS*, and *EUVE* detections we believe that these detections correspond to the same object.

CCD images of the field obtained with the University of Hawaii 2.2 m telescope on Mauna Kea and the IAC-80 telescope on Observatorio del Teide show within the error

† Based in part on observations obtained at the Michigan-Dartmouth-MIT Observatory.
‡ All coordinates in this paper are J2000.0

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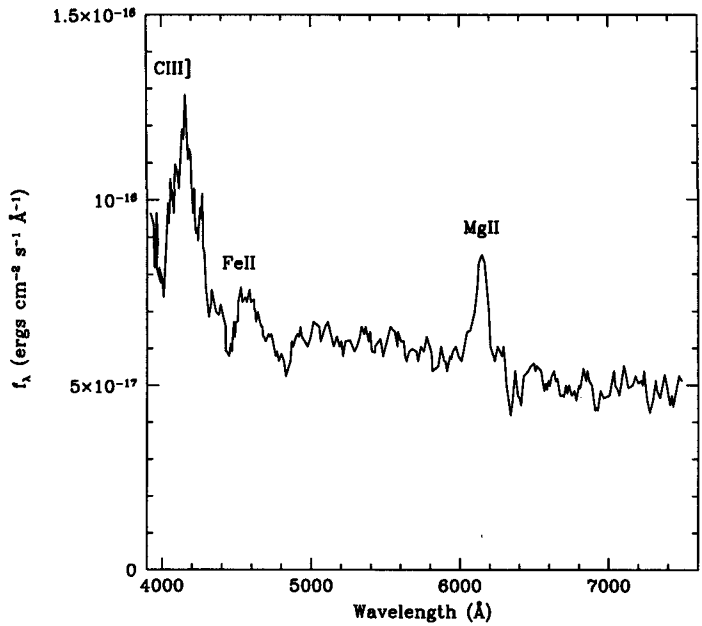

FIGURE 1. Optical spectrum of the faint object detected in the field. C III 1909 Å and Mg II 2798 Å lines seen in smission indicate a redshift of this object of 1.18. The spectral features are typical of QSOs.

circle of the *EUVE* detection a relatively bright object that we identify with the star GSC 02511 00033, included in the *Hubble Space Telescope* Guide Star Catalog, with magnitude 13.1.

Another fainter object, which we identify below as extragalactic, lies close to this star with an angular separation of 13″ that is unresolvable with the *EUVE* or WFC instrumentation.

3. Observations

3.1. *Visual and Far UV Observations*

An optical spectrum of the faint object that lies close to the main-sequence star in the field is shown in Figure 1. The spectrum shows characteristics typical of QSOs. Prominent in the spectrum are strong emission lines which we identify as redshifted C III 1909 Å, Fe II 2080 Å, and Mg II 2798 Å. From the observed wavelengths of C III and Mg II lines at 4135 Å and 6131 Å we deduce a redshift of 1.18. From the flux observed at 5500 Å we deduce an apparent visual magnitude of the QSO of 19.5 ± 0.2.

We obtained an optical spectrum of the relatively bright main-sequence star. The spectrum shows strong Ca II H and K lines in absorption and other spectral features typical of main-sequence G stars, comparison with the spectra published by Jacoby et al. (1984) leads us to classify the star as G2(±2)V.

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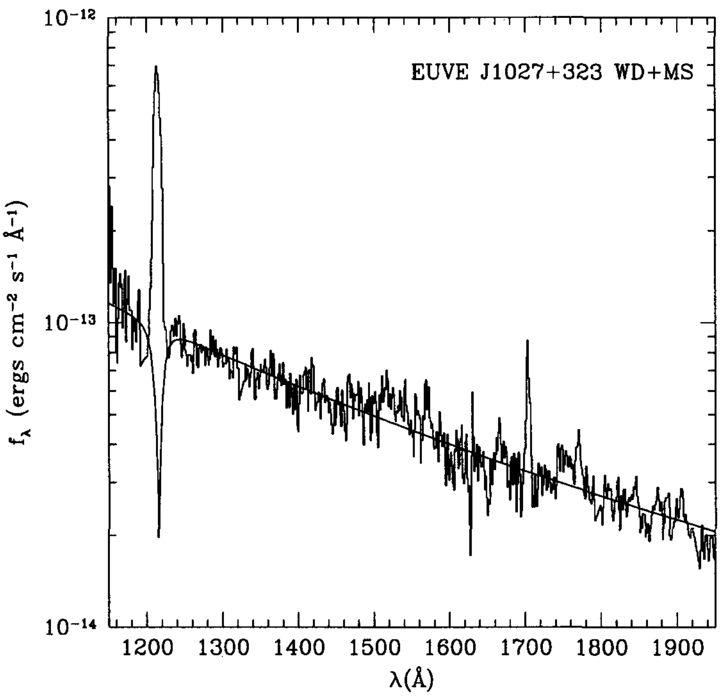

FIGURE 2. FUV spectrum of the bright star present in the field. A white dwarf synthetic spectrum ($T_{\rm eff}$ = 40,000 K, $\log g = 8.0$) is superposed on the spectrum and testifies to the presence of a white dwarf star "hidden" by the bright object.

An *IUE* short wavelength spectrum (SWP49778) taken in the direction of the main-sequence star is shown in Figure 2.† The spectrum is characterised by rapidly diminishing flux with increasing wavelength. Geocoronal Lyman α line emission is superposed on the corresponding stellar line whose blue wing is seen blueward of that emission. A relatively strong emission feature that does not match any known line is seen at ~1700 Å and could be due to stray light from the QSO: at a redshift of 1.18, the rest wavelength of this emission would be 783 Å, a broad Ne VIII λ774 Å emission has been observed in the spectra of QSOs (Hamann et al. 1995; Cohen et al. 1995). The overall shape of the spectrum is typical of a white dwarf star. Superposed on the spectrum shown in Figure 2 is a synthetic spectrum of a DA white dwarf computed using the code developed by Vennes (1992) assuming a canonical value of the white dwarf gravity, $\log g = 8.0$, and an effective temperature of 40,000 K. Hotter models which include heavy metal opacities would also be consistent with the *IUE* data.

3.2. *X-ray Observations*

The source EUVE J1027+323 was observed during the *ROSAT* survey using the Position Sensitive Proportional Counter (PSPC; Pfefferman et al. 1986). Shortward of 44.3 Å,

† Obtained from the Regional Data Analysis Facility at Goddard Space Flight Center

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the flux of this source is too low to be detected with an upper limit of 0.006 counts s^{-1} in the band from 5 to 44 Å. The count rate in the 44 to 100 Å band is 0.073 ± 0.016 counts s^{-1} (Schmitt 1995).

3.3. *EUV Observations*

The source EUVE J1027+323 was found in the Lexan/B band of *EUVE*. Bowyer et al. (1994) estimate the count rate from the source in this band to be 0.040 counts s^{-1}. At longer wavelengths the source was not detected.

The source was also detected by the Wide Field Camera (WFC) of *ROSAT* (Wells et al. 1990). Pounds et al. (1993) estimated the photon count rate toward the source to be 0.017 ± 0.005 counts s^{-1} in the C/Lexan/B S1 filter and $\leq$0.022 counts s^{-1} in the Be/Lexan S2 filter.

4. Discussion

Both QSOs and hot white dwarfs are known EUV and X-rays emitters. We consider two hypotheses for the objects in the field of EUVE J1027+323. For the first hypothesis we derive an *EUVE* effective area from the instrumental area given in Bowyer et al. (1995) combined with the intervening interstellar medium absorption. For the interstellar medium absorption we combine the interstellar cross sections of Rumph et al. (1994), with an estimate of $N(\mathrm{H\,I})$ to the sources. Later in this paper we obtain a distance to the white dwarf of ~400 pc. From Fruscione et al. (1994), we find $N(\mathrm{H\,I})$ to stars in this direction are 3×10^{19} (300 pc) and 6×10^{20} (350 pc). From the Bell Lab Survey the total Galactic $N(\mathrm{H\,I})$ in this direction is $\sim 2 \times 10^{20}$. We adopt $N(\mathrm{H\,I}) = 2 \times 10^{20}$ as a reasonable estimate for both the Galactic and extragalactic sources in this field. Following Vennes et al. (1993), we assume He I/H I=0.07 and He II/H I=0.03. From the count rates in § 3.2 we find an EUV flux, λf_λ, equal to 1.1×10^{-11} erg cm^{-2} s^{-1}.

Using the same value for the ISM absorption in combination with the *ROSAT* PSPC effective area (Pfefferman et al. 1986) and the photon fluxes measured we obtain fluxes $\leq 1.2 \times 10^{-13}$ erg cm^{-2} s^{-1} in the 5–44 Å band, and 4.6×10^{-13} erg cm^{-2} s^{-1} in the 44–100 Å band.

4.1. *Scenario A*

We assume that most of the flux detected in the X-rays emanates from the QSO and that both the white dwarf and the QSO contribute to the flux observed in the EUV. At high energies QSO spectra follow a power law of the form $f \propto \nu^{-\alpha}$ with ν ranging between ~1.3 (Mushotzky et al. 1993) and ~1.03 (Maccacaro et al. 1988). We adopt a value of 1.2 for the spectral index and use the flux observed in the 44 to 100 Å band to predict a flux from the QSO in the 5 to 44 Å wavelength range; this is 1.0×10^{-13} erg cm^{-2} s^{-1}. This value is less than the upper limit measured with the *ROSAT* PSPC. In the EUV we predict a flux of 7.1×10^{-13} erg cm^{-2} s^{-1}; this is 6% of the observed EUV flux. In this case the white dwarf will have a nearly pure hydrogen atmosphere and will produce the remainder of the EUV flux.

4.2. *Scenario B*

We now consider the case in which the EUV and X-ray flux is essentially due to the white dwarf. We use the photon fluxes measured by *EUVE* and *ROSAT* and hot white dwarf model atmospheres to set limits to the effective temperature of the star and the column density of the intervening interstellar medium. In Figure 3 we present the *EUVE* and *ROSAT* count rates in the $T_{\mathrm{eff}} - \log(N_{\mathrm{H}})$ plan. Assuming a canonical value of the stellar

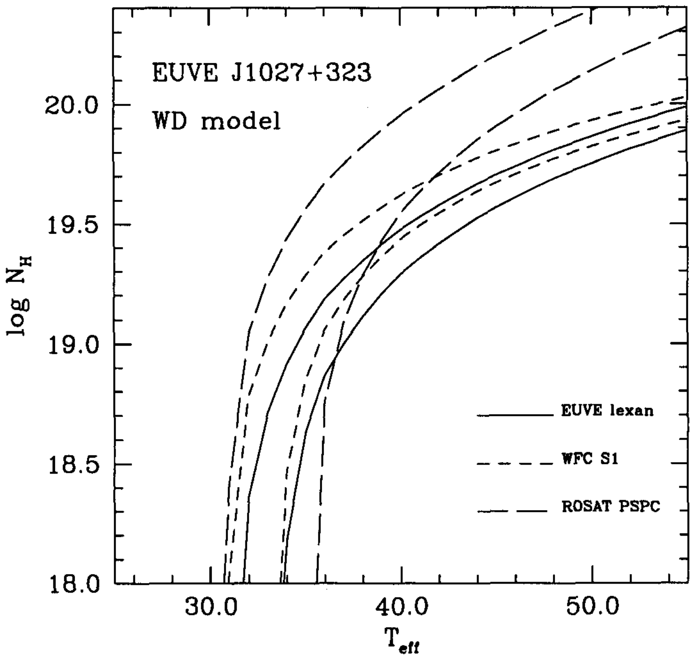

FIGURE 3. Range of T_{eff} vs. $\log N_H$ values derived from EUV and X-ray measurements. The count rates measured in these bands are analyzed assuming that $\log g = 8.0$.

gravity, $\log g = 8.0$, the count rates measured restrict the values of T_{eff} and $N(\mathrm{H\,I})$ to 37,000±5,000 K and $\leq 5 \times 10^{19}$ cm^{-2} respectively. In this case there would be virtually no metal opacity in the atmosphere of the white dwarf.

5. Conclusions

Our analysis of the field of the source EUVE J1027+323 has shown the presence of two previously uncataloged objects: a white dwarf hidden by a main-sequence star and a QSO. Detection of these objects had been hampered by their small angular separation from the visually brighter main-sequence star.

From the synthetic spectrum fit to its *IUE* spectrum we deduce an apparent visual magnitude of the white dwarf star of 17.2±0.2. The effective temperature that we have used, 40,000 K, is the lower limit set by the absence of red wing in the stellar Lyman α line; this result is consistent with the EUV result. With this value and the absolute magnitude of the white dwarf star deduced from its FUV flux, we find the distance modulus is within the range from 7.3 to 8.3. For the main-sequence star we find the distance modulus to be within the range from 7.9 to 8.7. These values give heliocentric distances from 380 to 550 pc to the main-sequence star, and from 290 to 460 pc to the white dwarf star. Given the overlap in distance in combination with the angular separation, lower than 10″, we believe it is highly likely that the objects are binary

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companions. In this case the distance to the system falls in the range from 380 to 460 pc.

If the white dwarf atmosphere is essentially pure hydrogen and is at a temperature of 40,000 K, the object would join a subclass of DA white dwarfs similar to GD 153 or HZ 43 which display pure hydrogen EUV continua in *EUVE* spectroscopy (Dupuis & Vennes 1995). A review by Chayer et al. (1995) present evidence for the presence of a weak mass loss which would deplete the atmospheres of these objects from heavier elements in a few Myr after the onset of the cooling sequence. If the white dwarf is found to be in a close binary rather than in a wide binary, the question of its surface chemical composition would place constraints on the efficiency of accretion mechanisms and mass loss rate from the main-sequence companion.

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