**EXTREME ULTRAVIOLET EXPLORER OPTICAL IDENTIFICATION CAMPAIGN. III.
A SOUTHERN HEMISPHERE SAMPLE OF ACTIVE LATE-TYPE STARS
AND WHITE DWARFS**

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ABSTRACT

We present optical identifications of 30 previously unidentified extreme ultraviolet (EUV) and soft x-ray sources coinciding with the position of faint sources detected during the all-sky surveys of the *Extreme Ultraviolet Explorer* (*EUVE*) in the 58–174 Å (0.071–0.214 keV) band and of the *ROSAT* Position Sensitive Proportional Counter (PSPC) in the 5–120 Å (0.1–2.4 keV x-ray) band. We present low-resolution spectra of the possible optical counterparts of the x-ray and *EUVE* sources obtained with 1.5 m telescope at CTIO in 1995 May and December and 1996 February. The optical counterparts for 23 sources are identified as late-type (dKe and dMe) stars, and 4 are identified as new DA white dwarfs. All spectra of sources identified as late-type stars show the Balmer series and Ca H and K lines in emission, indicating the signature of chromospheric activity. For the white dwarfs, the joint detection by the *ROSAT* PSPC and the *EUVE* Lexan band indicates that they have a low-abundance of metals and that their EUV emission is mostly attenuated by the local interstellar medium (ISM). © 1997 American Astronomical Society. [S0004-6256(97)00107-6]

1. INTRODUCTION

The *Extreme Ultraviolet Explorer* (*EUVE*) and *ROSAT* all-sky surveys conducted the first detailed studies in the extreme ultraviolet (EUV) waveband region of the electromagnetic spectrum. The second *EUVE* source catalog contains 734 objects, 245 of which have no known optical identification (“NOID”; Bowyer *et al.* 1996). The *EUVE* source list has been expanded by correlating marginal all-sky survey detections from the Lexan bandpass, centered at 100 Å, with *ROSAT* PSPC detections (Lampton *et al.* 1997), thus raising the number of *EUVE* sources to over 900 and raising the NOID number to 310. The ongoing *EUVE* Optical Identification Campaign series has reported on a subset of these *EUVE* sources (cf. Mathioudakis *et al.* 1995a; Craig *et al.* 1995; Craig & Fruscione 1997; Craig 1995, 1996). In this paper we present optical identifications for 23 new late-type (dKe and dMe) stars and 4 new DA white dwarfs observed at the Cerro Tololo Inter-American Observatory (CTIO) in 1995 May, 1995 December, and 1996 February, comprising about 20% of the southern faint NOID list. We present in Sec. 2 a brief description of the source selection criteria from which we derived our source list. In Sec. 3 we describe the optical identification procedure adopted and the derived results. In Sec. 4 we present ground-based optical spectroscopy of objects within the error circle of each EUV source, and based on the results of our analysis we discuss the implications for the *EUVE* source distribution in Sec. 5.

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2. *EUVE* OBSERVATIONS

The *EUVE* all-sky and deep surveys were primarily conducted over a 6 month period from 1992 July 22 to 1993 January 21. Both surveys are discussed in detail in Bowyer & Malina (1991) and Bowyer *et al.* (1996). During the all-sky survey, three co-aligned telescopes (the “scanners”) scanned the sky over the EUV wavelength range in four bandpasses centered at: Lexan/B (100 Å), Al/Ti/C (200 Å), Ti/Sb/Al (400 Å), and Sn/SiO or (600 Å). Simultaneously, a fourth telescope, the Deep Survey (DS) instrument, mapped a 2° × 180° strip of sky along the ecliptic in the two shortest EUV bandpasses, the DS Lexan/B (67–178 Å) and DS Al/C (157–364 Å), with an order of magnitude greater sensitivity than the all-sky survey. The effective areas for each telescope and filter combination are given in Bowyer *et al.* (1996).

Initial *EUVE* source catalogs, such as the first and the second *EUVE* source catalogs (Bowyer *et al.* 1994, 1996), listed source detections at 5σ to 5.5σ detection threshold levels. The faint EUV source catalog of Lampton *et al.* (1997) uses the bias search concept, to preselect search locations within a 90” positional coincidence with *ROSAT* survey detections, thus allowing a lower EUV detection threshold between 3.4σ and 5σ to be adopted. This method is sensitive to fainter sources while keeping a tolerable false detection rate.

The present work benefits from the above “biased search” of the *EUVE* survey, which cross correlates *EUVE* and *ROSAT* detections within a 90” positional tolerance (Lampton *et al.* 1997). Consequently, we detect 166 new *EUVE* sources, 61 of which are NOIDs. Combining this re-

TABLE 1. *EUVE* and *ROSAT* data for the southern sample of sources.

Name (1)	<i>EUVE</i>					<i>ROSAT</i>						
	R.A. (hh mm ss) (2)	Dec. (dd mm ss) (3)	l (4)	b (5)	T_{exp} (s) (6)	Count rate ^a (counts s ⁻¹) (7)	$\pm\sigma$ (counts s ⁻¹) (8)	Signif. ^b (σ^2) (9)	Ang. Sep. ^c (") (10)	Count rate ^d (counts s ⁻¹) (11)	$\pm\sigma$ (σ^2) (12)	
EUVE J0106–637	01 06 15	–63 47 04	300.1977	–53.2651	2308	0.015	0.005	13	...	...	...	...
EUVE J0239–196	02 39 15	–19 38 07	201.8320	–64.2119	...	0.003 ^e	...	...	202	0.070	0.019	1RXS
EUVE J0254–511	02 54 30	–51 09 00	267.2802	–56.5974	1985	0.023	0.006	21	46	0.122	0.022	1RXS
EUVE J0318–363	03 18 56	–36 24 24	238.8455	–57.5253	1441	0.023	0.006	12	52	0.121	0.034	1RXS
EUVE J0352–492	03 52 22	–49 13 29	257.9671	–48.9938	...	0.002 ^e	...	...	...	...	...	...
EUVE J0426–379	04 26 21	–37 57 50	240.7093	–44.0768	1203	0.030	0.009	23	52	0.555	0.057	1RXS
EUVE J0450–086	04 50 30	–08 38 23	206.6980	–30.7675	677	0.031	0.010	15	...	...	...	...
EUVE J0609–358	06 09 23	–35 49 35	242.5653	–23.4888	1935	0.020	0.008	16	57	0.367	0.024	1RXS
EUVE J0625–600	06 25 55	–60 03 07	269.3013	–26.3896	8493	0.008	0.002	13	23	0.539	0.025	1RXS
EUVE J0652–596	06 52 47	–59 41 05	269.6742	–23.0164	8525	0.100	0.003	19	61	<0.010	...	1RXS
EUVE J0702–018	07 02 56	–01 47 39	215.8403	–1.7378	1030	0.030	0.009	17	...	...	...	...
EUVE J0749–766	07 49 07	–76 42 14	288.9152	–23.1282	3476	0.038	0.006	89	36	0.594	0.070	1RXS
EUVE J0817–827	08 18 02	–82 43 41	295.5179	–24.2523	1912	0.020	0.006	16	50	0.791	0.054	1RXS
EUVE J0825–163	08 25 52	–16 23 40	238.8073	12.3110	1221	0.027	0.008	20	64	0.509	0.043	1RXS
EUVE J0835–430	08 35 37	–43 03 33	261.8855	–1.4789	2156	0.026	0.008	18	82	0.050	0.001	1WGA
EUVE J0836–449	08 36 27	–44 53 50	263.4458	–2.4634	2046	0.023	0.007	18	90	<0.05	...	1RXS
EUVE J0913–629	09 13 39	–62 59 46	280.9109	–9.8636	3616	0.013	0.004	15	81	0.145	0.020	1RXS
EUVE J1118–569	11 18 50	–56 58 47	290.5352	3.6464	2171	0.017	0.005	16	...	...	...	...
EUVE J1131–346	11 31 53	–34 37 50	284.8747	25.4362	1247	0.024	0.008	14	92	0.656	0.076	1RXS
EUVE J1145–553	11 45 55	–55 20 36	293.6464	6.3428	2816	0.018	0.005	22	47	0.456	0.043	1RXS
EUVE J1254–471	12 54 22	–47 05 36	303.4500	15.7755	816	0.031	0.010	17	62	0.10	0.024	1RXS
EUVE J1305–409	13 05 26	–40 54 50	305.7808	21.8804	813	0.028	0.011	13	96	0.062	0.017	1RXS
EUVE J1931–215	19 31 26	–21 34 16	17.4553	–18.1407	1033	<0.024	...	...	75	0.169	0.026	1RXS
White Dwarfs												
EUVE J0335–348	03 35 34	–34 48 28	235.6436	–54.2443	1700	0.033	0.007	37	102.8	0.063	0.005	1WGA
EUVE J0337–419	03 37 19	–41 55 46	247.5821	–53.2091	1809	0.029	0.007	31	71.4	0.145	0.034	1RXS
EUVE J0653–564	06 53 58	–56 25 22	266.3178	–21.9914	5581	0.012	0.003	18	...	...	...	...
EUVE J1535–774	15 35 40	–77 24 30	311.5610	–17.3805	875	0.067	0.013	50	16.4	0.485	0.054	1RXS

^a*EUVE* count rate in the Lexan/B band (58–174 Å or 0.075–0.21 keV).^b*EUVE* detection significance.^cAngular separation between the *EUVE* and the *ROSAT* source.^d*ROSAT* PSPC count rate in the 0.1–2.4 keV band or 5–124 Å (RASSBSC, Voges *et al.* 1996; WGA, White *et al.* 1995 in HEASARC WWW site).^e*EUVE* Right Angle Program source from McDonald *et al.* 1994.

sult with the second catalog NOIDs brings the total unidentified source number to 310. While we have concentrated on observing sources from the “faint” sample, we have also observed sources from the second catalog, such as EUVE J0239–169 and EUVE J0352–492. These sources are detected with the *EUVE* Right Angle Program (RAP), which takes advantage of serendipitous, longer, pointed observations with the survey telescopes during pointed guest spectroscopic observations (McDonald *et al.* 1994). Table 1 shows the *EUVE* all-sky and pointed data for the NOID sources: the *EUVE* positions, (*EUVE*) exposure times, Lexan/B (100 Å) bandpass count rates and count rate errors, and the detection significance are derived from *EUVE* all-sky survey data. We obtained the *ROSAT* PSPC count rates, associated errors, detection significance in the *ROSAT* survey and the *ROSAT* source identifications, where available, (the limiting count rate in RASSBSC is 0.05 counts s⁻¹) from the *ROSAT* All Sky Survey Bright Source Catalog (RASSBSC; Voges *et al.* 1997). These quantities, together with the calculated angular separation between the *EUVE* and *ROSAT* source positions, are also shown in Table 1.

3. OPTICAL OBSERVATIONS

The procedure for identifying *EUVE* sources with likely optical candidates in databases has been discussed in detail in the preceding optical identification paper (Craig *et al.* 1995). Previous optical identification campaigns to identify *EUVE* sources have found that using a 1–2 meter-class telescope with a moderate resolution spectrograph is adequate for identifying optical counterparts. We obtained spectroscopic data for our southern hemisphere sample of unidentified *EUVE* sources on 1995 May 20–22, December 19–22, and 1996 February 14–18 with the 1.5 m telescope at CTIO.

The CTIO instrumental setup used a Cassegrain spectrograph and LORAL (1200×800) CCD detector with a 300 lines mm⁻¹ grating and a 4.5 entrance slit for the 1995 December and 1996 February observations, covering the wavelength region of 3700–6750 Å. For the 1995 May observing run we used the CCD detector GEC 10 covering the wavelength region of 3750–6150 Å. Both instrument setups give a spectral resolution of ~9 Å.

The CTIO data were reduced using standard IRAF software. The spectra were trimmed and the bias-level sub-

TABLE 2. Optical data and physical parameters.

Name (1)	Source ^a No. (2)	R.A.opt (hh mm ss) (3)	Dec.opt (dd mm ss) (4)	Observation Date (5)	Exp. <i>T</i> (6)	<i>EUVE</i> ^b Sep. (7)	<i>ROSAT</i> ^c Sep. (8)	Mag ^d (<i>m_v</i>) (9)	Spectral Type (10)
EUVE J0106–637	1*	01 06 22	–63 46 40	09 Dec 95	1200	53.4	25.9	13.8	dM4e
EUVE J0239–196	1*	02 39 01	–19 37 03	09 Dec 95	1200	38.6	...	12.8	dM0e
	2	02 39 01	–19 36 48	09 Dec 95	1800	22.8	...	12.8	dK5
EUVE J0254–511	1*	02 54 34	–51 08 31	20 Feb 96	1200	36.0	11.0	12.7	dM3e
	3	02 54 36	–51 08 19	20 Feb 96	1200	63.6	19.7	15.1	dK0
EUVE J0318–363	1*	03 18 58	–36 23 32	09 Dec 95	900	56.9	5.0	17.2	dM4e
EUVE J0335–348	2*	03 35 34	–34 50 00	22 Feb 96	900	92.3	44.4	16.4	DA
	1	03 35 28	–34 49 30	22 Feb 96	900	89.9	35.2	16.6	G9
	4	03 35 34	–34 50 37	22 Feb 96	300	129.6	62.1	14.5	G9
EUVE J0337–419	1*	03 37 15	–41 55 24	21 Feb 96	1800	54.9	27.8	17.0	DA
EUVE J0352–492	1*	03 52 41	–49 14 28	10 Dec 95	1800	41.5	...	13.7	dK5e
	2	03 52 45	–49 13 59	10 Dec 95	2700	48.6	...	14.5	dK0
EUVE J0426–379	1*	04 26 17	–37 57 30	10 Dec 95	900	53.0	2.0	11.5	dK4e
EUVE J0450–086	1*	04 50 30	–08 37 10	23 Feb 96	180	73.8	15.8	13.2	dK4e
	2	04 50 29	–08 36 04	23 Feb 96	500	139.9	50.6	16.1	dM0
EUVE J0609–358	1*	06 09 19	–35 49 29	09 Dec 95	600	56.7	1.0	11.5	dM4e
EUVE J0625–600	1*	06 25 56	–60 03 27	09 Dec 95	600	18.7	3.9	12.7	dM5e
	2	06 25 55	–60 03 29	09 Dec 95	900	25.2	15.0	16.5	M2
EUVE J0652–596	1*	06 52 52	–59 39 56	21 Feb 96	1800	79.1	24.1	...	dM3e
	2	06 52 49	–59 39 56	21 Feb 96	1000	31.9	27.6	...	dK7
EUVE J0653–564	3*	06 53 48	–56 24 49	23 Feb 96	2700	89.8	42.8	17.0	DA
	1	06 53 52	–56 25 48	12 Dec 95	90	60.1	67.3	9.6	dK7
	2	06 53 55	–56 24 47	22 Feb 96	2700	42.4	17.8	14.9	dG7
EUVE J0702–018	1	07 02 57	–01 48 33	23 Feb 96	900	54.0	21.2	14.2	dF6
	3	07 02 56	–01 47 34	23 Feb 96	600	7.2	46.4	15.1	A2
	5*	07 02 59	–01 48 39	23 Feb 96	600	63.9	24.9	14.9	dM2e
EUVE J0749–766	1*	07 49 02	–76 42 06	09 Dec 95	600	...	...	11.8	dM5e
EUVE J0817–827	1*	08 17 40	–82 43 32	09 Dec 95	300	46.8	13.1	...	dM5e
	2	08 17 39	–82 43 13	09 Dec 95	1000	54.4	6.2	...	dK0
EUVE J0825–163	1*	08 25 52	–16 22 46	21 Feb 96	180	54.0	10.6	10.8	dM0e
	2	08 25 52	–16 23 08	21 Feb 96	600	32.0	32.2	18.0	G1
	3	08 25 48	–16 22 40	21 Feb 96	600	79.2	51.2	14.6	dK5
EUVE J0835–430	1*	08 35 39	–43 02 45	23 Feb 96	500	52.7	30.1	18.4	M11e
	2	08 35 39	–43 01 39	23 Feb 96	600	115.1	33.6	17.8	M2I
	3	08 35 41	–43 01 43	23 Feb 96	600	117.3	39.9	14.9	K5
	4	08 35 44	–43 01 46	23 Feb 96	600	124.8	57.5	14.5	A5
EUVE J0836–449	1*	08 36 32	–44 55 07	22 Feb 96	1200	90.0	11.7	18.2	dM1e
	2	08 36 30	–44 55 27	23 Feb 96	1200	148.8	61.2	...	G9
	3	08 36 33	–44 55 33	23 Feb 96	1200	148.8	61.2	...	G9
	4	08 36 33	–44 55 09	23 Feb 96	1200	148.8	61.2	...	G6
EUVE J0913–629	1*	9 13 30	–62 59 09	20 Feb 96	400	71.6	12.8	11.1	K0e ^e
	2	9 13 26	–62 59 25	20 Feb 96	600	92.9	32.2	16.0	F8
	3	9 13 35	–62 59 31	20 Feb 96	600	32.5	52.0	15.0	F6
	4	9 13 34	–62 58 29	20 Feb 96	900	84.6	48.4	15.9	K0
EUVE J1118–569	1*	11 18 53	–56 57 48	21 Feb 96	450	61.8	10.1	14.5	dM3e
	2	11 18 56	–56 57 15	21 Feb 96	450	101.1	42.4	12.9	dK5
	3	11 18 47	–56 56 54	21 Feb 96	450	119.5	63.8	15.7	dK0
EUVE J1131–346	1*	11 31 55	–34 36 26	21 Feb 96	150	86.6	12.5	11.8	dM2e
EUVE J1145–553	1*	11 45 52	–55 20 44	12 Dec 95	90	32.9	15.1	10.7	dK5e
	2*	11 45 48	–55 20 29	12 Dec 95	600	67.0	23.6	13.6	dM3e
EUVE J1254–471	1	12 54 22	–47 06 40	21 Feb 96	600	63.6	20.8	15.5	dK5
	2*	12 54 23	–47 06 18	21 Feb 96	300	41.6	27.2	14.9	dM3e
	3	12 54 26	–47 06 45	21 Feb 96	450	73.8	13.6	17.2	dK0
EUVE J1305–409	1*	13 05 30	–40 56 25	21 Feb 96	900	103.4	7.3	13.3	dM1e
	3	13 05 31	–40 56 04	21 Feb 96	600	86.3	15.2	15.3	dK5
	4	13 05 33	–40 56 38	21 Feb 96	180	128.6	36.6	13.1	G9
	5	13 05 34	–40 56 22	21 Feb 96	180	123.7	44.0	14.1	F8
EUVE J1535–774	1*	15 35 45	–77 24 42	22 Feb 96	600	19.5	5.7	17.7	DA
	2	15 35 39	–77 24 38	22 Feb 96	600	7.0	21.4	18.4	K5
	3	15 35 40	–77 24 53	22 Feb 96	600	11.4	22.8	17.3	K6
	4A	15 35 48	–77 25 25	22 Feb 96	600	51.5	50.8	14.2	dK5
	4B	15 35 49	–77 25 25	22 Feb 96	600	51.5	50.8	14.1	dM0
	5	15 35 51	–77 23 54	22 Feb 96	600	59.2	46.5	16.5	dG2
EUVE J1931–215	1*	19 31 26	–21 34 16	22 May 95	300	...	...	12.3	dM5e

^aCorresponds to the number in the finding chart.^bAngular separation between the optical and the *EUVE* source.^cAngular separation between the optical and the *ROSAT* source.^dFrom *V* bandpass spectrophotometry; the estimated error is 0.5 mag.^eShows very weak emission. Not included in Table 3.^fOptical counterpart.

FIG. 1. Finding charts of optical counterparts labeled with the *EUVE* source name. The candidate marked with arrow is the optical counterpart of the *EUVE* source as they are marked with (*) in column 2 of Table 2.

tracted. Pixel-to-pixel gain variations were removed by applying flat-field correction using an internal quartz lamp, and one-dimensional spectra were extracted. We used an He-Ne lamp for wavelength calibration; the resulting rms wave-

length errors were approximately $0.1 \text{ \AA}$. The standard stars EG 274 and LTT 2415 were observed for flux calibration in 1996 February, Feige 110 and LTT 3128 for 1995 December, and LTT 3864 for 1995 May.

FIG. 1. (continued)

In the CTIO 1995 May run, the wavelength coverage simultaneously excluded Ca II H and K and H α range. We also did not have the added advantage of using the *ROSAT* coordinates, which have a pointing accuracy of $30''$. The

combined effect of these circumstances yielded too few identifications in this observing run.

In the 1995 December and 1996 February observing runs, we used mainly the joint detection source sample. We also

FIG. 1. (continued)

had a much higher rate of successful identifications using a new LORAL CCD chip with a wavelength coverage of 3700–6750 Å and tighter constraints for *ROSAT* source coordinates. We have observed 77 fields during these three observing runs. We list identifications of 24 late-type stars

and 4 white dwarfs as possible *EUVE* optical counterparts. The optical identification of five active galactic nuclei, one quasar (Craig & Fruscione 1997), and another new magnetic CV, EUVE J2115–58.0 (previously reported; Craig 1996), bring the total number of identifications to 36. The candi-

FIG. 1. (continued)

dates from the remaining fields observed showed no obvious optical signatures of EUV sources.

Table 2 presents a summary of the optical observation log and derived physical parameters for our sample of late-type and DA white dwarf counterpart candidates for the *EUVE*

sources. Columns 1 through 10 give the EUVE source name, optical counterpart number as marked in the optical charts, right ascension and declination of the candidate as derived from the digitized Sky Survey maps, observation dates, exposure time, angular separation between the *EUVE* source

FIG. 1. (continued)

position and optical position of the candidate, angular separation between the optical and the *ROSAT* candidate, visual magnitude m_v , and the spectral type.

In Fig. 1 we show the finding charts for the fields studied. Possible source counterparts were first identified from the

$6' \times 6'$ Digitized Sky Survey Maps. All positions are given in J2000 coordinates and charts centered at the *ROSAT* coordinates. The $30''$ radius positional error circle of *ROSAT* is shown on the chart as solid circle. The positions of EUV sources are determined from the *EUVE* data, and they are accurate to $1'$ at the 90% confidence level and are shown as dashed circles. We observed marked candidates in each field and derived spectral types for all observed candidates. The *EUVE* optical counterpart is marked with an asterisk in column 2 of Table 2.

4. IDENTIFICATION PROCEDURES AND RESULTS

We compare the observed spectra with the spectral atlas of Jacoby *et al.* (1984) and determine the spectral types to within three subclasses. The empirical relation of spectral type and the depression of the TiO band ($4760 \text{ \AA}$) relative to the continuum from Mathioudakis (1992) is also applied as a check to verify the spectral types obtained with the spectral atlas method. In the cases where the optical candidate is chosen as the EUV counterpart, the atlas of Pettersen & Hawley (1989) was used for further detailed comparison. The visual magnitude, m_v , is derived by folding the measured absolute flux from the optical spectra of the V band ($5500 \text{ \AA}$) having a flux of a star with visual magnitude $m_v=0$, using absolute calibration photometry of Bessel (1979). Absolute visual magnitudes were obtained using the empirical correlation between the strength of the absorption band of TiO $4760 \text{ \AA}$ and the absolute magnitude calibrated by Pettersen & Hawley (1989).

Once the absolute magnitude is obtained, the spectroscopic distance can be estimated from the distance modulus. For the EUV candidates we estimated the neutral hydrogen column $N(\text{H})$ density along the line of sight to verify the distances using a three-dimensional interpolation method of P. Jelinsky (1996, private communication). This model uses a large database of hydrogen column densities (Fruscione *et al.* 1994) from *EUVE* and $N_{\text{H I}}$ measurements for individual stars. Generally, derived interstellar column densities are consistent with the observed EUV count rates. There are five sources for which the estimated columns are high, although derived distances are still reasonable. Higher columns could be a consequence of the $N(\text{H})$ modeling, which in some directions is particularly affected by the presence of only a few direct measurements in the database.

4.1 The K Stars and M Stars

More than 70% of the fields identified in this sample showed the characteristic spectral emission signature of dK or dM stars. Five of these 22 late-type stars are mid-to-late dKe types. These dK types show the telltale metallic lines, e.g., strong Ca H and K lines and molecular bands such as TiO at $4760 \text{ \AA}$, for later types. The summary of Balmer line fluxes, equivalent widths, spectral types, distances, and the estimated column densities for sources chosen as the optical counterpart to the EUV source are presented in Table 3. Figure 2 shows a sample optical spectrum of EUVE J0426 – 379.

TABLE 3. Results for EUV optical counterparts.

EUVE Name (1)	Line Fluxes					Equivalent Widths					TiO band (12)	Sp. Type (13)	<i>d</i> (pc) (14)	$\log N_H$ (cm^{-2}) (15)	Obs. Flux ^a (16)
	Ca K	Ca H	H α	H β	H γ	Ca K	Ca H	H α	H β	H γ					
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)					
		(10 ⁻¹⁴ erg cm ⁻² s ⁻¹ Å ⁻¹)													
		(Å)													
EUVE J0106-63	4.9	5.9	19.2	6.6	6.6	13.9	13.2	4.8	5.3	10.2	0.68	dM4e	24	17.80	3.5
EUVE J0239-196	5.6	3.7	10.6	3.9	0.4	5.4	2.8	1.7	0.9	0.12	0.83	dM0e	46	18.58	0.82
EUVE J0254-511	7.8	8.2	25.5	9.0	9.5	10.5	8.7	2.7	2.7	4.8	0.74	dM3e	14	18.88	7.0
EUVE J0318-363	9.1	9.4	34.2	12.9	11.7	11.2	8.7	2.8	3.3	5.6	0.72	dM4e	10	17.92	5.5
EUVE J0352-492	0.7	0.3	5.7	...	...	1.5	0.6	2.5	...	...	0.97	dK5e	132	19.10	0.80
EUVE J0426-379	12.3	12.1	36.7	19.0	4.6	3.0	2.4	1.9	1.2	4.0	0.91	dK4e	40	17.11	7.0
EUVE J0450-086	0.4	6.7	0.6	1.6	2.0	0.5	5.1	0.2	0.5	0.9	0.93	dK4e	87	19.47	21.0
EUVE J0609-358	37.0	37.5	71.3	35.9	33.0	11.4	9.2	2.7	3.0	4.3	0.74	dM4e	8	18.30	5.0
EUVE J0625-600	18.9	22.5	63.6	23.9	19.0	22.0	20.0	6.2	7.7	11.6	0.67	dM5e	10	18.50	2.1
EUVE J0702-018	1.4	1.3	4.0	1.9	1.3	15.6	10.0	3.3	4.3	5.2	0.76	dM2e	72	<19.28	15.0
EUVE J0749-766	29.4	32.0	106.0	45.2	36.9	14.4	11.7	4.2	5.4	8.2	0.68	dM5e	6	18.55	10.2
EUVE J0817-822	16.7	21.7	105.0	33.2	22.9	22.0	21.3	6.6	7.8	10.9	0.67	dM5e	8	18.20	5.0
EUVE J0825-163	22.0	15.8	40.0	12.3	5.0	4.6	2.6	1.0	0.5	0.5	0.89	dM0e	18	18.77	8.0
EUVE J0835-430	0.04	0.03	0.01	0.01	...	9.0	5.0	1.6	0.4	...	0.91	M1e	138	20.80	1360.0 ^b
EUVE J0836-449	0.05	0.01	0.01	0.05	0.01	2.3	4.0	0.2	4.2	0.5	0.81	M1e	132	19.60	20.5
EUVE J1118-569	1.5	1.9	3.6	1.8	1.7	11.1	11.7	2.2	2.8	4.5	0.75	dM3e	33	19.30	8.4
EUVE J1131-346	36.7	44.1	198.0	55.5	36.5	32.5	30.7	15.1	12.2	13.8	0.72	dM2e	24	17.70	5.7
EUVE J1145-553 (1)	13.5	11.9	37.8	13.7	...	1.4	1.1	1.0	0.4	...	0.88	dK5e	32	18.90	6.0
EUVE J1145-553 (2)	12.3	15.0	37.0	14.5	11.9	26.8	33.8	7.9	9.3	12.5	0.64	dM3e	13	18.60	5.0
EUVE J1254-471	3.1	5.2	13.9	7.1	5.2	27.0	41.9	8.6	15.9	24.0	0.69	dM3e	38	19.10	11.4
EUVE J1305-409	2.4	2.7	7.9	2.8	0.2	4.9	4.4	2.0	1.1	0.1	0.85	dM1e	14	18.80	8.4
EUVE J1931-215	17.0	20.3	...	19.7	15.0	16.0	16.7	...	6.6	7.5	0.70	dM5e	10	>18.90	7.7

^aThe observed flux derived from EUVE Lexan count rates. Units are 10⁻¹³ erg cm⁻² s⁻¹.^bThe observed flux derived using N_H value of 7.0×10^{20} cm⁻² (see Sec. 4.1).

The M stars were easily recognizable by their strong TiO bands. Emission from the Balmer series and Ca H and K lines is notable. Sample spectra for dMe subclasses 0 to 5 are shown in Figs. 3(a)–3(f), respectively. Subclasses for the dMe's, which were obtained by using the empirical relation of the TiO band at 4760 Å to the continuum, generally agreed with types chosen from atlases. Deeper depression of the TiO band corresponds to later M stars, but we classify a few stars with intermediate values as later M types. For example, EUVE J0609-358 had a TiO ratio of 0.74 but is classified as a dM4e. This particular star had very strong emission, which may slightly bias determination of the continuum. A second possible source of uncertainty comes from the fact that the MgH band at 4780 Å is stronger for later types and is not always resolved for our moderate resolution survey.

We have calculated observed fluxes for our sample (see Mathioudakis *et al.* 1995b) using the EUVE Lexan count rates, the coronal model of Monsignori Fossi & Landini (1994) with $\log T=6.7$, and the derived column densities mentioned above. Although dependence of the fluxes on column density is small (50% changes in N_H result in flux changes of $\leq 25\%$), several sources have derived columns near the limit for sources detectable in the Lexan bandpass. Luminosities for such sources then exceed those expected from coronal emission of late-type stars. For such sources we have used a maximum canonical value of N_H of 7.0×10^{20} , as is noted in Table 3. Most of the large N_H values result from not having enough sources in the three-dimensional interpolation to give an accurate estimate of column. EUVE J0835-430 and EUVE J0836-449 are the exception, and

their reddened spectra support their large derived column densities (discussed below).

Several sources have other notable characteristics. We discuss these individual cases presently.

EUVE J0318-363 can be associated with the 13th magnitude proper-motion star, BPM 48175, which suggests EUV and soft x-ray surveys are sensitive to fainter nearby dwarf stars and, perhaps, an uncataloged population.

EUVE J0426-379 is within 1' of the ROSAT source 1RXS J042616.9-375730 and is also positionally coincident with PPM 28022 (CD -38 1575), a 10th magnitude high proper-motion star. In addition, a very low column density

FIG. 2. Sample optical spectrum of dK4e star, EUVE J0426-379.

FIG. 3. Sample optical spectra of the Me stars.

($\log N_H = 17.1$) in the direction of EUVE J0426-379 is consistent with this source's marginal detection in the A/C (200 Å) band of 0.026 counts s^{-1} .

EUVE J0352-492 has a similarly moderate column density of $\log N_H = 20.3$, which is consistent with its A/C detection of 0.003 counts s^{-1} in the EUVE RAP (McDonald *et al.* 1994).

EUVE J0625-600 is coincident with *Einstein* slew source IES 0625-60 (Elvis *et al.* 1992).

EUVE J0749-766 changed from a NOID to a dMe identification in the Bowyer *et al.* (1996) second EUVE catalog based on preliminary optical identification work. Our finding of a dM5e spectral type is a refinement of this change.

EUVE J0835-430 and EUVE J0836-449 are two of the faintest sources identified in this study ($m_v \sim 18$). Although Balmer series and Ca H and K emission is easily discernible in their spectra, their luminosity class is not. However, to obtain a reasonable distance determination and column density they must be main-sequence stars. The columns derived from the N_H database are at the upper limit for sources detectable by EUVE. This fact is supported by the large amount of reddening seen in their spectra, which is in agreement with the reddening given by Neckel & Klare (1980), $1.9 \leq A_V \leq 2.6$, for their Galactic positions.

EUVE J1131-346 shows very strong emission, e.g., H α is a factor of 20 to 50 stronger than the other dM1-2e's in

this survey (see Fig. 4). EUVE J1131-346 is coincident with the possible isolated T Tauri star PDS 55, which was discussed in an *IRAS* survey by Gregorio-Hetem *et al.* (1992). The strong emission lines detected here support the idea that this source is an isolated T Tauri star, but higher resolution follow-up spectroscopy is needed for confirmation.

EUVE J1145-553 has two probable candidates, dK5e and dM3e stars. The dKe source is the more likely EUVE source since it is only 33' from the EUVE center, although we cannot rule out the contribution from the dM3e. EUVE J1145-553 is coincident with *Einstein* slew source IES 1143-55.0 (Elvis *et al.* 1992).

EUVE J1931-215 was identified in the second EUVE catalog (Bowyer *et al.* 1996) as a dMe based on preliminary results of this work. We now refine that identification as a dM5e.

5. WHITE DWARFS

We present four DA white dwarfs discovered as possible optical counterparts of faint EUVE/ROSAT non-identified sources. The optical spectra of these white dwarfs are shown in Figs. 5(a)-5(d).

We determine the atmospheric parameters by fitting the Balmer line profiles with the theoretical line profiles of

FIG. 3. (continued)

Wesemael *et al.* (1980). We use the profiles computed with the assumption of local thermodynamic equilibrium, pure hydrogen composition, and hydrogen line blanketing. We fit a combination of the $H\alpha$, $H\beta$, $H\gamma$, and $H\epsilon$ lines. In some cases, we had to exclude either or both $H\alpha$ and $H\epsilon$ lines because of a large uncertainty about the placement of the continuum. Table 4 lists the parameters derived for each white dwarf, and Fig. 6 shows the best fits to the Balmer lines. The four white dwarfs are the likely optical counterparts considering their high effective temperatures. We also estimate the absolute magnitudes using mass-radius relations derived from the Wood (1995) cooling sequence for a carbon white dwarf surrounded by He and H envelopes of 10^{-2} and 10^{-4} fractional mass and from the model atmospheres fluxes of Wesemael *et al.* (1980). Photometric distances are then estimated in combination with the visual magnitudes listed in Table 2.

We have also analyzed the *EUVE* Lexan filter count rates in order to constrain the interstellar column densities of hydrogen. The EUV fluxes of the white dwarfs are computed using synthetic spectra from a grid of LTE pure hydrogen models calculated using the code of Koester (1996). A table of synthetic count rates is calculated as a function of T_{eff} and $N(\text{H I})$ for a fixed value of the gravity given by our Balmer line fits. The solid angles to the stars are fixed by normalizing the model spectra to their visual magnitudes. The abun-

FIG. 4. Spectrum of EUVE J1131-346 showing strong Balmer emission.

dance ratios of interstellar He I and He II to H I are, respectively, fixed to 0.07 and 0.03. These ratios are representative of values measured in other lines of sight (e.g., Dupuis *et al.* 1995 and Barstow *et al.* 1997). By interpolating in the grid, we determine the interval of $N(\text{H I})$ consistent with the range of optical T_{eff} and the 1σ error on the count rates. Table 4 summarizes our results.

The four white dwarfs fall in the range of effective temperature in which the abundances of heavy elements are generally low enough not to suppress the EUV emission (Barstow *et al.* 1993; Finley 1996; Wolff *et al.* 1996; Marsh *et al.* 1996a; Vennes *et al.* 1996). The joint detections by the *ROSAT* X-ray Telescope and in the *EUVE* Lexan band suggest the new white dwarfs have a low metal abundance. Unfortunately, with the limited broad-band, EUV/soft x-ray, photometric data we have, we cannot obtain more detailed information about their atmospheric composition. Because we do not know their true photospheric composition, the column densities we have measured are in reality upper limits on $N(\text{H I})$. We further comment on the individual stars:

FIG. 5. Optical spectra of the white dwarfs.

TABLE 4. Parameters for the hot white dwarfs.

EUVE Name	T_{eff}	$\log g$	Distance (pc)	$N_{\text{H I}}$ (10^{19} cm^{-2})
EUVE J0335–348	$34848 \pm 600 \text{ K}$	7.95 ± 0.05	187	$2.83^{+0.78}_{-0.61}$
EUVE J0337–419	$51737 \pm 4000 \text{ K}$	7.61 ± 0.20	398	$1.08^{+0.15}_{-0.11}$
EUVE J0653–564	$37626 \pm 400 \text{ K}$	8.59 ± 0.15	159	$5.06^{+1.12}_{-0.85}$

EUVE J0335–348 has a surface gravity close to the average gravity of field white dwarfs. This source is typical of the brighter pure hydrogen white dwarfs detected in the EUVE all-sky survey.

EUVE J0337–419 is the hottest star in our sample and it has a rather low surface gravity. Above 50,000 K, computations of equilibrium radiative levitation in DA envelopes by Chayer *et al.* (1995) predict a detectable amount of heavy elements in white dwarf atmospheres. The predicted abundances are sufficiently large to suppress the flux in the EUVE Lexan band such that a star like EUVE J0337–419 should not be detected. The subsequent detection suggests that its abundances of heavy elements are lower than expected from the diffusion theory. EUVE J0337–419 would then be similar to the hot white dwarf HZ 43, a 50,000 K DA with a highly pure hydrogen atmosphere.

EUVE J0653–564, a high gravity star ($\log g=8.8$), lies near the end of the surface gravity distribution of field white dwarfs measured by Bergeron *et al.* (1992). It therefore represents a rare occurrence of a white dwarf with a high mass. Vennes *et al.* (1997) have published an analysis of EUVE

J0653–564 based on different optical data and models and have obtained results in good agreement with ours.

EUVE J1535–774 is another high gravity star ($\log g$ in excess of 8.5), but our spectrum is noisy so this source is not included in Table 4. Vennes *et al.* (1997) have measured the parameters for this star based on a higher signal-to-noise ratio spectrum ($T_{\text{eff}}=58,000 \text{ K}$, $\log g=9.14$, and photometric distance of 107 pc). Assuming these parameters, we find a $N(\text{H I})$ of $9.1 \pm 2.5 \times 10^{19} \text{ cm}^{-2}$. Vennes *et al.* discussed the detection of a larger number of massive white dwarfs

FIG. 6. (a)–(d) Best-fit solutions to Balmer lines (see Sec. 5).

FIG. 7. Aitoff projection of (a) late-type stars, (b) white dwarfs, and (c) NOID sources in Galactic coordinates.

FIG. 8. The number distribution of 918 *EUVE* optical counterparts as a function of identification type (see Sec. 6).

among EUV-selected white dwarfs than in optical samples (e.g., Bergeron *et al.* 1992). Marsh *et al.* (1996b) reached a similar conclusion based on the *ROSAT* WFC sample. Thus, the detection of two massive white dwarfs out of four found in our optical identification campaign may not be a coincidence.

6. EUV SOURCE DISTRIBUTION

Before the EUV sky was fully mapped during the *ROSAT* WFC (Pye *et al.* 1995) and *EUVE* (Bowyer *et al.* 1996) surveys, a widespread perception held that interstellar opacity would limit the number of observable EUV sources to only a few. This theory now disproven, we show in Fig. 7 the distribution of the current late-type, white dwarf, and NOID sources in an Aitoff projection in Galactic coordinates ($l=0^\circ$ at center and increasing leftward). We point out that distribution is a strong function of the local interstellar column density and that the spatial distribution of EUV sources is not isotropic. Diamond *et al.* (1995) and Welsh *et al.* (1994) reported the increased number of EUV sources in Galactic quadrant 3 ($180 < l^\text{II} < 270$, $b^\text{II} < 0$) where a particu-

larly low H I column is known. We find 50% of our late-type stars, and 3 out of the 4 newly identified faint white dwarfs, are in the direction of quadrant 3, further supporting this lower column direction enhancement. Lampton *et al.* (1997) also noted that the low number of faint objects in the direction of the 4th quadrant of the Galaxy, where nearby intervening H I column density is appreciable, also can be attributed to the non uniformity of the local ISM.

The source distribution of the combined Bowyer *et al.* (1996) and Lampton *et al.* (1997) catalogs is dominated by late-type stars ($\geq 50\%$). The second largest class of identified objects are the white dwarfs ($\sim 21\%$) followed by early-type stars, extragalactic objects, sources classified as "other," and cataclysmic variables (each contributing $\sim 10\%$). In Fig. 8 we show the number distribution as a function of the 918 sources grouped by identification class. In this light, the fact that of 80% of the sources we are able to positively identify are late-type stars, followed by a handful of white dwarfs, is not surprising. Although we have presently only identified $\sim 10\%$ of the *EUVE* unidentified objects, one is tempted to predict that the majority of these objects are active late-type stars, many of which may be high proper-motion objects and, generally, uncataloged.

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