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THE DISCOVERY OF EIGHT BRIGHT ACTIVE GALACTIC NUCLEI OBSERVED WITH THE *HEAO 1* SCANNING MODULATION COLLIMATOR

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ABSTRACT

Eight active galactic nuclei (AGNs; seven type 1 seyferts and one QSO) are reported. They are 14th and 15th mag objects with broad hydrogen lines and redshifts in the range $0.026 < z < 0.138$. The AGNs were discovered in a systematic program to identify the fainter X-ray sources of the *HEAO 1* survey. All are located in or near the X-ray positions of the *HEAO 1* scanning modulation collimator, the *HEAO 1* Large Area Sky Survey, and other X-ray experiments. The AGNs are H0307−730, PKS 0558−504, H0707−495, H1143−182, H1839−786, H1934−513, H2106−099, and H2132−626.

The X-ray and optical luminosities and many of the optical emission features of these AGNs resemble other bright and nearby Seyfert 1 galaxies. However, three of the galaxies exhibit very strong Fe II emission, and two additionally show very weak forbidden line spectra similar to I Zw 1. One of the I Zw 1 types, the previously unidentified radio source PKS 0558−504, is a QSO with unusually narrow hydrogen lines for a high-luminosity object ($M_v = -25.1$). The other, H0707−495, has an Fe II/Hβ emission ratio that is similar to the largest known values. Another galaxy, H2106−099, has relatively strong emission lines of Fe X and Fe VII, and it is a variable X-ray source. Finally, the one for which we have X-ray spectral measurements, H1839−786, exhibits an unusually hard power-law spectrum with an X-ray energy index of 0.1. We have detected weak radio emission from the two Seyfert galaxies accessible from the VLA (H2106−099 and H1143−182). Photometric magnitudes and the intensities of selected emission lines are given for each of the AGNs.

Subject headings: galaxies: nuclei — galaxies: Seyfert — galaxies: X-rays — quasars — X-rays: sources

I. INTRODUCTION

The first *High Energy Astronomy Observatory* (*HEAO 1*) provided the most sensitive X-ray survey of the entire sky. The *HEAO 1* Large Area Sky Survey (LASS) experiment detected 842 sources with fluxes 0.22 μJy or greater at 5.2 keV ($\sim 5 \times 10^{-12}$ ergs cm^{-2} s^{-1} in the energy range 2–10 keV, assuming a Crab-like spectrum; Wood *et al.* 1984). About half these X-ray sources remain unidentified, primarily because the combined results of the collimated (nonfocusing) detectors do not produce sufficiently precise celestial positions for X-ray sources fainter than ~ 10.0 μJy. Identification of the survey sources is highly desirable. These objects tend to represent the nearest or most luminous examples of their class, and they are primary samples for detailed astrophysical studies at all observable wavelengths.

We are conducting a systematic optical search program, briefly described in § III, intended to identify optically the fainter sources (<2.5 μJy at 5.2 keV) of the *HEAO 1* survey. Sources brighter than this limit were largely known and identified prior to the LASS catalog (cf. Piccinotti *et al.* 1982; Bradt and McClintock 1983), and positions from the *HEAO 1* scanning modulation collimator (MC) played a role in ~ 100 of these identifications. Here we apply new analyses to the data from the *HEAO* MC to further constrain X-ray positions cataloged by the *HEAO* LASS, *HEAO* A-2 (Goddard Experiment), *Ariel 5*, and *Uhuru* surveys. The MC produces multiple, precise ($\sim 30'' \times 2'$) X-ray positions that decrease the allowed celestial area of an X-ray source by a factor of 40–100, with a detection limit of ~ 0.5 μJy at 5.2 keV (see Schwartz *et al.* 1985).

This paper presents observations of seven bright and previously unknown Seyfert type 1 (Sy 1) galaxies and one QSO that are among the first optical identifications obtained from the current effort. These active galactic nuclei (AGNs) have visual magnitudes between 14.3 and 15.7, which places them among the brightest known AGNs (e.g., Weedman 1977). The Sy 1 redshifts range from 0.027 to 0.074, and the QSO is at $z = 0.137$.

AGNs are a firmly established class of X-ray sources (Elvis *et al.* 1978; Tananbaum *et al.* 1978), and the MC has been used to identify the X-ray emission from many known Sy 1 and other emission-line galaxies (Griffiths *et al.* 1979*a*, *b*; Dower *et al.* 1980). The *Einstein Observatory* (1979–1981) has further extended the AGN sample by discovering many AGNs from serendipitous detections in X-ray images of fields at high Galactic latitude (e.g., Grindlay *et al.* 1980; Chanan, Margon, and Downes 1981; Reichert *et al.* 1982; Kriss and Canizares 1982; Stocke *et al.* 1983; Pravdo and Marshall 1984). The galaxies presented here are a factor of 10–100 brighter at both optical and X-ray wavelengths than most of the serendipitous *Einstein* AGNs.

II. X-RAY OBSERVATIONS

The MC has been described in great detail in the literature (Gursky *et al.* 1978; Schwartz *et al.* 1978). Briefly, the instru-

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ment consists of two banks of argon-filled proportional counters, with fields of view restricted to 4° × 4° FWHM and with sensitivity in the range 1–13 keV. Counts are sorted into three energy channels. Four grids of parallel wires in front of each MC bank modulate the detected flux of an X-ray source as the detectors scan across the field. The phase of a signal folded at the modulation periodicity determines a set of bands on the celestial tangent plane that include the X-ray source position. The wires of one MC are rotated by 20° with respect to the other, and one set of wires is more finely spaced than the other (MC1: 30″ FWHM, 4′ periodicity; MC2: 2′ FWHM, 16′ periodicity). The intersection of the allowed positions from the two MC signals produces a multiplicity of parallelograms (historically and hereafter called "diamonds"). Each diamond has a maximum size of 1′ × 4′ to 90% confidence, and one of them is expected to contain the X-ray source. The imposition of other X-ray error boxes, principally the more sensitive *HEAO* LASS (Wood *et al.* 1984), reduces the number of diamonds which must be included in the search for the optical counterpart.

We have also conducted a limited analysis of *HEAO* LASS data to confirm the line of position of the X-ray source. The *HEAO* LASS catalog (Wood *et al.* 1984) is based on the first complete celestial scan by *HEAO 1*. In our analysis, the sum of all the LASS scan modules (1° × 4° FWHM collimators) is inspected for every detector transit over the AGN position during the entire satellite mission (three celestial scans in 18 months). The data from each transit are accepted for positional analysis only if the background rate appears uniform. This qualitative judgment is made after viewing a plot of the transit. In the X-ray maps given for each object, we indicate our LASS position with dashed lines only if it is different from the cataloged position.

III. THE PROGRAM TO SEARCH FOR OPTICAL COUNTERPARTS

The effort to identify the fainter X-ray sources in the *HEAO 1* survey typically requires consideration of between six and 30 MC diamonds in or near the LASS error box. Very many optical objects, to the POSS or ESO *B* limits, are included within these diamonds, and there is a need for wide-field techniques to distinguish candidates that exhibit characteristics associated with the optical counterparts of X-ray sources. We obtain and evaluate the optical candidates in four systematic steps of investigation:

1. Once the X-ray data analysis is completed, we routinely plot the X-ray positions superposed on objects in 60 catalogs of "Interesting Objects," e.g., Markarian objects, the Kukarkin variable star catalog, the Ohio radio catalog, etc. In most cases this mapping fails to deliver a viable candidate.

2. The optical search is initiated with an examination of the POSS or ESO Sky Survey plates. Prominent galaxies, clusters of galaxies, and particularly bright stars ($V \leq 10.0$) are candidates if their positions are consistent with the X-ray results.

3. Schmidt telescope observations are made of each X-ray source field to recognize objects that have a strong ultraviolet (UV) color. The photographs are made with adjacent *U* and *B* filtered images on the same plate, and the exposures reach 17.5–18.0 mag in each bandpass. The candidates are selected from a visual comparison of the images. UV excess is an established optical characteristic of both Galactic X-ray sources (Bradt and McClintock 1983) and certain bright extragalactic X-ray sources, such as Seyfert type 1 galaxies, many BL Lac objects, and QSOs (e.g., Stein and Weedman 1976; Stein *et al.* 1976).

4. After a list of candidates is assembled, the objects are studied spectroscopically to determine their physical nature. Spectral classifications can secure an identification if the object is a member of a well-known class of X-ray emitters (with plausible implied luminosity) or if its class is too rare to be located by chance in or near an error diamond. The goal is to make an objective statement about the likelihood of the proposed identification and about the nature and distinguishing optical properties of the counterpart.

Prior to spectroscopic observations, a further screening of candidate objects is frequently made from photoelectric photometry (*U*, *B*, and *V*) measurements. The color indices may reveal significant deviations from the main sequence (see Bradt and McClintock 1983), and evidence of photometric variability has promoted some candidates that were later identified as cataclysmic variable systems. In various special cases we have also carried out objective prism photography and radio observations (e.g., Schmelz, Feigelson, and Schwartz 1984) of X-ray source fields. The purpose is primarily to identify reddened optical counterparts or the rare AGNs that exhibit red optical continua (e.g., Stocke *et al.* 1983). The radio detections also provide important information regarding the classification of RS CVn– and BL Lac–type candidates.

Most of the known classes of X-ray sources detected by *HEAO 1* (Wood *et al.* 1984) have optical counterparts that would be recognized by one or more of the above criteria. The exceptions are some very bright X-ray sources that have intrinsically faint optical counterparts (the low-mass X-ray binaries), and others that are heavily obscured by interstellar matter or lie in severely crowded fields. These exceptions are primarily very near the Galactic plane or in globular clusters.

IV. THE OPTICAL OBSERVATIONS OF THE EIGHT AGNS

The AGNs reported in this paper were all discovered because of their strong UV appearance on Schmidt telescope photographic plates. The plates were obtained using the 36/24 inch (91/61 cm) Schmidt telescopes at Cerro Tololo Inter-American Observatory and at Kitt Peak National Observatory. The photographs were made with standard UG-II and GG 385 filters and with exposures of 50 and 9 minutes respectively, using IIa-O or IIIa-J emulsion-type plates.

The optical spectra were obtained at several observatories, using standard observatory spectrographs and data reduction systems. Most of the spectra shown in this article were obtained at the 3.9 m Anglo-Australian Telescope (AAT) with the RGO spectrograph and the IPCS. This is a two-dimensional, photon-counting system with 3000–7500 Å sensitivity, and the AGN observations were conducted with a spectral resolution of ~10 Å FWHM. At CTIO the SIT Vidicon system (Atwood *et al.* 1979) and "Big Red" image tube were used on the 1.5 m telescope (3700–7500 Å with resolution ~15 Å FWHM). Spectra were also obtained with the Mark II system, which is a photon-counting, intensified Reticon scanner (Shectman and Hiltner 1976) used on the 1.3 m telescope at the McGraw-Hill Observatory. The Mark II observations covered 3700–7400 Å with a resolution ~15 Å, and data reduction procedures have been described by Canizares, McClintock, and Ricker (1978). Flux calibrations were accomplished by observing spectrophotometric standard stars of Oke (1974) or Stone (1977).

Optical photoelectric photometry was performed with the 1.0 m telescope of the Australian National University at Siding Spring Observatory and with the 1.0 m (Yale) telescope at CTIO. The ANU observations employed a two-channel chop-

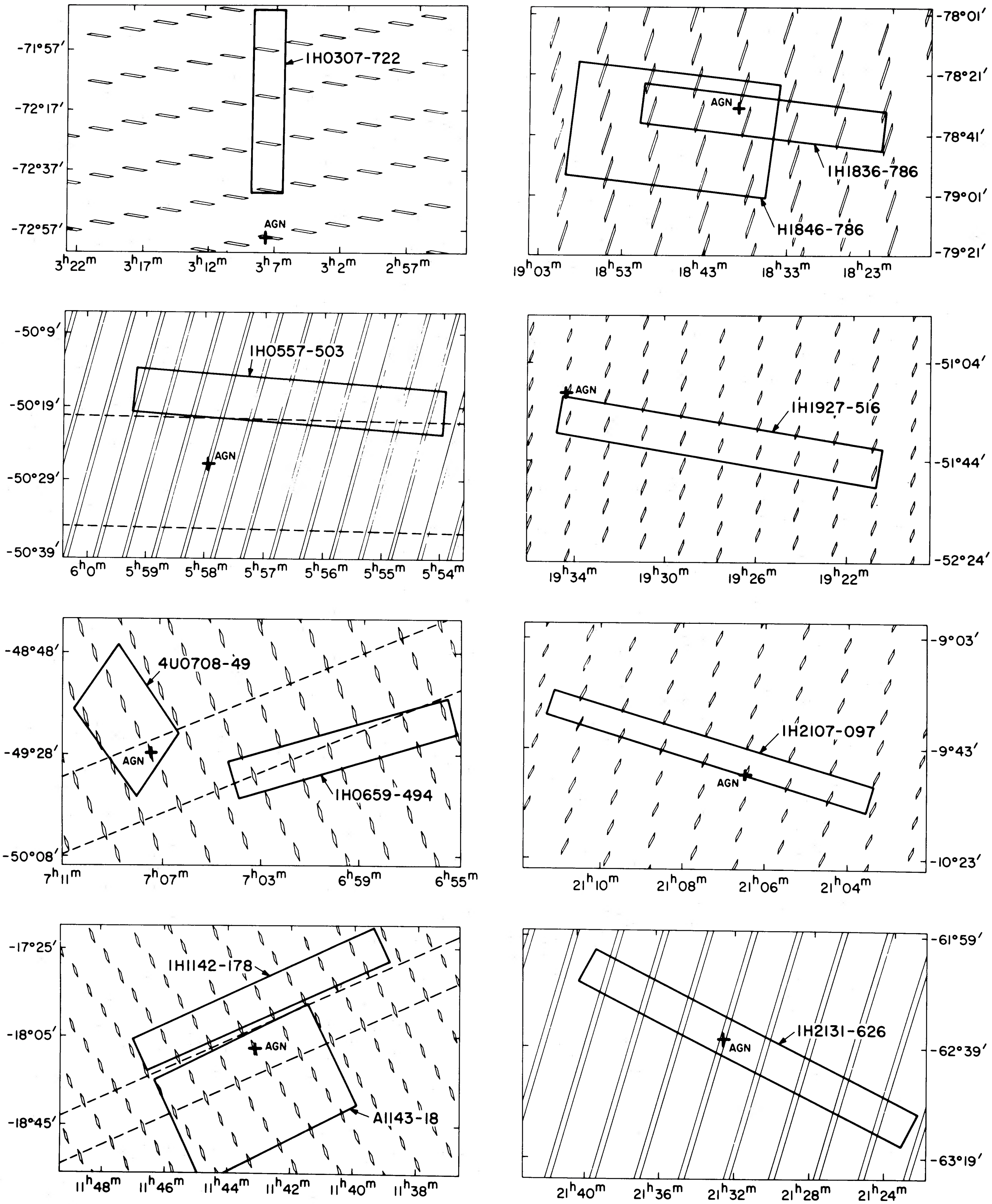

FIG. 1.—Maps showing the AGNs (*plusses*) and the allowed X-ray positions from the *HEAO* MC (*diamonds* or *bands*, depending on whether both or a single collimator produces a detection), the *HEAO* LASS ("1H"; Wood *et al.* 1984), the GSFC *HEAO* survey ("H"; Marshall *et al.* 1979), *Uhuru* ("U"; Forman *et al.* 1978), and the *Ariel 5* sky survey instrument ("A"; Ricketts 1978). Our own analysis of the LASS position (see § II) is shown with dashed lines for the three cases in which the results are different from the cataloged error boxes. Note the widely different scales.

ping photometer (Bessell 1985) with IP21 and S-20 photomultiplier tubes. The CTIO observations are made with a single-channel photometer and an RCA 31034 photomultiplier tube. All the photometric observations were made during clear and moonless conditions, with 1″–3″ seeing and 20″ apertures. Each AGN was measured on two or three separate nights. The data were corrected for atmospheric extinction and converted to *UBV* magnitudes by observing photoelectric standards of Landolt (1983) and Graham (1982).

V. RESULTS

In Figure 1 the positions of eight new AGNs are shown in comparison with *HEAO 1* and other X-ray positions. The statistical significances of the X-ray detections are discussed for each source later in this section. The MC results include data from all the *HEAO 1* celestial scans except in the case of H2106−099, which shows evidence of X-ray variability. In addition, all the MC detections appear spatially unresolved, which indicates that the angular sizes of the X-ray sources are less than 1′. In § VI we show that the probability of a spurious identification is small.

The X-ray fluxes reported below are derived from the LASS counting rates, assuming a 2–10 keV conversion factor of 2.0×10^{-3} LASS counts cm^{-2} s^{-1} (1.0×10^{-11} ergs cm^{-2} $s^{-1})^{-1}$. This factor was determined from a comparison of LASS counting rates and the *HEAO* A-2 flux measurements of bright Sy 1 galaxies (Mushotzky *et al.* 1980). This result is within 10% of the nominal 2–10 keV conversion factor given by Wood *et al.* (1984) for a Crab-like spectrum. The rms statistical uncertainty in the LASS count rates for the eight X-ray sources is ±14%.

Table 1 contains the celestial positions, redshifts, photometric magnitudes, and X-ray and optical luminosities for each of the AGNs. Our astrometry is typically accurate to 1″. When reporting luminosities and distance scales, we assume $H_0 = 50$ km s^{-1} Mpc^{-1} and $q_0 = 0$. Table 1 also contains the optical/X-ray energy index β_{ox} that connects the optical continuum flux at 4000 Å with the X-ray flux at 2 keV (i.e., $F_\nu \propto \nu^{-\beta}$) in the rest frame of the AGN. The continuum flux at 4000 Å is corrected for Galactic extinction by estimating $A_v = 0.18$ csc b (e.g., Schmidt 1968) and then applying the $E(\lambda - V)$ results of Bless and Savage (1972). Light loss at the spectrograph aperture is checked by comparing the integrated flux densities with the photometric results, using the photometric bandpasses and normalizations of Allen (1973). The calculations of β_{ox} and the emission flux of Hβ include a scaling factor that brings the spectral and photometric magnitudes into agreement, unless the deviation can be attributed to the photometric contributions of the host galaxy in the 20″ aperture, as in the case of H0307−730. The X-ray flux density at 2 keV is calculated from the 2–10 keV flux by assuming an X-ray power-law spectrum with an energy index of 0.7 (Mushotzky *et al.* 1980; Petre *et al.* 1984).

Optical finding charts for the AGNs are provided in Figure 2 (Plate 2). All the AGNs except PKS 0558−504 show an extended optical image, and this is the only distinction between our Sy 1 and QSO classifications. The stellar nuclei strongly dominate the optical emission for all the Sy 1 galaxies except H0307−730.

The optical spectra of the AGNs are shown in Figures 3 and 4, and emission line fluxes and Hβ widths are given in Table 2. All the AGNs show hydrogen emission lines that are much broader than the forbidden lines, and this is known to select AGNs of high X-ray luminosity (Kriss, Canizares, and Ricker 1980). Further important or unusual characteristics of the optical spectra are discussed below.

a) H0307−730 (Sy 1)

This Seyfert type 1 nucleus is found in a host galaxy which contributes a significant fraction of the total optical flux. The galaxy reddens the photometric $U-B$ value (20″ aperture) and the spectral continuum (Fig. 3), and it produces weak absorption lines (Ca II, *g*-band, Na I) that are typical of early Hubble-type spirals. The emission spectrum exhibits high excitation

TABLE 1

THE ACTIVE GALACTIC NUCLEI

Name	Other X-Ray Names	R.A. (1950.0)	Decl.	z (±0.001)	V[a]	$B-V$[a]	$U-B$[a]	M_v[b]	Identification Status[c]	L_x[d]	β_{ox}[e]
H0307−730	1H 0307−722	03ʰ07ᵐ40ˢ.1	−73°01′29″	0.0280	14.90	+0.58	−0.28	−21.5	A	43.75	1.03
PKS 0558−504	1H 0557−503	05 58 34.6	−50 26 55	0.1372	14.97	+0.21	−0.89	−25.1	B+	45.39	1.08
H0707−495	4U 0708−49 1H 0659−494	07 07 22.6	−49 28 13	0.0411	15.70	+0.32	−0.71	−21.9	A	44.24	1.06
H1143−182	A1143−18 1H 1142−189	11 43 08.3	−18 10 37	0.0330	14.58	+0.45	−0.56	−22.2	A	43.83	1.18
H1839−786	H1846−786 1H 1836−786 1M 1849−77	18 39 03.5	−78 35 06	0.0743	15.55	+0.59	−0.77	−23.2	B+	44.86	0.95
H1934−513	H1928−520 1H 1927−516	19 34 14.8	−51 16 35	0.0403	15.20	+0.47	−0.81	−22.1	B	44.18	1.09
H2106−099	1H 2107−097	21 06 28.2	−09 52 29	0.0268	14.32	+0.48	−0.63	−22.0	A	43.84	1.22
H2132−626	1H 2192−624	21 32 33.2	−62 37 27	0.0588	15.15	+0.53	−0.89	−22.9	B	44.53	1.04

[a] Optical photometry was performed with 20″ apertures. The 1 σ errors are 0.04 in V and 0.05 in the color indices.

[b] M_v was calculated from V with the assumptions $H = 50$ km s^{-1} Mpc^{-1} and $q_0 = 0$, and with a correction for Galactic absorption, $A_v = 0.18$ csc b (Schmidt 1968).

[c] "A" objects are very probable identifications of the X-ray source. "B" objects are probable identifications, with less certain detections by the Modulation Collimator. The plus indicates that the identification has subsequently been confirmed by an imaging X-ray observation.

[d] L_x is the 2–10 keV X-ray luminosity if the AGN emits the measured *HEAO* LASS flux. The units are log (ergs cm^{-2} s^{-1}). In the case of H2106−099, the value pertains to the first *HEAO 1* scan (see text).

[e] β_{ox} is the power-law index connecting the optical flux density at 4000 Å with the X-ray flux density at 2 keV in the AGN rest frame. The flux density at 4000 Å has been corrected for extinction in the Galaxy and for light loss at the spectrograph aperture, and the flux density at 2 keV is calculated from the 2–10 keV flux by assuming an X-ray energy index of 0.7 (see text).

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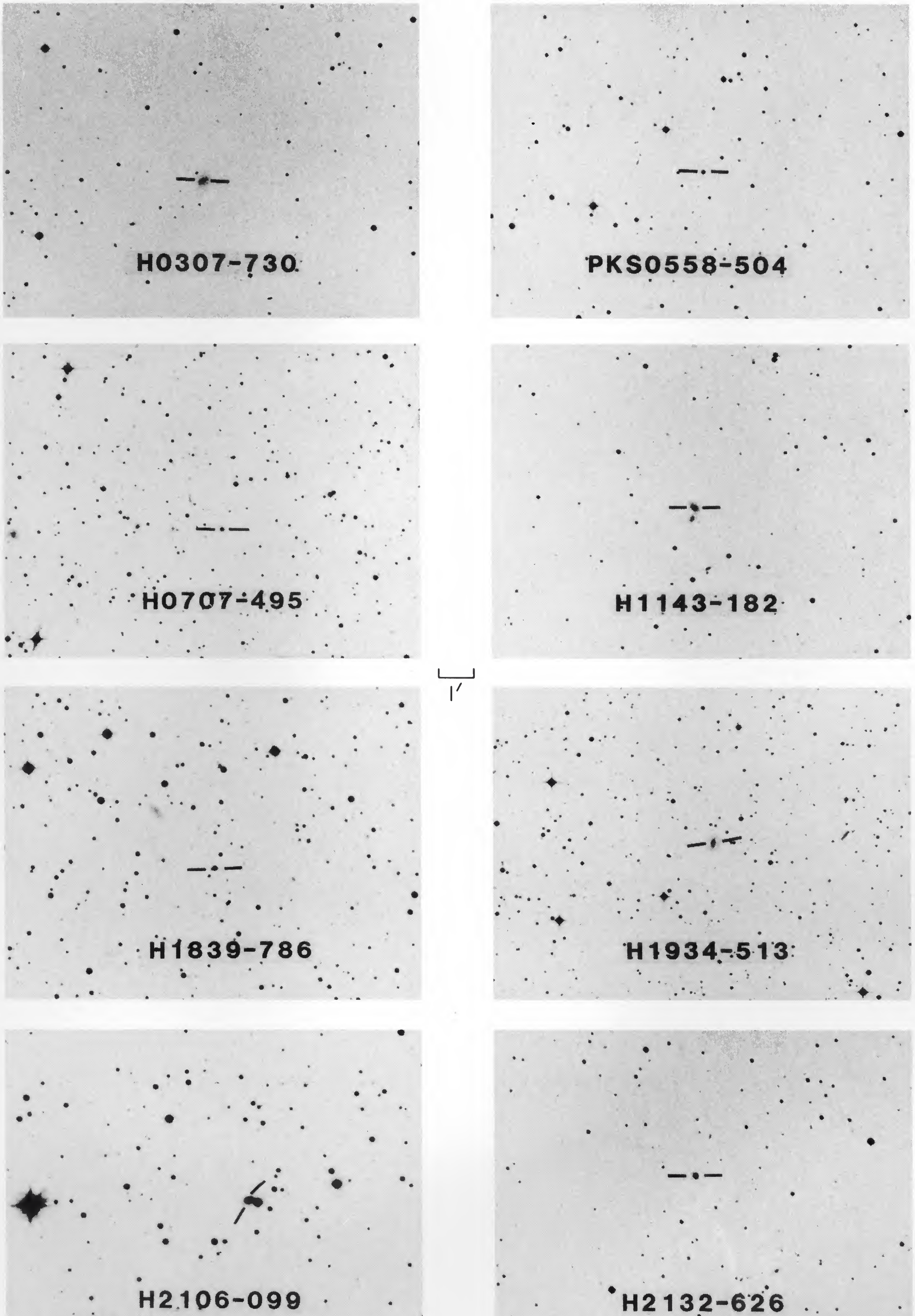

FIG. 2.—Optical finding charts for each of the eight new AGNs. All charts have east to the left and north toward the top. The scale indicated by the central 1′ bar is accurate to within 10% for each chart.

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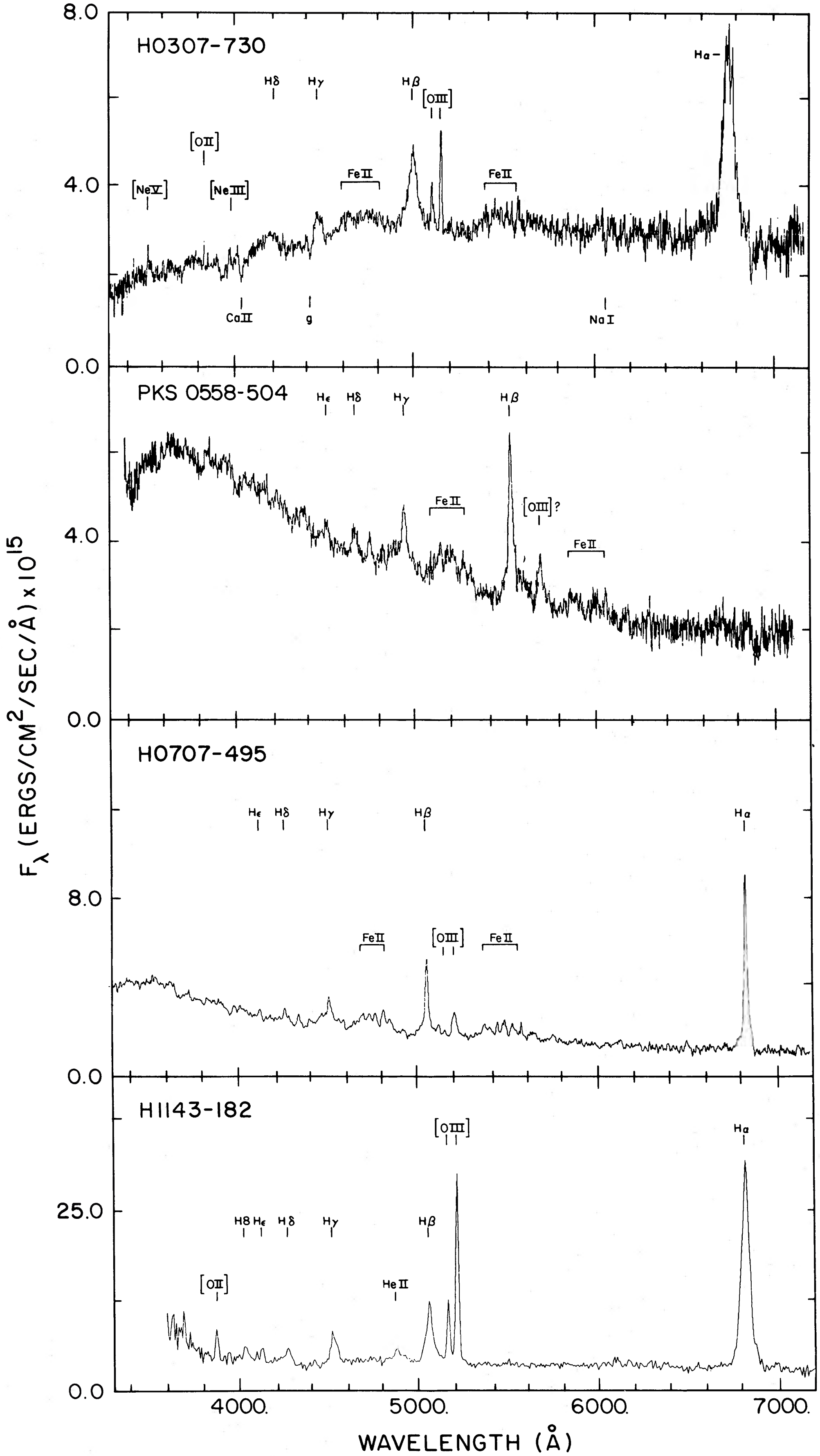

FIG. 3.—Optical spectra of four AGNs. H0307−730 and PKS 0558−504 were observed at the AAT on (UT) 1984 February 8, while H0707−495 was observed at the AAT on 1983 May 17. The spectrum of H1143−182 was obtained at the McGraw-Hill Observatory on 1983 March 15.

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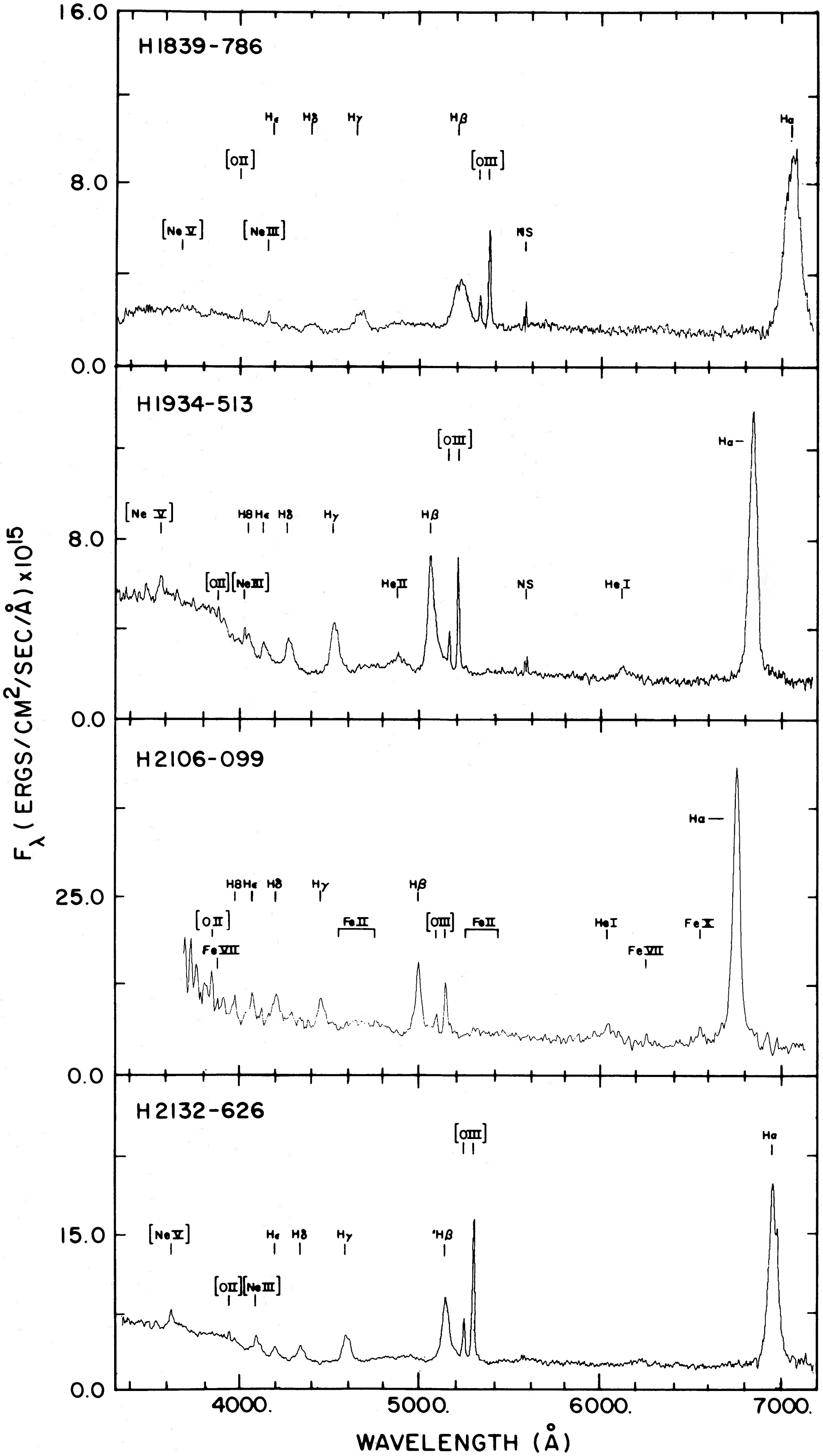

FIG. 4.—Optical spectra of four AGNs. The spectrum of H2106−099 was obtained at CTIO on 1982 October 25 (UT), and the other three AGNs were observed at the AAT on 1983 May 17.

TABLE 2

OPTICAL SPECTRAL MEASUREMENTS

NAME	FWZI (Hβ) (km s^{-1})	EQUIVALENT WIDTH OF Hβ (Å)	INTEGRATED LINE FLUX OF Hβ (10^{-13} ergs cm^{-2} s^{-1})	INTEGRATED RELATIVE LINE FLUXES (Hβ ≡ 1.0)[a]									
				Hα λ6562	Hγ λ4340	Hδ λ4101	He I λ5876	He II λ4686	Fe II Sum[b]	O III λ5007	O II λ3727	Ne III λ3868	Ne V λ3426
H0307−730	9400	36.0	1.08	2.95:	0.33	0.15:	...	...	1.47	0.24	0.030	0.024	0.050
PKS 0558−504	6400	48.7	1.58	x	0.24	0.16	0.12	...	1.56	0.12:	0.027	...	...
H0707−495	6300	60.7	1.04	2.22	0.25	0.16	0.09	...	2.77	0.14:	0.010	...	...
H1143−182	8000	119.2	4.86	3.76	0.44	0.22	0.10	0.30	...	1.21	0.168	0.083	x
H1839−786	12000	151.7	2.46	3.87:	0.30	0.11	0.12	...	0.77	0.30	0.025	0.032	0.011
H1934−513	12600	155.5	3.77	2.45	0.45	0.19	0.14	0.25:	0.35:	0.22	0.021	0.021	0.056
H2106−099	10700	96.2	5.54	4.68	0.41	0.31	0.42	...	1.05	0.29	0.039	0.091:	x
H2132−626	10200	157.2	3.61	3.01:	0.38	0.19	0.15	0.10:	0.54:	0.56	0.025	0.043	0.057

[a] Normalized to Hβ emission. An "x" indicates that the line was outside the observed spectral range, "..." that the lines are not detected with significance $>3.5\sigma$. A colon indicates uncertainty in the listed value. For Hα, He II, Fe II, and O III, the uncertainty arises from blended lines of N II, Fe II, He II, and Fe II respectively; in the other cases the uncertainty is statistical.

[b] The Fe II flux is summed over two broad intervals to include the multiplets near 4570, 5190, and 5320 Å, as labeled in Figs. 3 and 4.

lines of [O III], [Ne III], and [Ne V] as well as broad lines of H and Fe II, all of which are common Sy 1 features.

The AGN is contained within an *HEAO* MC error diamond, but the significance of the detection is weak (3.1 σ in MC1 and 2.6 σ in MC2, both in the range of 1–13 keV; see Fig. 1). The X-ray flux is 1.6×10^{-11} ergs cm^{-2} s^{-1} at 2–10 keV. The *HEAO* LASS catalog (Wood *et al.* 1984) lists a cluster of galaxies, STR 0308−723 (Duus and Newell 1977) as the likely X-ray source identification. Although the cluster is within the *HEAO* LASS error box, its characteristics (open; $N = 20$; $0.1 < z < 0.15$) do not support the identification. Furthermore, the cluster identification is not consistent with the spatially unresolved MC result. The AGN is nearby ($z = 0.028$), and the implied X-ray luminosity of 43.7 (log units, ergs s^{-1}) is very plausible (e.g., Elvis *et al.* 1978). We therefore propose that the AGN is the correct identification.

b) PKS 0558−504 (QSO)

A Schmidt photograph revealed a bright ($V = 14.97$) and very UV stellar image near the *HEAO* LASS error box, and the object's position was found to be within 9″ of the unidentified radio source PKS 0558−504 (with a positional accuracy of ~10″; Wright, Savage, and Bolton 1977). The spectrum (Fig. 3) shows a strong Fe II-emitting QSO ($z = 0.137$), with very weak forbidden lines and very narrow cores of H emission. This object is an extreme example of the type of Fe-emitting AGN represented by I Zw 1 and PKS 1510−08 (see Phillips 1977, 1978). The optical luminosity is high ($M_v = -25.1$); however, the FWZI (Hβ), as judged from the blueward wing, is only 6400 km s^{-1}, and the FWHM of Hβ is only 1500 km s^{-1}. Emission lines of Fe II lines complicate resolution of the redward profile of Hβ and of the [O III] lines, although the latter must be very weak since the [O III] line at 4959 Å is not evident. There are additional Fe II lines blended with and blueward of Hγ (see Phillips 1978). The strength of the Fe II emission is usually measured by the ratio of Fe II to Hβ emission, r(Fe II/Hβ), where the Fe II flux is summed over two broad intervals to include the multiplets near 4570 Å and those near 5190 and 5320 Å (Osterbrock 1977; Steiner 1981), as labeled in Figures 3 and 4. For PKS 0558−504, r(Fe II/Hβ) = 1.56, which is exceeded by only five of the 147 AGNs reviewed by Steiner (1981).

Some of the strong Fe II emitters, particularly I Zw 1 and PKS 1510−08, also show very weak forbidden line spectra, and several AGNs, such as I Zw 1 and Mrk 478, also exhibit relatively narrow H emission lines (Phillips 1977). PKS 0558−504 occupies a special position with regard to these, since it is both a high-luminosity and a very narrow line example among these strong Fe II–emitting AGNs. Fe II emission was found to be uncommon in moderate-redshift QSOs (Phillips 1977). Narrow-line QSOs may be even more unusual; one was observed at higher redshift by Uomoto (1984), but its weak Fe II and Mg II emission suggest that it is not related to AGNs like PKS 0558−504. Stocke *et al.* (1982) have also presented an X-ray–discovered narrow-line quasar with no indication of Fe II emission.

The *HEAO* MC detection of PKS 0558−504 is limited to a single collimator (3.4 σ in MC1 for the 1–13 keV channels; see Fig. 1). However, we have recently confirmed the identification through an observation by *EXOSAT*, the X-ray observatory operated by the European Space Agency. The automatic analysis of the CMA low-energy (LE) detector (0.04–2.0 keV) shows a single bright source that is 2″ ± 10″ from PKS 0558−504, in an X-ray image that was centered on the QSO with a field of view of 2°2 diameter. The LE flux of 0.108 ± 0.003 counts s^{-1} is fully consistent with the *HEAO* LASS flux (3.0×10^{-11} ergs cm^{-2} s^{-1} in the range of 2–10 keV) for an X-ray energy index of ~0.7 and a column density of $\sim 10^{20} N_H$ cm^{-2}. The complete analysis of the X-ray spectrum will be given at a later time.

c) H0707−495 (Sy 1)

This object is clearly a fainter ($V = 15.70$) and closer ($z = 0.041$) relative of PKS 0558−504. The Fe II lines are very strong, the forbidden lines are weak, and the hydrogen cores are again very narrow. We have measured r(Fe II/Hβ) = 2.77, which is nearly equal to the value for I Zw 1, the strongest Fe II emitter (relative to Hβ) reviewed by Steiner (1981), although a value of 4.71 is given for the very unusual AGN Mrk 231 (Phillips 1978; see also Boksenberg *et al.* 1977). Compared to PKS 0558−504, the forbidden lines are stronger, as [O III] λ4959 is clearly visible. The H lines appear asymmetric, and we estimate the FWZI of Hβ is ~6300 km s^{-1}, while the FWHM of Hβ is only 1000 km s^{-1}. The very narrow cores of the permitted emission lines is also exhibited in the profiles of the Fe II multiplets.

This X-ray source was detected by both *Uhuru* and *HEAO* LASS (2.4×10^{-11} ergs cm^{-2} s^{-1}), and the MC error diamonds (Fig. 1; MC1 has 3.0 σ significance and MC2 has 3.4 σ significance, both for the 2.5–13 keV energy channels) contain the AGN position. The galaxy is 2′ outside the field of view of an *Einstein* HRI observation targeted at the center of the *Uhuru* error box. The HRI detected a source, but only at its threshold (9 counts in 1845 s), in an optically blank field, and we consider it unlikely that this weak source, if real, is the same as the LASS source. The monitor proportional counter (MPC) gave an apparent detection of 0.18 ± 0.06 counts s^{-1} from the same observation, which would correspond to $0.84 \pm 0.26 \times 10^{-11}$ ergs cm^{-2} s^{-1} if from the Sy galaxy.

d) H1143−182 (Sy 1)

This Sy 1 galaxy is one of a pair (see Fig. 2), both of which have redshifts of 0.033 ± 0.001. Their separation orthogonal to the line of sight is about 20 kpc. The galaxy next to the Sy 1 shows normal absorption features without signs of nuclear activity or H II–type emission. The AGN spectrum (Fig. 3) shows broad H lines and strong He II λ4686 emission, and Fe II is absent.

The AGN lies within an *HEAO* MC error diamond (2.6 σ in MC1 and 3.1 σ in MC2, both for the 0.9–5.5 keV channels). The X-ray source was originally detected in a search for emission from Abell clusters with data from the *Ariel 5* sky survey instrument (Ricketts 1978). The source is also detected by the *HEAO* LASS (1.4×10^{-11} ergs cm^{-2} s^{-1} at 2–10 keV).

We have observed this object in a 10 minute VLA snapshot at 20 cm, and the AGN was detected with a flux of 5.6 ± 0.3 mJy, apparently unresolved in configuration C.

e) H1839−786 (Sy 1)

Figure 4 contains the spectrum of another Sy 1 nucleus, showing broad hydrogen emission lines with a FWZI(Hβ) ≈ 12,000 km s^{-1}. The host galaxy is the largest of this group, projecting an observable diameter of 35 kpc or more at $z = 0.074$. The optical luminosity ($M_v = -23.2$) is large for a Seyfert galaxy (e.g., Schmidt and Green 1983).

This X-ray source was one of the few remaining unidentified sources in the *HEAO* A-2 (Goddard) high Galactic latitude survey (Piccinotti *et al.* 1982). The AGN is within the *HEAO* LASS error box for this source (3.0×10^{-11} ergs cm^{-2} s^{-1} at 2–10 keV), as is a cluster of galaxies, STR 1839−787 (medium compact, $N = 20$, extremely distant; Duus and Newell 1977). The MC detection has significance of 4.0 σ (MC1) and 2.9 σ (MC2), both in the 2.5–13 keV energy channels. The AGN is included within the MC1 result, but it is slightly outside the less significant MC2 band (see Fig. 1). Since the MC detection is spatially unresolved, unlike X-ray emission from clusters of galaxies (Schwartz *et al.* 1979), the AGN candidate is favored.

After the Seyfert galaxy was located, we become aware of an *Einstein* IPC guest observation by Wood *et al.* targeted at the center of the LASS error box. During this observation, the star camera did not lock onto the guide stars, and this had prevented making an X-ray image of the field. In addition, the high-voltage supply of the IPC detector was off for most of the observation. We have used the *Einstein* data bank to construct the IPC image on the basis of the "map mode" aspect solution. In 281 s of usable data, the IPC detects a single source that is 40″ ± 1′ from the position of the Seyfert galaxy. We regard this as a confirmation of the identification.

In this same *Einstein* pointing, the MPC detected a flux of $4.8 \pm 0.3 \times 10^{-11}$ ergs cm^{-2} s^{-1}, and the X-ray spectrum was fitted by a power law with an energy index of 0.1.

f) H1934−513 (Sy 1)

This Sy 1 nucleus is found in a barred spiral galaxy which has a distinct ring on its outer edge (see Fig. 1). The phenomenon is not unusual among AGNs (Balick and Heckman 1982). The spectrum (Fig. 4) shows broadened emission of hydrogen, He I, and He II, and relatively strong lines of [Ne III] and [Ne V]. The hydrogen lines are very asymmetric, with much broader profiles on the redward sides. The UV "bump" appears very strong in this AGN (see Malkan and Sargent 1982; Malkan 1983).

The AGN is positioned just outside an *HEAO* MC error diamond (MC1 detection at 3.5 σ and MC2 at 3.8 σ, both in the 0.9–2.5 keV energy channels), near the edge of the *HEAO* LASS error box (2.2×10^{-11} ergs cm^{-2} s^{-1} at 2–10 keV). The identification is regarded, therefore, as probable.

g) H2106−099 (Sy 1)

This is the brightest ($V = 14.3$) and nearest ($z = 0.027$) of the AGNs presented here. Unlike the other AGNs described in this paper, this Sy 1 galaxy appears to be a variable X-ray source. The AGN is contained within an MC error diamond (MC1 detection at 3.1 σ and MC2 at 4.7 σ, both in the 2.5–13 keV channels), derived from the first *HEAO 1* scan of the source (1977 November 5–11). The source is not detected by the MC during the second or third scans by *HEAO 1* (1978 May 3–9 and November 6–12). Similarly, our analysis of *HEAO* LASS data indicates an 8.1 σ detection during the first scan ($2.25 \pm 0.39 \times 10^{-11}$ ergs cm^{-2} s^{-1} at 2–10 keV), while the second scan detection has only 2.3 σ significance, with a flux of $0.75 \pm 0.47 \times 10^{-11}$ ergs cm^{-2} s^{-1}. The third LASS scan contains data of poor quality.

The optical spectrum of this Sy 1 galaxy (Fig. 4) shows many typical AGN emission features, including Fe II emission and H emission with broad wings. Additionally, He I appears to be unusually strong, and there are very high excitation lines of [Fe X] λ6374 and of [Fe VII] at 3760 and 6086 Å. The [Fe X] line has been observed with similar relative intensity in several galaxies, such as NGC 4151 (Oke and Sargent 1968), 3C 390.3, and NGC 3783 (Cooke *et al.* 1976), all of which are variable X-ray sources (Charles, Longair, and Sanford 1975; Mushotzky *et al.* 1980). Thus, optical spectral features give circumstantial evidence which supports the identification of this X-ray source. H2106−099 appears to be a member of a select group of Sy 1 galaxies that are characterized by extremely hot gas components and a high degree of X-ray variability. VLA observation of this source at 20 cm gave a flux of 3.6 ± 0.3 mJy.

h) H2132−626 (Sy 1)

This Sy I galaxy exhibits broadened H emission and strong lines of [Ne III] and [Ne V]. This is the third case in which an AGN and a cluster of galaxies both lie within or near the *HEAO* LASS error box. The cluster is STR 2131−623 (medium compact, $N = 30$, estimated $0.1 < z < 0.15$; Duus and Newell 1977), and there is a possibility that the X-ray flux (2.2×10^{-11} ergs cm^{-2} s^{-1} at 2–10 keV) is shared between these objects. The AGN ($z = 0.059$) is detected in only one of the *HEAO* MC detectors (MC2 at 3.1 σ in the 6–13 keV channel). However, the implied X-ray luminosity of 44.6 (log ergs cm^{-2} s^{-1}) is a typical value for Sy 1 types. The AGN is the preferred (" probable ") identification of the X-ray source.

VI. DISCUSSION AND SUMMARY

Most of these newly discovered AGNs exhibit spectral characteristics that are typical of Sy 1 nuclei. The Balmer decrements are generally steeper than that predicted for radiative recombination (Osterbrock 1977), although H1934−513 and H2132−626 are near the recombination values. Fe II emission is often present, and He I is always observed, with values that tend to cluster around 10% of Hβ (see also Osterbrock 1977). However, there are also unusual properties among several of these AGNs. The Fe II lines of H0706−495, PKS 0558−504, and H0307−730 are similar to the six strongest Fe II emitters in a sample of 147 AGNs reviewed by Steiner (1981). Furthermore, PKS 0558−504 is a luminous AGN ($M_v = -25.1$) with, relatively, very narrow H emission lines and very weak forbidden lines. Additionally, H2106−099 appears to belong to a small group of Fe VII– and Fe X–emitting Sy galaxies that are highly variable X-ray sources, while H1839−786 has a very hard X-ray spectrum with an energy index of 0.1.

The strongest Fe II emitters, I Zw 1 and Mrk 231, are of further interest because they are known to be great sources of infrared emission. Their bolometric luminosities are easily the highest among Seyfert galaxies (Rieke 1978), but the nature of this emission is not understood. H0707−495 and PKS 0558−504 bear a distinct resemblance to I Zw 1. PKS 0558−504 is a particularly interesting target for infrared observation, since it is already more luminous optically and in X-rays than I Zw 1.

The emission line profiles of PKS 0558−504 and H0707−495 are very narrow for AGNs of high X-ray luminosity, but they do not resemble either the emission lines of Sy 2 galaxies nor the more discontinuous, two-component profiles that characterize the classifications in the range of Sy 1.5–1.9. The FWZI measures for Hβ are complicated by nearby Fe II lines; however, the values do not appear to be underestimated, since in both cases the full widths of Hα are 10%–15% *less* than the values given for Hβ (Hα of PKS 0558−504 was observed in an earlier spectrum obtained at CTIO).

We estimate a lower limit to the probability that our identifications are correct. From Huchra and Sargent (1973) the surface density of 0.05 deg^{-2} is derived for Seyfert galaxies (defined as $M_p \geq -23$) which appear brighter than $m_p = 16$. Although we may have as few as four to six diamonds inside the LASS error box, we may consider 20–40 diamonds "near" or along the length extensions as possible source locations. Forty diamonds of the maximum 4 $arcmin^2$ size would occupy 2.67 deg^2 for the ~ 60 X-ray sources that were investigated during the time in which the seven Sy 1 galaxies were discovered (other identification papers are in preparation). This area contains 0.13 spurious Sy 1 galaxies, which implies a probability of 88% that all seven identifications are correct. For QSOs a similar argument could be made using the density analysis of Schmidt and Green (1983), but the issue is superseded by the *EXOSAT* measurement of a single, bright X-ray source at a position consistent with that of PKS 0558 − 504.

The eight AGNs presented here have an average L_x of 44.3 (log X-ray luminosity in ergs s^{-1}). This is very similar to the mean of 44.2 for the broad-line AGNs in the compilation of Seyferts and low-redshift QSOs by Steiner (1981). Although this comparison involves different X-ray spectral ranges, the integrated fluxes in 2–10 keV versus the 0.5–4.5 keV band are virtually equal for a typical Seyfert X-ray energy index of 0.7 with little or no energy cutoff due to absorption (Mushotzky *et al.* 1980). The optical/X-ray spectral index has a mean β_{ox} of 1.08 ± 0.03 for these eight AGNs, and the mean is flatter (3 σ) than the mean index of 1.19 ± 0.03 for the X-ray–selected sample of Kriss and Camizares (1982). However, none of the eight AGN have β_{ox} values outside the range of the larger sample of Kriss and Canizares (1982), and the differences in the mean values may be due to different redshifts or to selection effects regarding the identification sequence (i.e., the optically brightest are first) of *HEAO 1* X-ray sources. X-ray fluxes are least certain for H1934 − 513 and H2132 − 626, as judged from the significance of the MC results.

The optical identification of the fainter sources in the *HEAO 1* survey promises to increase significantly the numbers of bright examples of several classes of X-ray sources. Although the MC observations are near the instrumental flux limit, the experiment plays a vital role in identifying the optical counterparts. Increasing the sample of bright objects is particularly important in the study of active galactic nuclei. AGN optical properties have proven to be complex and diverse, and progress in understanding the physical conditions and dynamics of the various emitting regions is crucially dependent on the detailed analysis of significant numbers of objects in the various subgroups (see Osterbrock 1984), which is most readily achieved for the brighter objects. The occasional discovery of extreme or unusual spectral characteristics in an AGN may encourage studies directed toward this end.

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