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IDENTIFICATIONS OF FIVE *INTEGRAL* SOURCES VIA OPTICAL SPECTROSCOPY

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ABSTRACT

The International Gamma-Ray Astrophysics Laboratory (*INTEGRAL*) is discovering hundreds of new hard X-ray sources, many of which remain unidentified. We report on optical spectroscopy of five such sources for which X-ray observations at lower energies (∼0.5–10 keV) and higher angular resolutions than *INTEGRAL* have allowed for unique optical counterparts to be located. We find that IGR J16426+6536 and IGR J22292+6647 are Type 1 Seyfert active galactic nuclei (with IGR J16426+6536 further classified as a Seyfert 1.5) which have redshifts of $z = 0.323$ and $z = 0.113$, respectively. IGR J18308–1232 is identified as a cataclysmic variable (CV), and we confirm a previous identification of IGR J19267+1325 as a magnetic CV. By comparing the spectrum of IGR J18214–1318 to colors of various types of stars, we conclude that it is probably a high mass X-ray binary.

Subject headings: galaxies: Seyfert — stars: cataclysmic variables — techniques: spectroscopic — X-rays: binaries — X-rays: individual (IGR J16426+6536, IGR J18214–1318, IGR J18308–1232, IGR J19267+1325, IGR J22292+6647)

1. INTRODUCTION

Since its launch on October 17, 2002, the International Gamma-Ray Astrophysics Laboratory (*INTEGRAL*) has discovered hundreds of new hard X-ray sources. According to the most recent census, of the ∼500 sources detected in hard X-rays at energies greater than 20 keV, 214 had not been well-studied (or even detected in most cases) before (Bodaghee et al. 2007). These new sources are called “IGR” sources, for *INTEGRAL* Gamma-Ray sources. Of these IGR sources, 50 had been identified as active galactic nuclei (AGN), 32 as high-mass X-ray binaries (HMXBs), 6 as low-mass X-ray binaries (LMXBs), and 15 as sources such as cataclysmic variables (CVs), supernova remnants, and anomalous X-ray pulsars, leaving 111 unclassified. Since this last census, much work has been done to identify the ∼50% of unclassified IGR sources (corresponding to ∼25% of all sources detected by *INTEGRAL*). Many have been identified as AGN, LMXBs and HMXBs, as well as relatively rare systems such as heavily absorbed supergiant HMXBs, supergiant fast X-ray transients, and Intermediate Polar (IP) CVs (e.g., Masetti et al. 2008; Chaty et al. 2008).

INTEGRAL is particularly well suited for finding such systems. Part of *INTEGRAL*’s Core Program involved scans of the Galactic plane (Winkler et al. 2003). One expects to find HMXBs here, as they consist of a neutron star or black hole accreting from a short-lived massive star, which would not be expected to move far from its birthplace in star forming regions of the Galactic plane. Other instruments observing at lower energies could not easily find these because of the obscuring dust and gas in the plane. Furthermore, objects such as heavily absorbed supergiant HMXBs suffer obscuration not only from the intervening medium, but also from local extinction (e.g., Rodriguez et al. 2003; Walter et al. 2006). In addition, *INTEGRAL* has found disproportionately many IP CVs according to the previously known population statistics, since they emit at these high energies more than non-magnetic CVs or polar CVs (Barlow et al. 2006). Currently, less than 10% of known CVs are magnetic. The majority of these are polars, so called since they show polarization of optical flux. These are systems in which the white dwarf has a magnetic field strong enough to synchronize the orbital period of the binary with the spin of the white dwarf. Intermediate polars have a weaker magnetic field that is not strong enough to cause synchronization, but they do display variability associated with the rotation of the white dwarf. Of the at least 15 CVs detected by *INTEGRAL*, the vast majority are these relatively rare magnetic systems, with most of those being IPs.

Identification of these unclassified sources requires observations of the source in the optical and/or infrared. The IBIS imager on *INTEGRAL* is unique among hard X-ray/soft γ-ray detectors in that it is able to locate point sources with an accuracy on the order of arcminutes (Gros et al. 2003). To identify a unique optical or infrared counterpart, however, the error circle must be reduced to the level of (sub-)arcseconds. Thus, from the *INTEGRAL* position, soft X-ray telescopes, such as the *Chandra X-ray Observatory*, *XMM-Newton*, and *Swift* observe the region. This typically allows identification of the optical counterpart, which can then be studied to yield an identification (e.g., Tomsick et al. 2006).

2. OBSERVATIONS AND ANALYSIS

We targeted *INTEGRAL* sources that had also been observed in soft X-rays, which allowed the position to be narrowed down from the *INTEGRAL* error circle (on the order of arcminutes) to less than $10''$. IGR J18214–1318, IGR J19267+1325, and IGR J18308–1232 were observed by the

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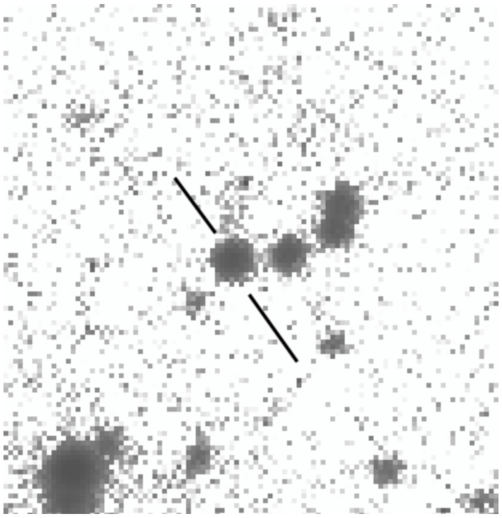


FIG. 1.— I-band image of the field of IGR J18214–1318 with the source ($I \sim 17$ mag) indicated. Three 300s exposures are combined, and the image is $40'' \times 40''$ and oriented so north is up and east is to the left.

Chandra X-Ray Observatory, providing positions with 90% confidence uncertainties of 0.64″ (Tomsick et al. 2008 a, b and in preparation). IGR J22292+6647 was observed by *Swift* (Landi et al. 2007), which reduced the position uncertainty to 3.6″. IGR J16426+6536 has one *XMM-Newton* source with a 1σ uncertainty of 8″ (Ibarra et al. 2008a) and two *ROSAT* sources within the *INTEGRAL* error circle. Optical/infrared counterparts for IGR J18214–1318 and IGR J19267+1325 were reported with the X-ray observations. We searched the USNO-B1.0 and 2MASS catalogs for optical and infrared counterparts to the other sources. IGR J18308–1232 and IGR J22292+6647 both have one optical/infrared counterpart. The X-ray sources associated with IGR J16426+6536 have three possible optical/infrared counterparts, and we observed the brightest optical source in the *XMM-Newton* error circle.

Images from the Digitized Sky Survey (DSS) showed a clear counterpart for all sources except for IGR J18214–1318. A clear image of this source is seen in Figure 1, from the medium resolution spectrometer TFOSC (TÜBİTAK Faint Object Spectrometer and Camera) which is mounted on the Russian-Turkish 1.5 m telescope (RTT150) located at Turkish National Observatory (TUG), Antalya, Turkey. The camera is equipped with a 2048×2048, 15 μm pixel (0.39″ pixel-1) Fairchild 447BI CCD chip. We took three 300s observations of the field in B, V, R and I filters on 2008 August 22, and only detected the source in the I band. After the standard bias and flat correction, we obtained the instrumental I magnitude of the counterpart using DAOPHOT in MIDAS. We carried out point spread function photometry for the corrected image to obtain the instrumental magnitude, and calibrated it by comparing to the magnitudes of the reference stars, which were obtained from the USNO-B1.0 catalog.

Between 2008 June 28 and June 30 we carried out spectroscopy of these targets with the RC Spectrograph on the 4-meter Mayall Telescope at Kitt Peak National Observatory. We provide an observing log in Table 1. We used a slit width of 1.5″, and rotated the slit to the parallactic angle. The wavelength range covered from 4750 A to 9500 A, with a dispersion of $\sim$3.4 A/pixel and a resolution of 13.8 A.

After applying the flat field correction, subtracting the bias and dark current, and removing cosmic rays, we extracted the spectra with standard procedures in IRAF (Image Reduction and Analysis Facility). We observed arc lamps for wavelength calibration immediately preceding and following each source. Checking against background sky lines, we find agreement to within $\sim$3 A. We also observed spectrophotometric standard stars Feige 110 and BD +33° 2642 for flux calibration. Conditions were variable throughout each night, making the flux calibration somewhat uncertain. We report fluxes using a single observation of Feige 110 for calibration because it falls roughly halfway between the other observations in flux, presumably providing a good indication of the average conditions. Note that using the other observations can change the flux measurements by up to $\sim$15%. All lines and their parameters are reported in Table 2.

3. RESULTS

3.1. *IGR J16426+6536*

IGR J16426+6536 has one *XMM-Newton* slew source at $\alpha(J2000) = 18^h17^m22^s$, $\delta(J2000) = -25°08'38''$ (Ibarra et al. 2008a) and two *ROSAT* sources within the *INTEGRAL* error circle. There is one USNO-B1.0 source within one of the *ROSAT* error circles and none in the other. The *XMM-Newton* source has two USNO-B1.0 sources within its 8″ (1σ) error circle. We observed the brighter of the two sources (USNO-B1.0 1555–0172189) in the *XMM-Newton* error circle.

This spectrum has redshifted emission lines, including broad Balmer lines and narrow forbidden lines (Figure 3.2a), indicating that this source is a Seyfert 1 AGN. This is congruous with its position out of the Galactic plane, with Galactic coordinates $l = 96.64°, b = +37.65°$. To further classify the source, we use the scheme described in Winkler (1992), namely, the ratio of the flux in $H\beta$ λ4861 to that in [OIII]λ5007, where these are the laboratory wavelengths. After dereddening the spectral lines using the Galactic absorption from Schlegel et al. (1998) along with the extinction law from Cardelli et al. (1989), we find $F(4861)/F(5007) = 1.5 \pm 0.1$, which makes this a Seyfert 1.5 galaxy. Calculating the redshift from both $H\beta$ and [OIII]λ5007 and averaging, we find $z = 0.323 \pm 0.001$. Though we did not observe all possible sources within the *INTEGRAL* error circle, the identification of the one we did observe as an AGN allows us to conclude that this is very likely the counterpart of the *INTEGRAL* source. We note that Parisi et al. (2008) came to similar conclusions from their spectroscopic analysis.

With a redshift of $z = 0.323$, this source is at a luminosity distance of $D_L = 1690$ Mpc, using $H_0 = 70$ km s^{-1} Mpc^{-1}, $\Omega_M = 0.3$, and $\Omega_\Lambda = 0.7$. We calculate the mass of the supermassive black hole using the relations described in Wu et al. (2004) and Kaspi et al. (2000). To use the relations, we recalculate the luminosity distance with the cosmological parameters used in those papers, $H_0 = 75$ km s^{-1} Mpc^{-1}, $\Omega_M = 1$, and $\Omega_\Lambda = 0$. This gives $D_L = 1380$ Mpc, from which we find the luminosity in $H\beta$ (dereddened as described above), $L_{H\beta} = 4.9 \times 10^{41}$ erg s^{-1}. Combining this with the rest-frame FWHM velocity of the broad line region (from $H\beta$), $v_{FWHM} = 2000$ km s^{-1}, gives a black hole mass of $M_{BH} = 9 \times 10^6$ $M_\odot$.

3.2. *IGR J18214–1318*

IGR J18214–1318 was observed by *Chandra*, which found one source at $\alpha(J2000) = 18^h21^m19^s.76$, $\delta(J2000) = -13°18'38''.9$, coinciding with USNO-B1.0 0766–0475700. The X-ray spectrum yields a column density of $N_H = (11.7^{+3.0}_{-2.7}) \times 10^{22}$ cm^2 and $\Gamma = 0.7^{+0.6}_{-0.5}$. With a Galactic hydrogen column density of $N_H = 2.4 \times 10^{22}$ cm^{-2}, this implies a local absorption of $N_{\rm H} = (7-15) \times 10^{22}$ cm^{-2}, which was suggested to be from the wind of a high-mass star (Tomsick et al. 2008a). This source was also observed by *Swift*, which found a position and photon index consistent with that obtained by *Chandra*, but a lower hydrogen column density of $N_{\rm H} = (3.5^{+0.8}_{-0.5}) \times 10^{22}$ cm^{2}, indicating that $N_{\rm H}$ is variable in this source (Rodriguez et al. 2008).

We find that the optical spectrum has a very reddened continuum (Figure 3.2b). From this, we infer that the source is relatively distant, since significant reddening would be expected for a distant source in the Galactic plane ($l = 17.69^\circ, b = +0.48^\circ$). Convolving the spectrum with the filters from Bessell (1990), we find $V = 22.2 \pm 0.2$, $R = 19.3 \pm 0.2$, $I = 16.6 \pm 0.2$, where the errors are from the 15% systematic uncertainty in flux. We note that the I band magnitude from the photometric observation made at TUG, $I = 16.92 \pm 0.17$, agrees within the errors. We first consider the possibility that the source is a CV. Combining the apparent magnitudes with typical absolute magnitudes for CVs ($M_V \sim 9$ and $(V-R)_0 \sim 0$ (Masetti et al. 2008)) and a range of extinctions from $A_V = 5-15$ mag results in distances that range from $d = 4-440$ pc. This distance range is far too close to account for the observed amount of extinction (assuming the optical extinction is interstellar), which allows us to rule out the possibility that the source is a CV. The distance implied for an LMXB is not inconsistent with the amount of extinction, but the source has a hard X-ray spectrum which would be very unusual for an LMXB (Muno et al. 2004).

These considerations allow us to conclude that it must be either an HMXB or a symbiotic star system. In Figure 2, spectral shapes typical of both are interpolated from the colors in Ducati et al. (2001) and plotted with extinctions of $A_V = 5, 7.5, 10, 12.5,$ and 15, using the extinction relations from Cardelli et al. (1989). The infrared magnitudes from DENIS and 2MASS (reported in Tomsick et al. 2008a) along with the optical spectrum for the source are overlayed. These show that the data are consistent with a B0V star or an O9I star with extinction of $A_V = 12.5-15$. The model K2III star spectra provide a worse fit to the data. The J-band magnitude requires an extinction of $A_V \sim 7.5$, while the optical data are consistent with $A_V = 10-12.5$. We conclude that IGR J18214–1318 is probably an HMXB rather than a symbiotic star system. We also note that the upper limit on the equivalent width of $H\alpha$ is consistent with $H\alpha$ equivalent widths of OB stars (Leitherer 1988). The Galactic hydrogen column density combined with the relationship between visual extinction and hydrogen column density detailed in Predehl & Schmitt (1995) ($A_V = 0.56 N_H [10^{21} {\rm cm}^{-2}] + 0.23$) gives a visual extinction of $A_V = 13.7$, which is consistent with the extinction inferred from colors for stars of type B0V and O9I. Considering a range of spectral types and using absolute magnitudes from Cox (2000) with $A_V = 13.7$, we find distances that range from $d = 3-7$ kpc for B0V to O5V stars and $d = 9-10$ kpc for A0I to O9I stars, giving an overall distance range of $d = 3-10$ kpc. However, using the general relation of $2\ A_V/$kpc (Tielens 2005), the lower limit of visual extinction ($A_V = 12.5$) implies a distance of at least 6 kpc, suggesting that the most likely distance range is $d = 6-10$ kpc. In addition, the observed variation in hydrogen column density argues in favor of a supergiant (and, therefore, a distance near the upper end of the range), since HMXBs with supergiant companions are known to show variations in column density (Prat et al. 2008).

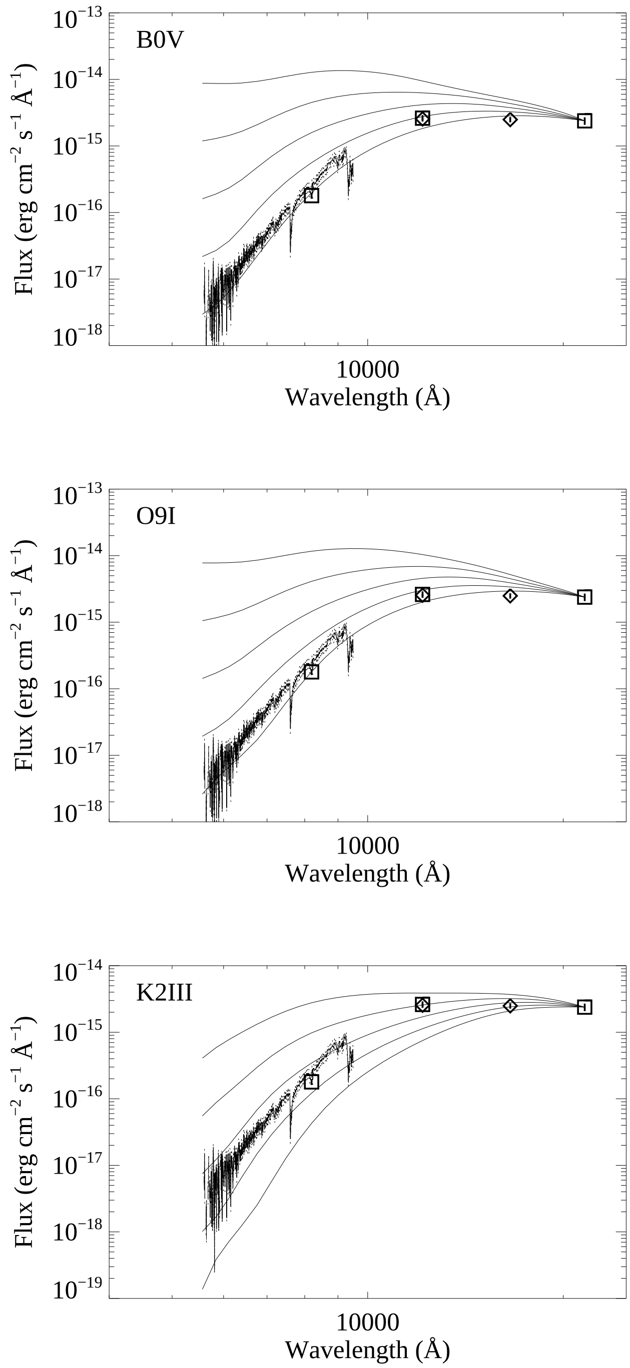
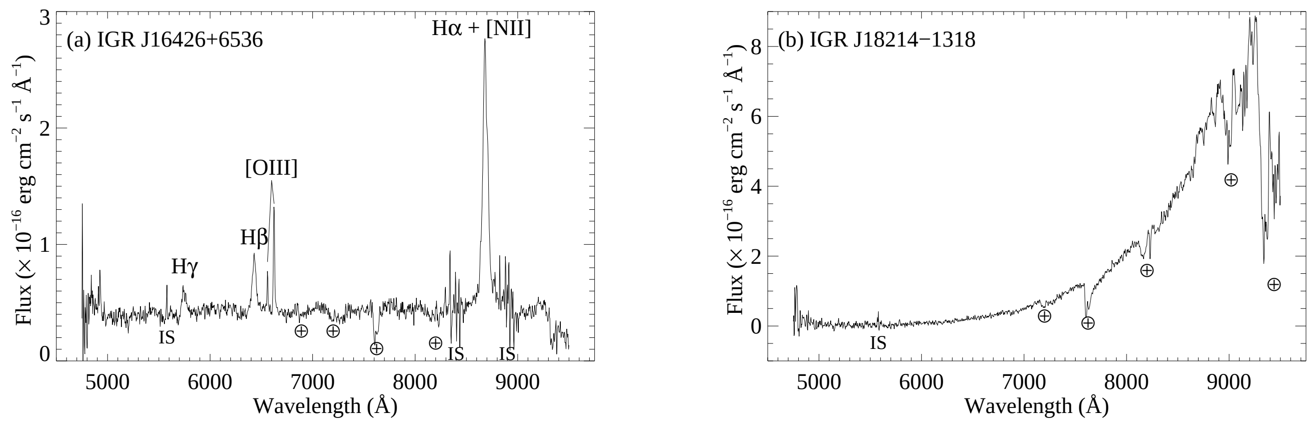
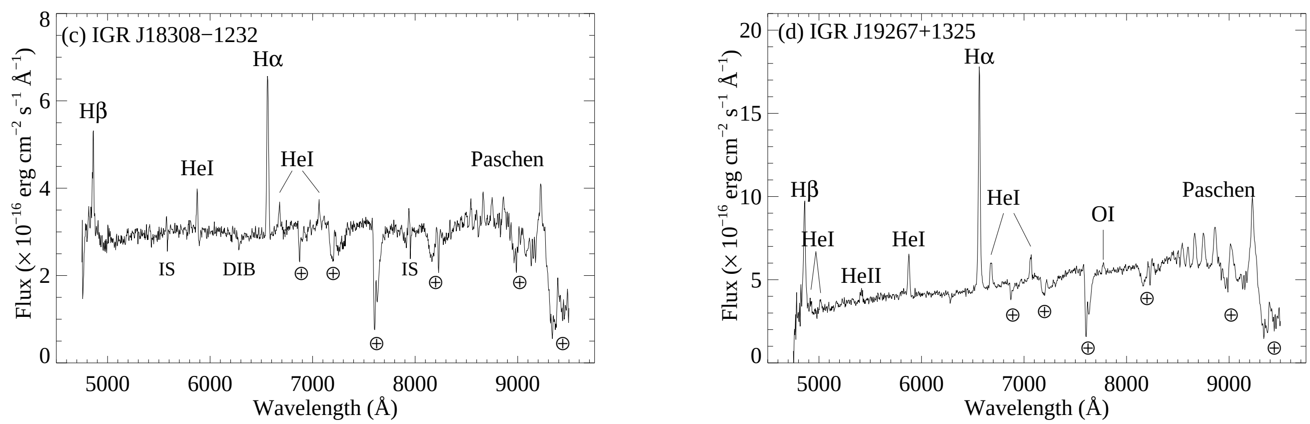


FIG. 2.— The smooth lines are spectral shapes of B0V, O9I, and K2III stars interpolated from published colors with varying degrees of extincion. Starting from the top line, the spectra are plotted with $A_{\rm V} = 5, 7.5, 10, 12.5,$ and 15. All are normalized to have the same K magnitude. The squares indicate the DENIS magnitudes, and the diamonds indicate the 2MASS magnitudes of the optical counterpart of IGR J18214–1318. The spectrum taken at Kitt Peak is plotted with dotted lines overlayed to indicate the upper and lower bounds due to the 15% uncertainty in flux calibration.

3.3. *IGR J18308–1232*

IGR J18308–1232 was observed by *Chandra*, which found one source at $\alpha(J2000) = 18^h30^m49^s.94$, $\delta(J2000) = -12^\circ32'19''.1$, coinciding with USNO-B1.0 0774–0551687.





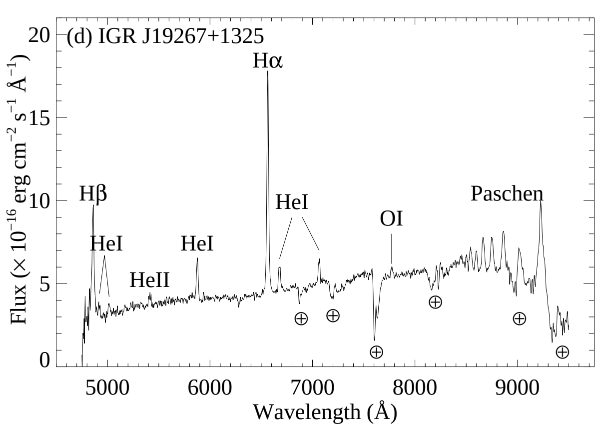


FIG. 3.— Optical spectra of (a) IGR J16426+6536, an AGN, (b) IGR J18214–1318, a probable HMXB, (c) IGR J18308–1232, a CV, (d) IGR J19267+1325, a magnetic CV, and (e) IGR J22292+6647, an AGN. The labels "IS", "DIB", and $\oplus$ indicate interstellar emission lines, diffuse interstellar background, and telluric absorption lines, respectively.

The X-ray spectrum gives a hydrogen column density of $N_{\rm H}$ = $(3^{+3}_{-2}) \times 10^{21}$ cm^{-2} and Γ = $0.4^{+0.4}_{-0.3}$, where the errors are at the 90% confidence level (Tomsick et al. in prep.). Note that this source is referred to as IGR J18307–1232 in Ibarra et al. (2008b), where they report an *XMM-Newton* slew-survey counterpart at $\alpha(J2000)$ = $18^h30^m49^s.6$, $\delta(J2000)$ = $-12^\circ32'18''$ with a 1σ uncertainty of $8''$, consistent with the *Chandra* position.

The optical spectrum shows Balmer, Paschen, and HeI lines in emission (Figure 3.2c), all consistent with z = 0. These lines are typical of both CVs (Warner 1995) and LMXBs (van Paradijs & McClintock 1995), but the hard X-ray spectrum is typical for a CV, and, as noted above, is not expected for an LMXB. It is also very similar to other CVs found by *INTEGRAL* (e.g., Masetti et al. 2008). Using the hydrogen column density and the aforementioned relation between column density and visual extinction, we find A_V = 1.9, which translates into A_R = 1.4. Combining this with the typical values for CV absolute magnitudes listed above and the USNO-B1.0 magnitude of $R = 16.3 \pm 0.3$, we find $d \sim 150$ pc.

3.4. *IGR J19267+1325*

IGR J19267+1325 was observed by *Chandra*, which found one source at $\alpha(J2000)$ = $19^h26^m26^s.99$, $\delta(J2000)$ = $+13^\circ22'05''.1$, coinciding with USNO-B1.0 1033–044065. Although the source for IGR J19267+1325 falls just outside of the 90% confidence *INTEGRAL* error circle, it was the only bright X-ray source *Chandra* found in the area. Fitting the X-ray spectrum gives $N_{\rm H} = (2.1 \pm 0.9) \times 10^{21}$ cm^{-2} and $\Gamma = 0.68 \pm 0.13$ (Tomsick et al. 2008b).

The optical spectrum shows Balmer, Paschen, HeI and HeII emission lines at z = 0 (Figure 3.2d). These lines, along with the hard X-ray spectrum, suggest a CV nature (e.g., Masetti et al. 2008). Furthermore, the HeII line and large equivalent width of $H\beta$ (49 ± 2A) suggest a magnetic CV (Silber

1992)[8]. Steeghs et al. (2008) also identify this source as a probable magnetic CV. They find an equivalent width of $H\alpha$ equal to 120 A, while we find $EW_{H\alpha} = 64 \pm 1$ A. Based on two measurements from the INT Photometric H-Alpha Survey (IPHAS), they find moderate short term variability in $H\alpha$ of 0.1 mag, which is not large enough to explain the difference in equivalent widths found, though there could be a larger maximum variability. Based on *Swift-XRT* periodicity data, Evans et al. (2008) confirm that it is a magnetic CV, identifying it as an intermediate polar CV. Using the hydrogen column density and the relation between visual extinction and hydrogen column density mentioned previously, we find $A_V = 1.4$, which translates to $A_R = 1.1$. Combining this with the typical values for CVs above and the USNO-B1.0 magnitude of $R = 16.0 \pm 0.3$, we find $d \sim 150$ pc.

3.5. *IGR J22292+6647*

IGR J22292+6647 was observed by *Swift*, which found a source at $\alpha(J2000) = 22^h29^m13^s.5$, $\delta(J2000) = +66^\circ46'51''.8$, coinciding with USNO-B1.0 1567–0242133. There is a radio source at this location (87GB 222741.2+663124), described as an asymmetric double (Gregory & Condon 1991), which suggests this may be an AGN (Landi et al. 2007). This is congruous with its position out of the Galactic plane, with Galactic coordinates $l = 109.56^\circ, b = +7.69^\circ$.

The optical spectrum has a flat continuum dominated by one strong and broad emission line (Figure 3.2e). If we assume that the strong feature is $H\alpha$, we find a redshift of $z = 0.113 \pm 0.001$. The broad hydrogen line indicates this is a Seyfert 1 AGN.

4. DISCUSSION AND CONCLUSIONS

We have firm identifications of four IGR sources and one probable identification. IGR J18308–1232 and IGR J19267+1325 are CVs. They have distances on the order of a couple hundred parsecs, which is typical of other CVs detected by *INTEGRAL* (e.g., Barlow et al. 2006; Masetti et al. 2006). The identification of IGR J19267+1325 as a magnetic CV is not surprising. As a result of the hard X-rays emitted by magnetic systems, the majority of CVs detected by *INTEGRAL* have been magnetic (Barlow et al. 2006) even though such systems only comprise $\sim 10\%$ of the CV population as a whole. *INTEGRAL* observations of CVs, therefore, unambiguously show that the magnetic field plays an important role in the hard X-ray emission of these systems.

IGR J16426+6536 and IGR J22292+6647 are Seyfert 1 AGN, and IGR J16426+6536 is further classified as a Seyfert 1.5 AGN. The 127 *INTEGRAL*-detected Seyferts (which have an average redshift $z = 0.033$) and the 34 IGR Seyferts (with average redshift $z = 0.035$) are plotted in Figure 4. With redshifts of $z = 0.323$ and $z = 0.113$, respectively, IGR J16426+6536 and IGR J22292+6647 are considerably more distant than average. In fact, IGR J16426+6536 is an interesting case since it is the highest redshift IGR Seyfert, though there is one *INTEGRAL*-detected Seyfert, PKS 0637–752, with a higher redshift of $z = 0.651$.

We conclude that IGR J18214–1318 is probably an HMXB. It has an extremely reddened continuum, indicating much absorption along the line of sight, which implies a fairly large distance. The observed colors and flux are consistent with an extincted high mass main sequence or supergiant star (and the variable hydrogen column density may argue for the latter). In addition, the X-ray spectrum shows significant local absorption, which could come from a wind from a high mass star. An infrared spectrum may be one way to confirm the identification. The infrared suffers less extinction than the optical, and typical features of a massive star would be seen in such a spectrum, if the object is an HMXB.

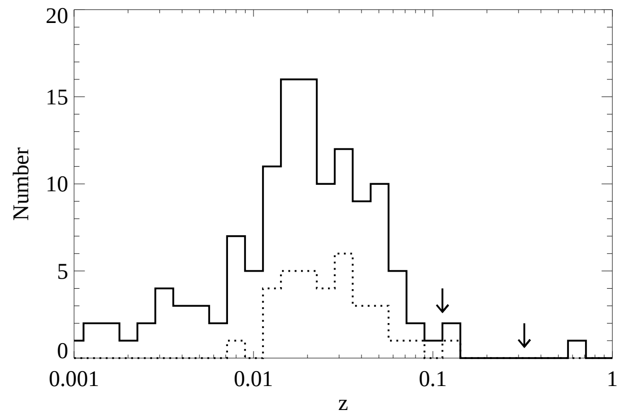


FIG. 4.— The solid line is the number of Seyfert galaxies detected by *INTEGRAL* and the dotted line is number of IGR Seyfert galaxies as a function of redshift (Bodaghee et al. 2007). The arrows indicate IGR J22292+6647, with $z = 0.113$, and IGR J16426+6536, with $z = 0.323$.

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[8] See http://asd.gsfc.nasa.gov/Koji.Mukai/iphome/issues/heii.html

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TABLE 1
OBSERVATIONS: KITT PEAK OPTICAL SPECTROSCOPY

IGR Name	Optical Counterpart	RA (J2000)	Dec (J2000)	Start Time (UT)	Exposure Time (s)
J16426+6536	USNO-B1.0 1555–0172189	$16^h43^m03^s.99$	$+65°32'51''.2$	2008 June 29, 4.0 h	3600
J18214–1318	USNO-B1.0 0766–0475700	$18^h21^m19^s.72$	$-13°18'38''.8$	2008 June 28, 9.3 h	3600
J18308–1232	USNO-B1.0 0774–0551687	$18^h30^m49^s.87$	$-12°32'19''.2$	2008 June 30, 8.8 h	1800
J19267+1325	USNO-B1.0 1033–0440651	$19^h26^m27^s.00$	$+13°22'04''.4$	2008 June 28, 10.6 h	3×600
J22292+6647	USNO-B1.0 1567–0242133	$22^h29^m13^s.90$	$+66°46'51''.9$	2008 June 30, 11.2 h	827

TABLE 2
SPECTRAL LINES OF IGR SOURCES

Line	Quantity[a]	J16426+6536 (AGN)	J18214–1318 (HMXB?)	J18308–1232 (CV)	J19267+1325 (CV)	J22292+6647 (AGN)
Hα	EW	$290. \pm 4^b$	< 4.3	26 ± 1	64 ± 1	760 ± 20^b
	Flux	13.8 ± 0.2^b	< 0.1	7.7 ± 0.2	28.4 ± 0.2	27.2 ± 0.8^b
	λ_{fit}	8683 ± 3^b	...	6562 ± 3	6564 ± 3	7307 ± 3^b
Hβ	EW	46 ± 2	...	9.7 ± 1.3	49 ± 2	...
	Flux	2.0 ± 0.1	...	3.1 ± 0.4	15 ± 1	...
	λ_{fit}	6430 ± 3	...	4860 ± 3	4859 ± 3	...
Hγ	EW	25 ± 3	...	...	...	...
	Flux	1.0 ± 0.1	...	...	...	...
	λ_{fit}	5746 ± 4	...	...	...	...
[O III] $\lambda4959$	EW	7.2 ± 1.1	...	...	...	...
	Flux	0.32 ± 0.05	...	...	...	...
	λ_{fit}	6560 ± 3	...	...	...	...
[O III] $\lambda5007$	EW	32 ± 1	...	...	...	...
	Flux	1.4 ± 0.1	...	...	...	...
	λ_{fit}	6624 ± 3	...	...	...	...
O I $\lambda7772, 7774, 7775$	EW	...	...	...	2.2 ± 0.4	...
	Flux	...	...	...	1.2 ± 0.2	...
	λ_{fit}	...	...	...	7774 ± 3	...
He I $\lambda4921$	EW	...	...	...	4 ± 1	...
	Flux	...	...	...	1.1 ± 0.4	...
	λ_{fit}	...	...	...	4920 ± 4	...
He I $\lambda5015$	EW	...	...	...	5 ± 1	...
	Flux	...	...	...	1.5 ± 0.3	...
	λ_{fit}	...	...	...	5015 ± 3	...
He I $\lambda5876$	EW	...	...	4.6 ± 0.6	12 ± 1	...
	Flux	...	...	1.4 ± 0.2	5.0 ± 0.2	...
	λ_{fit}	...	...	5874 ± 3	5876 ± 3	...
He I $\lambda6678$	EW	...	...	3.8 ± 0.5	8.2 ± 0.4	...
	Flux	...	...	1.2 ± 0.2	3.8 ± 0.2	...
	λ_{fit}	...	...	6677 ± 3	6678 ± 3	...
He I $\lambda7065$	EW	...	...	2.9 ± 0.5	6.1 ± 0.4	...
	Flux	...	...	0.91 ± 0.15	3.1 ± 0.2	...
	λ_{fit}	...	...	7063 ± 3	7065 ± 3	...
He II $\lambda5412$	EW	...	...	...	5.1 ± 0.9	...
	Flux	...	...	...	1.8 ± 0.3	...
	λ_{fit}	...	...	...	5412 ± 3	...

[a] EW is the equivalent width in A and line flux is measured in units of 10^{-15} erg cm^{-2} s^{-1}. Errors are at the 68% confidence level and upper limits are at the 90% confidence level. Note that the line flux is also subject to the 15% systematic uncertainty in overall flux level, which is not included here. The wavelength from the Gaussian fit is λ_{fit}, and the error is dominated by the ~ 3 A uncertainty in wavelength calibration.

[b] Hα is blended with [N II] lines.