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INFRARED HUNTING FOR NEW HIDDEN HARD X-RAY SOURCES: OBSERVATIONS AND INSTRUMENTATION

Dae-Sik Moon[1,2,3,4]

RESUMEN

Recientemente, se han descubierto una gran cantidad de fuentes de rayos-X duros (15–60 keV) con ayuda de satélites de rayos-X, especialmente por el satélite *INTEGRAL* que cuenta con equipo para observar en rayos-gamma y rayos-X duros y suaves. En algunas ocasiones estas nuevas fuentes de rayos-X duros muestran enormes extinciones de $N_{\rm H} \simeq 10^{24}$ cm^{-2} — lo que explica que hayan permanecido ocultas hasta la fecha. Estas fuentes son usualmente binarias de rayos-X muy oscurecidas o núcleos activos de galaxias donde su emisión de rayos-X suaves (y también la mayor parte ultravioleta y óptica) está oscurecida por el medio que las rodea. Presentamos los esfuerzos observacionales en curso para estudiar estas nuevas fuentes, especialmente a las binarias de rayos-X, así como un nuevo espectrógrafo en infrarrojo-cercano (NIR) para el telescopio Keck I.

ABSTRACT

Recently many new hard X-ray (e.g., 15–60 keV) sources have been discovered by X-ray satellites, especially by the *INTEGRAL* satellite equipped with a hard X-ray/soft gamma-ray observing capability. These new hard X-ray sources sometimes reveal enormous extinction of $N_{\rm H} \simeq 10^{24}$ cm^{-2} which is why they have been hidden. They are usually highly-obscured X-ray binaries or active galactic nuclei of which soft X-ray emission (and also most of the ultra-violet and optical) is obscured by the surrounding medium. I introduce on-going observational efforts to study these new sources, especially the X-ray binaries, as well as a new near-infrared spectrograph for the Keck I telescope optimized for deciphering the nature of these new, heavily-obscured, hard X-ray sources.

Key Words: **X-RAYS: BINARIES — INSTRUMENTATION: SPECTROGRAPHS**

1. INTRODUCTION

Recently a growing number of new hard X-ray sources have been discovered with the *INTEGRAL* X-ray satellite by its IBIS/ISGRI soft gamma-ray detector. These new *INTEGRAL* X-ray sources not only show largely power-law spectra in the ∼15–60 keV range, but they are also defined by very large absorption column densities of hydrogen nuclei which correspond to visual extinctions $A_V \gtrsim 100$. The extremely large absorption has probably hidden these sources from previous X-ray missions that lacked sufficient hard X-ray sensitivity; in the soft X-ray range ($\lesssim 2$ keV) they are almost invisible even to the sensitive *Chandra* and *XMM-Newton* satellites.

Noticeably many of these new hard X-ray sources have been identified with very bright near-IR companions in the 2MASS data while they are still heavily obscured in the optical. This makes it possible to extend the efforts for understanding these new sources to near-IR spectroscopic observations as described below.

2. NEAR-INFRARED SPECTROSCOPIC OBSERVATIONS OF HIGHLY-OBSCURED X-RAY BINARIES

The left panel of Figure 1 shows a near-IR spectrum of IGR J16318–4848 which is prototypical of these new heavily-obscured hard X-ray binaries identified by *INTEGRAL*. The spectrum was taken with the CorMASS spectrograph (Wilson et al. 2001) on the Magellan telescope, and it covers the 0.8–2.4 μm wavelength range with $R \simeq 300$ resolution. As seen in Figure 1, the near-IR spectrum of IGR J16318–4848 shows a rich array of emission lines from a B[e] star companion (Filliatre & Chaty 2004). The right panel of Figure 1 shows a sample of 2 μm near-IR spectra of two other highly-obscured X-ray binaries that are also rich in emission lines. The spectra were obtained with the long-slit near-IR spectrograph of the Palomar Hale 5-m telescope (Larkin et al. 1996), and the resolution is ∼700.

The preliminary results of our near-IR spectroscopic studies indicate that the bright near-IR com-

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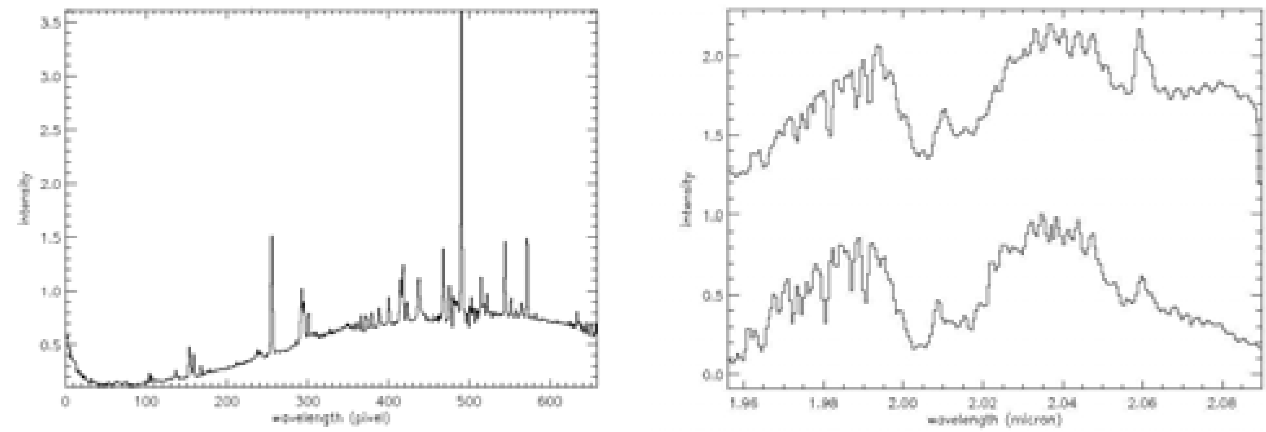

Fig. 1. *Left Panel:* A near-IR spectrum of IGR J16318–4848 obtained with the CorMASS spectrograph aboard the Magellan telescope. The spectral coverage is 0.8–2.4 μm (from the left to right) and resolution is $\sim$300. *Right Panel:* Sample spectra of two highly-obscured X-ray binaries around 2 μm obtained with the long-slit near-IR spectrograph of the Palomar Hale 5-m telescope. The spectral resolution is $\sim$700.

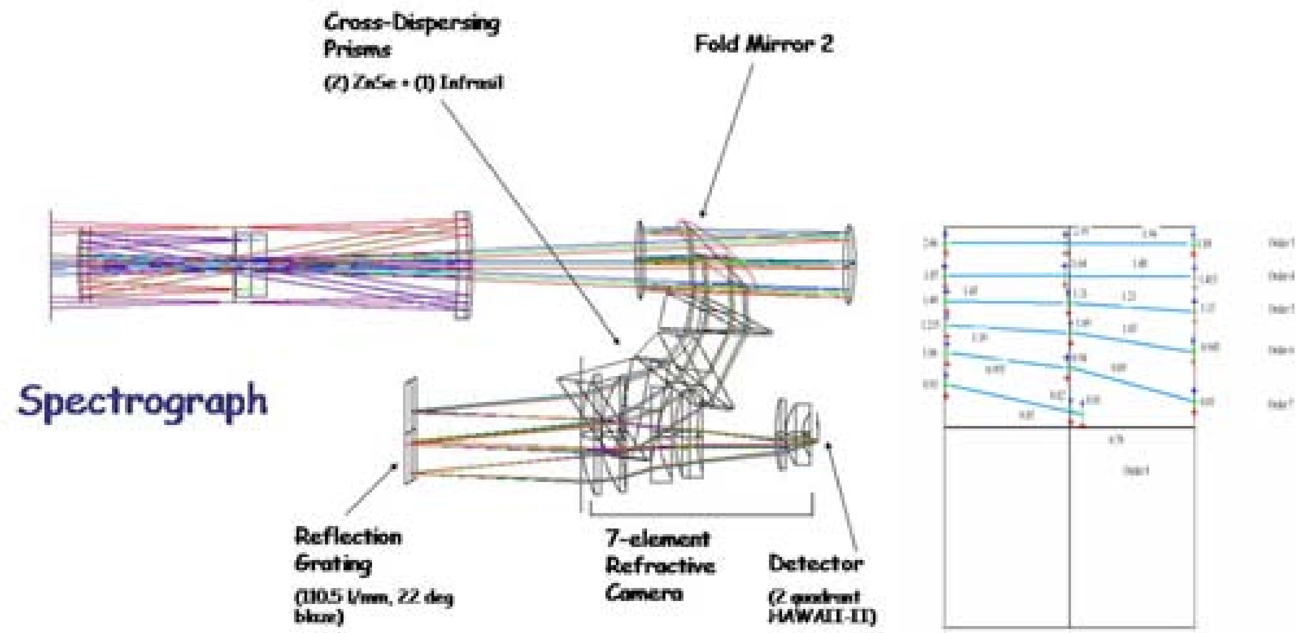

Fig. 2. *Top Panel:* The main optical system of NIRES. *Bottom Panel:* The format of the NIRES detector with six echelle orders covering 0.8–2.5 μm with two adjacent quadrants of an Hawaii II detector array.

panions of the new, highly-obscured, hard X-ray binaries are most likely OB-type stars that may have circumstellar disks.

3. A NEAR-INFRARED ECHELLE SPECTROGRAPH FOR THE KECK I TELESCOPE

Being partly motivated by the potential of the near-IR spectroscopy for understanding the nature of the new highly-obscured *INTEGRAL* hard X-ray sources, we are building a near-IR echelle spectrograph (NIRES) for the Keck I telescope. NIRES is a cross-dispersed spectrograph (the main disperser is a reflecting grating while the secondary cross disperser is three prisms) with a slit-viewing camera. The left panel of Figure 2 shows the main components of the NIRES optical system. The slit size is $0.5'' \times 15''$

and the dispersion utilizes six orders from the grating on two adjacent quadrants of an Hawaii II 2K detector array. The slit-viewing camera covers an approximately $2' \times 2'$ field of view at fixed K_s band with a Hawaii I 1K detector array. The most important feature of NIRES is its wide spectral coverage — 1.7 μm over the 0.8–2.5 μm range with a single exposure, with resolution $R \simeq 3000$, as shown in the right panel of Figure 2. Because of this wide spectral coverage with medium resolution, NIRES will be very efficient to observe new highly-obscured objects such as the *INTEGRAL* hard X-ray binaries.

4. CONCLUSIONS

INTEGRAL has discovered new, highly-obscured, X-ray binaries in the hard X-ray; near-IR spectroscopic observations have proven essential to understand them. New IR spectrographs with wide spectral coverage, such as NIRES, will also be invaluable to study these objects.

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