FLAMINGOS-2: A Near-IR Multi-Object Spectrometer Ideal for Surveying the Galactic Center

S. Nicholas Raines, Stephen S. Eikenberry, and Reba M. Bandyopadhyay
University of Florida, Department of Astronomy, 211 Bryant Space Science Center, Gainesville, FL 32611

Abstract. FLAMINGOS-2 (PI: S. Eikenberry) is a $5M facility-class near-infrared (1-2.5 µm) multi-object spectrometer and wide-field imager being built at the University of Florida for Gemini South. Here we highlight the capabilities of FLAMINGOS-2, as it will be an ideal instrument for surveying the accreting binary population in the Galactic Center.

1. Introduction

Chandra observations have shown that there is a much larger population of accreting binaries in our Galaxy than was previously recognized, with a particular concentration in the Galactic Center (GC; Wang et al. 2002; Muno et al. 2003). IR spectroscopy is the only way to definitively identify the true stellar counterparts to these X-ray sources (e.g. Bandyopadhyay et al. 1999). Due to the extreme field crowding, to successfully find the true counterparts to the XRBs in the GC we need to obtain spectra of ∼1000-1500 IR stars - a nearly infeasible task to perform via traditional longslit single-object spectroscopy.

FLAMINGOS-2 (PI: S. Eikenberry; Eikenberry et al. 2006) is a facility-class near-IR (1-2.5 µm) multi-object spectrometer (MOS) and wide-field imager being built at the University of Florida for Gemini South. Here we highlight the capabilities of FLAMINGOS-2, as it will be an ideal instrument for surveying the accreting binary population in the GC. Utilizing custom aperture masks in a 2×6 arcminute² field-of-view (FOV), simultaneous multi-object spectroscopy of up to ∼90 targets will be possible at resolving power ∼1300 in the H + K band. With this resolution and FOV, combined with the Gemini 8-m aperture, our team at UF will be able to efficiently perform the first spectroscopic survey of this GC population with high S/N to a limiting magnitude of K ∼17 during our guaranteed time (cf. Eikenberry et al., Bandyopadhyay et al., these proceedings).

2. FLAMINGOS-2 Optical Path & Components

FLAMINGOS-2 has a fully cryogenic optical train, illustrated in Fig. 1, with 9 spherical refractive elements and two front-surface gold flat mirrors. The window and 7 of the lenses are single-crystalline CaF₂; the other two lenses are made from Ohara SFTM-16. Progressing from the top to the bottom of the figure, light first passes through the window to a focus. The MOS wheel lies at the telescope focus and contains an imaging aperture and, most importantly, a selection of custom aperture masks (“mosplates”); it also caries 6 long slits. It is immediately followed by a selectable baffles, called the Decker wheel, and the field lens. The optical path then is folded by the flat mirrors to the other two elements of the collimator optics. At this point the beam is collimated. Two wheels carrying a selection of filters for imaging and spectroscopy are spaced on either side of the Lyot wheel. FLAMINGOS-2 was designed for operation with the telescope’s f/16 beam but it also can accept the ∼f/30 beam
from the Gemini Multi-Conjugate Adaptive Optics (MCAO) system, and the Lyot wheel carries pupil stops for both modes of operation. The final mechanism is a wheel carrying a selection of grisms; it also includes a clear aperture for the imaging mode of operation. Light is then re-imaged onto the Hawaii-II array by a 6-element camera lens assembly.

Standard near-IR J, H, and Ks filters are installed in one of the filter wheels; Gemini may additionally offer a Y-band filter (0.97-1.07 µm). Two specialty spectroscopy filters are installed in the other filter wheel, one covering the J + H bandpasses, the other covering H + K. Three grisms reside in the grism wheel, two with moderate resolving power, \( R(=\lambda/\delta\lambda) \approx 1300 \), and one grism with high resolving power, \( R \approx 3300 \). The \( R \approx 1300 \) grisms are used in conjunction with the J + H or H + K bandpass filters, while the \( R \approx 3300 \) grism is used with the J, H, or Ks standard near-IR filters for out-of-bandpass blocking.

3. FLAMINGOS-2 MOS Mode

Several features of FLAMINGOS-2 make it ideal for surveying the Galactic Center: (a) a wide imaging FOV of \( \sim 6.2 \) arcminutes\(^2\) (\( \sim 3.1 \) arcminutes\(^2\) with MCAO), (b) the ability to carry up to 9 custom mosplates at a time, (c) the mosplates’ large spectroscopic FOV of 2×6.2 square arcminutes (1×3.1 square arcminutes with MCAO), (d) the cooling of the masks to cryogenic temperatures which allow low internal instrument background for operation in the K-band, and (e) the ability to quickly exchange the set of mosplates.

The MOS wheel, shown in Fig. 2a, is 0.9 meters in diameter. It has three circular apertures positioned around the periphery of the wheel; one is left open for imaging and the other two usually contain pinhole masks for engineering. Equally spaced between the circular apertures are 9 rectangular slots for holding custom mosplates. A test mosplate
Figure 2.  (a) Engineer holding the 0.9 m diameter moswheel. One of the three circular apertures around the periphery is for imaging and is \( \sim 234 \text{ mm} \) in diameter, which corresponds to \( \sim 6.28 \text{ arcmin} \). The wheel can carry 9 mosplates. (b) A FLAMINGOS-2 test mosplate; 8 slitlets of varying lengths are visible. The region interior to the mounting frame is \( \sim 76 \text{ mm} \times \sim 232 \text{ mm} \), which corresponds to \( \sim 2.0 \text{ arcmin} \times \sim 6.2 \text{ arcmin} \).

is shown in Fig. 2b. The mosplate FOV (f/16-mode) has sufficient sky-coverage to design custom mosplates containing up to \( \sim 90 \) slitlets.

Mosplates can be changed during the daytime without thermally cycling the entire instrument. Also shown in Fig. 1 is a gate valve, positioned between the field lens and the folding flat mirrors. At the end of a night of observing this valve is closed, the MOS dewar cooling is halted, and a warm-up heater is turned on. Several hours later, during the daytime, an engineer can open the access port on the side of the MOS dewar. Each mosplate is held in a frame which slides into the edge of the MOS wheel. The observed plates are removed, and a new set of mosplates, each one already mounted in a frame, are slid into place. The engineer then closes up the access port and begins the process of evacuating and cooling the dewar. Once it is cold enough the gate valve is then re-opened. By design, this should be completed in time for the observers who return that evening.

If each plate is observed for only 1 hour, \( \sim 800 \) spectra could be obtained with a single night’s observation using all 9 mosplates. With only three nights of observing potentially up to \( \sim 2400 \) spectra could be obtained. Thus FLAMINGOS-2’s MOS mode of operation is ideally suited for identifying the true stellar counterparts to the X-ray sources in the GC.

References

Bandyopadhyay, R.M., et al., 1999, MNRAS 306, 417
Eikenberry, S.S., et al., 2006, Proc. SPIE 6269, 39
Muno, M.P., et al., 2003, ApJ 589, 225
Wang, Q.D., Gotthelf, E.V., & Lang, C.C., 2002, Nature 414, 148