RevMexAA (Serie de Conferencias), **26**, 151–152 (2006)

FRIDA: DIFFRACTION LIMITED IMAGING AND INTEGRAL FIELD SPECTROSCOPY WITH GTC

J. A. López,[1] V. Bringas,[6] S. Cuevas,[2] J. J. Díaz,[5] S. Eikenberry,[4] C. Espejo,[2] R. Flores,[2] F. J. Fuentes,[2] J. Gallego,[7] F. Garzón,[5] P. L. Hammersley,[5] R. Pelló,[8] A. Prieto,[5] B. Sánchez,[2] and A. Watson[3]

RESUMEN

FRIDA (in**FR**rared **I**mager and **D**issector for the **A**daptive optics system of the Gran Telescopio Canarias) está siendo diseñado como un instrumento con óptica limitada por difracción con capacidades de imagen de banda ancha y angosta y espectroscopía integral de campo para operar en el intervalo de longitudes de onda de 0.9 – 2.5 μm. FRIDA es un proyecto de colaboración entre los socios principales de GTC, a saber, España, México y Florida. Las principales características de diseño de FRIDA se describen en esta contribución.

ABSTRACT

FRIDA (in**FR**rared **I**mager and **D**issector for the **A**daptive optics system of the Gran Telescopio Canarias) is being designed as a diffraction limited instrument with broad and narrow band imaging and integral field spectroscopy capabilities to operate in the wavelength range 0.9 – 2.5 μm. FRIDA is a collaborative project between the main GTC partners, namely, Spain, México and Florida. The main design characteristics of FRIDA are described in this contribution.

Key Words: **INSTRUMENTATION: ADAPTIVE OPTICS — INSTRUMENTATION: SPECTROGRAPHS**

1. INTRODUCTION

GTC will shortly be the single largest operating optical / infrared telescope in the world and as such, it will have two distinct advantages in the study of faint objects in the local and distant universe. The first is that the light grasp of a telescope scales as D^2, the square of the diameter, and so GTC will gather more photons than any other optical / infrared telescope. The second is that the angular resolution of a telescope is proportional to λ/ D, and so once the adaptive optics system is operating, the GTC will have the finest resolution of any infrared telescope. Furthermore, when observing point sources in the background limit, the combination of light grasp and diffraction limit will give GTC a D^4 advantage over smaller telescopes. FRIDA will use diffraction-limited optics to avoid degrading the hard-won image quality delivered by the adaptive optics system of GTC. FRIDA will be sensitive in the near infrared regime, where the highest Strehl ratios are achieved, and will deliver high quality imagery in broad and narrow bands and spatially resolved spectroscopy with the use of an integral field unit. FRIDA is being designed to be installed at the Nasmyth platform, behind the adaptive optics system, it will use a single 2048 × 2048 Hawaii 2 Rockwell detector. The same detector will be used for the imaging and IFS operating modes.

2. SCIENTIFIC CASE

The operating wavelength range of FRIDA will expose dusty environments and will probe a spectral range rich in absorption and emission lines from many different species and gas phases. With these characteristics FRIDA will be able to tackle a large number of astrophysical problems. The interest for FRIDA in the GTC community is broad, the scientific cases range from solar system bodies to high-redshift galaxies, including resolved stellar popula-

[1]Instituto de Astronomía, UNAM, Apartado Postal 877, Ensenada, Baja California, 22800, México (jal@astrosen.unam.mx).

[2]Instituto de Astronomía, UNAM, 04510, México, DF (chavoc, beatriz, jfuentes, flores, espejo@astroscu.unam.mx).

[3]Centro de Radioastronomía y Astrofísica, UNAM, Apartado Postal 3–72, 58090, Morelia, Michoacán, México (a.watson@astrosmo.unam.mx).

[4]Department of Astronomy, University of Florida, 211 Bryant Space Center, Gainsville, FL 32611-2055 USA (eiken@astro.ufl.edu).

[5]Instituto de Astrofísica de Canarias, Vía Láctea s/n, La Laguna, Tenerife, Spain (fgl, plh, jdg@iac.es prieto@mpia.de).

[6]Centro de Ingeniería y Desarrollo Industrial, P. de la Cuesta 702, Querétaro, Qro., 76310, México (vbringas@cidesi.mx).

[7]Depto. de Astrofísica y CC de la Atmósfera, Universidad Complutense de Madrid, E-28040, Spain (jgm@astrax.fis.ucm.es).

[8]Laboratoire d' Astrophysique de l'Observatoire Midi-Pyrénées, 14 Av. Edouard Belin, F-31400, Tolouse, France (roser@ast.obs-mip.fr).

tions, close binary systems, young stellar objects and star formation environments, circumstellar phenomena in advanced stages of stellar evolution and active galactic nuclei.

3. BASIC LAY-OUT

The basic optical scheme of FRIDA is shown in Cuevas et al. (2006) and López et al (2006). Light from the GTC adaptive optics system (Devaney et al. 2004) enters from the left through the dewar window. The optics forms a dual re-imaging system. The spatial scale is selected by changing the pre-optics. In the imaging mode the integral field unit (slicer or dissector) is retrieved and inserted back for the spectroscopic mode.

The present design introduces a series of modifications in the spatial scales in the imaging mode, eliminates anamorphic scales in the IFU mode and modifies the slicer format described in Cuevas et al. (2006) but otherwise it keeps the same main design architecture and operational modes philosophy. A version of this contribution containing figures and a table of parameters for FRIDA can be found in López et al. (2006).

4. IMAGING

In imaging mode FRIDA will provide broad-band and narrow-band filters and two selectable spatial scales that provide adequate Nyquist sampling of 0.010 arcsec/pixel and 0.020 arcsec/pixel with corresponding field of view 20.48×20.48 arcsec and 40.96×40.96 arcsec. The finer scale will provide adequate sampling of the almost limited core in J and H bands and the coarser scale will provide adequate sampling in the the K band.

5. INTEGRAL FIELD SPECTROSCOPY

FRIDA will provide an integral field spectroscopy mode using an image slicer. The IFU design is based on FISICA (Eikenberry et al. 2004). The selectable spatial scales parallel to the slices will be 0.010 arcsec/pixel and 0..020 arcsec/pixel and the corresponding scales perpendicular to the slices will be 0.020 arcsec/slice and 0.040 arcsec/slice. Each slice will project to two pixels in the spectral direction. For an image slicer with thirty slices these scales yield fields of view of 0.65×0.60 arcsec and 1.30×1.20 arcsec. The available spectral resolutions will be R $\approx$ 1000, R $\approx$ 5000 and R $\approx$ 30,000. The combination of high spectral resolution and high spatial resolution will be a unique capability of FRIDA. The optical model for the IFU is shown in López et al. (2006). Ray tracing has been designed with the Zemax Non Sequential Components mode.

6. PERFORMANCE

The expected performance of FRIDA has been modeled for imaging and spectroscopy of point and resolved sources with continuum and emission line spectra. The model includes sky background, OH supression, thermal background from the telescope and the AO system, the transmission of the instrument, the efficiency of the detector and the expected Strehl ratio delivered by the AO system. The figure of merit for imaging and spectroscopy is the magnitude at which a signal to noise ratio of 10 per resolution element is reached in the core. The 1 hour limiting magnitudes for a signal to noise ratio of 10 in direct imaging of point sources are 25.5 in Z, 25.1 in J, 24.2 in H and 23.0 in Ks. The corresponding one hour continuum point-source limiting magnitudes per resolution element for R = 5000 with the fine scale are 19.5 in Z, 19.4 in J, 19.3 in H and 18.6 in Ks and for the coarse scale 20.2 in Z, 20.1 in J, 20.0 in H and 18.8 in Ks.

7. SUMMARY

FRIDA will be a diffraction limited instrument, fully cryogenic, operating in the near infrared 0.9 – 2.5 μm regime. It will provide narrow and broad imaging capabilities with scales of 0.010 and 0.020 arcsec/pixel and corresponding fields of view of 20.48×20.48 arcsec and 40.96×40.96 arcsec. Using the same detector, FRIDA will also provide integral field spectroscopy at low, intermediate and high spectral resolutions over smaller fields of view (0.65×0.60 arcsec and 1.30×1.20 arcsec). An upgrade path for long-slit spectroscopy has also been included. FRIDA is currently at the preliminary design stage. FRIDA shall be at the telescope in 2010, right after the GTC- AO system has been commissioned.

We are grateful to the GTC project office, a grant from the Grupo Santander (Spain) through Encuentros Astrofísicos Blas Cabrera (UNAM - IAC) and our home institutions for their support.

REFERENCES

Cuevas, S. et al. 2006, NewA Rev, in press
Eikenberry, S. et al. 2004, SPIE 5492, 1264
Devaney, N., et al. 2004, SPIE 5490, 913
López et, al. 2006, RevMexAA Ser. Conf., Proceeding from the Third México-Korea Workshop on Astrophysics, in press