Manchado, Arturo; Barreto, Mary; Acosta, José; Prada, Francisco; Domínguez, Carlos; Delgado, José M.; Hernández, Elvio; Lopez, Roberto; Manescau, Antonio; Moreno, Heidy; Redondo, Pablo; Sanchez, Vicente; Tenegi, Fabio

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Revista Mexicana de Astronomía y Astrofísica, vol. 16, febrero, 2003, pp. 43-45
Instituto de Astronomía
Distrito Federal, México

RevMexAA (Serie de Conferencias), **16**, 43–45 (2003)

LIRIS (LONG-SLIT INTERMEDIATE RESOLUTION INFRARED SPECTROGRAPH) PROJECT STATUS

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RESUMEN

LIRIS es un proyecto del Instituto de Astrofísica de Canarias que consiste en un espectrógrafo de resolución intermedia para el infrarrojo cercano. Está concebido como un instrumento de uso común para el Telescopio William Herschel en el Observatorio del Roque de los Muchachos (La Palma).

ABSTRACT

LIRIS is an Instituto de Astrofísica de Canarias project that consists of a near-infrared intermediate- resolution spectrograph, conceived as a common user instrument for the William Herschel Telescope at the Observatorio del Roque de los Muchachos (La Palma).

Key Words: **NEAR-INFRARED SPECTROGRAPHS**

Science with the GTC 10-m Telescope (Granada, España, 5-8 febrero 2002)
Editors: José Miguel Rodríguez Espinosa, Francisco Garzón López & Verónica Melo Martín

1. INTRODUCTION

The advances in infrared (IR) technology over the past few years, especially in the fields of detectors and cryogenics, has allowed the development of IR spectrographs with similar characteristics to those in the optical range. LIRIS, Long slit Intermediate Resolution Infrared Spectrograph, (Manchado 2000) is conceived as a common-user instrument for the William Herschel Telescope (WHT) to fill a gap in the current instrumentation at the Roque de los Muchachos Observatory (ORM). LIRIS will have imaging, long slit and multiobject spectroscopy observing modes ($R = 1000$–3000). Coronography and polarimetry capabilities will eventually be added. An imaging capability will allow easy target acquisition for spectroscopy.

2. SCIENTIFIC DRIVERS

Given its common-user status, it should be possible to use LIRIS for a wide range of astrophysical disciplines, including stellar, planetary, extragalactic and cosmological physics. Better than list an exhaustive list of scientific cases, we will describe three scientific cases where LIRIS is expected to provide important contribution.

2.1. *Hot bottom-burning in AGB stars*

Asymptotic giant branch (AGB) stars are at a late stage in their evolution. These stars are expected to be oxygen-rich, when masses are less than 2 $M_\odot$ or greater than 4 $M_\odot$, while they are carbon-rich for intermediate masses between 2 and 4 $M_\odot$. Models predict that massive oxygen-rich AGB stars undergo hot bottom-burning (HBB). HBB occurs when the bottom of the convective envelope reaches a temperature higher than 5×10^7 K, at which point hydrogen is burnt through the CNO cycle. During this process ^{7}Li is produced, and ^{12}C is converted into ^{14}N; thus, the ^{12}C/^{13}C ratio decreases from solar-type values of 40 to 3. Therefore, by observing the ^{12}CO and ^{13}CO bands in H and K, the ^{12}C/^{13}C ratio can be calculated and the correlation between the efficiency and activation of HBB and other AGB parameters can be studied.

2.2. *Brown dwarfs and planet searches*

Brown dwarfs and young giant planets exhibit strong methane bands that allow easy identification in the J band. Using the LIRIS coronography mode, it will be possible to detect brown dwarfs and young giant planets via NIR imaging. For example, in a binary system, the companion star of HD 167605B could easily be detected in the K band with a seeing of 0.5 arcsec.

2.3. *Multiobject spectroscopy in the J band of $z \sim 1$ galaxies*

The multislit mode will allow us to carry out NIR spectroscopy in the J band for several galaxies at $z \sim 1$. At this redshift, the Hα line will be located in the J band, so the Hα luminosity function can be worked out. From this luminosity function, the star

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TABLE 1

INSTRUMENT FEATURES

Focal station	Cassegrain
Wavelength range	0.9–2.4 μm
Array format	Rockwell Hawaii 1024 $\times$ 1024 HgCdTe
Detector scale	0.25 arcsec/pixel
Observing modes	Imaging, long slit spectroscopy, multiobject spectroscopy, coronography with apodization masking, and polarimetry
Imaging FOV	4.2 $\times$ 4.2 arcmin^2
Imaging sensitivity (1 hr, $S/N = 3$, FWHM = 0.5″)	$K = 21.4$, $H = 22.9$, $J = 24.0$, $z = 24.4$
Available slits	Long slit: (0.5, 0.75, 1, 2.5, and 5) arcsec $\times$ 4.2 armin Multiobject: 10 multislit masks available (up to 24 slits per mask)
Spectral coverage and sensitivity (continuum and $t = 1$ hr, $S/N = 3$, FWHM = 0.5″)	$R = 1000$ z & J (0.887–1.531 μm). Limiting mags $J = 21.3$, $z = 22.0$ $R = 1000$ H & K (1.388–2.419 μm). Lt. mags $K = 18.6$, $H = 19.9$ $R = 3000$ z (0.997–1.185 μm). Lt. mag $Z = 21.2$ $R = 3000$ J (1.178–1.403 μm). Lt. mag $J = 20.3$ $R = 3000$ H (1.451–1.733 μm). Lt. mag $H = 19.5$ $R = 3000$ K (2.005–2.371 μm). Lt. mag $K = 18.0$

TABLE 2

COMPETITIVENESS OF LIRIS VS. 8 M TELESCOPE INSTRUMENTS[a]

Instrument	Exp. time per object	Total exp. time (5 obj)
LIRIS (multislit)	—	10800 s
ISAAC (long slit)	2300 s	10500 s

[a] $R = 3000$ spectroscopy in a 4.2 $\times$ 1 arcsec^2 field with 5 objects. Given exposure time is for 3σ detection of an emission line at 1.25 μm with a flux of 6×10^{-17} erg s^{-1} cm^{-2}.

forming rate (SFR) will be derived. This SFR will allow direct comparison with semi-analytic cosmological models. As an example, in Table 2 we show the competitiveness of the multislit spectroscopy mode of LIRIS vs. ISAAC on the VLT.

3. GENERAL DESCRIPTION

3.1. *Optics*

The optical system is based on a classical collimator/camera design. The expected throughput (averaged across the wavelength range) for the optics is 80% in the imaging mode and and 64% in the spectroscopic mode. The total throughput, including filters, grisms, and detector, is 35% in the imaging mode and 30% in spectroscopic mode. Grisms are used as the dispersion elements (the grism transmission is assumed to be 80%). Low resolution grisms are manufactured in Corning 9754 while medium resolution will be manufactured in ZnSe. A set of filters (broad band z, J, H, K_s and narrow band Brγ, K continuum, H continuum, [Fe II], H_2 ($v = 1 \rightarrow 0$), H_2 ($v = 2 \rightarrow 1$), CH_4 and He I) have been acquired through a consortium headed by Alan Tokunaga. The detail optical design and the conceptual mechanical design were subcontracted to the Royal Observatory of Edinburgh.

3.2. *Mechanics*

The mechanical design is based on a modular concept and comprises the following modules: an aperture (slit) wheel, the collimator assembly, the central wheel assembly (formed by two filter wheels, the pupil wheel and the grism wheel), the camera wheel, and finally the detector assembly with its focusing mechanism. The detector will be mounted in a cold translation mechanism to compensate for non-achromaticity throughout the observing spectral range. The slit wheel has 16 positions: one blank position, five long slits, and 10 multislit positions. The two filter wheels contain 12 positions each and will house the filters and the Wollaston prisms. The pupil wheel contains 12 positions and will house the pupil masks, plus an optional apodization mask with a rotation mechanism for coronagraphic capabilities. The grim wheel has ten positions for grisms. The camera wheel has four positions and will carry the camera and the optics to reimage the pupil onto the detector plane, as well as an aperture and a black aperture. All mechanisms use Phytron cryogenic stepping motors, and the control system is based on a VME system.

The instrument is precooled with LN_2, and the cooling system is a two-stage closed-cycle refrigerator (CTI model 1050C), which works according to the Gifford–McMahon cycle.

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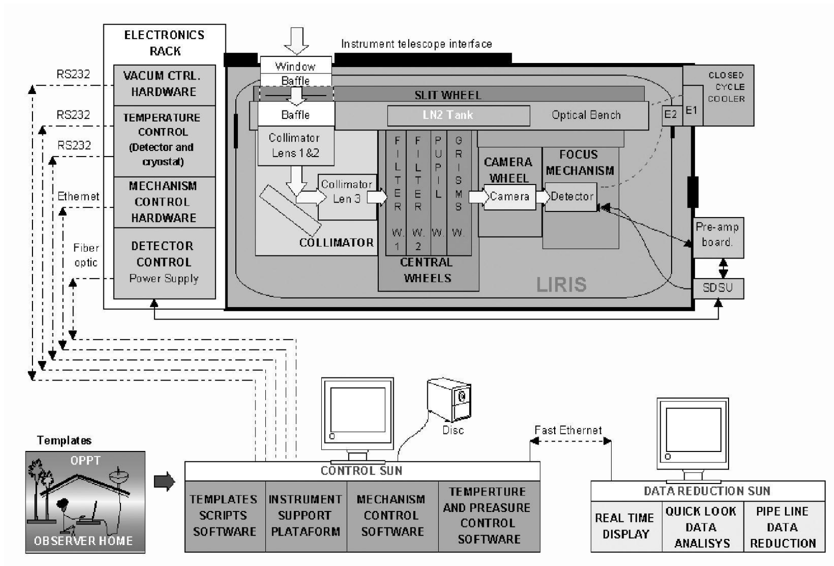

Fig. 1. Schematic representation of LIRIS.

3.3. *Detector*

The detector is a Hawaii 1024 × 1024 HgCdTe array using a SDSU controller, which communicates with the control computer (a SUN workstation) using the SBUS card. An agreement has been established between the IAC and the Isaac Newton Group (ING) to develop jointly the detector control system and the mechanism control software for the two infrared instruments (LIRIS/IAC and INGRID/ING). The LIRIS Software system is being designed to be fully integrated in the observer environment available at the WHT. A common observer will have access to the following software packages: Instrument Simulator Software, Templates Generator Software, Instrument Support Platform User Interface, LIRIS Mechanism and thermal Control Software, Real Time Display, Quick Look Data Analysis, and Pipeline Data Reduction.

4. CURRENT STATUS

At present LIRIS is in the assembly, integration, and verification phase. The collimator, camera, slits wheel mechanism, and the main central wheel (filter 1 and the pupil wheel) mechanism have been successfully tested in test cryostats under cryogenic conditions. They have also been pre-integrated on LIRIS to check the interfaces.

Test multislit masks have been manufactured by Electric Discharge Machining and successfully tested, and have achieved a roughness of 1.15 ± 0.15 μm. The engineering and the scientific detectors have been tested in cryogenic conditions on a purpose-built detector test bench. The main characteristics of the science degree array at 80 K are as follows: read-out noise 20 e^-, dark current 0.065 e^- s^{-1}, bad pixels $< 1.5\%$, and the detector behaves linearly within 2% up to 50% of the full-well (175000 e^-). The signal offset was found to vary 670 e^-/K with the detector temperature. The current temperature controller permits a stability of better than 0.005 K, which implies a signal offset variation less than 4 e^-.

In 2001 November, the LIRIS cryostat integration was started (vacuum tank, optical bench, closed-cycle cooler, radiation shields, etc.), in 2001 December the first cool-down was successfully carried out, and first commissioning at the telescope is expected by 2003 January. Information on LIRIS is available at http://www.iac.es/proyect/LIRIS/.

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