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THE PREPARATION OF THE GTC FOR THE SCIENTIFIC OPERATION OF CANARICAM

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RESUMEN

CanariCam es una cámara del infrarrojo medio con capacidad para realizar imagen, espectroscopía, coronografía y polarimetría, que ha sido fabricada por la Universidad de Florida para operar en el GTC. CanariCam está diseñada para trabajar en el límite de difracción del GTC a 8 μm. Para alcanzar la calidad de imagen y sensibilidad requeridas, la operación debe realizarse bajo condiciones atmosféricas muy restrictivas y nuevas funcionalidades deben ser implementadas en el telescopio.

ABSTRACT

CanariCam is a mid-IR camera and spectrograph with coronographic and polarimetric capabilities, built by the University of Florida to operate at the GTC. CanariCam is designed to work at the diffraction limit of the GTC at 8 μm. To reach the required image quality and sensitivity, the operation must be carried out under stringent atmospheric conditions and new telescope functionalities must be implemented.

Key Words: instrumentation: polarimeters — instrumentation: spectrographs — methods: observational — telescopes

1. INTRODUCTION

GRANTECAN faces the challenge of operating the facility mid-IR instrument CanariCam (Telesco et al. 2008). Intensive work has been carried out in the past two years to be able to start the scientific exploitation of CanariCam from March 1st, 2012. This goal will be possible thanks to the close collaboration between the GTC staff and the expert team that built the instrument.

Observing in the mid-IR from the ground is a challenging task due to the high and variable thermal background associated to the Earth's atmosphere, which is highly dependant on the atmospheric water vapor content. In the regions of the mid-IR spectrum where the atmospheric emission is typically low, background emission may then be dominated by the telescope and instrument entrance window thermal radiation. Special observing techniques, like chopping and nodding, must be used to remove most of the background emission. In addition, to reach the telescope diffraction limit, it is necessary to use telescope functionalities that are not needed for the operation of seeing-limited visible instruments. One of such functionalities is the phasing of the telescope's primary mirror (M1). It consists of making the relative piston steps between mirror segments much smaller than the wavelength at which the diffraction limit is required. It is also fundamental to be able to perform fast guiding. Fast guiding consists of sending tip-tilt demands to the secondary mirror at high frequency (tens of Hertz), based on the image of a guide star, to correct the science image for the jitter associated with the seeing. Finally, the incorporation of a new instrument to the operation also requires the adaptation the operation system, including the extension of the Phase-2 form (the user interface to define the observations) and the development of some means of measuring the amount of water vapor in the atmosphere in real time.

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2. PREVIOUS WORK

Once CanariCam had arrived at the GTC in 2008, in the months previous to September 2010, there was intensive work at the GTC to test chopping and nodding, which have to operate simultaneously with slow guiding. It was also necessary to prepare the Nasmyth-A focal station, i.e. the field de-rotator and the acquisition and guiding system (A&G). Work had to be done to ensure the rotation of the tertiary mirror (M3) tower, which is needed to change automatically between the the Nasmyth focal stations. Movable blocking baffles located at M2, whose deployment is mandatory to avoid stray light during observations in the visible, had to be prepared for remote retraction during mid-IR observations, to minimise the generation of mid-IR background emission. During this period important effort was also put into phasing of M1, which was not integrated within the GTC control system (GCS). Last but not least, work was also done in ensuring the proper communication between CanariCam and the telescope.

On September 2010, the first on-sky commissioning of CanariCam was attempted. First light was achieved and the first diffraction rings could be seen on an image of a standard star. However, this run was plagued with multiple telescope sub-system failures, and no useful commissioning data could be obtained.

After September 2010, much effort was spent on improving system robustness. In parallel, the phasing process was developed to a point where it was completely integrated in the GCS. At the same time that these developments were taking place in GRANTECAN, the company SAC (Servicios Avanzados Canarios) developed a monitor of precipitable water vapor (PWV) for the IAC, which is currently providing real-time atmospheric water vapor content data to the community operating telescopes at the ORM.

Finally, on June 2011, a second on-sky commissioning run took place and very useful data were taken to ensure the full commissioning of the imaging mode and low resolution spectroscopy at 10 μm. Also during the same run, polarimetric data were taken, which are sufficient to check that this mode is working as expected. However, more data are needed in order to fully commission CanariCam polarimetry.

Two more observing runs were performed in July and August 2011 (two nights each), which allowed us to take some more polarimetric data (available only at 10 μm) and low resolution spectroscopic data at 20 μm.

3. CURRENT STATUS

Currently (November, 2011), CanariCam has been commissioned for imaging and low-resolution spectroscopy at 10 μm. Phasing the primary mirror is fully integrated in the GCS, although this process needs up to 5 hours of night time in continuous acceptable seeing ($\leq 1.2''$) and sky transparency conditions. Phasing accuracy during the June commissioning run was 0.25 μm (rms). The Phase-2 interface is ready for the two commissioned modes. Besides, GTC have access to PWV real time data, provided by the IAC at `http://www.iac.es/proyecto/site-testing/index.php?option=com\_wrapper\&Itemid=122`.

Images taken with CanariCam during commissioning have a typical FWHM of the PSF between 1.1 and 1.5 times the diffraction-limited FWHM, the factor being highly dependant on the seeing conditions and the wavelength of the observations. Such images, even though in many cases clearly show the first Airy ring (and in some cases also the second ring), they do not reach the theoretical diffraction limit of the GTC, particularly in the bluer part of the 10 μm window. Nevertheless, the image quality can be generally improved (see Figure 1) by applying appropriate reduction techniques (shift-and-add). A bright point source is needed in the CanariCam field of view, though, to apply successfully such reduction techniques. Since most of the seeing degradation occurs at timescales (few tens of milliseconds) too short to be corrected by reduction techniques, fast guiding is required to reach the telescope diffraction limit.

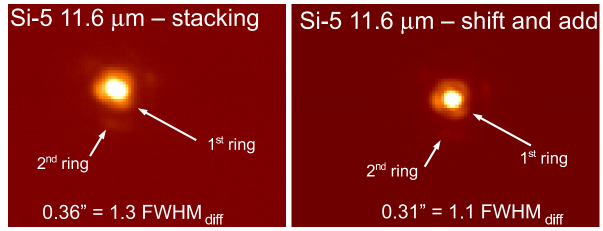

Fig. 1. Image quality improvement by using shift and add techniques during data reduction, due to the lack of fast guiding. The FOV is $7'' \times 7''$ and the chop throw was $15''$ in the vertical detector direction. The star brightness in the Si-5 filter is 30.7 Jy.

We have also noted that the images appear elongated along the direction of the chopping motion (chop tails). Such chop tails are hardly noticeable when chop throws $\leq 10''$ are used, but are rather prominent for large chop throws, e.g. $50''$. This problem is currently under investigation. Until it is solved, it will have an impact on the image quality of extended sources that need chop throws larger than the detector size.

4. FUTURE WORK

The work in the months after November 2011 will be focused on: (1) solving the problem with the chop tails, (2) preparing the whole operation system for the use of CanariCam, (3) automating the process of M1 phasing so that it can be routinely performed by the night operation team, (4) commissioning the remaining CanariCam modes and (5) development and implementation of fast guiding.

The latest information about the instrument and telescope can be found at `http://www.gtc.iac.es/en/pages/instrumentation/canaricam.php`.

REFERENCES

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