Ground-Based Astronomy in the 10 and 20 μm Atmospheric Windows at ESO: Two New Instruments, VISIR for the VLT and TIMMI2 for La Silla Now Under Way

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1. Introduction

This article gives a brief report about the status of ESO's instrument projects for the 10 and 20 μm atmospheric windows. Both projects have passed recently important milestones (contract signature, kick-off meeting) and for both projects the most pressing concern – the availabilty of suitable detector arrays – seems to be no longer of relevance as two manufacturers (SBRC and Rockwell) now offer suitable arrays.

On the other hand, the success of ISO, the European Infrared Space Observatory, may lead to a large increase of requests for ground-based follow-up observations exceeding the capabilities of TIMMI, ESO's present instrument for this kind of astronomy at the 3.6-m telescope.[1] The scientific interest and potential for astronomy in this wavelength range has been described previously in this journal (Käufl, 1993). An exhaustive collection of scientific projects for these instruments, especially VISIR, can be found in the proceedings of the ESO workshop "Science with the VLT"[2].

2. VISIR

The project was prepared by an extensive Phase-A study by a consortium of institutes led by the *Service d'Astrophysique* (SAP-DAPNIA) of the CEA, Saclay (France). The contract between ESO and the consortium led by the *Service d'Astrophysique* was signed on November 7, 1996. Partner to the consortium are the Netherland's Foundation for Research in Astronomy, Dwingeloo (The Netherlands) and the *Institut d'Astrophysique Spatiale*, Orsay (France). The principle investigator for VISIR is Pierre-Olivier Lagage (SAP), the co-investigator is Jan-Willem Pel, Kapteyn Astronomical Institute, Groningen (The Netherlands). VISIR stands for VLT-Imager and Spectrometer for the Mid-Infrared. The result of the phase-A study has been reported recently by the study team in *The Messenger* (Lagage et al., 1995). This article gives both a description of the observing modes (diffraction-limited imaging with variable magnification in the 10 and 20 μm atmospheric windows and low-, medium- and high-resolution spectroscopy (i.e. $\lambda/\Delta\lambda$ approaching $\approx$ 30,000) and the principles of the optomechanics. Thereafter the concept has been subject to a consolidation phase, and for the present status the reader is invited to consult the ESO web-page for VISIR (http://www.eso.org/vlt/instruments/visir/) or the web-page of the consortium (http://www-dapnia.cea.fr/Phys/Sap/Experiences/VISIR/Home_VISIR.html).

At present, VISIR is in its predesign phase where also all relevant prototype tests are being made. Commissioning of VISIR, which shall be mounted to the Cassegrain focus of VLT unit telescope #3, is planned for the first quarter of 2001 and release to visiting astronomers will occur in the third quarter of that year. At the end it should be noted that VISIR is by far the most powerful instrument for this wavelength range under construction for any large telescope project. Moreover VISIR observers will particularly benefit from the VLT site, especially the rather low water vapour content on Paranal.

3. TIMMI2

In the context of the La Silla 2000 initiative of the STC, ESO received a proposal by the Sternwarte Jena (Germany) to replace the present TIMMI instrument

Figure 1: This figure (courtesy University of Jena) shows the optomechanical setup of TIMMI2. The approximate size of this optomechanical assembly is in all directions less than typically 400 mm. The light is entering from the right and after deflection on the collimator mirror sent by a folding mirror through the pupil stop, filter/grism wheel and the objective wheel down towards the detector, a 256×256 pixel Rockwell Si:AS BIB detector. The detector – as well as the entire instrument – will be cooled by a commercial 2-stage closed-cycle cooler. The cryostat entrance window is partially obscured by the mask/slit wheel and the retractable $\lambda/2$-plate which will be used for polarimetry.

[1]TIMMI is to the best of my knowledge still the only instrument available worldwide for unconditional observations by visiting astronomers. While TIMMI – due to the rapid technical progress in the field – is no longer unique but has formidable competition by various visiting instruments available in the community, its performance has recently been improved thanks to the refurbishment of the 3.6-m telescope in the infrared configuration which will be reported in one of the upcoming issues of *The Messenger.*

[2]*ESO Astrophysics Symposia,* Springer 1995, ed. J.R. Walsh & I.J. Danziger.

at the 3.6-m telescope by an improved version taking advantage of the progress in detector technology. Recently, a corresponding Memorandum of Understanding has been signed by the Sternwarte Jena and ESO. Similar to TIMMI, this new instrument will follow the concept of an 'infrared EFOSC', i.e. it is a focal reducer with variable magnification allowing for grism spectroscopy and polarimetry. The principal investigator for TIMMI2 is Hans-Georg Reimann, Jena (Germany). The TIMMI2 observing modes will be:

- diffraction-limited imaging at 10 and 20 μm
- imaging polarimetry at 10 μm
- low-resolution (i.e. $\lambda/\Delta\lambda \approx 200$) long-slit spectroscopy at 10 and 20 μm
- a medium-resolution (i.e. $\lambda/\Delta\lambda \approx 1000$) cross-dispersed Echelle mode is being considered.

For more details please consult the ESO web-page (http://www.eso.org/vlt/instruments/visir/timmi2, or the Sternwarte Jena web-page (http://www.astro.uni-jena.de/Users/rei/timmi2.html. Design work for TIMMI2 has already progressed substantially before the official signature of the Memorandum of Understanding. The present planning for TIMMI2 foresees the release of TIMMI2 to ESO visiting astronomers at the end of 1998. As a concluding remark it should be noted that TIMMI2 will be by far the most advanced instrument available at any observatory (including visiting instruments).

4. Performances

Both VISIR and TIMMI2 will allow for imaging and long-slit spectroscopy with diffraction-limited spatial resolution, i.e. factors of 10 to 20 better than ISOCAM, the imaging instrument of ISO, however, generally at the price of compromised sensitivity. Readers interested in the full details should consult the web pages giving sensitivity estimates for spectroscopy for the different cases. It should be noted that these sensitivity numbers depend largely on the Earth's atmosphere. Within the clear parts of the atmosphere, TIMMI2 and even more VISIR in spectrospcopy are extremely competitive with ISO. In the case of objects smaller than typically 3 arcsec, TIMMI2 and VISIR can outperform ISO substantially. In imaging the point-source sensitivity at 10 μm (10σ in 1 hour) is estimated to be 5 mJy for TIMMI2 and 0.6 mJy for VISIR.

References

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10- and 20-μm Imaging with MANIAC[1]

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Introduction

MANIAC is the new Mid- And Near-Infrared Array Camera built at the Max-Planck-Institut für Extraterrestrische Physik (MPE). It is designed as a modular two-channel instrument that will offer simultaneous observations in the near infrared (NIR) from 1 to 5 μm and in the mid-infrared (MIR) from 8 to 28 μm as well as a mid-infrared imaging spectroscopy mode. The first phase of the project, the MIR channel, has been completed and successfully commissioned in March 1996 at the ESO 2.2-m telescope at La Silla. Further improvement of data quality was achieved on a second observing run during October/November 1996 at the same place. In this article we present first results of broad-band N (8–13 μm) and Q (18–23 μm) observations, the latter being the first full Q-band images taken from La Silla.

[1]MANIAC is not an ESO instrument. It is described here because it is used on the ESO/MPG 2.2-m telescope at La Silla and it covers the same wavelength range as the ESO instruments VISIR and TIMMI2 described in the preceding article.

Mid-Infrared Channel

The MIR channel is based on a 128 × 128 pixel Si:As array manufactured by Rockwell International, U.S.A. The array can be operated in different read-out modes with single read or double sampling being the modes most commonly used. The control electronics from Wallace Instruments, U.S.A., can read out the detector using four output channels at a top speed of 400 images per second.

MANIAC's field of view is 44 × 44 arcsec^2 (scale = 0.345 arcsec/pix) at the Cassegrain focus of the 2.2-m telescope with the f/35 secondary. The spatial resolution is determined by the diffraction limit of the telescope. The camera optics is a purely reflective gold-coated three-mirror system with achromatic performance. At present, the camera is equipped with a total of 13 broad- and narrow-band filters with a spectral resolution between 2 and 70. The filter set is complemented by a circular variable filter (CVF) operating from 7 to 14 μm at a spectral resolution of about 50.

Observations at MIR wavelengths require cryogenic temperatures for the instrument to minimise its own thermal emission. Therefore, detector, filters and mirrors are cooled down to 4.2 K using liquid helium. Technical details about optical design and data-acquisition system are described elsewhere (Böker, 1996, Böker et al., 1997).

Performance

Extensive testing was done in the laboratory and under observing conditions. The detector is linear up to $8 \cdot 10^6$ electrons (full well capacity). The total transmission at 10 μm including optics, filters, and detector is 11%. The measured noise equivalent power in the N-band is NEP = 2. . .5 mJy/arcsec^2 (1σ, 1 hour), depending on the observing conditions we have had during our two runs. Our data show only a small amount of excess noise indicating that the instrument is running close to background-limited performance.

The use of the Q-band filter (18–23 μm) is restricted to good observing conditions, which means a dry atmosphere. The full well capacity is already passed by the fastest possible read-out at about 20% humidity.

The well-known chop-nod technique was applied throughout our observations. During the observations it became clear that the chopping f/35 secondary at the 2.2-m telescope is certainly not optimised for use at MIR wavelengths. The