The 3D-NTT Instrument

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The 3D-NTT is a visitor instrument to be put at the Nasmyth focus of the NTT.
The 3D-NTT is the fruit of a collaboration between LAM (Marseille), GEPI (Paris) and LAE (Montreal)

Constructing Team:


Also involved in the making of the instrument:

Fresnel Institute, Marseille + LMA, Lyon (coating) together with several private companies:
SESO, Fogale, Cedrat, Immervision, Photon-etc, BMV Optical

Science Team:

Principle of the 3D-NTT

It is an integral field spectrometer offering two observing modes:

- Low order FP
  (Tunable Filter)
- High order FP

It is an integral field spectrometer offering two observing modes.
(a) High Order Fabry-Perot
High resolving power, small tuning range

Monochromatic rings

(i) Stack of interferograms @ high R

(b) Low Order Fabry-Perot
Low resolving power, large tuning range

Central Monochromatic region (Jacquinot spot: J-Spot)

(ii) Stack of monochromatic images @ low R

Stack of images and spectra @ high R

Stack of images and spectra @ low R
Some history about the Fabry-Perot interferometer

2 semi-reflecting plates of glass, parallel, producing an interference pattern

(Fabry and Perot, Marseille, 1892)
What is the principle of a Tunable Filter?

It is a Fabry-Perot interferometer in which the plates are so close to one another (a few microns) that you do not see anymore interference rings through it when looking at a monochromatic source but a spot (Jacquinot spot).

Changing the spacing between the plates then enables to tune the transmitted wavelength.
What is new with our Tunable Filter?

• Long range piezoelectric actuators
  (from ~ 3 μm up to 200 μm)

• Coating providing a constant finesse all over the visible range
Mechanics of the Tunable Filter

Design: SESO  Manufactured by GEPI (Paris Observatory)

Diameter: 30cm (useful 10cm)  Height: 12 cm
Weight: 16kg
Glass plate control
Tunable Filter Controller

Much smaller than the classical « CS100 »

Insures parallelism and positioning of the glass plates with an accuracy of 10 nm over the 200 µm gap
We will use two such devices in the 3D-NTT (one for LR and the other one for HR)
3D-NTT Fabry Perot optical characteristics

**Spectral resolution**
- HR FP: 10,000 to 40,000
- LR FP: 500 to 10,000

**Wavelength range**
- 370-850 nm

**Interference Order**
- Finesse HR: 220 to 835
- Finesse LR: 30 to 630

Figure 2 — Réflectivité et finesse de la solution B à 27 couches
Summary of characteristics of the 3D-NTT:

**TUNABLE FILTER MODE** (R ~ 500 à 1000) ⇒ *monochromatic images*

- **Field of view**: ~ 17' x 17' (or 10' Ø without “Phase shift”)
- **Wavelength range**: 350nm to 850nm
  - NB: range of a standard thin blue sensitive CCD (to reach the 3727Å [OII] line)
- **Spectral resolution**: tunable from 500 to 10 000 (@Hα)
- **Detector**: CCD (4096 x 4096 with 12 µm pixels)
  - scale: ~ 0.25"/pixel

**HIGH RESOLUTION MODE** (R ~ 10 000 à 20 000) ⇒ *Velocity fields*

- **Field of view**: ~ 8.5' x 8.5'
- **Wavelength range**: 350nm to 850nm
  - NB: range of etalon coatings optimized for 350nm to 850nm (L3CCD → 1 µm)
- **Spectral resolution**: from 10 000 to 40 000 (@ Hα)
- **Detector**: L3CCD (1600 x 1600 with 16µm pixels)
  - scale: ~ 0.33"/pixel
Low resolution mode observations

Example of images produced by a Tunable Filter

NGC1365 observed with the TTF on the AAT for measuring abundances from line-ratios

(Veilleux et al. 2003)
Another example of what can be done with the Tunable Filter of the 3D-NTT

H\textalpha+ [NII] image of NGC4438 + M86
(Tal, van Dokkum & Kenney, 2009)
Evidence of gas heating through gravitational interactions
N.B. 3D-NTT FOV in TF mode is 17’x17’
« Phase-shift effect »

Change in the transmitted wavelength across the FOV (here for the TTF) when the Tunable Filter is placed in the pupil plane.

In the 3D-NTT the TF may be placed either in the pupil or in the focal plane.

The transmitted wavelength is then the same from center to edge. The price to pay is a smaller FOV (10’ Ø instead of 17’x17’)
High resolution mode observations

Examples of velocity fields observed with GHASP
UGC 8937 UGC 528
UGC 2866 UGC 11218
Detectors efficiency

High resolution mode
L3CCD 1600x1600 E2V
(zero readout noise)

Low resolution mode
CCD 4kx4k E2V « blue »
(readout noise 2 e-)

Graph 1:
Quantum efficiency vs. wavelength (nm)

Graph 2:
Transmission efficiency vs. wavelength (nm)
3D-NTT Science Programmes

Two “Large programmes” have been approved by ESO’s OPC (2006):

- "Characterizing the interstellar medium of nearby galaxies with 2D maps of extinction and abundances" (PI M. Marcelin)
  51 nights (2 periods)

- "Gas accretion and radiative feedback in the early universe" (PI J. Bland Hawthorn)
  20 nights (2 periods)
Large Programme « Galaxies »

Observation of the ionized gas in SINGS galaxies (43 out of 75 can be observed from La Silla) with Tunable Filter in order to map:

• stellar formation

• dust extinction and metal abundance (from line ratios maps)

• observed lines:
  - [OII] 372.7 nm
  - H beta 486.1 nm
  - [OIII] 495.9 - 500.7 nm
  - [NII] 654.8 - 658.4 nm
  - H alpha 656.3 nm
Goal:

Better understand the nature, origin and evolution of these galaxies, comparing the 3DNTT maps with maps obtained in FIR (MIPS/Spitzer) and UV (Galex) for a detailed analysis of extinction and its relation with other physical quantities such as metal abundance.

The data obtained for nearby galaxies will have a high resolution (both spatial and spectral) and will serve as a reference sample for studies at larger redshift led with larger telescopes (later with ELT).
Large Programme « QSOs »

Observation of 30 quasars at $z \sim 2$ in the Lyman alpha line (redshifted at 380 to 400 nm for $z \sim 2.2$ to 2.3) with the Tunable Filter, with 5 deep images for each target (one at the quasar redshift, two blueshifted and two redshifted).

Goal:

The aim is to detect galaxies with a high stellar formation rate around quasars, in order to check if quasars with a high UV luminosity suppress the stellar formation around them as suggested by recent observations with the TTF on the AAT (Barr et al. 2004 et Francis & Bland-Hawthorn 2005).

If such an observation is confirmed, it will put strong constraints on the cosmological models.
AAT TTF observation in 6˚A band at 3845˚A of the field of an extremely powerful QSO at z ~ 2 (Francis & Bland-Hawthorn 2004). PKS 0424-131 is the bright source at the centre of the field. The field is 400” east-west and 235” north-south, a subset of what will be possible with the 3D-NTT. The other sources in the field are not associated with the QSO, and we did not detect any line emitting sources at the redshift of this extremely powerful UV source. This is highly unusual for lower power quasars (e.g. Barr et al 2004; Baker et al 2001).

Example of a quasar field detection with the TTF at the AAT
In stark contrast to top picture, a huge (250 kpc) ionized Hα nebula was discovered about MR 2251-138, a low-redshift quasar with a lower intrinsic UV flux. (a) and (b) are red and blue shifted, narrow band images, (d) is the sum of these; (c) is an I band image of the field. The field is 180” in size. The nebula is thought to be shock-excited due to gas accreting onto the QSO host in one or more mergers.
Comparison of 3DNTT with other TF
(MMTF/Magellan, OSIRIS/Grantecan, BTFI/SOAR)

Advantages of 3D-NTT:

• Large FOV 17’x17’ (better than BTFI 3’ and Osiris 6.7’ but smaller than MMTF 27’) and FOV 10’ Ø without « phase-shift »

• Blue sensitivity (MMTF>500nm)

• Possibility of high resolution mode (not on MMTF nor OSIRIS but BTFI also)

Disadvantages:

• No Adaptive Optics

• Visitor Instrument (not maintained by local staff)
Present status

- Optics ready (made in Canada by BMV Optical) about to be shipped to France

- Mechanics ready (made by GEPI, LAM and LAE) about to be sent to Marseille for final integration

Lenses and Mirrors supports

Main structure

Fabry-Perot support
2010- Planning

- Integration and tests of the instrument at LAM (jan-apr)
- Tests and calibration at LAM (may-june)
- Shipping to Chile (july)
- Preparing and testing in La Silla (sept-oct)
- First light (oct-nov)
Good News:

- Optics and mechanics have been manufactured
- Blocking filters ordered (13 filters enabling to observe all interesting lines)
- Tunable Source about to be ordered (Werner Zeilinger, Wien)

Bad News:

- Problem of manpower for the integration (O. Boissin’s heart attack)
- Delay for coating of the two Fabry-Perot (Fresnel Institute gives up…)
- Lens scratched in Montreal (needs repolishing by BMV Optical)
- Time allocated for first light in march 2010 given back to ESO (9 nights: 5 « science nights » for E. Pompei, about compact groups of galaxies + 2 « technical nights » + 2 « commissioning nights »)
Conclusion

Prepare your proposals of observing programs for Period 86 (oct 2010 – march 2011) deadline march 2010

Short programs that can be used as tests for the 3D-NTT (a few nights with both modes)

Large Programs will be proposed from Period 87