OSIRIS-FIRST SCIENTIFIC PROGRAM

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Abstract

OSIRIS (Optical System for Imaging and low/intermediate-Resolution Integrated Spectroscopy) will be one of the Day One instruments for the Spanish 10.4m telescope GTC at La Palma. One of the scientific projects to be addressed with OSIRIS is the study of the galaxy population in clusters of galaxies at high redshift. Part of the cluster sample could be selected by means of the Sunyaev-Zeldovich effect as provided by the Gran Telescopio Milimétrico (GTM). The optical survey will be complemented using other future facilities in the NIR such as the Espectrógrafo Multiobjeto InfraRojo (EMIR), also in the GTC. The spectroscopic and photometric capabilities of PACS and SPIRE covering the spectral range 60 - 670 μm, will both feed this survey and allow us to complement and extend it. In summary, the combination of the GTM, OSIRIS and FIRST capabilities will likely provide a deep insight into the evolution of clusters of galaxies and galaxies in clusters. Although only one of the OSIRIS scientific projects is outlined here, most of the OSIRIS projects, developed and carried out by the OSIRIS Scientific Team, will use FIRST instruments to tackle their scientific objectives.

Key words: Clusters: evolution – Galaxies: formation – Missions: FIRST

1. Introduction

1.1. The GTC and OSIRIS

The Optical System for Imaging and low Resolution Integrated Spectroscopy (OSIRIS) will be a Day-One instrument of the Spanish 10.4 m telescope Gran Telescopio Canarias (GTC), whose First Light is planned for 2002. GTC will be installed at the Observatorio del Roque de Los Muchachos in La Palma, Spain. OSIRIS primary modes are imaging and low resolution long slit and multiple object spectroscopy. The instrument is designed to operate from 365 to 1000 nm with a field of view of 7x7 arcminutes and a maximum spectral resolution of 2500. Among the OSIRIS main features are the use of tunable filters (TF) for direct imaging. The two tunable filters of OSIRIS will allow obtaining narrow band imaging (2-4 nm FWHM) in any region of the full spectral range from 365 through 1000 nm. This capability, together with charge shuffling techniques (Bland-Hawthorn & Jones 1998), will provide GTC with an instrument able to observe any spectral absorption or emission line at any place of the optical domain. For this reason OSIRIS will be a powerful tool for the study of the ionised gas in extragalactic objects at a wide range of redshifts.

OSIRIS is being designed by a Consortium of the Instituto de Astrofísica de Canarias (IAC) and the Instituto de Astronomía-Universidad Nacional Autónoma de México (IA-UNAM). The optical design, the manufacture of part of the camera lenses and the optical alignment are responsibility of the IA-UNAM. The IAC is responsible for the rest of the instrument design and construction, including assembly, integration and verification. OSIRIS will be the sole scientific optical instrument available at the GTC on Day One, and no other optical instrument is expected to be available during the first years of GTC operation. OSIRIS will be a workhorse instrument for a high variety of scientific cases, with the potential to attack a wide range of classical and edge-front competitive observational programs.

1.2. The GTM

The Large Millimeter Telescope or Gran Telescopio Milimétrico (GTM) is a joint endeavour of the University of Massachusetts (USA) and the Instituto Nacional de Astrofísica, Optica y Electrónica (México). With a dish of 50m diameter, the GTM will constitute the largest millimeter antenna in the world. Due to the excellent site conditions for millimeter studies, the GTM will be installed atop Cerro La Negra (Puebla, México) at 4600 m above sea-level.

The first light instruments will be a broad band ($\sim$50 GHz) bolometer camera ($\sim$150 pixels) at 1 mm and a heterodyne focal plane array at 3 mm. The bolometer camera (BOLOCAM) is designed to have a large mapping speed in order to carry out deep surveys (Olmi & Mauskopf 1998). One of the scientific projects to be carried out with BOLOCAM is a survey of the Sunyaev-Zeldovich effect to detect candidates of clusters of galaxies with the aim to study its origin and evolution.

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2. The OSIRIS Scientific Program

The OSIRIS Scientific Team is composed by more than 50 astronomers from 21 institutions of 8 different countries. This Team is leaded by the instrument PI (Jordi Cepa) and structured around four different Projects that constitute the OSIRIS Scientific Program:

- The evolution of galaxies
- The Local Universe
- Late stages of stellar evolution
- Interstellar Medium

The main objective of the OSIRIS Scientific Team can be summarised as follows:

"To develop projects for the joint scientific exploitation of OSIRIS, GTM and FIRST in cutting edge areas of astrophysics. In general, the OSIRIS Scientific Team is intended to be more than a team to exploit OSIRIS, but a team to tackle high interest areas of astrophysics using all tools needed and available to Team members".

The agreement of collaboration being devised for the interchange of GTC and GTM observing time will help to fulfil this objective.

The present contribution will give a brief overview on the Project "The Evolution of Galaxies" and their relation with GTM and FIRST.

3. The Evolution of Galaxies

3.1. Scientific Aims

Clusters of galaxies have long been recognised as objects providing important information about many cosmological aspects. Also, the study of galaxy clusters provides not only valuable information about the processes of its formation and evolution, but of the formation and evolution of galaxies.

Previous studies of clusters of galaxies at z<1 have revealed significant evolution in the morphology and colour of the cluster members. One of the most noticeable of these changes is the progressive blueing of cluster galaxies with redshift (Butcher & Oemler 1984). Cluster population is also a function of cluster structure and location within the cluster (Oemler 1974). It is suggested that these effects are due to an enhanced elliptical formation rate at early times in the environments that would later become the cores of clusters.

Early and late-type cluster galaxies differ not only in their spatial distribution but also in their kinematics. Moss & Dickens (1977) claimed that the velocity dispersion of the population of late-type galaxies is significantly larger than that of the early-type galaxies. This is confirmed by e.g. Biviano et al. (1992). These differences can be understood as the result of the evolution of the galaxy population. Several mechanisms may affect the morphology and the star formation rate (SFR) of a galaxy as it passes through the dense cluster core, such as ram pressure, merging, tidal stripping. Also, the initial collapse of the cluster may have segregated spirals and ellipticals in different orbits.

Systematic studies have been carried out to understand all these processes by analysing the kinematics and distribution of galaxies in clusters. However, these observations are limited to redshifts around or below 0.5.

Our main goal is to study the change with redshift of the fraction of star forming galaxies and their global kinematics in a sample of clusters of galaxies at high redshift. The objectives of our program are the following:

- Study of the SFR in clusters
- History of star formation in galaxies
- Chemical abundances in cluster members
- Spatial distribution of morphological types within clusters
- Study of environmental effects in galaxies in clusters

3.2. High z studies with OSIRIS

OSIRIS provides the tools to address all these questions via deep broad- band images of clusters, narrow-band imaging of selected emission lines using tunable filters and multiple-object spectroscopy (MOS) of cluster members. This information will allow deriving conclusions about stellar populations, emission gas properties, star formation, object classification, extinction and kinematics of cluster members.

One of the main issues is the sample selection. At high redshift (larger than 0.5 - 0.6), identified clusters are scarce, and optical techniques to search for clusters may be inefficient. Future X-ray surveys with XMM may provide large numbers of high-redshift cluster candidates (e.g. Romer 2000).

A technique to select clusters at any redshift is through the Sunyaev-Zeldovich effect (Zeldovich & Sunyaev 1969) in the millimeter range. The GTM/LMT facility will be very useful in selecting high-redshift clusters candidates (López-Cruz & Gaztañaga 2000). Clusters can be identified and its redshift determined using OSIRIS, since the best range to detect galaxies in the redshift range 1.5-3.0 is the near-UV/blue (Steidel 2000).

3.3. The power of GTM-OSIRIS-FIRST

The combined use of OSIRIS, GTM and FIRST is a powerful tool to study galaxy formation and evolution either in clusters or in the field. OSIRIS may cover the redshift range between 0 and 3 through known emission lines ([OII], Hα and Lyα). The sub-mm and mm telescopes with instruments such as BOLOCAM at GTM and PACS and SPIRE at FIRST, will cover the redshift range from 0 up to 10. These may observe the galaxy SED peak in the wavelength ranges 80-200 micron (PACS), 200-600 micron (SPIRE) and 400-880 micron (GTM, SPIRE).

GTM will be used as an input to OSIRIS by selecting cluster candidates using the Sunyaev-Zeldovich effect. FIRST and GTM will be used to follow- up high-redshift galaxies previously identified by OSIRIS in order to obtain their bolometric luminosity and address evolutionary studies. FIRST will be also used to feed OSIRIS with new high-redshift cluster candidates. With this scheme we expect to obtain a view of galaxy evolution from 0 to 10 in redshift.

The involvement of several OSIRIS Scientific Team members in GTM and FIRST, together with the recent agreement of collaboration for the interchange of GTC (OSIRIS, EMIR) and GTM observing time will allow to implement the previous scheme and to fulfil the OSIRIS Scientific Program.

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