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ISM RESEARCH WITH A 6.5-m DIAMETER TELESCOPE

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RESUMEN

En esta contribución me referiré a algunos proyectos observacionales sobre el Medio Interestelar los cuales serían altamente beneficiados con el uso de un telescopio de 6.5-m de diámetro. También comentaré sobre la instrumentación idónea requerida para realizar estos proyectos.

ABSTRACT

In this contribution I will address some observational projects on the ISM research that would have a big benefit with the use of a 6.5-m telescope. I will also comment on the suitable instrumentation to achieve these projects.

Key words: **ISM: KINEMATICS AND DYNAMICS — ISM: SUPERNOVA REMNANTS — GALAXIES: KINEMATICS AND DYNAMICS — GALAXIES: ACTIVE — INSTRUMENTATION: SPECTROGRAPHS**

1. INTRODUCTION

"The Optical–IR Mexican 6.5-m Telescope (TIM)" project offers the opportunity of thinking of several problems that should be addressed with this facility. In the following I will restrict the list of possibilities to only three topics. These are:

(a) *Kinematics and dynamics of the ISM.* Very interesting projects could be achieved in this subject as I will discuss in Section 2. This should be done both for the ionized and the molecular ISM. This latter by means of studies of the H_2 2.12 μm line.

(b) *IR imagery.* Given the development of IR imaging detectors of low noise and the possibilities offered by adaptive optics to remove the effects of atmospheric turbulence, imagery at IR wavelengths (from 1 to 20 μm) of star forming regions, proto-planetary nebulae, planetary nebulae (PNe), supernova remnants (SNRs) and the ISM in early-type galaxies seems to me a new field where much could be learned. The studies of the inter-relationship between the ionized and the molecular gas in star forming regions and PNe, for example, will help in understanding the propagation and evolution of ionization fronts and shocks. The molecular content of the several types of objects in galaxies with different metallicities will give us a better understanding of the molecular content of the host galaxy now traced mainly by CO observations which are subject to chemical abundance bias.

(c) *Studies of the coronal gas.* Faint emission of the coronal lines of highly ionized atoms such as [Fe X] (λ6375) and [Fe XIV] (λ5303) traces the presence of gas at a few million degrees K. This gas is produced in supernova remnants and in the cooling flows in clusters of galaxies, for example. Studies of these emissions coupled with X-ray observations are highly valuable in establishing the thermal nature of X-ray sources and the conditions of thermal ionization equilibrium. Imagery performed in these lines (or other lines tracing cooler gas such as [Ne V] (λ3425.9) will provide insights in the studies of the structure of the shocks, and possibly, the studies of the abundances of heavy elements in these objects.

These are three topics which surely will have much improvement with the use of large diameter telescopes. In the following I will focus my attention to the first one due to time limitations.

2. KINEMATICS AND DYNAMICS OF THE ISM

The study of kinematics of several kind of objects allows the comprehension of the sources of energy in a galaxy and the inter-relationship between stars and gas. This also makes possible more realistic theoretical models on the dynamics of these objects. Several projects on the kinematics of ISM will have a large benefit with the use of a 6.5-m telescope. Those cover a broad variety of objects. Let me mention the following projects:

2.1. H-H Objects and Star Forming Regions

The study of the high-velocity bipolar outflows is interesting in the understanding of the star formation process because it is thought that these outflows are linked to the evolution of the accretion disks. Kinematic studies of the fast optical jets and of the slower molecular flows may thus give us insights on the time evolution of the accretion at the protostar as well as the nature of the circumstellar medium. At the same time, detailed observations of the dynamics of stellar jets (in lines at optical wavelengths), such as the study performed on the system H-H 46/47 by Morse et al. (1994), and of molecular outflows (i.e., at the shocked H_2 line at 2.12 μm) may help in establishing the the driving mechanism of those molecular outflows.

Consequently, kinematic studies of stellar jet systems and of molecular outflows, and in general, of the environments of star forming regions, both in the optical and IR regimes could be interesting projects to achieve with a large diameter telescope.

2.2. Multi-Wavelength Studies of Planetary Nebulae, Supernova Remnants, Bubbles and Superbubbles

Detailed and global kinematic observations of these objects, complemented with data at radio and X-rays, give us insights on the dynamic interaction of the stars with the ISM. In the case of massive stars, their winds, ionization fronts and supernova explosions change the structure of the ISM by creating structures whose diameters range from a few parsecs to kiloparsecs. The kinematic studies performed in several SNRs, bubbles and superbubbles in the Magellanic Clouds (Rosado 1986; Le Coarer et al. 1993; Rosado, Le Coarer, & Georgelin 1994; Chu & Kennicutt 1994; Rosado, Le Coarer, & Georgelin 1995; Laval et al. 1995) have allowed us to identify shocked nebulae and SNRs, to study the collective interactions between wind-blown bubbles and SNRs, to know the origins of the high turbulence found in some of them and to know how the complex stars–ISM interactions affect the host galaxy and are affected by the galactic environment. For example, in a recent kinematic study of the H II nebular complex N19 in the Small Magellanic Cloud, Rosado et al. (1994) have identified at least three structures whose kinematics, morphology and [S II]/Hα line ratios are characteristic of SNRs. The comparison with data in other wavelengths suggests that these structures are separated entities formed by three supernova explosions of stars belonging to the rich stellar association interior to this nebula (Rosado et al. 1995). This and other works have shown that those nebular complexes are excellent laboratories where SNRs and wind interactions can be studied. Besides, they allow to study how the energy from stars is liberated to the disks of galaxies.

An extrapolation of these studies to more distant galaxies of different types and with a broader range of interstellar environments will give us valuable clues on how these interactions influence the galactic evolution. In order to extend these studies to more distant galaxies, higher sensitivity and spatial resolution are required. Also, it would be important to know the kinematics of the associated molecular gas by means of observations in the line of the H_2 molecule at 2.12 μm. Thus, telescopes of large diameters and with the adequate instruments will be highly valuable in achieving this kind of projects.

2.3. Active and Starburst Galaxies

An observational project aiming to constrain the kinematic organization and dominant excitation mechanisms of ionized gas in active galaxies is very valuable to undertake with telescopes of large diameter and the adequate instrumentation because they require of high sensitivity and spatial resolution. These studies should include both the galactic environment in order to identify large-scale patterns produced in starbursts and the nucleus, to put some restrictions on the source of the violent motions found in the circumnuclear narrow-line regions (Tully 1995; Cecil 1995). There are several physical mechanisms that can interplay to disrupt galaxies from equilibrium conditions and only with the study of a sample of these objects one will be able to isolate those mechanisms to have a better knowledge of what is going on in these nuclei. An interesting study has been recently published (Veilleux et al. 1994) on the kinematics of a nuclear superbubble in the active galaxy NGC

3079. From this study, it is not yet clear which one is the source of the powerful outflow found: the AGN or the nuclear starburst. Nevertheless, detailed studies of more of these wind-blown superbubbles of galactic scale would give insights on the exciting source.

2.4. Gas in Elliptical Galaxies

The discovery of gas in elliptical galaxies opens the opportunity of studying its kinematics to know its origin. There are some observations pointing towards different origins for the detected gas (Plana & Boulesteix 1995; González 1995) but it is necessary to increase the studied cases in order to isolate the relevant mechanisms. Again, these observations will be benefited with the use of a large diameter telescope.

3. INSTRUMENTAL REQUIREMENTS

To accomplish the projects discussed in Section 2 it is necessary to have a combination of telescope/instruments, working in the optical or IR wavelengths, with the following characteristics:

- High sensitivity.
- High spectral resolution.
- High spatial resolution.
- Wide field.

This is very ambitious and consequently, we cannot think of a single ideal instrument which satisfies all these requirements. In particular, the fact of having 2D detectors of limited dimensions while the data required are mostly 3D (two spatial dimensions plus a spectral one), exemplifies the big limitation that all the instruments have. Another point refers to the spectral domains of interest: optical and IR, where the detectors and the instrumental techniques are so different. It is thus, necessary to think in two or three instruments which complement to each other.

Some suitable instruments for the kinematic studies of the ISM are:

- Scanning Fabry-Perot interferometers.
- Fourier Transform spectrographs.
- Long-slit or multi-slit echelle spectrographs.

Most of the observational work discussed here has been performed with Scanning Fabry-Perot Interferometers. However, as mentioned before, all the instruments have their limitations and one cannot expect to solve a series of astrophysical problems with the use of a single instrument.

These instruments correspond to the type of "Integral Field Spectrometers" (see Connes & Le Coarer 1995, for a detailed discussion on modern 3D spectrometers) and they could have high versatility. Indeed, they can share the same focal reducer which acts as what is called a "Courtès toolbox" and by addition or removal of different devices, within the slit space and the afocal space, such as grisms, Fabry-Perot interferometers, enlarger lenses, fiber bundles, or other devices, they could be conceived to solve a wide variety of astrophysical projects if provisions are taken in advance. As an example, a multi-slit spectrometer (FOSC–type) could share the same focal reducer than a scanning FP interferometer by exchanging the grism by the scanning Fabry-Perot and by placing instead of the multi-slit an interference filter. Thus, I would like to invite the audience to think of innovative spectrometers which could place the TIM in an advantageous position in the study of ISM.

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