ABUNDANCE GRADIENTS AND STAR FORMATION IN SPIRAL GALAXIES

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Abstract. The star formation rate (SFR) in stellar systems can be obtained from observations of young and bright objects, such as HII regions and HII complexes. On the other hand, radial abundance gradients can be derived from photoionized nebulae (HII regions and planetary nebulae) both for our Galaxy and other spirals. In this project, we plan to investigate a sample of photoionized nebulae in different galaxies, so that the SFR and the magnitude and variation of the gradients can be inferred.

Instrumentation. The project requires spectroscopic observations of emission lines from planetary nebulae in the optical and near infrared, typically from [OII] 3727-29 A to [OII] 7320-30 A. A good instrumental configuration would include a multiobject spectrograph with gratings allowing a moderate resolution ($R \sim 2000 - 5000$) in this spectral domain. Good image quality is also required.

1. Introduction

Radial distributions of the amount of gas, elemental abundances and the star formation rate in galaxies are essential quantities to model the chemical evolution of these systems (cf. Mollá et al. 1996). In particular, the SFR and radial abundance gradients can be derived on the basis of observations of young and bright objects, such as HII regions, HII complexes and planetary nebulae (PN). In this project, we plan to investigate a sample of photoionized nebulae in different galactic systems, so that the SFR can be inferred, which may confirm the occurrence of bursts in these objects, such as the one detected by Rocha-Pinto and Maciel (1997) for the Galaxy. At the same time, the study of several HII regions within a given galaxy will be of enormous help in the establishment of the magnitude and spatial variations of abundance gradients in these systems, especially regarding the behaviour of the gradients at large distances from the galactic centre (Costa et al. 1997).

2. Abundance gradients

Radial gradients in spiral galaxies are well established for the ratios O/H, N/H and S/H, as measured in HII regions (Zaritsky et al. 1994). The abundances are generally based on spectrophotometric observations of emission lines in the optical and near infrared, coupled with the application of appropriate photoionization models. The high excitation, low metallicity HII regions in the outskirts of galaxies allow the detection of weak lines required for the abundance determinations such as [OIII] 4363A, [NII] 5755A, etc. An alternative method, involves the fitting of abundance related parameters depending on the intensity of the [OII] 3727A, [OIII] 4959A,5007A, Hβ lines, etc. Recent work on abundance gradients have used telescopes in the range 2-4 m with a resolution of 2-5 A. Average gradients amount to -0.10 dex/kpc, and some flattening in the outer regions of the spiral disks has been proposed (Díaz 1989), although the actual shape may vary for different galaxies.

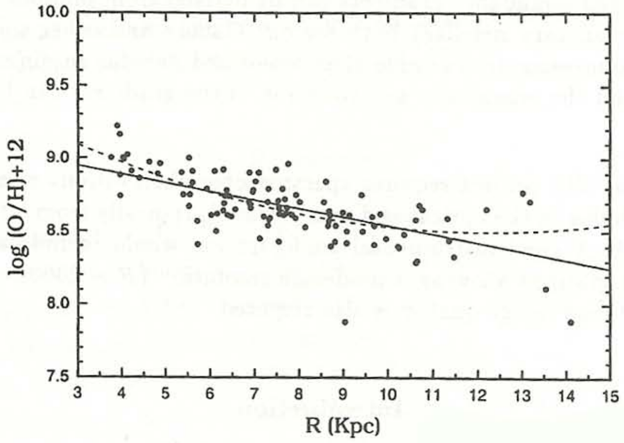

Figure 1. O/H radial abundance gradient for type II planetary nebulae.

Results for the Milky Way are in a certain sense more difficult to interpret than in other galaxies, as there are inconsistencies between the stellar results as compared with photoionized nebula data (cf. Maciel 1997). Data from HII regions (Simpson et al. 1995) and PN (Faúndez-Abans and Maciel 1986, Maciel and Köppen 1994, Maciel and Chiappini 1994) are consistent with an O/H gradient of about -0.07 dex/kpc in the inner parts of the Galaxy, close to the solar radius. In the outer parts, the situation is not clear, and data on HII regions (Vílchez and Esteban 1996) and planetary nebulae (Costa et al. 1997) suggest that there is some flattening for distances larger than 13 kpc, as shown in Figure 1 (dashed line) for the O/H ratio (Quireza and Maciel 1997), although a roughly constant gradient is not excluded on the basis of far-infrared abundances of HII regions in the outer Galaxy (Ruddolph et al. 1997).

3. The star formation rate

Determinations of the radial distribution of the SFR in spiral galaxies are largely based on estimates of the Hα emission fluxes related to the Lyman continuum photons from young massive stars (cf. Kennicutt 1989). The basic method used was described by Wilson and Scoville (1991), and relates the Hα luminosity and the SFR. For some objects, detailed radial distributions of the surface density of the SFR have been obtained on the basis of UBV colours and the Hα flux. Results generally show some declining in the SFR away from the centre, often with the presence of a ring of enhanced star formation. Similar results are known for the Galaxy, where such a region largely coincides with the molecular ring in the galactic disk. Also, a determination of an enhanced star formation era, or burst, has been recently made for the Milky Way (Rocha-Pinto and Maciel 1997), suggesting that a similar phenomenon may occur in other spirals. Since HII regions and PN reflect the SFR history at different epochs, an interesting extension of this project would be an estimate of the time variation of the SFR on the basis of the luminosity functions of the photoionized nebulae.

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