STAR FORMATION RATE FROM UV EMISSION AND GAS SURFACE DENSITY IN LATE-TYPE GALAXIES

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ABSTRACT: Far-UV (200 nm) fluxes of late-type, disk-dominated galaxies are used as tracers of their current star formation activity. After dust extinction corrections, the UV luminosity per unit area is compared to the gas surface density for a sample of 28 non resolved spiral galaxies and through the disk of Messier 51 at a resolution of 50" (imposed by CO data). In both cases, the current star formation rate per unit area shows a very good correlation with the total (atomic and molecular) gas surface density; much weaker correlations are found when one gas phase alone is concerned.

1. Introduction

The far-UV flux ($\sim$ 200 nm) of spiral galaxies is widely dominated by the light from intermediate mass stars ($\sim 5M\odot$). With the reasonable assumptions of a fixed initial mass function (IMF) and a constant star formation rate (SFR) over $\sim$ 10^8 years, the UV emission from young stars is simply proportional to the SFR, the constant of proportionality depending only on the IMF (Donas et al, 1987). UV observations performed with balloon-borne experiments by the Laboratoire d'Astronomie Spatiale in collaboration with the Observatoire de Genève have been used in this context. The targets are non resolved, isolated or clustered galaxies as well as nearby well resolved galaxies. The effective wavelength is 200 nm ($\Delta\lambda \sim 15$ nm). For the last runs of observations the resolution was about 15 arcseconds (FWHM).

2. Corrections for dust extinction

The UV emission of galaxies is largely affected by dust extinction. Thus, a correction must be performed before any quantitative interpretation of this UV emission The UV flux of a galaxy is first corrected for dust extinction in our Galaxy using the blue extinctions from Burstein and Heiles (1984) and the Galactic reddening law of Savage and Mathis (1979). The resulting extinction is low compared to that occuring in the observed galaxy. Two methods are used to estimate this internal dust extinction. The first is based on the total ($HI+H_2$) gas content and the use of Galactic dust to gas ratio and reddening law (Savage and Mathis, 1979). The dust is also assumed to be mixed with the young stars and to have about the same scale height. On a sample of 28 galaxies the mean extinction at 200 nm is found to be 1.4 mag (Buat et al, 1989). The second method is based on the infrared emission and on an energetic balance: the UV emission from young stars which is absorbed by the dust is reemitted in the infrared.

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Thus, the total ($1-500\ \mu m$) IR luminosity of the observed galaxies is estimated from IRAS data (at 60 and 100 μm) and the fraction of this IR emission which is due to an UV absorption at $200nm$ ($\Delta\lambda = 15nm$) is evaluated with an oversimplified model of heating of the local atomic component in our Galaxy (Pérault et al, 1988). To estimate the UV extinction along the line of sight, the same non isotropic distribution of the UV emission as in the first method is assumed. For the same sample of the 28 galaxies the mean UV extinction is found near unity with this method. It is worth noting that these dust extinction corrections are only expected to have a statistical significance and not to be valid for each individual case.

3. Results

3.1 NON RESOLVED GALAXIES

After dust extinction corrections, the UV emission is compared to the gas content atomic and molecular on a sample of 28 late-type galaxies for which HI and CO data are available (Fig. 1; see also Buat et al, 1989). The H_2 component is deduced from CO observations using a constant CO to H_2 conversion factor (Stark et al, 1986). Both the UV luminosities and the gas contents are divided by the isophotal area of the galaxies in order to use normalized quantities. The UV luminosity per unit area is found to correlate well with the *total* gas surface density (with a correlation coefficient $R \sim 0.9$) whereas the correlations are worse with either the atomic or molecular phase alone. The result holds for the two scenarii of dust extinction corrections. In fact dust extinction corrections affect only the slope of the linear regression of the logarithm of the SFR per unit area on that of the total gas surface density: this slope is lowered from 1.6 (with the method based on gas content) to 1 (with the method using IR emission). It is concluded that the SFR per unit area in late type galaxies appears to depend on the total gas surface density whatever its phase is.

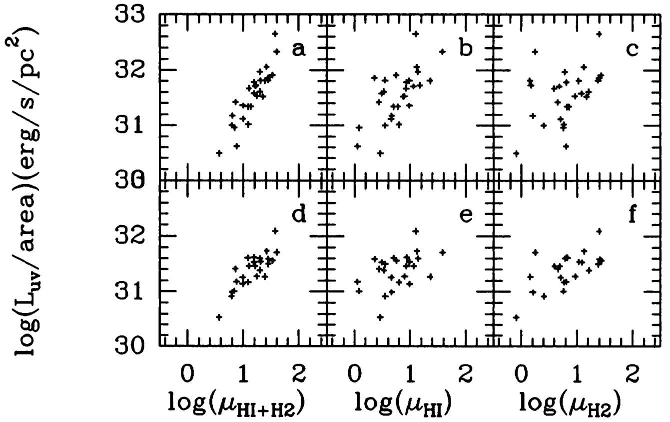

Figure 1. The UV luminosity per unit area is plotted against gas surface densities: extinction corrections are based on gas content in **a,b,c** and on IR emission in **d,e,f.**

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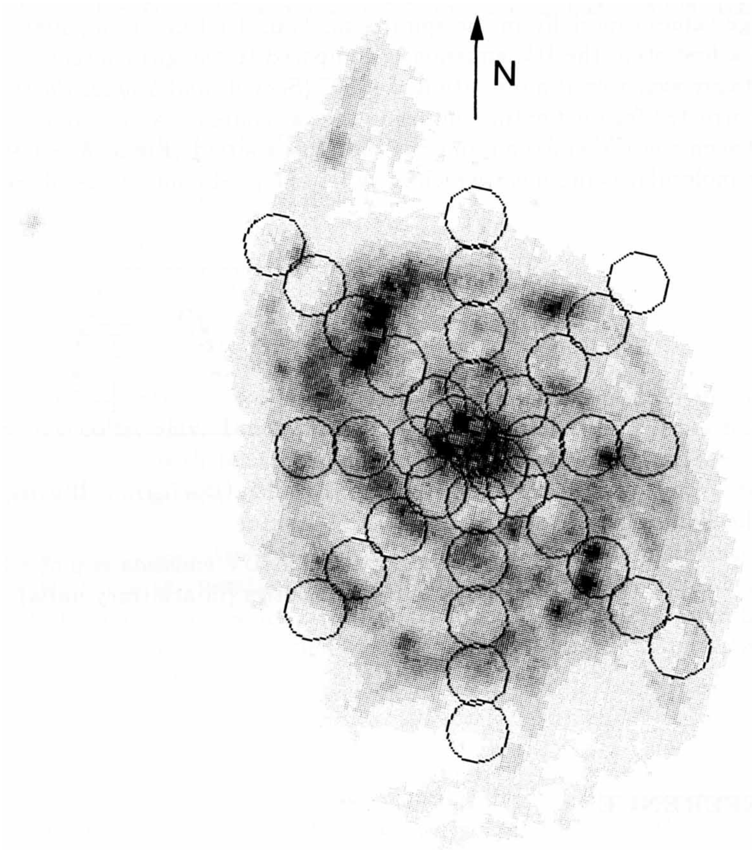

Figure 2: The UV emission of Messier 51 at $200nm$. The regions where a comparison between the UV emission and the gas content has been performed are shown.

3.2 MESSIER 51

This nearby Sc galaxy has been observed recently at $\sim 200nm$ (Fig.2 and Vuillemin et al, 1990). Its UV emission is largely affected by dust extinction which can reach very large values especially in the spiral arms (van der Hulst et al, 1988).
As a first step, the UV emission is compared to the gas content in regions where CO data are available at a resolution of $\sim$ 50" (Scoville and Young, 1983). The UV emission is corrected for dust extinction using the gas content. A very good correlation is found between the UV emission and the total gas content (Fig 3, $R = 0.93$) as well as with the molecular component which is by far the predominant gas phase in this galaxy.

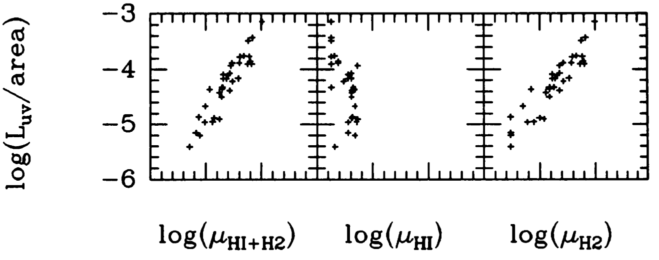

Figure 3: The UV emission is plotted against gas surface densities (in arbitrary units).

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