The determination of the molecular gas mass in galaxies of different type and luminosity using $^{12}$CO(1-0) data and a constant value of $X$ can introduce strong systematic errors. An alternative method has to be applied. Let us assume a metallicity dependent gas to dust ratio, calibrated on the Milky Way and on the Magellanic clouds. If we...
Figure 1. The relationship between the $X$ conversion factor and the $\text{H} \alpha + [\text{N II}]$ E.W. (top) and the metallicity index $12 + \log(O/H)$ (bottom) for the sample of nearby galaxies. The dotted-dashed line is the best fit to the data; the dotted line is the best fit given by Arimoto et al. (1996).

Unfortunately far-IR data covering the whole spectral range 100-1000 $\mu$m are now only available for a few galaxies. Since the peak of the far-IR emission of normal galaxies is $\sim 200$ $\mu$m, data at $\lambda > 100$ $\mu$m are necessary to constrain the cold dust temperature, fundamental parameter in the determination of the cold dust mass. Some galaxies have been recently observed at 200 $\mu$m by ISOPHOT. The dust temperature of the normal galaxies observed by Alton et al. (1998) and Contursi et al. (2000) seems fairly constant in galaxies of different luminosity (Fig 2).

If we assume a constant cold dust temperature, $T_{\text{dust}}=21$ K, with dust distributed along a disc of comparable size than the optical disc we can estimate the total dust mass for thousands of objects observed by IRAS. This exercise is here done for 266 normal galaxies in the Coma/A1367 supercluster region and in the Virgo cluster with data available at other wavelengths (IRAS, HI, CO, H$\alpha$, metallicity, H band (1.65 $\mu$m); Boselli et al. 2001).

The dependence of $X$, as measured for our sample of 266 galaxies, on the UV radiation field (traced by the $\text{H} \alpha$ E.W.) and the metallicity ($12 + \log(O/H)$) is compared in Fig. 3 to that observed for the sample of nearby galaxies. Since lower metallicities and higher UV radiation fields are typical of dwarf galaxies, this implies a relationship between $X$ and the H band luminosity and/or the B absolute magnitude (Fig. 4). The relationships between $X$ and the $\text{H} \alpha$ E.W., the metallicity, the H band luminosity and the absolute B magnitude observed in the sample of nearby galaxies are valid, at least at the first order, also for the 266 objects in the Coma/A1367 supercluster and in the Virgo cluster. Since most of the nearby galaxies observed in CO do not have $\text{H} \alpha$ and/or metallicity measurements, Fig. 4 can be used to universally calibrate $X$ as a function of the absolute B magnitude and the H band luminosity, these last observables being available for most of the objects. This empirical calibration is useful to remove any first order systematic effect in the determination of the total molecular hydrogen mass of galaxies using CO line measurements.

The determination of the molecular hydrogen content using a constant gas to dust ratio can be done only once
The $^{12}$CO(1-0) to $H_2$ Conversion Factor in Normal Late-Type Galaxies

359

Figure 3. The relationship between the $X$ conversion factor and
a) the Hα+[N II]E.W., b) the metallicity index $12 + \log(O/H)$
for the sample of galaxies in the Coma/A1367 supercluster and
in the Virgo cluster (small symbols) compared to that observed
for the sample of nearby galaxies.

the total dust mass is accurately estimated. The dust
mass strongly depends on the dust temperature $T_{\text{dust}}$,
thus $T_{\text{dust}}$ must be measured with high accuracy. Since
in normal galaxies the peak of the dust emission is at $\sim$
200 $\mu$m, a full coverage of the 100-1000 $\mu$m spectral range
is needed for an accurate determination of $T_{\text{dust}}$. Furthermore
the dust column density can be exactly measured
only once the dust distribution along the disc is known.
Data at higher spatial and spectral resolution are thus
needed to accurately characterise the physical properties
(dust temperature, spatial distribution) in different types
of galaxies.

This exercise, which looks very promising once far-IR data
from future generation facilities such as FIRST will be
available, is at present limited by the large uncertainty on
the total dust mass determination from IRAS data. How-
ever, it can already be conclude that molecular hydrogen
masses measured from CO data can be underestimated by
a factor of $\sim 10$ in low mass galaxies if a constant CO to $H_2$
conversion factor is used.

2.1. THE CONTRIBUTION OF FIRST

The FIRST satellite will provide a unique opportunity for
studying the properties of the ISM of external, nearby
galaxies. Joint PACS and SPIRE observations of large
samples of nearby galaxies with available multifrequency
data will allow to:

- accurately measure the SED in the wavelength range
  100-1000 $\mu$m, thus correctly estimate $T_{\text{dust}}$ and $M_{\text{dust}}$
in hundreds of galaxies.

- see the dust distribution along spiral discs in resolved
  objects, and thus properly determine the dust column
density.

- accurately estimate $X$ in a statistical significant sam-
  ple and to see using a multifrequency statistical analysis,
  how $X$ changes with the physical properties of the
  ISM such as the UV radiation field and metallicity.

- see the radial variation of $X$ on galactic discs, pre-
  dicted from the metallicity and star formation gradi-
  ents observed in spiral galaxies.

Altogether multifrequency data, including UV, optical, mid-
and far-IR, radio continuum as well as single line
measurements (Hα, CO, HI,...) will be useful to accurately
characterize, on scales of $\sim 1$ kpc, the physical properties
of the ISM of a large sample of nearby galaxies spanning
a large range in morphological type and luminosity. The
statistical analysis of this large database will allow to put
strong observational constraints on model of galaxy for-
mation and evolution.
Acknowledgements
This work is done in collaboration with J. Lequeux and G. Gavazzi. I thank J.M. Deharveng for interesting suggestions and discussions.

References