THE CORRELATION OF CO AND IR EMISSION FROM GALAXIES: WHAT DOES IT TELL US?

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Almost all galaxy properties correlate with each other to some degree; in this bounty of agreement, how are we to extract essentials? Fortunately, there is a framework in which to interpret CO correlations. Empirical studies have indicated that the fundamental galaxy properties are scale and form (Whitmore 1984), and theoretical work has implied that this follows from the physics of galaxy formation (see Lin and Pringle 1987, and references therein). It is known that the CO luminosity of galaxies is a function of both their scale (Young and Scoville 1982) and their form (Verter 1987). But the interpretation of any individual correlation is shrouded by uncertainties in the conversion from observables to source population properties.

As an example, consider the correlation between CO luminosity, L(CO), and far-infrared luminosity, L(FIR), of entire galaxies. If we lump together all galaxies from IR-luminous mergers, through normal spirals, to dwarf irregulars, this correlation spans 7 orders of magnitude (Tacconi and Young 1987). Among normal spirals there is an order of magnitude scatter, but still a very strong correlation (Kenney 1987, Verter 1988). Neither axis of this plot can be interpreted with equanimity.
The 3 main uncertainties in converting CO emission to molecular mass are:
(1) Cloud Ensemble - Is the ISM dominated by GMC's (eg. M51) or cirrus (eg. M31)?
(2) Metallicity - The non-linearity of CO self-shielding is such that spirals are largely insensitive to this, but in irregulars cloud emissivity is drastically reduced.
(3) Gas Temperature - Optically thick CO emission is proportional to source temperature.
These issues are summarized in Verter (1987) and Maloney and Black (1988).
The 3 main uncertainties in converting far-IR emission to either total gas mass or number of young stars are:

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(1) Cloud Ensemble - What fraction of the IR arises from dust heated by OB associations, or from dust heated by the general interstellar radiation field?
(2) Metallicity - Optically thin dust emission is proportional to the dust/gas ratio.
(3) Dust Temperature - Optically thin dust emission is proportional to the 5th or 6th power of T, depending on grain emissivity.

These issues are discussed by Maloney (1987). The operation and importance of all 6 issues above are still under debate. Since L(FIR) is a convolution of gas density with stellar heating, much of the heating occuring at large distances from the energy source (Boulanger and Perault 1988), the L(CO)-L(FIR) correlation cannot easily reveal the nature of either the cloud or stellar population.

An alternate approach to placing CO luminosities in the framework of galaxy properties is taken by Verter (1988). The CO luminosities of a representative sample of Sa-Sc galaxies was tested for correlation with 10 galaxy properties that express a mixture of galaxy scale and form. The relative dependence of CO emssion on these two axes was assessed from the relative strengths of the correlations. Very few previous correlation studies, summarized in Verter (1988), were compatible for intercomparison. Verter (1988) found that L(CO) correlates strongly with tracers of galaxy scale, weakly with tracers of galaxy form, and best with L(FIR). Not surprisingly, L(CO) is closely tied to the reservoir of gas and young stars; apparently this reservoir is not strictly a measure of galaxy scale or form. More comparative studies of mapped galaxies are needed to bridge the gap between the triggering of local star formation processes, and their dependence on global galaxy parameters set at the time of formation.

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