A survey of galaxies in CO

Torsten Elfhag
Stockholm Observatory
S-133 36 Saltsjöbaden
Sweden

Abstract. A large survey of galaxies in the CO (J=1-0) line is presented. Among different types of active galaxies, within the sample, the detection rate is found to be: Starbursts (15%), Liners (60%), Seyferts (30%). A look at the subsample that is located within 40 Mpc (H_0= 75 km s^{-1} Mpc^{-1}) regarding local density of galaxies reveals no substantial difference between detections and non-detections.

1. Introduction.

In the literature there has been some discussion regarding a possible evolution of galaxies were the primary driving force is thought to be large scale star formation (Balzano (1983), Weedman (1983)). When the burst of star formation is completed the accumulation of compact remnants, especially in the central region, would lay the foundation for an active galaxy.

The general belief regarding Seyferts, and even more strongly active galaxies, is that a single central black hole (truly a monster with M in the range of 10^7- 10^8 $M_\odot$) is the cause of the observed events. But it is not implausible that a large amount of smaller black holes (or even neutron stars) clustered within a rather small volume close to the galactic centers also could explain the observations. Since extended radio emission can be observed in some of these sources (where the emission is thought to emerge from supernova remnants) it can be seen as evidence for a more extended active scenario in these galaxies.

Also, the trigger of the burst is supposed to be anything from a close encounter to merging with another galaxy. It could therefore be expected that some correlation would occur, within parts of the sample, with the surrounding density of galaxies.

2. Observations and data reduction.

The observations of ^{12}CO (J=1-0, ν = 115271.204 MHz) emission from 120 galaxies were performed during 1985 - 1987 using the 20m millimeterwave radome enclosed telescope of the Onsala Space Observatory (OSO). During

1988 additional observations were done of some low declination objects and one southern object (NGC 1365) with the 15m Swedish - ESO Submillimeter Telescope (SEST) at La Silla, Chile.

As the OSO telescope became equipped with a SIS - mixer in 1986 approximately the first half of the observations were performed with a Schottky barrier diode mixer and the latter half with the SIS. Receiver temperatures ranged from 300 to 500 K for the Schottky and 150 to 300 K for the SIS. A dual beamswitch method was used to obtain the spectra with a 512 x 1 MHz filter bank giving a resolution of 2.6 km s^{-1}. The beamwidth of the 20m at 115 GHz is 33".

SEST is equipped with a Schottky barrier diode mixer and is used together with a 728-channel acousto-optical spectrometer, which yields a velocity resolution of 1.8 km s^{-1}. The receiver temperature was about 370 K and the beamwidth of the telescope is 44".

All galaxies were observed at their central position. Mapping was done on 11 of the detections, but those results will be discussed elsewhere. The galaxies were primarily chosen from the samples of Balzano (1983), Hummel (1980), Keel (1983) and Stauffer (1982). Of the 120 galaxies observed roughly 50% were detected in CO.

3. Results and Discussion

Interaction between galaxies is generally thought to be one of the prime causes for increased star formation. The resulting shocks would heat and compress the gas. In the denser parts of the clouds the gas would cool rapidly and fragment into new stars. Since CO is the second most common molecule formed in these clouds after H_2, and the easiest one to observe, it would be observable if we had a major outburst of star formation.

Nilson (1973) gives in his catalogue a note, "Pw", for each galaxy that he can identify with an optical companion. He describes the galaxies as a pair whenever there are no other nearby objects of similar size or brightness and it is deemed possible that they might form a physical pair. Among the surveyed galaxies 24 has such a designation, 17 of them are not detected in CO, i.e. 70%. Of course caution must be taken when interpreting the data since closeness on a photographical plate not necessarily means a physical one.

Tully (1988), though, gives in his catalogue a parameter called the local density ρ_{xyz}, the density of galaxies brighter than $M^{b,i}_B$= -16 in the vicinity of each entry in the catalogue. The local density at each specified location is

$$\rho_{xyz} = \sum_i \rho_i \,.$$ (see Tully for the def. of ρ_i)

An isolated galaxy will have ρ_{xyz} =0.06 galaxies Mpc^{-3} and in the center of the Virgo cluster the value will be 5 galaxies Mpc^{-3}. The mean result for galaxies within the survey that are at distances less than 40 Mpc (the limit of the catalogue) is:

detected in CO ρ_{xyz} =0.47 (47 galaxies)

not detected in CO ρ_{xyz} =0.58 (30 galaxies).

These values must also be taken with some caution since we have some ellipticals among the non-detections (we only expect low amounts of gas in ellipticals). If they are sorted out we get ρ_{xyz} =0.48 galaxies Mpc^{-3} (22 galaxies), i.e. essentially the same value as for the detections. It therefore seems like that we do not have any substantially different local environment between the two groups.

Within the sample we have 25 Starburst galaxies (chosen from Balzanos (1983) list), 15 Liners and 16 Seyferts. The detection rates among the different types are: Starbursts 15%, Liners 60%, Seyferts 30% (values have been rounded off). In other words, we find the smallest amount of molecular gas where we perhaps should expect the most. Either the star burst phenomenon is a rapid event where the clouds form stars efficiently or these galaxies are not what we think they are. They have been chosen because of their blueness and stellarlike nucleus and these criteria might simply express the lack of large amounts of gas. Also, if we believe in the star burst scenario, these bursts must occur several times to explain such Seyfert galaxies as NGC 1365 and NGC 7469 which both contains huge amounts of gas and both are strong infrared emitting galaxies.

References.

Balzano, V.: 1983, Astrophys. J. **268**, 602.
Hummel, E.: 1980, Astronomy & Astrophys. suppl. **41**, 151.
Keel, W.: 1983, Astrophys. J. suppl. **52**, 229.
Nilson, P.: 1973, Uppsala General Catalogue of Galaxies.
Stauffer, J.: 1982, Astrophys. J. suppl. **50**, 517.
Tully, B.: 1988, Nearby Galaxies Catalog.
Weedman, D.: 1983, Astrophys. J. **266**, 479.