CO in Early Type Galaxies

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During the last two years, observations of the molecular cloud content of early type galaxies have drastically changed our view of these systems as inert gas-poor galaxies with little or no star formation activity. Systematic surveys in the CO (J=1-0) line (Wiklind and Henkel, 1988a,b; Thronson, private communication) have shown that an IR selected sample of early type galaxies contains typically 10^7-10^8 $M_\odot$ of molecular hydrogen gas. This is similar to the typical HI masses found in these galaxies (Knapp et al., 1985; Wardle and Knapp, 1986).

The majority of the detections comes from a survey that we are conducting, using the IRAM 30-m telescope and the newly constructed SEST telescope in Chile. We have also incoporated results from Thronson (private communication), as well as NGC 185 (Wiklind and Rydbeck, 1986) and NGC 4472 (Huchtmeier et al., 1988). The H_2 masses have been computed from the CO integrated intensity, using a $N(H_2)/I_{CO}$ conversion ratio of $2 \cdot 10^{20}$ cm^{-2} (K km s^{-1})$^{-1}$. The distances have been derived from our measurements of the radial velocities, corrected for the Solar motion relative to the center of the Local Group and for the Virgocentric flow (Aaronson et al., 1982). We have adopted a Hubble constant of 100 km s^{-1} Mpc^{-1}, with an assumed distance of 13.5 Mpc to the Virgo cluster. Since both the conversion ratio and the assumed Hubble constant are "conservative", this means that the derived H_2 masses are lower limits, unless the molecular cloud properties of the early type galaxies are greatly different from those of the Milky Way.

For comparision with the molecular cloud properties of our sample of early type galaxies, we have from the literature compiled a list of the molecular cloud properties, as well as FIR and blue luminosities, for 123 spiral galaxies. In Figure 1 we show the H_2 mass distributions for the two samples (light bars for the spirals, dark bars for the early type galaxies). It is evident that the spiral sample, on the average, has about an order of magnitude more H_2 gas than the early type galaxies. A similar difference can be seen in Figure 2, which shows the distributions of the log(SFR). The star formation rate (SFR) can be derived directly from the FIR emission, as estimated by the IRAS, in a similar manner as Thronson and Telesco (1986). The SFR is here assumed to be directly proportional to the FIR luminosity: $SFR = 3.2 \cdot 10^{-10} L_\odot\ M_\odot\ yr^{-1}$. The typical star formation rates for the early type galaxies are around 0.1 - 1 $M_\odot$ yr^{-1}. In Figure 3 we have plotted the distributions of the ratio of F_{60}/F_{100}, as measured by the IRAS. Although the L_{FIR} (SFR) distributions are different by about an order of magnitude, the distributions of the dust temperatures appear to be the same. Since we do not belive that the dust properties are significantly different in the early type galaxies than in spiral galaxies, this result means that the heating mechanism of the dust is as efficient in the early type sample as in the spiral sample. This indicates that the efficiency of star formation in early type galaxies might be higher than for the spiral sample. In Figure 4 we have plotted the distributions of $\log(L_{IR}/L_{CO})$ for the two samples. The ratio of L_{IR}/L_{CO}, which is proportional to the ratio $SFR/M(H_2)$, is usually taken as a measure of the star formation efficiency (SFE). From this figure it is evident that *the SFE for the early type galaxies is, on the average, as high or possibly higher than that of the spiral galaxies.* This result may indicate that *spiral density waves are not necessary for efficient formation of massive stars.*

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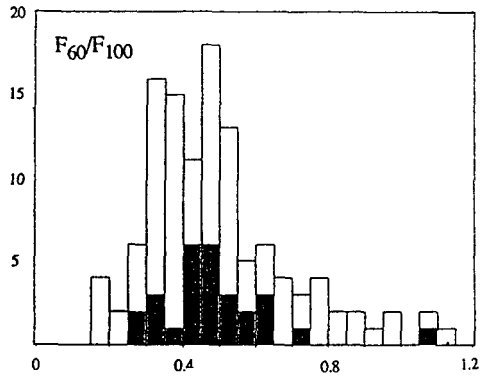

Figure 3

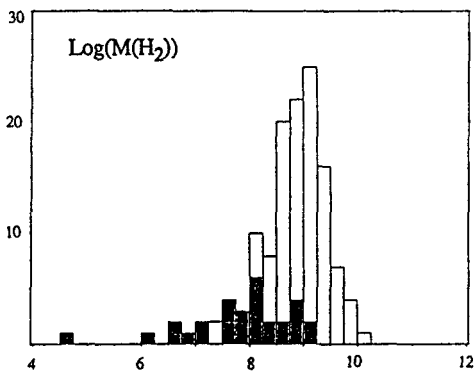

Figure 1

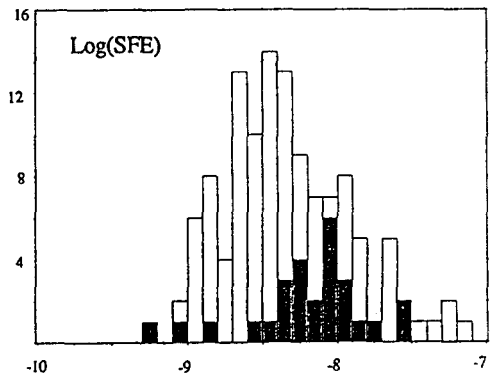

Figure 4

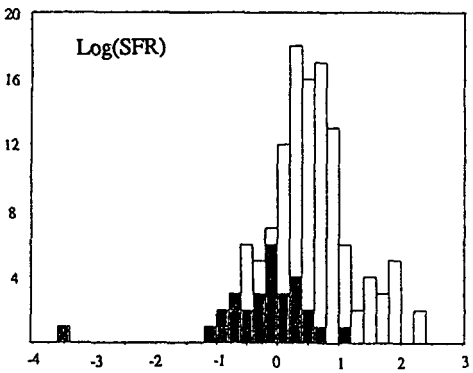

Figure 2

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