The Case of Missing ^{13}CO in Mergers

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We present a comparison of the ^{13}CO and ^{12}CO emissions of six systems of merging galaxies : NGC 828, NGC 3256, NGC 4194, NGC 6240, Arp 220, and Arp 299. The observations were made in both J=1–0 and J=2–1 transitions with the IRAM 30 m and SEST 15 m telescopes. In all galaxies but NGC 828, the ^{13}CO is much weaker than in spiral galaxies. Figure 1 shows the ^{12}CO (1–0) and ^{13}CO (1–0) lines observed towards NGC 828, while Fig. 2 displays the same lines for NGC 4194. The average emissivity ratios measured at the few kiloparsec scale are :

$$^{12}CO\ (1–0) / {}^{13}CO\ (1–0) \approx 30,$$
$$^{12}CO\ (2–1) / {}^{13}CO\ (2–1) \approx 40.$$

These values are significantly larger than those usually measured in normal spiral galaxies, which are always between 5 and 15 for the J=1–0 line.

We show that such a peculiar behaviour cannot be interpreted as due to the dominant presence of diffuse gas and it cannot be attributed to optically thin CO emission either. The faint ^{13}CO emission of mergers must result from either an underabundance of ^{13}CO or an overabundance of ^{12}CO. They may be accounted for by different mechanisms :

• ^{13}CO molecules are more easily photodissociated than ^{12}CO ones – however our observations seem to rule out physical conditions characteristic of photodissociation regions ;

• in the course of the merging, large amounts of unprocessed gas, with a high [$^{12}CO/^{13}CO$] abundance ratio, are driven from the external regions of the progenitor galaxies to the new nucleus ; this could increase the [$^{12}CO/^{13}CO$] ratio by a factor of 2 ;

• the interstellar medium can also be quickly enriched in ^{12}C – thus in ^{12}CO – by a factor of 2, due to selective nucleosynthesis of this isotope (vs. ^{13}C) in the massive stars born during the starburst.

The last two processes can thus significantly contribute to the weakness of the ^{13}CO lines. The high ^{13}CO-to-^{12}CO line ratios that we have measured are due to the deep transformations that take place in the interstellar medium during the merging and the starburst : indeed, the only object with nearly normal line ratios, NGC 828, appears less perturbed and active in star formation than the other sources in the sample. In most mergers, the faintness of the ^{13}CO emission may indicate that the conversion factor from ^{12}CO emissivities to H_2 column densities could differ substantially from the standard galactic value.

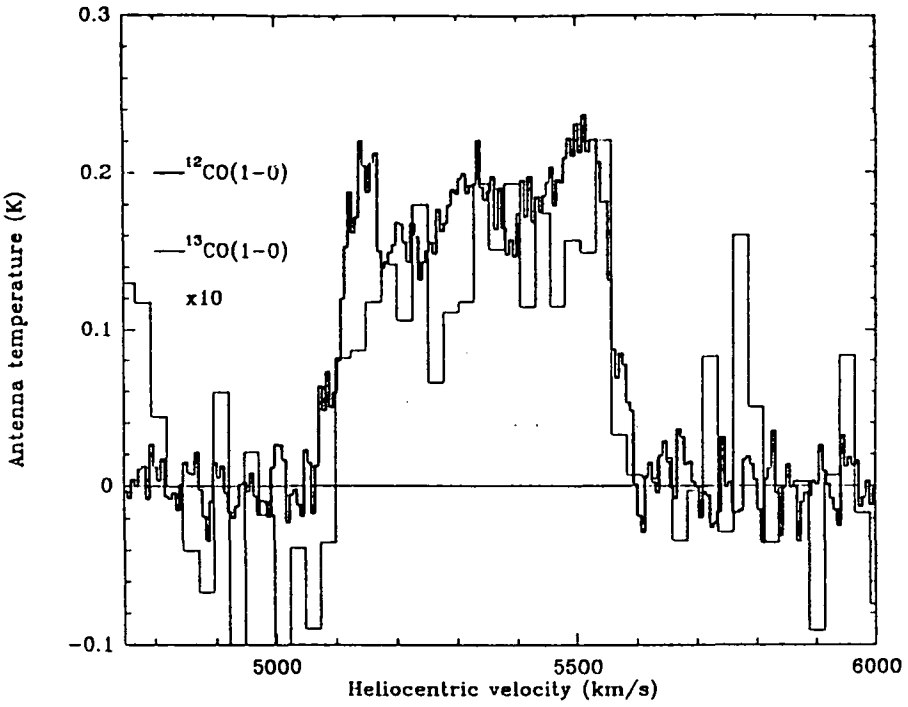

Figure 1 : The ^{13}CO emission of the merger NGC 828 is about 10 times weaker than its ^{12}CO emission, as found in normal galaxies (spirals).

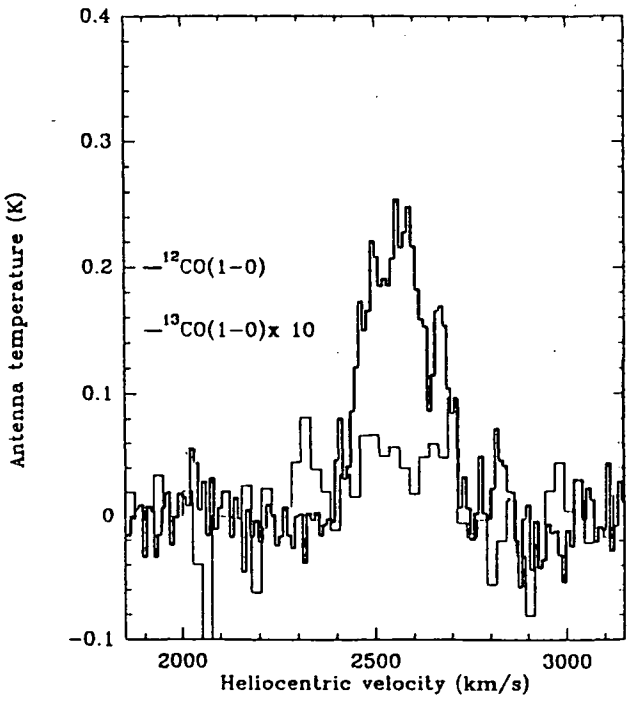

Figure 2 : The ^{13}CO line of the merger NGC 4194 is extremely weak : 55 ± 22 times weaker than the ^{12}CO line. This phenomenon is present in five mergers out of those six we have observed : NGC 3256, NGC 4194, NGC 6240, Arp 220, and Arp 299.