for example virial theorem masses.

Preliminary SEST CO results confirm the estimates by Cohen et al. (1988) that for the same amount of H_2, CO in the LMC is about five times weaker than in the Galaxy. In the SMC the limited data indicate CO to be of order ten times weaker. Curiously, the data in the 30 Doradus region show a trend for the CO to H_2 ratio in the LMC to be closer to Galactic for the largest and most massive clouds (Booth et al., 1989). Clearly, these results are only preliminary and need careful further investigation. The results are of importance, not only for our understanding of the Clouds, but also for interpretation of CO measurements of more distant (dwarf) galaxies.

Another area of interest, also with respect to photo dissociation models and the physical condition of the molecular interstellar medium, is that of the isotopic ratios $^{12}CO/^{13}CO$ and $^{13}CO/C^{18}O$. Under Galactic conditions and opacities, the first is of order 5–8. In the LMC, we have measured several CO emission peaks with $^{12}CO/^{13}CO$ ranging from 7 to 16, with a mean of 9. In the SMC, the (preliminary) mean appears to be around 12. The important result is not that these ratios are significantly higher than in Galactic objects, but rather that they are not even higher. In the one peak (N 159) where all three CO isotopes have been detected we find $^{12}CO : ^{13}CO : C^{18}O$ = 500 : 70 : 1 (Booth et al., 1989), which is unusually weak for $C^{18}O$. Again, more measurements and careful modelling are needed before final conclusions are drawn; such measurements are in progress.

Both the limited maps obtained during commissioning (Booth et al., 1988) and a several degrees long, fully sampled scan at constant right ascension through 30 Doradus, N 158, N 160 and N 159 show the presence of a significant, rather clumpy molecular complex, extending well southwards of optical objects such as N 159. The same complex, clumpy molecular cloud structure has been found to be associated with the large H II region complex N 11 in the northwest of the LMC, which has been fully mapped. Detailed studies of such regions are of importance, because combination of the molecular data with IRAS infrared maps, and abundant optical information yields insight into the large-scale process of star formation that gave rise to the existence of such H II region complexes.

In the SMC, it was found that IRAS sources were about the only reliable detection criterion for molecular emission. In this galaxy, CO is generally weak and predominantly seen in the southwest end of the bar, although clouds are present throughout the SMC. Several small clouds (about 30 pc in size) have been mapped in the SMC, notably those associated with the H II regions N 12, N 27 and N 88. Mapping of the southwest bar, and of individual clouds throughout the SMC is in progress, but the going is slow because of the weak CO signals, and consequently long integration times (of the order of 30 minutes per point) needed.

The above is merely a first glimpse of the molecular population of our nearest extragalactic neighbours in space. Much work remains to be done before the important questions on physical conditions and processes can be answered with confidence. This first glimpse, however, is an exciting preview of things to come.

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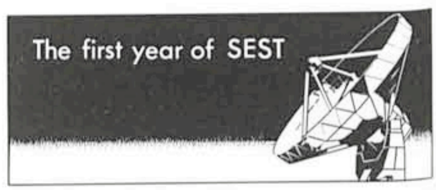
CO Isotopic Emission and the Far-Infrared Continuum of Centaurus A



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Introduction

Centaurus A (NGC 5128) is a peculiar elliptical galaxy with a prominent dust lane. At a distance of about 3 Mpc (*The Messenger* No. **44,** p. 1) it is the closest radio galaxy, and to date it has been observed in almost every accessible wavelength band. Here we report on recent measurements with the SEST telescope which have contributed to our understanding of the molecular interstellar medium in this spectacular object.

First we briefly describe the status of the observations at other wavelengths. The cm-radio emission of Centaurus A is characterized by a compact milliarcsecond core (Kellermann 1974, Shaffer and Schilizzi 1975) and, on larger angular scales, a jet extending over several arcminutes (Burns et al., 1983) with giant radio lobes on either side of the dust lane. The warped dust lane (Bland et al., 1987) and a system of faint, narrow shells around the elliptical galaxy (Malin et al. 1983) suggest that Centaurus A is a relaxed remnant of a merger of a disk and an elliptical galaxy. Centaurus A is also a strong source in the X-ray (Feigelson et al., 1981) and γ-ray domain (von Ballmoos et al., 1987). Observations prior to 1983 are summarized in the review article by Ebneter and Balick (1983).

Investigation of the interstellar medium in Centaurus A has begun only recently. A map of the 21-cm H I emission, which traces the bulk of the atomic gas, has been obtained by van Gorkom (1987). The molecular interstellar medium can be traced by line emission of CO, the second most abundant molecule in the universe. The ^{12}CO J = 2-1 emission in the dust lane has been partially mapped by Phillips et al. (1987) at the CSO in Hawaii. Furthermore at the nucleus the 158 μm [C II] fine structure line has been measured (Crawford et al., 1985). This is one of the brightest far-infrared cooling lines and is indicative of photoionization regions which originate when strong UV light illuminates the surfaces of adjacent molecular clouds.

Observations with SEST

Since Centaurus A is a southern source, the SEST telescope is ideally placed to investigate its millimetre and submillimetre radiation and, to date, two independent observing programmes have been carried out in order to study the molecular interstellar medium. This phase of the interstellar medium is of particular interest since it is intimately related to the star-formation process in galaxies. Eckart et al. (1989) obtained a complete map of the ^{12}CO J = 1-0 line emission (Fig. 1) and measured the ^{12}CO J = 2-1, ^{13}CO J = 1-0, and the $C^{18}O$ J = 1-0 lines at selected positions. Israel et al. (1989) have studied the absorption

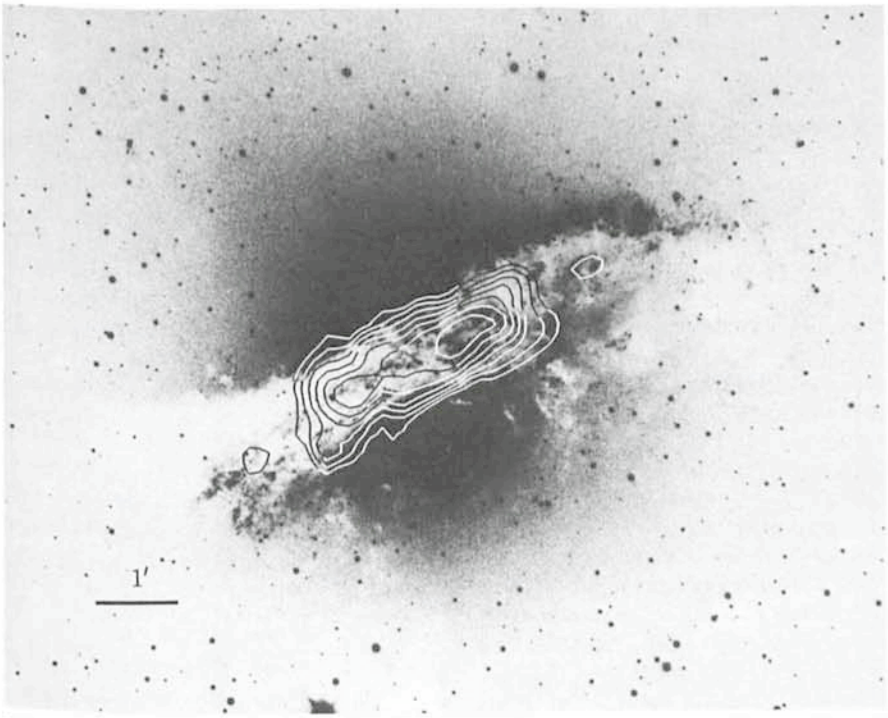

Figure 1: *Contour map of the integrated ^{12}CO J = 1-0 emission of Centaurus A superimposed on an optical image. The emission is well concentrated along the dust lane. Contour intervals are 17.5, 22.5, 27.5, . . . K km s^{-1}. The peak intensity is 54 K km s^{-1}.*

features in the CO lines against the nuclear continuum source.

The main results of these observations are that the bulk molecular material is closely associated with the dust lane and contained in a disk of about 180″ diameter with a total molecular mass of about 2 10^8 $M_\odot$. The total molecular mass of the disk and bulge is of the order of 3 10^8 $M_\odot$. The molecular gas in the nucleus is warm with a kinetic temperature of the order of 15 K and a number density of 10^3 to 3 10^4 cm^{-3}. Absorption features in the ^{12}CO and ^{13}CO lines against the nuclear continuum indicate that the properties of giant molecular clouds are comparable to those in our Galaxy.

Comparison with Other Data

The molecular data have been combined with 100 μm and 50 μm far-infrared emission of Centaurus A in order to study the variations in the gas and dust distributions (Eckart et al., 1989). These far-infrared data were taken with the CPC instrument on board IRAS and show that the dust temperature in the dust lane is about 42 K. The ratio between the far-infrared luminosity and the total molecular mass is 18 $L_\odot/M_\odot$ which is close to the mean value obtained for isolated galaxies. For giant molecular cloud complexes in our Galaxy, this ratio is of the order of 1 to 10 $L_\odot/M_\odot$. A comparison of the ^{12}CO J = 1-0 and the far-infrared data indicates that a considerable amount (about 50 %) of the far-infrared emission at 100 μm is not intimately associated with massive star formation. This emission is larger in extent than the molecular disk and is probably due to diffuse gas clouds in Centaurus A, similar in nature to the "cirrus" emission in our Galaxy.

The absorption features detected in the CO emission lines are coincident with known H I, C_3H_2, and H_2CO absorption lines, although the molecular content of gas in red and blue shifted clouds (with respect to the centre velocity of v_{LSR} = 550 km s^{-1}) seem to be different. A combination of new molecular data obtained with the SEST, H_2 emission from an unresolved nuclear source measured with the 3.6-m telescope at La Silla (Israel et al., 1989), and literature data suggest that the nucleus of Cen A is surrounded by a disk of 2 10^7 $M_\odot$. Such a disk, with an outer edge radius of 160 pc and with a density distribution of $n \propto r^{-2}$, is consistent with all existing observations of the nuclear region of Centaurus A.

Future observing programmes that are currently in progress or have already been scheduled will investigate the distribution of the molecular material with the highest possible spatial resolution, the molecular line emission in high density tracers – such as HCN, CS, and HCO^+, as well as the absorption features in those species. A combination and detailed analysis of these data will cast more light on the nature of the interstellar medium and star formation in Centaurus A and elliptical radio galaxies in general.

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Molecules in External Galaxies

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The 15-m SEST telescope is the unique facility to study with high resolution the molecular component of galaxies in the southern sky. One could object that galaxies in the northern sky already give a large enough sample to investigate, but there are outstanding objects that can only be studied from the southern hemisphere; apart from the obvious Magellanic Clouds, it is well