Other prominent emitters of sub-mm radiation are external galaxies. Their stellar population heats the galactic dust to temperatures of 20 to 40 K. From the amount of dust one may calculate how much gas is contained in a particular galaxy. This quantity is very important because it finally determines how many stars can be created and how bright the galaxy appears in the sky. We observed a number of galaxies only accessible from the southern hemisphere in order to study the global star formation in these objects.

SN 1987 A Detected!

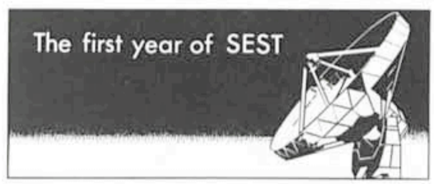
As mentioned above, observing conditions improved during the nights and they were best a few hours after midnight. That was the time when all colleagues had gone to bed and the Large Magellanic Cloud came into the field of view. Knowing all the limitations given by the imperfect performance of the telescope, on the one hand, but trusting in the excellent sensitivity of our bolometer, on the other hand, I "wasted" a few hours before sunrise and pointed the SEST towards SN 1987 A, the most spectacular event in the southern hemisphere. There was no idea at that time what signal could be expected from this object at 1.3 mm but everybody agreed that it must be extremely faint. In addition, at that time there had been no detections at wavelengths longer than 20 μm so that it was quite a challenge to try the supernova.

During the integration I was carefully watching the strip chart recorder. Sometimes, I had the impression that the pen moved in the right direction when the telescope switched from the source to the blank sky, but this could as well have been a product of my imagination. Nevertheless, after the third night of staring at the strip chart I was sure that there was a faint signal from SN 1987 A. Meanwhile our software specialists had reached a stage where they could reduce – to a limited extent – the bolometer signals from SEST. Of course, the first data I suggested looking at were those of the supernova. After a few hours, there was something to celebrate: we had detected very weak 1.3-mm emission from SN 1987 A of 29 mJy! To exclude a possible contamination by emission from the LMC, we observed two additional nearby positions, however, without any significant signal. This was the final proof that the observed flux was indeed coming from the supernova.

The origin of this radiation is not quite clear because both emission from hot dust as well as free-free emission from the ionized outer part of the former star may contribute. Combining our data with observations at other wavelengths we come to the conclusion that most of the 1.3-mm flux density is due to free-free emission; dust has formed in the former star's envelope and must be distributed in an extremely clumpy manner. Of course, it will be of interest to study the development of SN 1987 A at sub-mm wavelengths in the future and to verify this interpretation. Unlike in other spectral regions – SEST will be the only choice for that purpose in the southern hemisphere.

CO Observations of the Magellanic Clouds

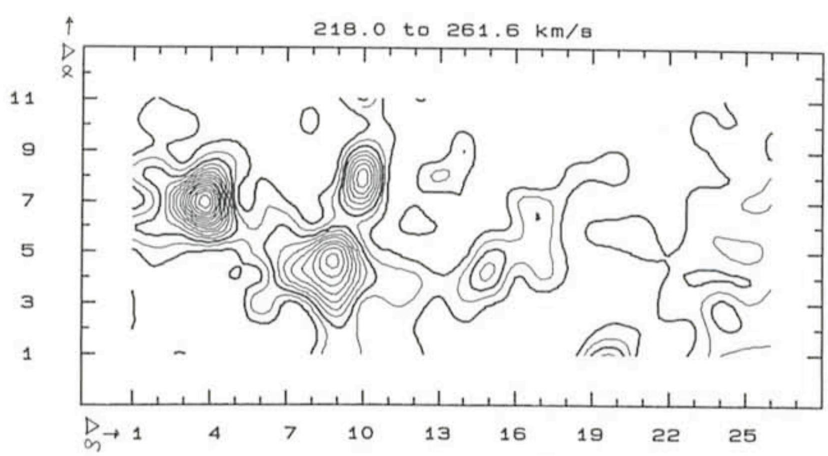
F. P. ISRAEL, Sterrewacht Leiden, the Netherlands



The commissioning of the SEST on La Silla has opened up a new era in the study of the interstellar medium in the Magellanic Clouds. With this telescope, for the first time extensive, detailed studies of the (CO) molecular component of the clouds has become possible. Previously, a rather limited number of sightlines had been sampled with resolutions of 1 to 2 arcmin (see review by Israel, 1984), and a CO map covering the whole LMC, but with a coarse resolution of 8 arcmin (125 pc) was obtained from Cerro Tololo (Cohen et al., 1988).

The SEST, with its 40 arcsec beam at the J = 1-0 ^{12}CO transition and its large aperture, yielding a high sensitivity, thus is a major step forward. It was immediately realized by ESO and by Sweden that a major target for the SEST would be the Magellanic Clouds, objects unique to the Southern Hemisphere, but that a systematic study would require a large block of observing time owing to the large angular dimensions of the Clouds (LMC: 720 SEST beams across; SMC: 180 beams across). This led to the designation of an ESO-Swedish SEST Key Programme 'CO study of the Magellanic Clouds', and the formation of a consortium headed by L. E. B. Johansson (Onsala) and F. P. Israel (Leiden) to conduct this programme.

The programme aims at a systematic study of the CO content of the Magellanic Clouds. Several aspects are of importance. Foremost is a determination of the CO to H_2 ratio, as H_2 is the major molecular component of the interstellar medium, thought to be present in galaxies in amounts comparable to those of H I. This ratio is almost certainly lower than Galactic in low-metallicity, UV-rich galaxies such as the Magellanic Clouds due to stronger photodissociation in such environments. Clue to this important ratio can be obtained from a comparison of (area, position) integrated CO intensities with



Map of the N 160/N 159 region in the LMC in the J = 1-0 ^{12}CO transition integrated over the velocity range 218 to 261 km/s. The two CO clouds slightly left of the centre of the map are associated with N 159. The bright CO cloud at the left is located in a visually inconspicuous region between N 159, N 172 and N 173. The much weaker CO cloud just right of the centre is associated with N 160 (from Booth et al., 1989).

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.

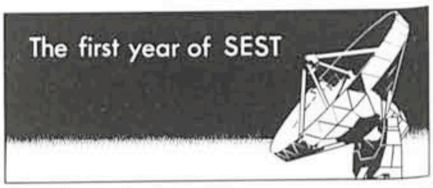
References

Booth, R.S., et al., 1989, *Astr. Astrophys.* in press.

Cohen, R.S., et al., 1988, *Astrophys. J.* (Lett) **331,** L95.

Israel, F.P., 1984 in: *Structure and Evolution of the Magellanic Clouds,* IAU Symp. 108, Eds. S. van den Bergh and K.S. de Boer, Reidel, p. 319.

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



A. ECKART, Max-Planck-Institut für Physik und Astrophysik, Institut für Extraterrestrische Physik, Garching, F. R. Germany

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