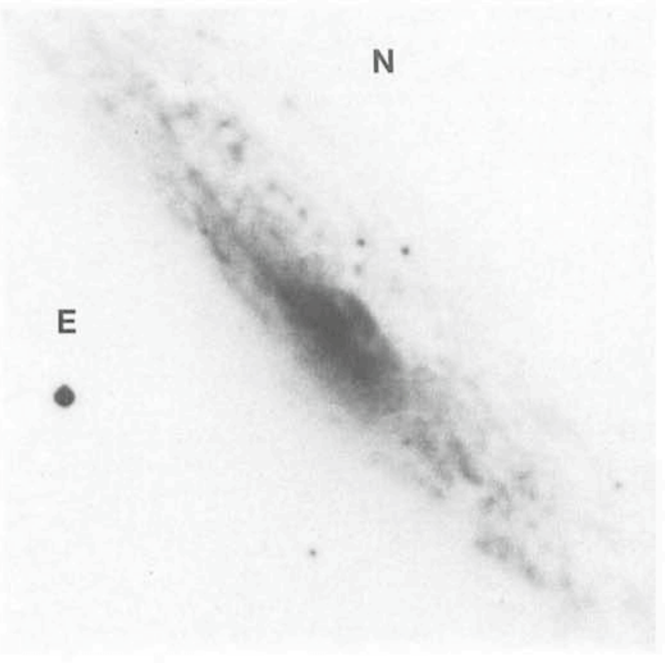

Fig. 2: *The Sc galaxy NGC 1448. The star 25" E, 5" S of the nucleus is the recently discovered supernova (IAU Circ. 3877, 3878). This is a CCD picture obtained on October 27/28, 1983, by O.-G. Richter and H. Pedersen with the 2.2 m telescope. The seeing was ~ 0".7. The field is ~ 60" square, the pixel size is 0".36.*

in a photographic mode. The seeing was for the most part better than 1 arcsec and all instruments seemed to perform at the expected levels.

At the present stage we are working towards the final adjustments in order to make use of all automatisms foreseen for the next observing period. We have good reason to believe that the telescope will be fully operational on January 1, 1984, as planned, and that European astronomers will then be able to take full advantage of this powerful new telescope in Chile.

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

GIORDANO, Paul (F), Optical Technician, 1.11.1983
REISS, Roland (D), Electronics Engineer, 21.11.1983
JENSEN, Bjarne (DK), Electronics Engineer, 1.1.1984
LOPRIORE, Sergio (I), Mechanical Engineer, 16.1.1984
GROTE, Rainer (CH), Project-Draughtsman, 1.3.1984

Chile

LINDGREN, Harri (S), Astronomer, 1.10.1983
URQUIETA, Arturo (USA), Senior Optical Technician, 1.10.1983
KAABERGER, Ulf (S), Electro-mechanical Engineer, 16.10.1983
LE SAUX, Paul (F), Instrumentation Engineer, 8.11.1983

Departures

Europe

KAZIMIERZAK, Bohumil (B), Mechanical Engineer, 29.2.1984

Chile

MULLER, André (NL), Senior Astronomer, 30.9.1983

FELLOWS

Arrivals

Europe

SURDEJ, Jean (B), 1.10.1983
ANGEBAULT, Louis (F), 1.1.1984
JÖRSÄTER, Steven (S), 16.1.1984

Chile

CHALABAEV, Almas (F), 1.3.1984

Departures

Europe

KOTANYI, Christopher (B), 30.11.1983

ASSOCIATES

Departures

Chile

GREGORY, Thomas (USA), 22.11.1983

Infrared Continuum and Radio Molecular Line Studies of Circumstellar Shells

Nguyen-Q-Rieu, N. Epchtein and T. Le Bertre, Observatoire de Meudon

Introduction

Long-period variables radiate most of their energy in the near and mid-infrared regions. The energy distribution of Mira variables peaks around 2 μm and the well known infrared source IRC+10216 is very bright between 2 and 20 μm. Many late-type stars are not seen at optical wavelengths but appear as strong infrared objects. Re-emission of stellar radiation by warm circumstellar grains is responsible for the infrared continuum flux. Both visible and unidentified infrared cool stars also emit radio molecular lines which are excited by collision with molecular hydrogen or by infrared radiation. Combined infrared and radio observations are therefore of great interest to determine molecular excitation processes.

Late-type stars are characterized by the mass-loss phenomenon. Matter is continuously expelled from the star through a combination of mechanisms such as shock heating and radiation pressure on grains. This can result in a stratification of the circumstellar shell, and molecular line emission serves as probes of physical conditions in different layers. In particular, SiO maser emission (rotation lines in ground and excited vibrational states) and infrared vibration-rotation molecular lines which are excited in extreme conditions, i.e. high gas density and temperature, arise near the stellar photosphere. By contrast, millimetre thermal emission of CO and linear carbon chain molecules, the cyanopolyynes $HC_{2n+1}N$, takes place in the stellar envelope at about 10 to 10^3 stellar radii (Fig. 1). Different shell layers can be sampled by observing appropriate molecular transitions.

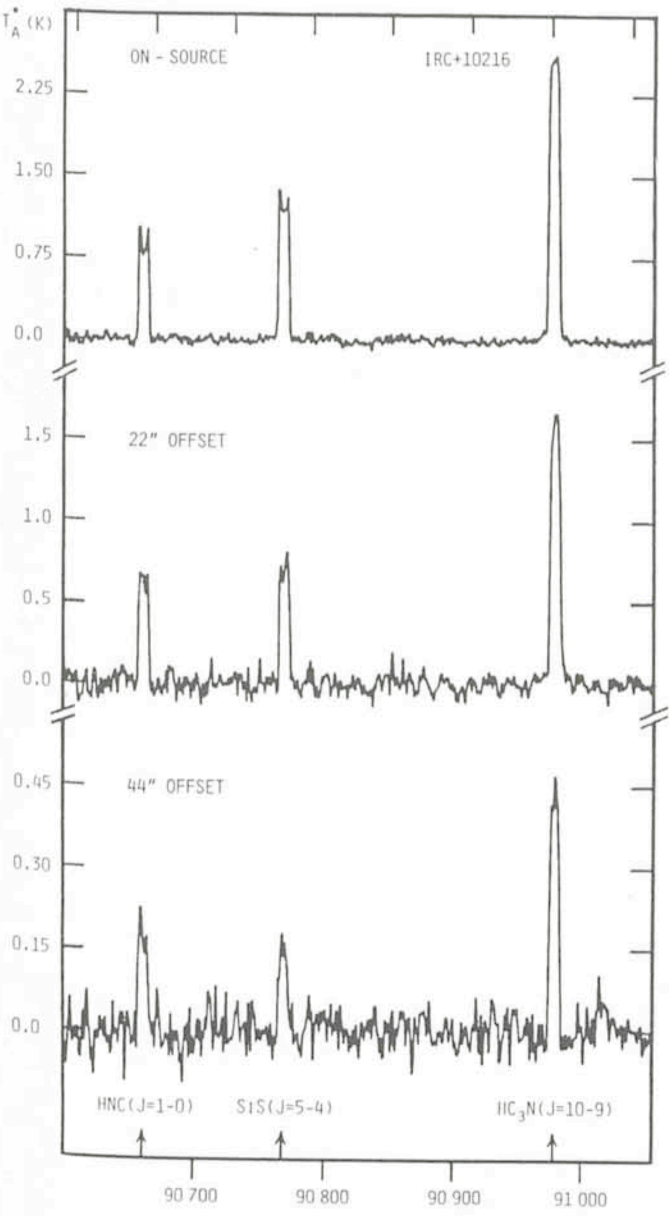

Fig. 1: *Simultaneous observations at 3.3 mm with the 20 m radio telescope of the Onsala Space Observatory (Sweden) of the rotational transitions of hydrogen isocyanide, HCN (J = 1–0, silicon monosulfide, SiS (J = 5–4) and cyanoacetylene HC_3N (J = 10–9) toward and at two offset positions from the Carbon star IRC + 10216 (from Olofsson et al. 1982 [6]). Note that the line is broad (full width at zero power ~ 30 km s^{-1}), suggesting that the circumstellar shell is expanding at a velocity of ~ 15 km s^{-1}.*

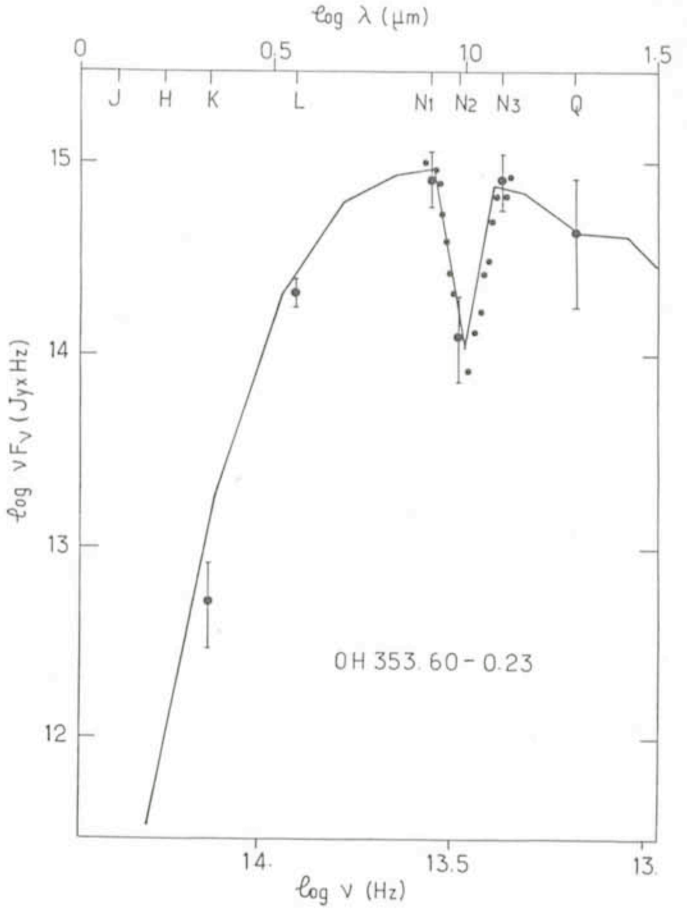

Fig. 2: *Infrared spectrum observed at La Silla of the OH maser source OH 353.60–0.23. The solid curve is derived from radiative transfer calculations (see text) and corresponds to the best fit to the observational data (filled circles). Data (small dots) in the silicate dip (~ 10 μm) were obtained with a higher resolution, λ/Δ λ~ 50.*

Infrared Continuum

We have performed infrared photometric and spectrophotometric observations between 1 and 10 μm in a number of late-type stars, using the 1 m and 3.6 m ESO telescopes at La Silla. The selected objects encompass a variety of microwave characteristics, from strong OH, H_2O and SiO masers (oxygen-rich stars) to weak CO, HCN and cyanopolyyne thermal emission sources (carbon-rich stars). As an illustration, we discuss two cases: the OH maser, OH 353.60–0.23, and the thermal molecular line emitter, IRC+10401.

The infrared counterpart of the OH maser, OH 353.60–0.23, has been detected by Epchtein and Nguyen-Q-Rieu (1) during a search for infrared emission from maser sources in the southern galactic plane, at La Silla. Fig. 2 shows the energy distribution in the near and mid-infrared region (2). The strong dip around 10 μm corresponds to the silicate feature which is the signature of an oxygen-rich star.

IRC+10401 is one of the reddest cool stars with a colour index J–K = 5. There is no evidence of any silicate feature in the spectrum obtained at La Silla (Fig. 3), suggesting that this source is a carbon star.

The circumstellar shell of both sources is so thick that the central star is barely visible.

Molecular Line Emission

OH emission from OH 353.60–0.23 has been detected by Caswell et al. (3). The 1612 MHz line (one of the 4 OH hyperfine transitions in the Λ- doublet of the ground state) is inverted and corresponds to a maser spectrum with two narrow spikes at the wings. These maser peaks arise from the material confined in a narrow double cone whose apex is the central star and whose axis is aligned along the line of sight where the amplification is maximum (4).

IRC+10401 is not an OH maser source, but exhibits thermal emission. We have detected, in collaboration with Olofsson and Johansson (Onsala Space Observatory), thermal HCN and CO line emission in the millimetre wavelength, using the Onsala (Sweden) 20 m radio telescope (6). The HCN (ground-state rotational transition J=1–0) at 3.4 mm is very broad (full

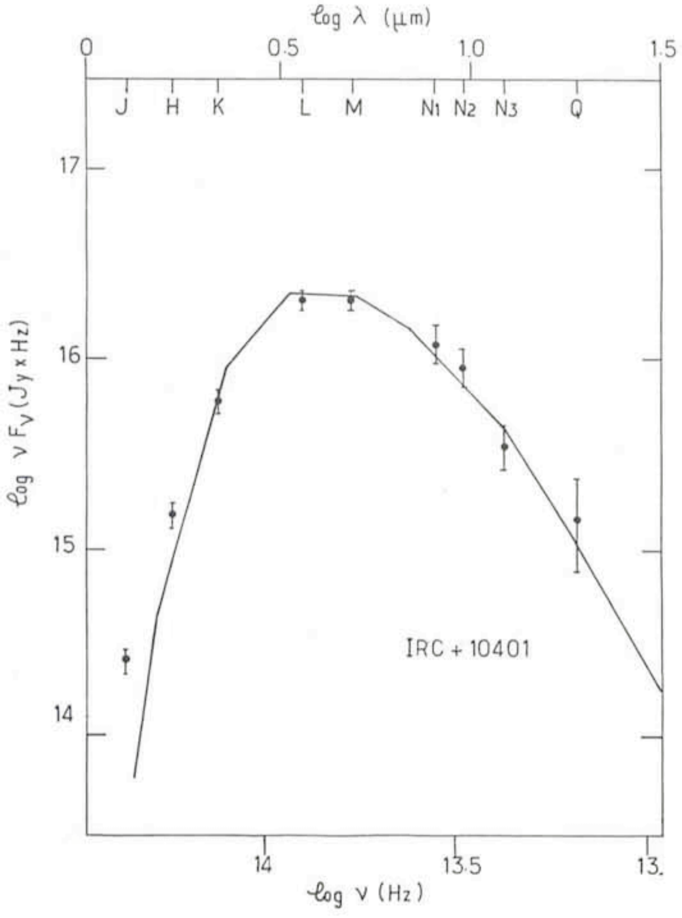

Fig. 3: *Infrared spectrum observed at La Silla of IRC + 10401, an unidentified infrared source, which emits thermal molecular line emission in the millimetre range. The legends are the same as in Fig. 2. No silicate feature is detected.*

width at zero power ~ 80 km s^{-1}), suggesting that the circumstellar shell is expanding at a velocity ~ 40 km s^{-1}, which is approximately equal to half of the linewidth. However, the spectrum can be affected by the presence of blended HCN quadrupole components. The expansion velocity can therefore be slightly smaller.

Shell Parameters

We derive the shell parameters by performing radiative transfer calculations similar to those developed by Leung (5). We assume that the shell is expanding uniformly and the stellar temperature is 2,000–2,500 K. With reasonable assumption on grain characteristics (dirty silicate or graphite), distance (usually kinematic) and gas to dust ratio (~ 100), the fit of the calculated emergent IR spectrum to the observed data gives information on the shell physical conditions. For OH 353.60–0.23, we derive a stellar luminosity, $L_* \sim 8\times10^4 L_\odot$, a dust mass-loss rate, $\dot{M} \sim 3\times10^{-6} M_\odot$/yr. The gas density which is assumed to vary as $1/r^2$ is ~ 10^8 cm^{-3} in the inner region. This quantity as well as the infrared flux are very important in the determination of the excitation of the molecular lines (2). Whereas the optically thick CO line is excited by collision with H_2, the OH and HCN lines are excited by radiation. In the case of HCN, the molecules are excited from the ground-state to higher vibrational states through the absorption of infrared photons. Subsequent cascades will populate high-lying rotational levels of the ground vibrational state, leading to the emission of millimetre lines.

Conclusion

Infrared and radio molecular line observations provide invaluable information not only for the investigation of the shell parameters but also for the understanding of the physical processes in the circumstellar material, namely the excitation of molecular lines. Late-type stars undergo periodic intensity variation in both infrared continuum and infrared and radio molecular line emission. Molecular species, such as SiO, which have high dipole moment (μ_{SiO}~3 Debye) are very sensitive to radiation. The change of the line shape as a function of the stellar phase (period of infrared light curve ~ 300–700 days) merely reflects the variation of the stellar flux. Time monitoring studies in the infrared and millimetre molecular line emission is thus of great importance to elucidating the interaction through the mass-loss phenomenon between the innermost and outer parts of the circumstellar envelope.

References

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(3) Caswell J. L., Milne D. K., and Wellington K. J., 1981, *M.N.R.A.S.* **195,** 89.
(4) Nguyen-Q-Rieu, Laury-Micoulaut C., Winnberg A., and Schultz G. V., 1979, *Astronomy and Astrophysics* **75,** 351.
(5) Leung C. M., 1975, *Astrophysical Journal* **199,** 340.
(6) Olofsson H., Johansson L. E. B., Hjalmarson A, Nguyen-Quang-Rieu, 1982; *Astronomy and Astrophysics* **107,** 128.

"To UGC 6697. – When you reach the point where all reasonable assumptions seem not to fit with the observed facts: the rotation curve looks like that of a frisbee, the spectral index like that of a fire-work and the morphology seems the one of a Havana cigar . . . then it is perhaps better to take a few days off and look for radical alternatives." (Painting by Beffo Gavazzi.)