INVESTIGATION OF CIRCUMSTELLAR SHELLS BY MID-INFRARED HETERODYNE SPECTROSCOPY

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Heterodyne spectroscopy at 11 μm combines high spectral resolution ($\lambda/\Delta\lambda \sim 10^6$), high spatial resolution (< 1 arcsec at 3 m telescopes) and high penetration depth. Therefore, it seems promising to use it also for the investigation of bright circumstellar atmospheres.
We have used our heterodyne spectrometer (Rothermel et al. 1983) for preliminary observations of a number of sources (Schrey 1986). In the following the observation of IRC 10216 will be discussed, where a few absorption lines of silane (SiH_4) have been observed (Fig. 1).
Fitting the experimental data to the relation:

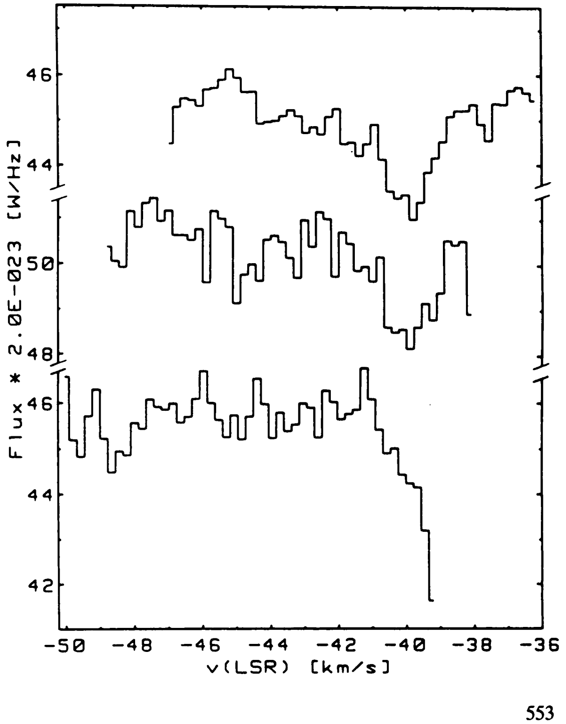

Fig. 1: Silane absorption lines in IRC 10216

Transition, frequency ν, equivalent width W:

$-P^{+}(4)F_2 \leftarrow F_1$:
26939885±3 MHz, 15±3 MHz
$-Q^{\circ}(8)F_2 \leftarrow F_1$:
27043262±10 MHz, 7±2 MHz
$-P^{+}(5)F_2 \leftarrow F_1$:
26835800±200 MHz, 8±4 MHz

The spectral resolution is 0.2 km/sec, the integration time per spectrum 2000 sec.

I. Appenzeller and C. Jordan (eds.), Circumstellar Matter, 553–554.

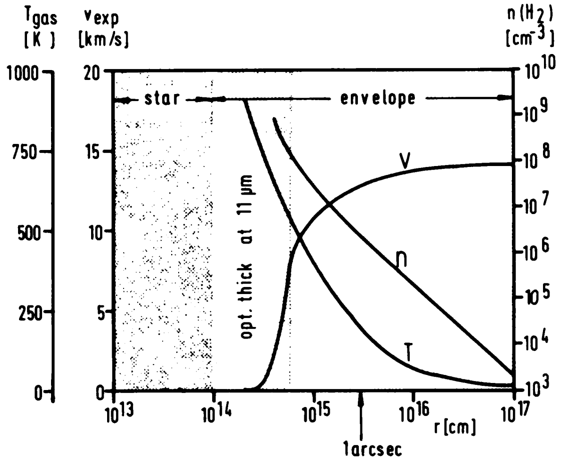

Fig. 2: H_2 density n, gas temperature T, and expansion velocity v as a function of the distance r from the star. The model of Lafont et al. 1982) is used with the asymptotic expansion velocity (14 km sec^{-1}) from Huggins and Healy (1986).

$$W/g\nu \sim N \exp(-E/kT_{rot})$$

with E, g the energy and statistical weight of the absorbing level, one obtains the rotational temperature T_{rot} and column density N:

$$T_{rot} = 140 \pm 30 \text{ K}, \quad N = (8.5 \pm 1.3)\cdot 10^{14} \text{ cm}^{-2}$$

A short interpretation of our measurement follows on the basis of Fig. 2.

The location (i.e. shell radius r) of the absorbing silane can be obtained:

- from the measured centroid velocity(13.5km/sec): $r=8.10^{15}$cm
- from T_{rot}, which equals the kinetic temperature: $r=5.10^{15}$cm
- from the range of expansion velocities over the length of the absorbing column, if given by the line width: $4.10^{15} < r < 10^{16}$cm. Since no absorption at lower expansion velocities has been found, SiH_4 has been formed at r, probably by radical reactions on silicate grains. Similar molecules are formed in that region, e.g. CH_4 (Clegg et al. 1982). The ratio of silane to molecular hydrogen is 4.10^{-7} for $r \sim 3.10^{15}$cm. The solar Si/H ratio is 4.10^{-5}. The amount of Si locked up in SiH_4 is comparable to that in SiS and larger than that in gaseous SiO (Lafont et al. 1982).

Our measured continuum flux($1.4\cdot 10^4$ Jy) can be compared with the IRAS 12 μm band value($2.4\cdot 10^4$). This flux is due to an optically thick dust shell with a radius of 6.10^{14} cm and a temperature of 500 K.

References:

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