THE OH CIRCUMSTELLAR MASER IN LATE-TYPE STARS

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A recent investigation based upon the OH luminosity distribution (Nguyen-Q-Rieu et al. 1979) has shown that Type I OH sources associated with Mira variables (OH Miras) are weak OH sources and are therefore only detected within ~ 1 kpc from the Sun. Type II OH-Miras, which are more intense and rarer than Type I OH-Miras, are probably more distant objects. The group of unidentified Type II OH-IR sources probably consists of Type II OH-Miras of high OH luminosity. The IR colour index, which is usually higher for Type II sources, suggests that they have a colder and denser dust shell.

High maser gains ($\tau \sim -20$) can be obtained for the 1612 MHz line (Type II sources) from a model of radiative pumping by far-IR radiation from cold dust (grain temperature $T_g \sim 120$ K) (Elitzur et al. 1976). The pumping of the main lines (Type I sources) is difficult to achieve without invoking some asymmetrical effects which invert the lambda-doublets (Bujarrabal et al. 1980a). The most powerful inversion process is based on the IR line overlap (see also Lucas 1979). We have investigated such an effect in the case of a large-scale velocity field in an expanding circumstellar shell of radius R and thickness ΔR, using the Sobolev approximation to treat the radiative transfer (Bujarrabal et al. 1980b). The velocity field is $V(r) = V_M\ (r/R)^{\varepsilon}$. The IR radiation field due to dust can be expressed as

$$I_\lambda = (2h\nu^3\ W/c^2)\quad (80/\lambda\mu)^p\ (e^{h\nu/kTg}-1)^{-1}\ .$$

W represents the averaged optical depth of dust grains at 80 μ.

The results of calculations are given in the Figure as a series of curves, displaying the OH optical depth as a function of $n_{OH}r/V$; n_{OH} is the OH volume density. The following conditions have been assumed:

$$\varepsilon = 0.25;\ W = 5.10^{-4};\ p = 2;\ T_g = 350\ \text{K};\ V_M = 5\ \text{km s}^{-1};\ \Delta R = 0.5\ R$$

The kinetic temperature T_K and the hydrogen density n_{H_2} are taken equal to 100 K and 10^5 cm^{-3}, respectively. In these conditions, the

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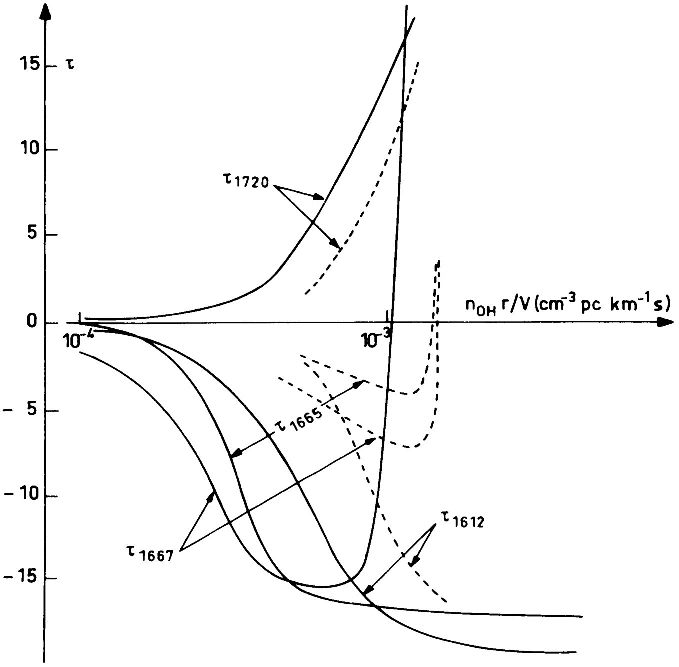

influence of various collisional laws is of little importance, since the pumping is essentially radiative (see also Omont 1979). We have assumed equal downward transitions between magnetic sublevels. The Figure shows that when IR overlap is taken into account (full line curves), the optical depths of the main lines and the 1612 MHz line are increased by a factor of 2 to 3 with respect to the case of no overlap (dashed line curves). The efficiency of the pumping by line overlap can be estimated by calculating the 35μ flux required to achieve a main line optical depth $\tau \sim -15$. The IR flux F is equal to $I_{35\mu}\Omega$; Ω corresponds to the angular size of the OH shell. For a linear diameter $\sim 10^{16}$ cm and a heliocentric distance $\sim$1 kpc, $F_{35\mu}$ is $\sim$7.5 Jy, which is much smaller than the IR flux expected to be observed in Mira variables (Nguyen-Q-Rieu et al. 1979). In the absence of overlap, the 35μ flux would be $\sim$10 times higher. Therefore, the line overlap pumping can be very efficient in the envelope of Mira variables.

REFERENCES

Bujarrabal, V., Destombes, J.L., Guibert, J., Marliere, C., Nguyen-Q-Rieu, Omont, A.: 1980, Astron. Astrophys. (in press).
Bujarrabal, V., Guibert, J., Nguyen-Q-Rieu, Omont, A.: 1980, Astron. Astrophys. (submitted).
Elitzur, M., Goldreich, P., Scoville, N.: 1976, Astrophys. J. 205, 384.
Lucas, R.: 1979, paper published in these Symposium Proceedings.
Nguyen-Q-Rieu, Laury-Micoulaut, C., Winnberg, A., Schultz, G.V.: 1979, Astron. Astrophys. 75, 351.
Omont, A.: 1979, paper published in these Symposium Proceedings.