THE PUMPING OF INTERSTELLAR OH MAIN LINE MASERS: AN EFFICIENT MECHANISM

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Hyperfine components of the far-infrared lines of OH are separated by velocity intervals ranging from about .6 to 8.0 km s^{-1} (fig. 1). As early as 1969 Litvak had suggested that overlapping of these components due to either thermal or systematic motions could be the source of OH main line inversion. We investigate here the effects of overlapping due to systematic motions.

Our study is restricted to the rather simplified scheme of a quiescent maser cloud pumped by a hot neighbouring cloud moving with a velocity v (-10 to +10 km s^{-1}) with respect to the maser cloud. Any line overlap due to thermal or microturbulent random motions inside the maser cloud is neglected. The spectrum emitted by the pumping cloud is calculated assuming LTE (temperature T_p), Doppler thermal broadening, and a column density of molecules N_p. The 28 lowest levels of OH are included in the computations. Dust emission and collisions with charged and neutral particles are treated in the same way as by Guibert et al. (1978). The radiative transfer in the maser cloud is treated in the following way: for non-maser transitions we use the standard escape probability method (Goldreich and Kwan 1974); for the maser transitions we use a generalization of the spherical maser solution of Goldreich and Keeley (1972) to compute the maser brightness temperature as a function of the unsaturated maser parameters (gain and source function).

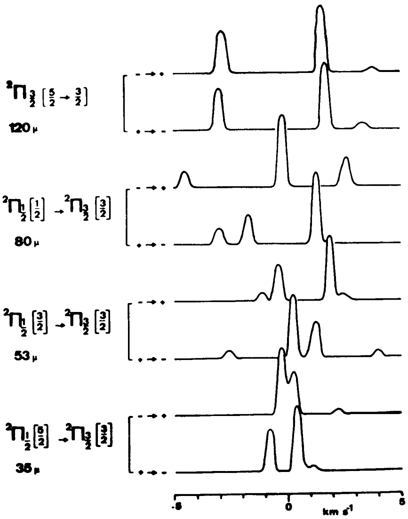

Figure 1: the hyperfine structure of the far-infrared transitions linking the OH ground state to low-lying rotational states

Results are shown (fig. 2) for a pumping cloud of N_p=3x10^{16} cm^{-2} molecules

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at temperature T_p=300 K filling 10% of the sky as seen from the maser cloud. The column density of the maser cloud is 10^{15} cm^{-2} its hydrogen number density 10^6 cm^{-3}, and its temperature 100 K. The mechanism is very efficient since unsaturated inversion ratios (percentages of lower masing state molecules pumped to the upper masing state in the absence of saturation) are as high as 60% for the main lines and 90% for the satellite lines. Inversion is mainly obtained from excitation of the $2\Pi\,1/2(J=3/2)$ rotational state, as is expected at the temperature of the pumping cloud (300 K).

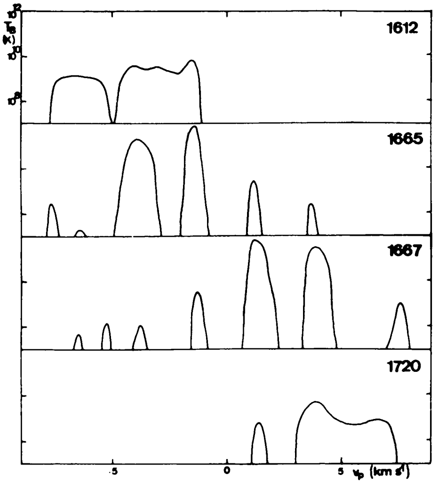

Figure 2: predicted brightness temperature of a spherical maser, as a function of pumping velocity v_p

The velocities needed to obtain an efficient inversion are not too large (-8 to +8 km s^{-1}). Velocities of this order of magnitude are certainly present since the velocity intervals between the maser features are generally a few km s^{-1}. Expansion movements would enhance 1665 MHz emission with respect to 1667 MHz emission, as is observed. A high column density (3 10^{16}cm^{-2}) and temperature (300 K) are needed for the pumping cloud. Winnberg et al. (1978) found absorption in W3(OH) in the $2\Pi\,3/2(J=9/2)$ lines of OH with a rather large optical depth (.06) and inferred a column density of 10^{16} to 10^{17} cm^{-2}, assuming a rotational temperature of 100 K. Thus evidence may be presented of an excited medium of high OH abundance.

We think that our model may lead to a relatively simple account of OH maser phenomena close to HII regions. A similar model is proposed to explain the main line emission of OH/IR stars (Nguyen-Q.-Rieu 1979).

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