NATURE OF MEGAMASERS

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The physics of megamasers OH and H_2O is considered shortly. Both phenomena concern clouds. OH megamasers are clouds of nearnuclear disk, H_2O megamasers are clouds flying from or to AGN.

Galaxies in which OH and H_2O megamasers are observed are rich in molecular gas ($M_{H2} \approx 4\ 10^9$ - $2\ 10^{10} M_o$) and possess enormous luminosities in the IR range ($L \approx 10^{11}$-$3\ 10^{12}\ L_o$) (Martin et al 1989 ; Baan 1990 ; Staveley-Smith et al., 1989). More than 50 OH and H_20 megamasers are discovered to date (Baan, 1990). These galaxies are also characterized by very powerful outbursts of star formation, by Seyfert properties of their nuclei and powerful fluxes in the UV range. The isotropic luminosity is $L_{OH} \approx 10$ - $10^4 L_o$, $L_{H2O} \approx 10^2$ - $5\ 10^2 L_o$. The typical luminosity of Galactic OH sources is $L_{OH} \approx 10^{-5} L_o$, H_2O sources is $L_{H2O} \approx 10^{-4} L_o$. Redshifts of these galaxies are $Z \approx$ 0.01-0.12.

λ =18 cm	λ = 1.35cm
OH Δv =300-500 km/s	H_2O Δv up to 700 km/s
size l< 500 pc $\tau \leq 1$ $F_\nu \approx$ mJy	size l< 1-3 pc $\tau \gg 1$ $F_\nu \approx$ mJy
Structures practically coincide	Structures are shifted

OH megamasers

As follows from analysis of observational data, wide-band emission in main radio lines (1667 and 1665 MHz) extragalactic OH masers having a size > 100 pc are unsaturated with optical depths τ <1 (the weak maser gain by molecules of radio continuum of the disk and the nucleus). Observations with the VLA (Schmeltz et al., 1987) show that emission is quite extended. Galaxies with megamasers OH have unique IR characteristics. In radio lines J = 5/2 $^2\Pi_{3/2}$ and J = 1/2 $^2\Pi_{1/2}$ are observed absorption features (Henkel et al. 1986, 1987).

F. Combes and F. Casoli (eds.), Dynamics of Galaxies and Their Molecular Cloud Distributions, 438–440.

The conditions for formation of OH megamasers in central kpc region of some galaxies are :
1) there must be a powerful infrared radiation at λ =53 μ and at other wavelengths (pumping radiation); a turbulent motion of the gas with 0.7km/s < V_{turb} < 5km/s is necessary in order that some infrared lines overlap and the temperature of the pumping radiation (T_{rad}) must be higher than the kinetic temperature of the molecules (T_{kin}) ;

2) there should be an extended 18 cm continuum radiation I(0), which will be enhanced by the inverted molecules in an unsaturated way

$$I = I(0) \exp(\alpha l) = I(0) \exp \tau$$

3) a sufficient amount of "inverted" molecules is needed to obtain the optical depth :

$$\tau = \frac{h\nu B \,\Delta n\, l}{4\pi\Delta\nu} = \frac{\lambda^2 A_{F'\text{--}F}\,\Delta n\, l}{8\pi\,\Delta\nu} \approx 1$$

$\tau \approx 1$ if $\Delta\nu \approx 1.6$ MHz ($\Delta v \approx 300$ km/s) is reached at the length $l \approx 15$ pc when n $\approx 10^3$ cm^{-3} and $n_{OH}/n_{H2} \approx 10^{-7}$.

The degree of the inversion $\Delta n/n' \approx 84\%$ if $n_{OH} l \approx 1.5\ 10^{15}$ cm^{-2} ($T_{rad} \approx 100$ K, $T_{kin} \approx 40$K). As follows from this excitation mechanism the observed width of the megamasers radio line is produced by 50-600 radiating clouds because, for realization of effective pumping, the dispersion of velocities must be within the limit 0.7 km/s < δ < 5 km/s.

H_2O megamasers

The kinematics of extragalactic H_2O masers is more complex than those of Galactic ones since it is associated with active galactic nuclei (AGN). Since the size of maser emission of H_2O is very small (<3.5pc Moran, 1984), we must reject the hypothesis that 100-500 sources similar to W49 make a contribution to luminosity due to the unacceptable high densities of OB stars in the nuclei of these galaxies (M82 and NGC253 is <3pc^{-3}). Many physical processes in the vicinity of AGN are naturally explained by the presence of the ensemble of clouds (Whittle and Saslay 1986). Radiation pressure, gravitation and hydrodynamic head resistance in the interclouds medium have an effect on the moving clouds in AGN. The motion of such clouds is described by the Emden-Fowler equation

$$y'' = x^{-s} y^2$$

the solution of which cannot be obtained in the explicit form, but which has been studied in asymptotes (the "s" - parameter determines the distribution of intercloud gas by their radius). From the estimate of the behaviour of the velocity of clouds (Fabrika, 1981).

$$v(r) \approx \frac{m_0 v_0 (R-r)^3}{12\, R^s} \quad \text{for } R > r$$

in which R is radius when still, m_0 and v_0 is initial mass and velocity. It follows that solutions can be found when in the process of deceleration the velocity of the motion of clouds becomes lower than parabolic velocity and then some time later, the cloud will stop and will begin falling towards the centre. The blue and red structures in H_20 megamasers can be due to collisions of decelerated clouds fejected from the nucleus with clouds or condensations of the near-nuclear molecular disk, when $v_{rel} \approx 100$ km/s. These clouds before the interaction have the sizes of $\approx 10^{12}$-10^{14} cm and densities n $\approx 10^7 - 10^{11} cm^{-3}$.

Radiation models of pumping H_2O masers are less effective than collisional models (Strelnitskii 1984, Tarter and Welch, 1986, Norman and Kylafis, 1987). The pumping process is due to the excitation and deactivation of the rotational levels of the H_2O molecules by electrons and H_2 molecules when $T_e >> T_{H2}$. From the simplest estimate of the maser's luminosity in the saturated mode:

$$L = h\nu \; n_1 \, \Delta p \, V \, N$$

in which n_1 is the number of H_2O molecules at the upper signal level 6_{16},Δp - pumping velocity, can get the efficiency of the process of the creation of inversion. To ensure luminosity $L_{H2O} \approx 5 \; 10^2 L_0$ the value $n_1 \Delta p$ must be $\approx 3 \; 10^4$ $cm^{-3} s^{-1}$, if the volume $V \approx 4 \; 10^{45}$ cm^3 and the number of maser structures $N \approx 100$.

Let me stress the necessity of measuring their sizes and dynamics by such global experiment as the "Radioastron". Investigating the dynamics of these clouds it is possible to specify the Hubble constant.

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