ANALYSIS OF VLBI SPOT MAP OF H_2O MASERS FOR THE HII REGION COMPLEX IC133 OF SPIRAL GALAXY M33

YU ZHI-YAO
Shanghai Astronomical Observatory, 80 Nandan Road, Shanghai 200030, China

1. Introduction

Interstellar H_2O masers in the Galaxy occur in active star forming regions. The spectrum often shows multiple distinct features. The VLBI maps reveal that each spectral feature corresponds to emission of spatially distinct maser sources (maser spots), whose sizes are $\approx 10^{13} cm$. The maser in M33 is associated with the HII region complex IC133, which has been studied optically by Boulesteix et al. (1974) and Kiwitter and Aller (1981). This maser is the nearest ($\leq 1Mpc$) extragalactic H_2O source visible in the northern sky, although it is not the strongest. It is known to have persisted for over a decade, and its spectra consistently show peak flux densities of ≈ 1.5 Jy and at least 10 features spread over ≈ 50 $km\ s^{-1}$ (Huchtmeier, Eckart and Zensus 1988). Using VLBI Greehill et al. (1990) have obtained the positions of 14 H_2O maser spots.

We have developed a model of multiple distinct rotating and expanding rings, to explain the distribution of those positions.

2. Model and results

The disc geometry and adopted coordinate systems are in Fig. 1. The ring center is assumed as origin of the coordinate system which has the X–Y plane in the plane of the disc and the Z–axis along the ring rotation axis. In general, the disc will be inclined at some angle θ to the line of sight.

For the i-th maser spot in the disc ring we have obtained the following relation (Yu, 1994): $\rho_i^2 = \rho^2 - \frac{\rho^2}{v_e^2}\left(\frac{(v_i - v_0)}{cos\theta} - \omega\rho_i D\right)^2$ where ρ_i is the projected angular distance of the spot from the origin, and v_i its radial velocity, ρ is the radius of the generic disc ring, v_e and ω its expansion and angular velocity respectively, v_0 is the systemic radial velocity of the disc rings and D the distance of M33. The quantities ρ, v_e and ω characterize each disc

R. Ekers et al. (eds.), Extragalactic Radio Sources, 181–182.

https://doi.org/10.1017/S0074180900080463 Published online by Cambridge University Press

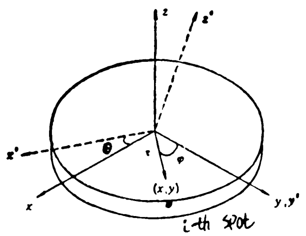

Figure 1. The disc geometry and adopted coordinate system. The primed coordinates represent the observer's system (the X'-axis is the observer's line of sight and the Y'-Z' plane is the plane of the sky.)

ring. Since v_0, D, and θ are known we can derive from the above equation a linear relation between ρ_i^2 and $\Gamma = [\frac{(v_i - v_0)}{cos\theta} - \omega\rho_i D]^2$

We assume a position for the disc ring center on the map of the H_2O maser spots and measure ρ_i and v_i of every spot. In a plot of ρ_i^2 vs Γ we find that the points are grouped in a few regions and seem to belong to different curves. Thus we fit the data assuming several concentric co-rotating disc rings and adjust the position of disc ring center until we obtain a straight line for every disc ring. A least square fit of the data provides the values of ω, ρ^2 and v_e. The best fit to the data is obtained with two rings with radii differing by 0.4 pc, and expansion velocities differing by 19 km s^{-1}. Adopting $v_0 = +\ 0.52$ km s^{-1}, D = 270 Kpc, $\theta = 0$ (Greenhill et al. 1990) we find that the position of the disc ring center is 14.5 mas East and 0.0 mas North of the center of the maser spot map. Our results are given in table 1, where the spot numbers are from Greenhill et al. (1990).

Ring No.	Spot No.	$\omega(s^{-1})$	r(pc)	$v_e(kms^{-1})$
1	1,2,3,4,6,7	1.6610^{-14}	10.1	245
2	5,8,9,10,11,12,13,14	1.6610^{-14}	10.5	264

The tangential velocity of the maser spots on rotating and expanding disc ring, $v_t = \omega\ r = 1.66 \times 10^{-14} r$, is $v_{t1} = 5.05\ kms^{-1}$ and $v_{t2} = 5.25$ km s^{-1} for discs 1 and 2 respectively. The 14 maser spots span about 30 mas (3×10^{17} cm) and 12 of them are located in IC133M while spots 11 and 14 belong to IC133SE. Our analysis, instead, indicates that they are distributed in a different way: six of the spots in IC133M on the smaller disc, the remaining plus the two in IC133SE on the other.

References

Boulestei, J., Courtes, G., Lavel, A., Monnet, G., Petit, H., 1974, *A& A*, **37**, 33
Greenhill, L.J., Moran, J.M., Reid, M.J., winn, C.R., Menete, K.M., 1990, *ApJ*, **364**, 513
Huchtmeier, W.K., Eckart, A., Zensus, J.A., 1988, *A& A*, **200**, 26
Kiwitfer, K.B., Aller, L.H., 1981, *MNRAS*, **195**, 939
Yu, Zhi–yao, 1994, *Acta Astrophysica Sinica*, **14**, 66