STELLAR PULSATION: (II) MULTIPLE DISTINCT SHELLS

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

Abstract. We can find the conclusion with our analysis for VLA observation of OH maser and CO (2-1) emission line that they are distributed on some different distinct shells in the circumstellar envelope, respectively.

For an expanding spherical envelope the angular radius R_0^A is given by

$$R_0^A = R^A(V)\left[1 - \frac{(V - V_0)^2}{V_e^2}\right]^{-\frac{1}{2}} \tag{1}$$

where $R^A(V)$ is the angular radius at LSR velocity V, V_0 is systemic radial velocity, V_e is circumstellar expanding velocity (Bowers et al. 1983). Formula (1) is changed as following

$$[R^A(V)]^2 = [R_0^A]^2 - \left[\frac{R_0^A}{V_e}\right]^2 (V - V_0)^2 \tag{2}$$

We may see from formula (2), a shell has determinate R_0^A and V_e for each shells, $[R^A(V)]^2$ is linear monotonous decrease by degrees function of $(V - V_0)^2$. Thus we may divide the envelope into shells according to these regions where the distribution of points, which coordinates are $[R^A(V)]^2$, $(V - V_0)^2$, is ranged by the orientation of linear monotonous decrease by degrees in $[R^A(V)]^2 - (V - V_0)^2$ map, then do statistic fitting. The error of statistic fitting is least.

The data of VY CMa selected by the paper are from Bowers et al. (1983). We have obtained that VY CMa OH 1612 MHz masers occur on three distinct expanding shells (i.e. shell A, B, and C), their corresponding angular radii $[R_0^A]$ and expanding velocities $[V_e]$ are 2.43, 3.08, 3.21 arcsec and 24.0, 30.4, 34.9 km s^{-1}, respectively. Given R_0^A, the linear radius R_0 can be determined if the distance is known. The distributions of VY CMa OH 1612 MHz points are seen from Fig. 1, 2, and 3.

We have also obtained the multiple expanding shells at the analysis and explanation of the CO (2-1) emission line. For an expanding spherical envelope parabola is adaptable (Knapp 1982). Therefore we may obtain

$$T_A^*(V) = T_A^*(\text{peak})\left[1 - \frac{(V - V_0)^2}{V_e^2}\right] \tag{3}$$

Astrophysics and Space Science **210**: 169–172, 1993.

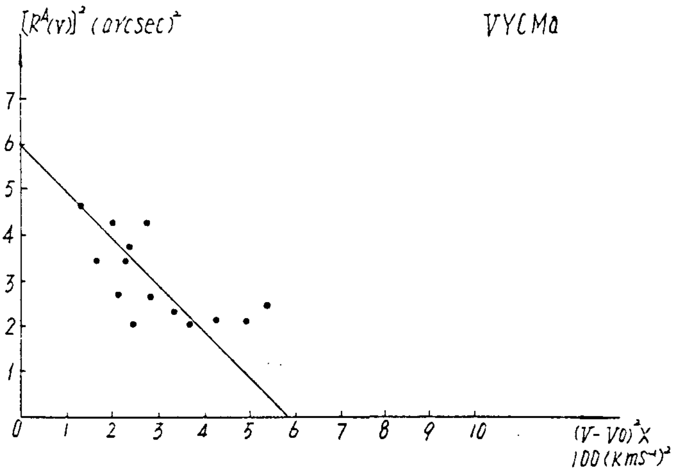

Fig. 1. The Distribution on Shell A

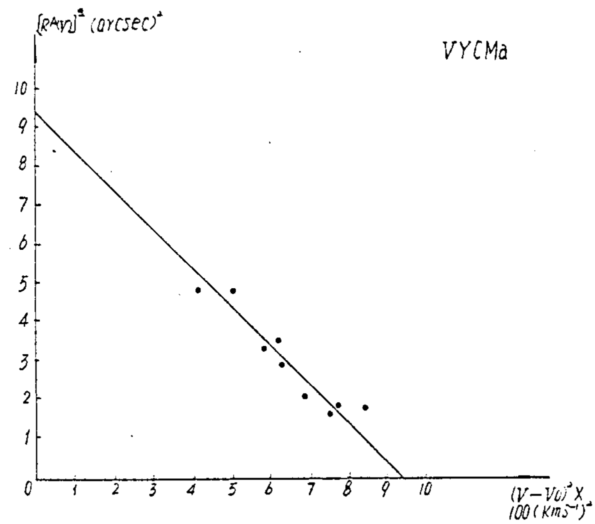

Fig. 2. The Distribution on Shell B

where T_A^* (peak) is the antenna temperature of peak. $T_A^*(V)$ is the antenna temperature at V. We take some points at the CO (2-1) emission line (27 points for CIT6). We measure a group of $T_A^*(V)$, V for each point, farther some groups of $(V - V_0)^2$, $T_A^*(V)$. We draw $T_A^*(V) - (V - V_0)^2$ map. We find that these points, which coordinates are $T_A^*(V)$ and $(V - V_0)^2$, are distributed at several regions from the $T_A^*(V) - (V - V_0)^2$ map (three regions for CIT6). At each region the distribution of the points is ranged by the orientation of linear monotonous decrease by degrees. According to formula (3) we may obtain

https://doi.org/10.1017/S0252921100014123 Published online by Cambridge University Press

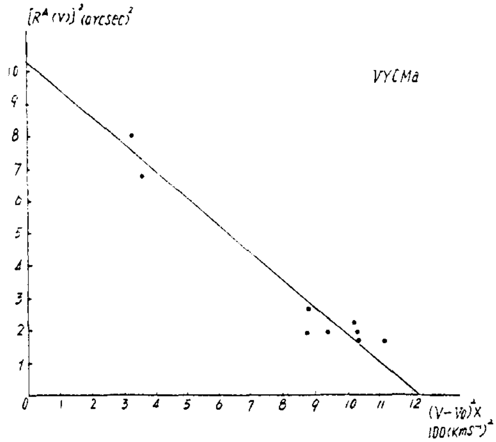

Fig. 3. The Distribution on Shell C

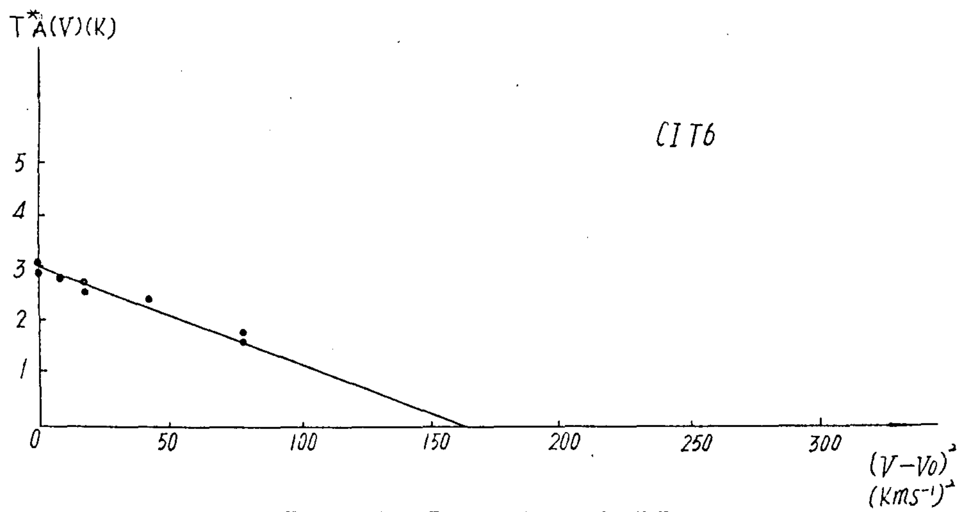

Fig. 4. The Distribution on Shell D

$$T_A^*(V) = T_A^*(\text{peak}) - \frac{T_A^*(\text{peak})}{V_e^2}(V - V_0)^2. \tag{4}$$

For a shell which radial distance from stellar center is r, and expanding velocity is V_e, T_A^* (peak) and V_e are determinate. $T_A^*(V)$ is linear monotonous decrease by degrees function of $(V - V_0)^2$. Using $T_A^*(V) - (V - V_0)^2$ map and formula (4) we divide the envelope into shells according to the regions in $T_A^*(V) - (V - V_0)^2$ map where the distribution of points is ranged by the orientation of linear monotonous decrease by degrees.

The observational data are selected from Knapp (1982). We have obtained that CIT6 CO (2-1) molecules also occur on three distinct expanding shells

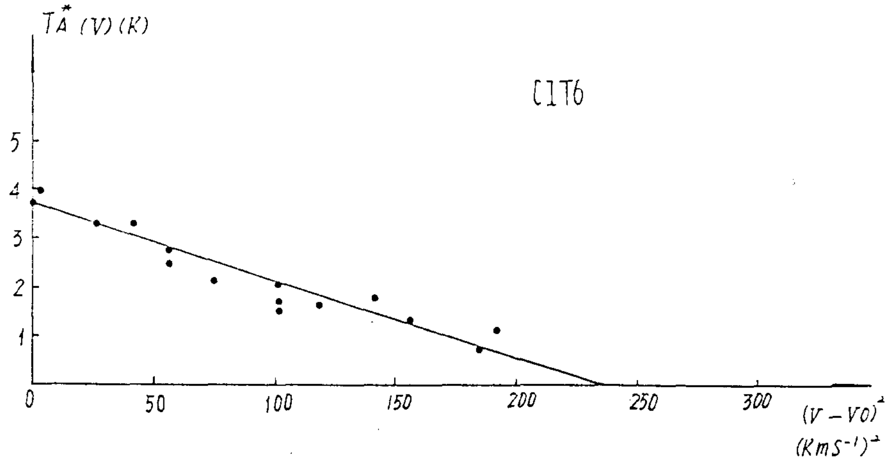

Fig. 5. The Distribution on Shell E

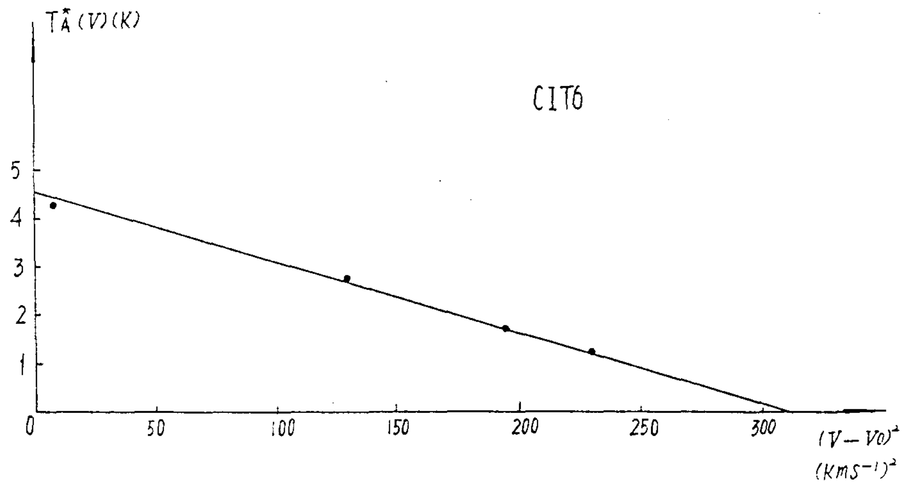

Fig. 6. The Distribution on Shell F

i.e. shell D, E, and F), the corresponding peak antenna temperature [T_A^* (peak)] and expanding velocity [V_e] are 3.1, 3.8, 4.5 K and 12.7, 15.2, 17.4 km s^{-1}, respectively. The distributions of the points of shell D, E, and F are seen from Fig. 4, 5, and 6, respectively.

References

Bowers, P. F. et al.: 1983, *Astrophysical Journal* **274**, 733.
Knapp, G. R. et al.: 1982, *Astrophysical Journal* **252**, 616.