Astrophysical Phenomena Revealed by Space VLBI
H. Hirabayashi, P.G. Edwards and D.W. Murphy (eds.)

Monitoring of the Orion-KL Water Maser Outburst

H. KOBAYASHI[1], T. SHIMOIKURA[2], T. OMODAKA[2] & P.J. DIAMOND[3]

[1] *NAO, Ohsawa 2-21-1, Mitaka, Tokyo 181-8588, Japan*
[2] *University of Kagoshima, Kohrimoto 1-21-35, Kagoshima 890-0065, Japan*
[3] *MERLIN, University of Manchester, Jodrell Bank Observatory, Macclesfield Cheshire SK11 9DL, United Kingdom*

Abstract

In December 1997 the Orion-KL water maser source was discovered to be undergoing an outburst and, in February 1998, a VSOP observation successfully yielded fringes on the source from HALCA to several VLBA antennas (see Color Figure 10). This confirmed the capabilities of the 22 GHz VSOP observing system elements, i.e. phase transfer, onboard frequency stability, and orbit determination accuracy. Following the VSOP observation, we monitored the Orion burst maser with VLBA-only observations at 2 week intervals. The outburst peaked at 5×10^6 Jy in September 1998, and then declined to a few times 10^5 Jy, which is its normal intensity. By tracing the structure and velocity changes of the maser spots from the outburst phase to the declining phase, we find there are two velocity components at the region of the flaring water maser with a 0.2 km/s velocity difference. The separation of two components is observed to decrease as the maser intensity increases and, at the time of the outburst peak, the position of two maser components coincide. This strongly suggests that the overlapping of the two masers causes the luminous outburst.

1 Introduction

An ultra-luminous outburst of an Orion-KL water maser was first observed from 1983 to 1984 (Matveyenko et al. 1988, Garay et al. 1989). At that time, the total flux density reached values as large as $\sim6.7\times10^6$ Jy — around 200 times stronger than usual. In December 1997 another outburst of the Orion-KL water masers was discovered using the 6 m telescope of the University of Kagoshima (Omodaka et al. 1999). Two theoretical models have been proposed for such outbursts. One is a coplanar model, in which a thin plane passes through the line of sight and the optical depth of the maser emission becomes larger (Elitzur et al. 1992). The other is an overlapping maser spot model, in which two maser spots lie along the same line of sight, with the background maser emission being amplified by the foreground maser. For this model, the two maser spots must coincide not only in position but also velocity (Boboltz et al. 1998). There has not been observational clear evidence to support either model, mostly because there were no VLBI monitoring observations during the last burst!

After the previous outburst, a VLBI image was obtained (Matveenko et al. 1998). For the investigation of the maser burst mechanism, it is very important to obtain frequent VLBI observations with high spatial-resolution during the outburst.

2 Observations

Monitoring observations were performed with the VLBA. Observations were carried out from 1998 May 10 to 1999 February 10 at two week intervals. In total, 16 days were used with a 3 hour observation each day. The typical synthesized beam size is $0.3\,\mathrm{mas} \times 0.7\,\mathrm{mas}$ with a position angle of around 0°. The velocity resolution was $0.05\,\mathrm{km/s}$. Fringes were detected on all VLBA baselines, confirming that the maser spots are compact.

3 Results

In Figure 1, the intensity profile of the water maser outburst is shown. It increased from December 1997 to September 1998, reaching a peak of 4.8×10^6 Jy, a little less than the previous outburst. In the previous burst, the maser intensity oscillated during the increasing phase, however this time the intensity changed more smoothly. This suggests the latest burst was simpler than the previous one.

Figure 2 shows three maps of the maser region at the velocity of peak intensity from the epochs 1, 2, and 3 indicated on Figure 1. They show that there are two components at the position of the maser burst, with the weaker component apparently passing through the stronger component. As the absolute position is uncertain, it is impossible to know which is stationary. When the two components coincided, the intensity of the burst maser was at its peak.

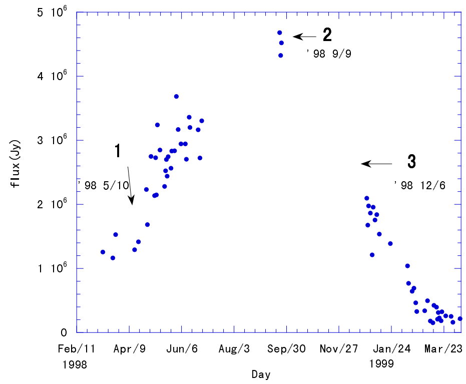

Figure 1: Time profile of peak flux of the bursting 7.6 km/s maser component.

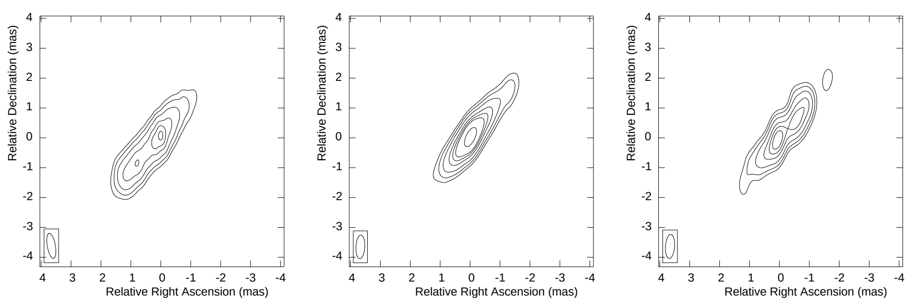

Figure 2: Three epoch maps of the bursting 7.6 km/s maser components. The dates are indicated on Figure 1. The maps shows the apparent passage of the weaker component across the stronger component. Contour levels are 2, 4, 8, 16, 24, 32, 64 and 128 by 10^4 Jy/beam. The peak fluxes are 3.5×10^5, 9.2×10^5 and 4.7×10^5 Jy/beam, respectively.

4 Discussions

The maps of the Orion-KL maser burst show two components interacting with each other. This result therefore seems to support models in which overlapping masers produce strong bursts. The position of the current maser burst is the same as that of the previous burst. The apparent transverse velocity of one maser with respect to the other is 7.4 km/s. If the two maser components constitute a binary system, the total mass is around $0.1\,M_\odot$ and the separation length is around 3 AU. Such values are typical for the usual parameters of water maser spots.

Acknowledgements. We gratefully acknowledge the VSOP Project, which is led by ISAS in cooperation with many organizations and radio telescopes around the world. The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

References

Boboltz, D.A., Simoneti, J.H. & Dennison, P.J. et al. 1998, *ApJ*, **509**, 256

Elitzur, M., Hollenbach, C.J. & McKee, C.F 1992, *ApJ*, **394**, 221

Garay, G., Moran, J.M. & Haschick, A.D. et al. 1989, *ApJ*, **338**, 244

Matveyenko, L.I., Graham, D.A.& Diamond, P.J. 1988, *SvAL*, **14**, 468

Matveyenko, L.I., Diamond, P.J & Graham, D.A. 1998, *SvAL*, **24**, 623

Omodaka, T., Maeda, T., Miyoshi, M. et al. 1999, *PASJ*, **51**, 333