Astrophysical Masers and their Environments
Proceedings IAU Symposium No. 242, 2007
J.M. Chapman & W.A. Baan, eds.

doi:10.1017/S174392130701294X

G23.657−0.127, what can we learn from a perfect methanol maser source?

Anna Bartkiewicz[1], **Huib Jan van Langevelde**[2,3], **Marian Szymczak**[1] **and Andreas Brunthaler**[4]

[1]Centre for Astronomy, Nicolaus Copernicus University, Gagarina 11, Torun, Poland
email: annan@astro.uni.torun.pl

[2]Joint Institute for VLBI in Europe, Postbus 2, 7990 AA Dwingeloo, email: langevelde@jive.nl,
[3] Sterrewacht Leiden, Postbus 9513, 2300 RA Leiden, The Netherlands

[4] Max Planck Institute fur Radioastronomie, Auf dem Hugel 69, 53121 Bonn, Germany
email: brunthal@mpifr-bonn.mpg.de

Abstract. In the course of following up compact methanol masers at 6.7 GHz which were found in the Torun blind survey (Szymczak *et al.* 2002), we discovered a ring structure in the source G23.657−00.127. This source provides interesting insights into whether methanol masers arise in rotating disks around massive stars, in their outflows, or behind shocks. By monitoring the 12.2 GHz masers, which fortunately follow the same structure, we hope to resolve the kinematics of the ring. Moreover, the symmetry of the source points to the existence of a central source. Early results on the nature of this source indicate the existence of a hyper–compact H II region.

Keywords. methanol maser, stars: formation, instrumentation: high angular resolution

---

Methanol masers at 6.7 GHz are a valuable tool in modern studies of *how massive stars are born* as they enable us to investigate the surrounding regions around protostars on scales of 100–1000 AU. Recent VLBI observations at 6.7 GHz with milliarcsecond (mas) resolutions revealed a new class of spherically symmetric methanol maser sources (Bartkiewicz *et al.* 2005). The maser ring in G23.657−00.127 has become a unique laboratory for detailed research into how and where methanol masers arise in an isolated massive star forming region. The morphology and the dynamics of the maser spots at 6.7 GHz have not allowed us to establish the origin of the ring-like structure yet. To do this we have begun a wide range of follow–up observations including detection of 12.2 GHz methanol maser line, proper motion studies at both 6.7 and 12.2 GHz, and searching for the continuum counterpart of the central source.

Using the VLBA we have recently imaged the 12.2 GHz methanol masers. These show good correlations in space and velocity with the 6.7 GHz ring (Fig. 1). The brightness of the co-propagating masers implies a cold, $T_{kin} \sim 30$ K, but dense, $n_H \sim 10^7$ cm^{-3}, environment (Sobolev *et al.* 1997). Currently, we are carrying out multi-epoch observations, spread over a year, at 12.2 GHz. These should allow us to determine the nature of the ring and to distinguish between rotation and expansion. We also expect to estimate an exact distance to the source from the simultaneous measurement of its parallax.

The spherically symmetric structure of the masers clearly points to the existence of a central source. Our VLA observations at 22 and 43 GHz towards the centre of the ring show weak emission. This could originate from a hyper-compact H II region, or from dust continuum. These new detections of counterparts at sub-cm wavelengths fit well with the spectral energy distribution of the infrared counterparts (1.25–100 μm), which we presented earlier (Fig. 2). A two black-body model by Walsh *et al.* (1999) fitted to

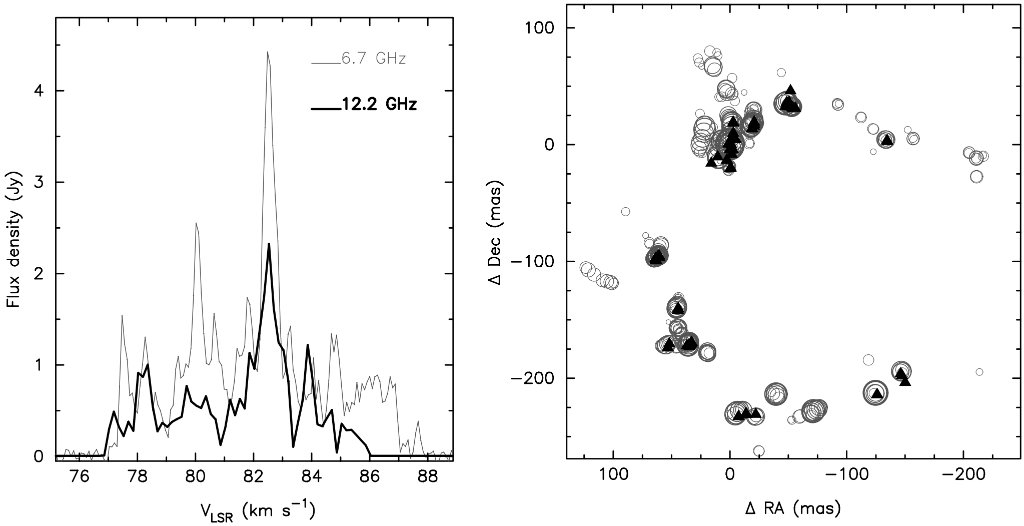

Figure 1. Spectra and distributions of 6.7 (circles) and 12.2 GHz (triangles) methanol masers seen towards G23.657−00.127.

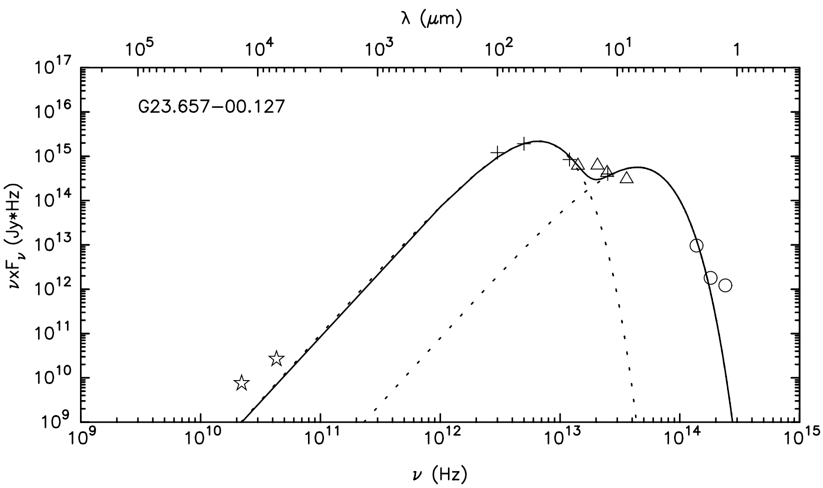

Figure 2. Spectral energy distribution towards the ring. Stars trace the tentative radio emission detected using VLA, while 2MASS, MSX6C and IRAS objects are marked by circles, triangles and crosses, respectively. Fitted lines represent a model of two black-body components (Walsh *et al.* 1999).

the data implies temperatures of 80 K and 540 K for the cold and hot dust, respectively (Bartkiewicz *et al.* 2005).

We hope to complete the observations soon and to be able to establish what is going on in G23.657−00.127.

References

Bartkiewicz, A., Szymczak, M. & van Langevelde, H. J. 2005, *A&A* 442, L61
Sobolev, A. M., Cragg, D. M. & Godfrey, P. D. 1997, *MNRAS* 288, L39
Szymczak, M., Kus, A. J., Hrynek, G., Kepa, A. & Pazderski, E. 2002, *A&A* 392, 277
Walsh, A. J., Burton, M. G., Hyland, A. R. & Robinson, G. 1999, *MNRAS* 309, 905