Where methanol masers spring

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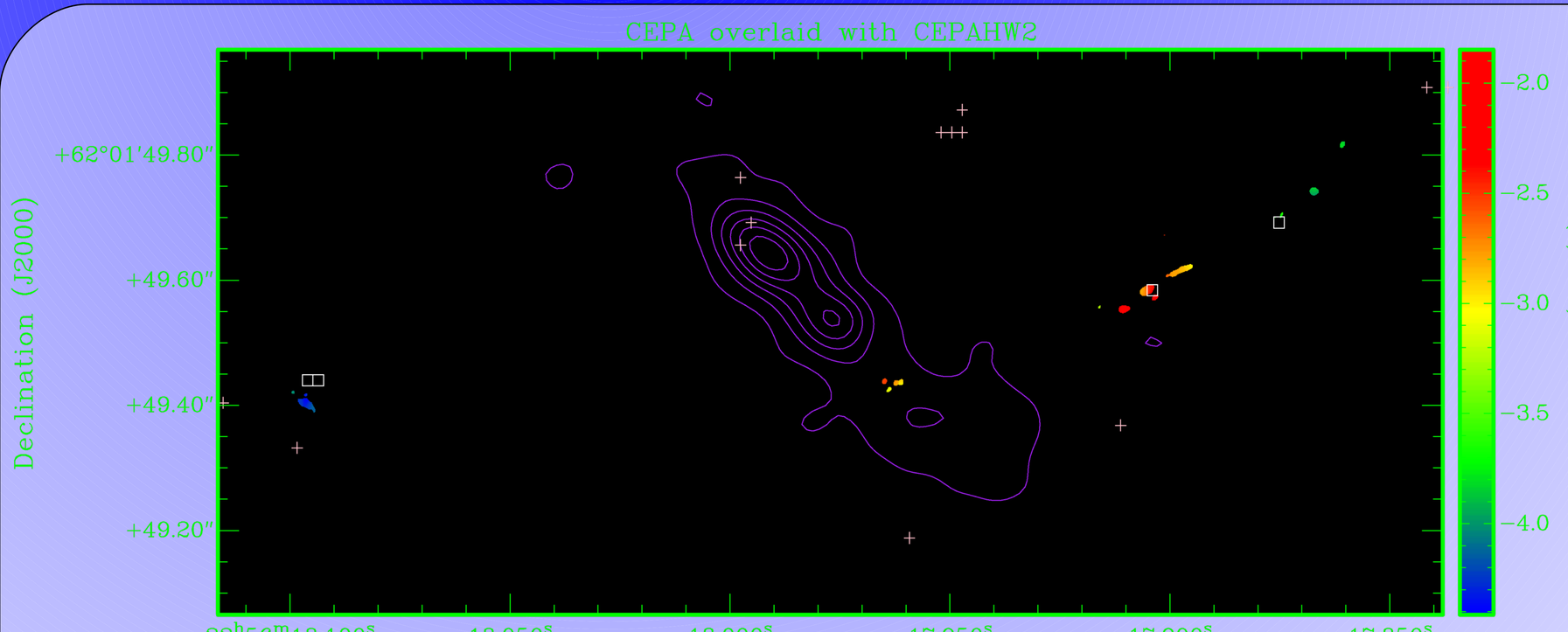
Summary

We have obtained large field (~2'), astrometric, high resolution, VLBI data for the 6.7 GHz methanol maser in 12 regions of high mass star formation. So far we have only calibrated and imaged the inner regions in these large fields. A computer code (in ParselTongue) to automatically search these regions for maser emission is under development. We are currently following up these observation with sub-mm observations of thermal methanol in an effort to map and understand the methanol abundance, temperature and excitation on size scales comparable to those on which the methanol maser emission occurs.

Finding the origin of methanol masers

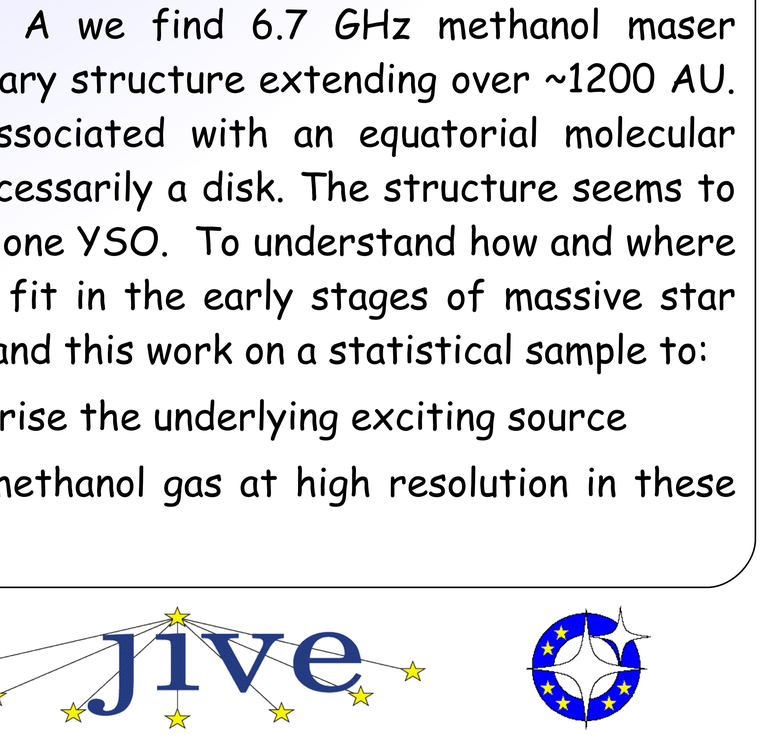
To understand methanol masers, we must find the exciting young stellar object (YSO) at its origin. In earlier studies, where such an association could be argued with high resolution, size scales of 500-1000 AU have been found (Bartkiewicz et al. 2005; Phillips & van Langevelde 2005). This could be associated with circumstellar material, but is also similar to the size of hyper-compact (HC) HII regions or trapped HII regions (Kurtz et al. 2000; Keto et al. 2003). One should be cautious that in regions of high mass star formation there could be confusion of several YSO's on these scales.



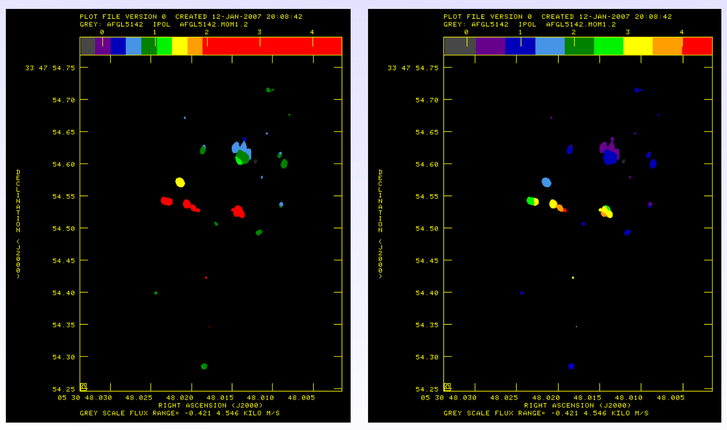
Cep A

Velocity field of methanol masers in Cep A overlaid on K band continuum (contours) (Torelles 1998). Also shown are 12 GHz methanol masers (white squares) (Minier et al. 2001), 22 GHz water masers (white circles) (Torrelles et al. 1996 & 2001; Vlemmings et al. 2005) and 1.6 GHz OH masers (pink pluses) (Bartkiewicz et al. 2005).

In Cep A the 6.7 GHz methanol masers trace a filamentary structure extending over ~1.7" (1200 AU), straddling the waist of Cep A (HW2). The velocity structure does not display an obvious sign of rotation around the central object. However, if the small velocity gradient arises from a disk we find the enclosed mass to be ~5 M_{SUN} for an inclination of 70°. Several YSOs in the region have been reported (Martín-Pintado et al. 2005), it is not yet clear whether the methanol masers trace individual objects or occur in the surrounding large scale environment. To the west the 6.7 GHz masers are found in the same position as the 12 GHz methanol masers (Minier et al. 2001). However, to the east the 6.7 GHz masers are co-spatial with the 22 GHz water masers (Vlemmings et al. 2005) but offset from the 12 GHz methanol masers. This could simply be an effect of observations at different epochs.



AFGL 5142



In AFGL 5142 the 6.7 GHz methanol masers have been argued to trace infall towards a 24 M_{SUN} YSO (Goddi et al 2005). In the figure above is shown the velocity field of the methanol masers in our data. Note that both figures show the same masers with different scaling.

Conclusions

In the case of Cep A we find 6.7 GHz methanol maser emission in a filamentary structure extending over ~1200 AU. This seems to be associated with an equatorial molecular structure, but not necessarily a disk. The structure seems to encompass more than one YSO. To understand how and where the methanol masers fit in the early stages of massive star formation we will expand this work on a statistical sample to:

i) locate and characterise the underlying exciting source

ii) characterise the methanol gas at high resolution in these regions.

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