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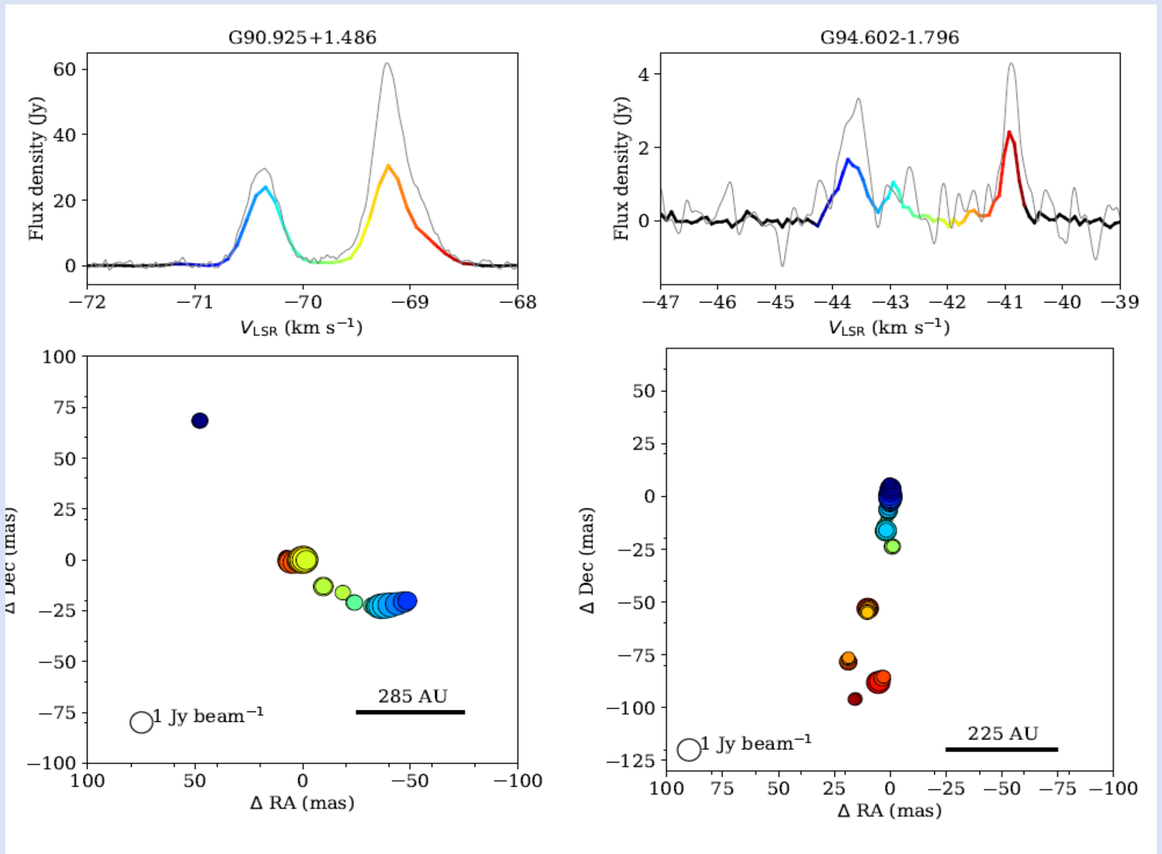
VLBI observations of two variable sources from Irbene methanol maser monitoring program

The Irbene monitoring program of 42 objects began in March 2017 to study the methanol 6.7 GHz maser emission variability. More than 70% of sources are variable, but only one or two spectral features often vary significantly. Three of them were imaged by the EVN network to derive the structures of these sources and to identify the positions of regions responsible for changes in flux density. Here we report the results for two of them, **G90.92+1.49 and G94.602 – 1.796 (V645 Cyg).**
Observations were carried out on **31 October 2019**. Following antennas took part in this experiment that lasted for 10 hours: **Jodrell, Efelsberg, Medicina, Onsala, Torun, Westerbork, Yebes, Sardinia, Hartebeesthoek, Irbene and Tianma.**



Top: Spectra of G90.925+1.486 (left) and G94.602-1.796 (right) as obtained by EVN (color) and the Irbene 16m radio telescope (grey line) on 31 October 2019.
Bottom: Distributions of methanol maser spots. The colors are related to the LSR velocity as in the spectra. The spot size is proportional to the logarithm of its flux. Coordinate center points (0,0) corresponds to the brightest maser spot positions and are as follows: RA=21h09m12.97474s, Dec=+50°01’03.6580, RA=21h39m58.25507s, Dec=+50°14’20.9989" (J2000) for G90.925+1.486 and G94.602-1.796 respectively.

G90.925+1.486

This high-mass star-forming region lies at the distance of 5.9(+1.3/- 0.9) kpc as derived via trigonometric parallax by Reid, M.J., et al. 2019, ApJ, 885, 131.

We found 47 methanol maser spots that form seven cloudlets. Maser emission was found in the velocity range from -71.31 to -68.31 km s^{-1}. The emission covers ca. 108 mas x 100 mas area corresponding to ca. 637 AU x 590 AU and the southern part shows the clear velocity gradient of 0.007 km s^{-1}AU^{-1} calculated for the whole emission from the red spot to the blue one . Comparison with the single-dish spectrum shows that the feature at the LSR velocity of -69.2 km s^{-1} is significantly resolved by 63% and the -70.3 km s^{-1} feature by 19%. In general, the integral flux density ratio S_{int}(EVN)/S_{in}t(Irbene) equals 0.43. The mean FWHM of the seven cloudlets is 0.30 km $^{s-1}$. We imaged the brightest components of the emission when comparing with the JVLA regions (Hu et al. 2016, ApJ, 833, 18).

The VLBA data from the BeSSeL survey (http://bessel.vlbi-astrometry.org/) showed 25 masers grouped in four cloudlets as observed on 8 December 2012. Based on their spatial structures, LSR velocities and positions, we identified them as the same 4 cloudlets in our EVN 2019 images. It is clearly seen, that one of them has showed the most similar morphology in both epochs, the position angle of +84◦ and the structure has stayed linear. The remaining three cloudlets, with linear or extended structures, have changed up to 40◦ during these seven years. VLBA 2012 results show that the spectral feature at the LSR velocity of −70.3km s^{-1} was brighter than the one at −69.2km s^{-1}; the same was seen in the single-dish monitoring by Szymczak et al. (2018, MNRAS, 474, 219) during 55000 – 56350 MJD period. Contrary to this, from the beginning of Irbene monitoring (MJD 57832) the −69.2 km s^{-1} feature was observed to be brighter. We note that the overall structure has persisted although the high variability of the spectrum.

G94.602-1.796 (V645 Cyg, AFGL2789)

The distance is estimated to be 4.5 (+0.3/. 0.2) kpc. (Reid et al. 2019).
It is an high-mass young stellar object containing O7 spectral type star with variable gas outflows.

We found 61 methanol maser spots that formed seven cloudlets in the LSR velocity range from -40.55 to -44.4 km s^{-1} . Spots are distributed over 150 AU x 520 AU. There is a clear elongation of the emission along the north-south direction with a velocity gradient of 0.035 km s^{-1} mas^{-1} corresponding to 0.008 km s^{-1} AU^{-1}. The integral flux density ratio S_{int}(EVN)/S_{int}(Irbene) equals 0.42. The mean FWHM of the seven cloudlets is 0.37 km s^{-1}. Interestingly, the velocity gradient in north south direction appears of all cloudlets expect one. There is a hint that the NS elongated structure has been stable over last 19 years when comparing with an image from Val’tts et al. (2002, arXiv:astro-ph/0205452). We note, the EVN image is similar to the JVLA one from Hu et al. 2016 (ApJ, 833, 18).

The source was observed on 3 Dec. 2012 using VLBA (the BeSSeL survey). Twelve spots formed six cloudlets that we can relate to five cloudlets imaged in EVN 2019 observations. Due to the worse velocity resolution of 2012 data, we could not analyze detailed mas structures of every single cloudlet. But we note, that the overall source morphology persisted during these seven years.

During our variability monitoring since 2017, we see variability with no regularities in G90.925+1.486 and G94.602−1.796 sources, but all spectral features change synchronously. The spatial structure is stable over years, although the single-dish spectra vary significantly. So we expect that observed variability is not related to the appearance or disappearance of the maser cloudlets.

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