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Bursting H_2O maser source G25.65+1.05: from single-dish to space VLBI

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on behalf of the Maser Monitoring Organization (M2O)

In 2017-18 the source of outstanding H_2O maser bursts G25.65+1.05 have been intensively studied with a wide range of baselines – from compact array (JVLA) and ground VLBI (EVN, VLBA, KaVA) to space VLBI (RadioAstron mission supported by VLBA and EVN telescopes) – the report gives a brief summary of these observations.

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1. Introduction

The source G25.65+1.05 (RAFGL7009S, IRAS 18316-0602) is one of only three Galactic water masers together with W49N and Orion KL that are known to flare to the level of 10^5 ($T_b \sim 10^{17}$ K). But in contrast to them, the source is less known and did not attract as much attention before – there are only single-dish data on H_2O maser emission. Long-term monitoring of H_2O maser with the RT-22 of the Pushchino Radio Astronomy Observatory (Moscow region) showed three flares in 2002, 2010, and 2016 with the flux density of 3 400, 19 000, and 46 000 Jy, respectively [1]. The next powerful burst of 65 000 Jy was detected in September 2017 [2, 3] with RT-22 of the Crimean Astrophysical Observatory. In October 2017 shortly after this burst the source showed new increase of flux density – see [2, 4]. The most recent burst was short-lived: the peak flux density rose from ~20 to 76 KJy within half a day on November 20; the source faded to ~20 KJy on November 22 [5].

2. Observations

Detected H_2O maser bursts with flux densities of 60-70 kJy triggered intensive study of G25.65+1.05 with a wide range of baselines – context for the various observations carried out on the source lately is presented on Fig. 1.

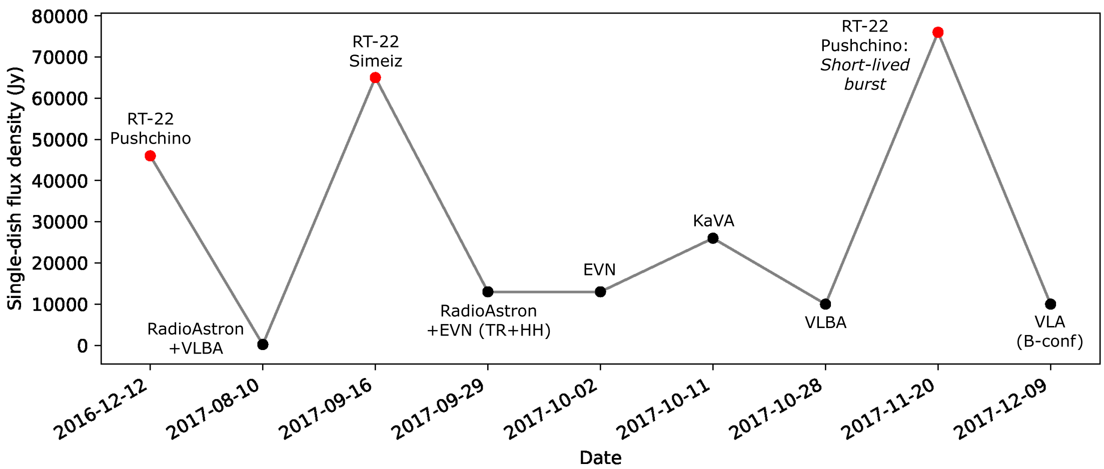

Figure 1: Timeline of G25.65+1.05 observations. Red points indicate H_2O maser bursts detected in the single-dish monitoring with RT-22 Pushchino and RT-22 Simeiz; black points – VLBI and compact array observations of the source (see references in the text).

1. **RadioAstron: 10-m SRT + VLBA** [6]

The very first VLBI study of 22 GHz H_2O maser in G25.65+1.05 was carried out on August 10th, 2017 in simultaneous observation of the source with 10-m Space Radio Telescope and Very Long Baseline Array (VLBA) in the frames of space VLBI project RadioAstron. This is the only stable-state VLBI observation of the source at the moment, it took place on non-bursting epoch between bursts of December 2016 and September 2017. Achieved projected baseline length of ~3 Earth

Diameters provided an angular resolution of about $\sim$80 μas. In the experiment the signal was detected on all space-ground baselines and a detailed high-resolution map of the H_2O maser emission in the field was obtained.

2. **RadioAstron:10-m SRT + 32-m Torun + 26-m HartRAO** [7]

The second RadioAstron session was conducted on September 29th, 2017 and become the closest to the burst observation of the source. In the experiment the unique projected baseline length of 9 Earth Diameters and angular resolution of $\sim$24 μas were achieved. But very limited ground-based telescope support prevented us from imaging of H_2O maser emission in the field. Only two antennas of intermediate size participated – 32-m radio telescope of the Torun Centre for Astronomy of Nicolaus Copernicus University (Torun, Poland) and 26-m radio telescope of the Hartebeesthoek Radio Astronomy Observatory (Johannesburg, South Africa). Analysis of the flux density as a function of the baseline length for the bursting H_2O maser feature in the source showed that the estimated size of the features is $\sim$25 μas with a brightness temperature $T_b \sim 3 \times 10^{16}$ K.

3. **EVN / VLBA / KaVA** [9]

In the period between bursts of September and November 2017 there were three ground VLBI observations of G25.65+1.05. Observations were carried out with:
- the European VLBI Network (EVN) on October 2nd, 2017;
- the Korean very-long-baseline interferometry (VLBI) network (KVN) and VLBI Exploration of Radio Astrometry (VERA) Array (KaVA) on October 11th, 2017;
- the Very Long Baseline Array (VLBA) on October 28th, 2017.

In the listed VLBI experiments the study of the fine spatial structure of the bursting H_2O maser feature was conducted with angular resolution of $\sim$0.5 mas. For more details see the article of R.A. Burns et al. “Multi-epoch VLBI of a double maser super-burst” in these conference proceedings.

4. **VLA B-configuration** [10]

The first multi-frequency compact array overview on continuum and maser emission in the source was carried out with B-configuration VLA on December 9th, 2017. Observations were made at 22 GHz and at three methanol frequencies: 6.7 GHz and 12 GHz (class II CH_3OH masers) and 44 GHz (class I CH_3OH masers). For the first time ever four continuum sources are resolved in the field. Thanks to fast data reduction with VLA CASA Calibration Pipeline the maps of 22 GHz H_2O maser spots were obtained for the first time, despite the fact that it was the final observation in the presented series. The absolute position of the 22 GHz H_2O bursting feature is determined in the experiment (available phase reference sources are weak and tend to be resolved with VLBI resolution). Class II methanol maser emission at 6.7 GHz seems to trace an edge-on disk rotating around one of the detected continuum sources. Detected 6.7 GHz CH_3OH masers are spatially associated with not-bursting 22 GHz H_2O masers. The first map of 44 GHz CH_3OH maser emission in the source was obtained. Four spatial clusters of 44 GHz CH_3OH masers are distributed perpendicular to large-scale outflow revealed in molecular line observations of the source [11].

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3. Summary

The high intensity of the burst provides a large dynamic range for the analysis of the parameters of compact structures that are detected in the source on ground-ground and space-ground baselines. VLBI observations of the source show that correlated flux density remains almost constant with increasing baseline length – this indicates that the detected feature is very compact.

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