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GECKO: Network of Telescopes and Follow-up Observation of GW190425

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Abstract. GW190425 is the second gravitational wave (GW) event caused by a binary neutron star (BNS) merger. We report the result of the follow-up observation of GW190425 by the Gravitational-wave Electromagnetic-wave (EM) Counterpart Korean Observatory (GECKO). Our observation demonstrates that GECKO can detect EM counterpart of a GW170817-like event.

Keywords. gravitational waves, stars: neutron, galaxies: general

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1. Introduction

Despite the discovery of about 90 GW sources so far, accurate determination of their positions has been difficult due to the poor localization capability of current GW detectors. Identification of EM counterparts of GW sources can determine GW positions accurately and their host galaxies. Yet, finding EM counterparts is challenging because they are generally faint and fade rapidly. A global network of telescopes and employing efficient follow-up strategy are essential in order to rapidly discover EM counterparts any time out of a wide search area.

GECKO is a global network of 1-2m class optical telescopes, being used by Korean astronomers for identifying GW EM counterpart as fast as possible. We also had a limited access to Gemini and UKIRT during the O3 run. Here, we introduce the GECKO project and report our follow-up observation of GW190425 (Abbott et al. 2020), a BNS merger event expected to produce a kilonova (KN) as an EM counterpart.

2. GECKO Observation of GW190425

GW190425 is a poorly localized BNS merger event with the localization area within 90% confidence of about 7,461 deg^2 and the luminosity distance of 156 ± 41 Mpc.

Observing Strategy: Due to the large localization area, we adopted a galaxy-targeted observation by prioritizing host galaxy candidates within GW localized box with GLADE catalog (Dálya et al. 2018). We assigned score to each selected candidates based on recent simulation results for probable host galaxies in Mapelli et al. 2018 and Artale et al. 2019.

Follow-up observation: We started the follow-up observation at 90 minutes to 7 days after the GW trigger with the imaging depths of 19-22 AB magnitudes at 5σ. We could cover areas in both hemispheres (Fig. 1), but only 5% (400 deg^2) of the 90% confidence localization area. However, we were able to cover ∼600 host galaxy candidates, 30% of the assigned score.

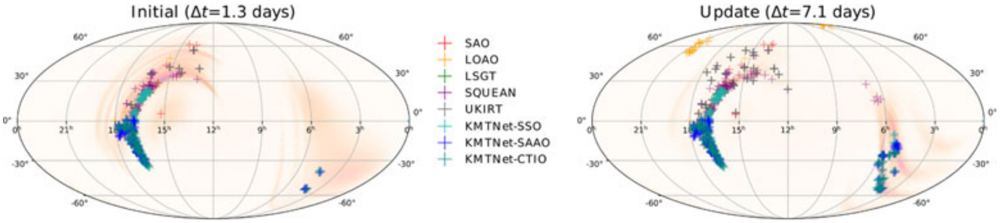

Figure 1. GW localization area of GW190425 (shaded area) and GECKO follow-up pointings (crosses).

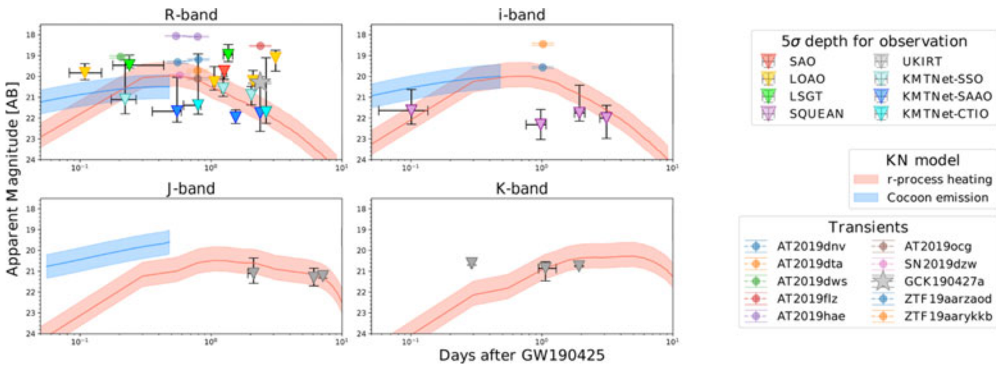

Figure 2. 5σ depths as a function of time after the emergence of GW190425 from GECKO facilities, along with brightness of transients from our observations and KN model light curves (red shaded area; Kasen et al. 2017, and blue shaded area; Piro & Kollmeier 2018)

3. Results and Discussions

GW EM counterpart candidates: From our observation, we found 1,336 solar moving objects, 9 already reported transients and one unreported unknown transients, dubbed in GECKO190427a (Fig. 2). Most transients have already been reported to be SNe. Meanwhile, we derived the photometric redshift of GECKO190427a from its host galaxy spectral energy distribution. We found the value of ~ 0.15 or the luminosity distance of ~ 700 Mpc, too far to be the EM counterpart of GW190425. In conclusion, no plausible EM counterpart was found.

Comparison with KN models: We compared observational depth with KN models (Fig. 2; Kasen et al. 2017, and Piro & Kollmeier 2018). If a GW170817-like KN appeared among the area covered by us, it should been detected (Fig. 2). Furthermore, our observation demonstrates that a GW170817-like KN can be detected out to a few hundred Mpc.

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