OISTER

Optical and Infrared Synergetic Telescopes for Education and Research

光赤外線天文学大学間連携事業

光赤外線大学間連携 OISTER によるマルチメッセンジャー天文学

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光赤外線大学連携 OISTERは、日本の9大学と国立天文台が国内外の可視光・赤外線望遠鏡を有機的に結びつけ、突発天体・現象に即応した多波長・多モード同時観測を実現し、また、各大学のみでは実現困難な人材育成をおこなうプロジェクトである。2022年度から始まった第3期では、マルチメッセンジャー天文学や時間領域天文学を含む幅広い研究を進めている。OISTERに参加する望遠鏡は、これまでにも、重力波イベントGW170817の観測や、高エネルギーニュートリノ事象IceCube-170922Aの電磁波対応天体の捜索に参加し、成功を収めてきた。また、ガンマ線バーストや超新星爆発など、重力波・高エネルギーニュートリノ事象と関連が予想される天体の観測にも積極的に取り組んでおり、成果を上げてきている。例えば、GRB 211211Aは、継続時間が長いガンマ線バーストでありながら、紫外線から近赤外線の放射はコンパクト天体の合体によるキロノバ現象によって説明されうる特異な天体（Troja et al. 2022）だが、この成果にも、OISTERの観測が貢献している。今後も、重力波・高エネルギーニュートリノ事象の可視光・赤外線対応天体のフォローアップ観測と、関連した天体の観測を進めることで、重力波源の多様性の解明、天体合体プロセスの物理の解明、rプロセス元素の起源の解明や、高エネルギーニュートリノ源やその発生プロセスの解明を目指していく。

Telescopes of the OISTER

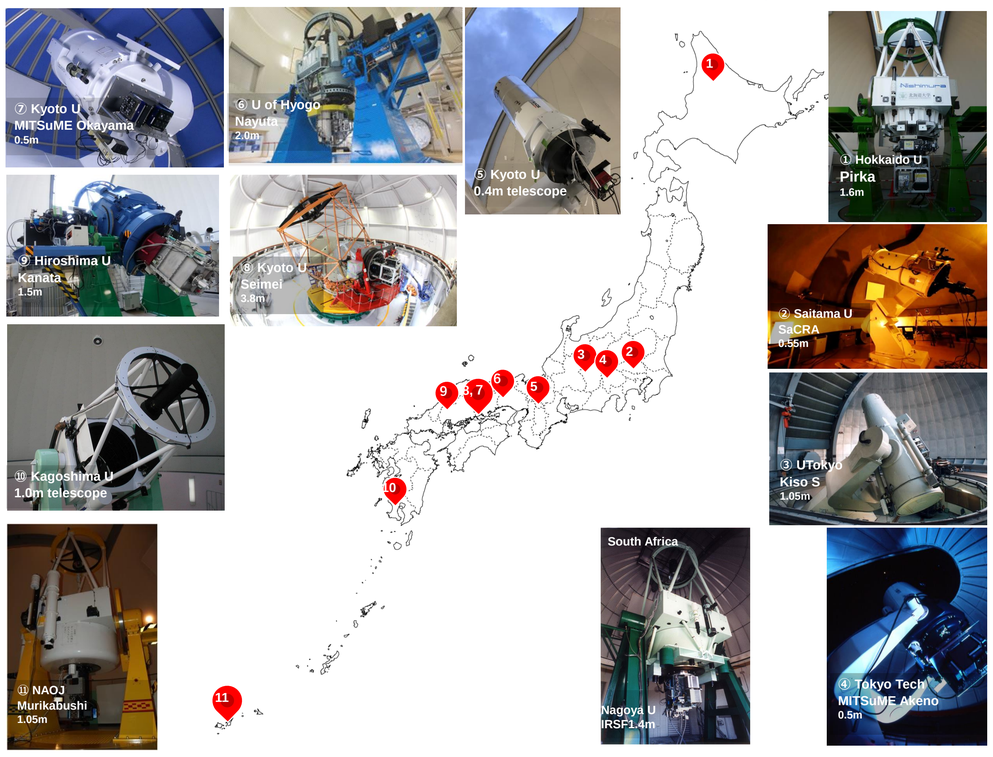


Fig. 1 Observatories operated by the OISTER (9 universities and NAOJ)

Observational Targets of the OISTER

Focusing on the multi-messenger astronomy and time-domain astronomy, we have observed various targets including gravitational waves, neutrino events, supernovae, flare stars, dwarf novae, X-ray binaries, AGNs, GRBs, exoplanets, Solar system objects, pre-main-sequence stars.

Fig. 2 Wide variety of objects for the OISTER observations (left) and white papers published in 2021 (right).

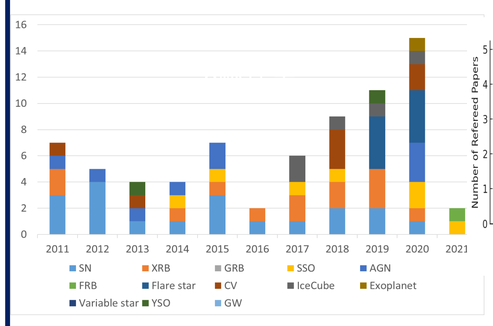


Fig. 3 Number of the OISTER observations

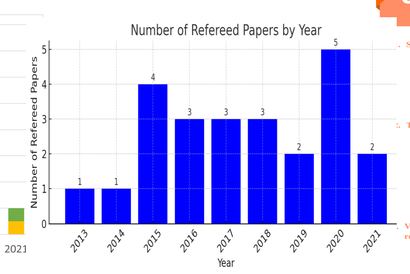
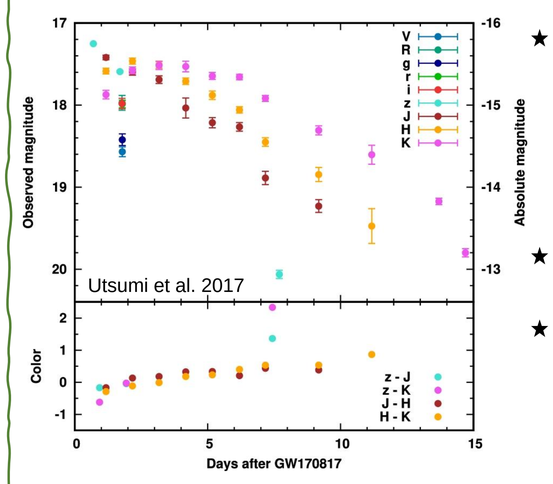


Fig. 4 Number of the refereed papers resulting from the OISTER projects

Multi-Messenger Astronomy: Follow-up Observations of Gravitational Waves

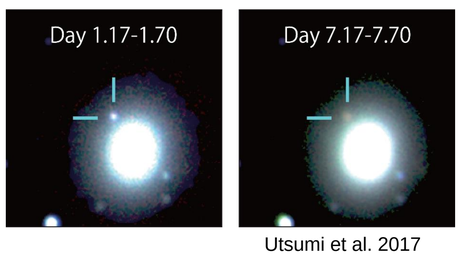
Many telescopes of the OISTER are participating in the Japanese collaboration for Gravitational-wave Electro-Magnetic follow-up, **J-GEM**, conducting optical and infrared follow-up observations of gravitational waves (GWs).

Follow-up Observations of GW170817



- ★ The J-GEM observed AT2017gfo/SSS-17a, the optical counterpart of GW170817, which was caused by a binary neutron star (BNS) merger and resulted in the only optical counterpart observed to date.
- ★ The observed light curve can be understood by kilonova model.
- ★ The near-infrared data were mainly taken by the IRSF telescope in Sutherland, South Africa, participating in the OISTER.

Fig. 6 Light curve of the optical counterpart

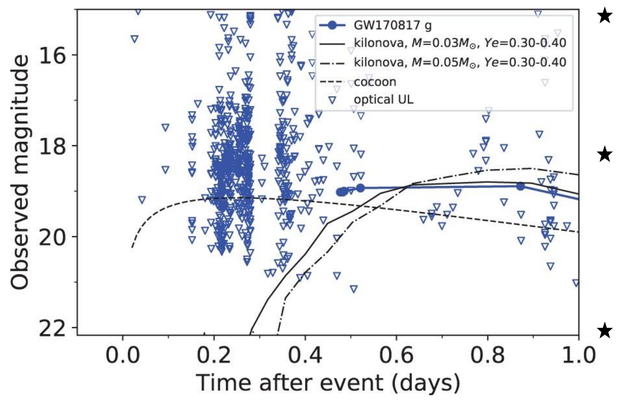


Utsumi et al. 2017

56” x 56”
optical z band: Subaru/HSC
near-infrared H, Ks band: IRSF telescope

Fig. 7 Three-color composite images from the J-GEM observations

Follow-up Observations during the LIGO-Virgo O3 run



Sasada et al. (2021)

Fig. 8 Limiting magnitudes of the J-GEM observation during O3.
The lines are expected magnitudes of optical counterpart at 100 Mpc.

- ★ Telescopes of the OISTER conducted observations of candidate galaxies within the GW error region through the J-GEM.
- ★ During O3, the J-GEM observed 23 GW events, focusing on NS+NS and NS+BH(NS: neutron star , BH: black hole), where electromagnetic waves are expected.
- ★ At most, 170 galaxies were observed in a single event, S190425z.
- ★ Observations for GWs within 100 Mpc can be expected to result in detection
- ★ Observations are also ongoing during the O4 run.

Follow-up Observations of GRB211211A

Troja et al. 2022

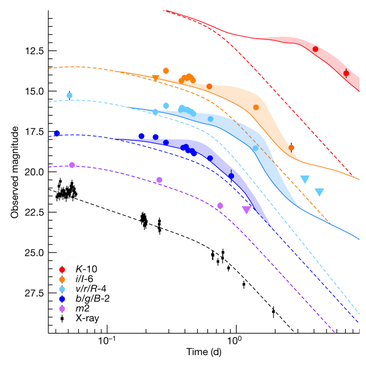


Fig.5 Multicolor light curves compared to models’ predictions of a kilonova (solid line) in addition to the non-thermal emission (dashed line).

- ★ Some of the OISTER telescopes are conducting immediate observations of GRBs.
- ★ The MITSuME Akeno 50cm telescope observed GRB 211211A starting 0.24 days after the Fermi trigger (GCNC #31217).
- ★ Despite the long duration of GRB211211A, observations in ultraviolet to near-infrared suggest that it can be explained by a kilonova from the merger of compact objects (Troja et al. 2022, Nature, 612, 228). The MITSuME contributed to this result through optical observations.

Educational Activities

To nurture highly-skilled youths by offering opportunities for undergraduate/master/Ph.D. students and Postdocs to engage in not only extensive science activities but also productive educational programs including on-site observations and instrumentation experiences. We have been conducting a variety of educational programs such as short-term stay training, workshops, and various seminars.

Short-Term Stay Training Program

Objective: Skill enhancement for students and researchers. Developing individuals who utilize their expertise while possessing a broad perspective and thinking abilities.
Target: Graduate students and Postdocs affiliated with OISTER institutions, who are engaged in research in the optical and infrared observational astronomy.
Support Details:

- Travel expenses provided for the stay, limited to the domestic travel
- Basic instruction related to observation and analysis, and equipment and system development

Duration of Stay: Several days to about one week.
Number of implementations: 21 cases from 2013FY to 2022FY

- Spectroscopy: 9, Equipment & System Development: 5, Polarimetry: 3, Imaging: 4

Number of the degree holders related to the OISTER

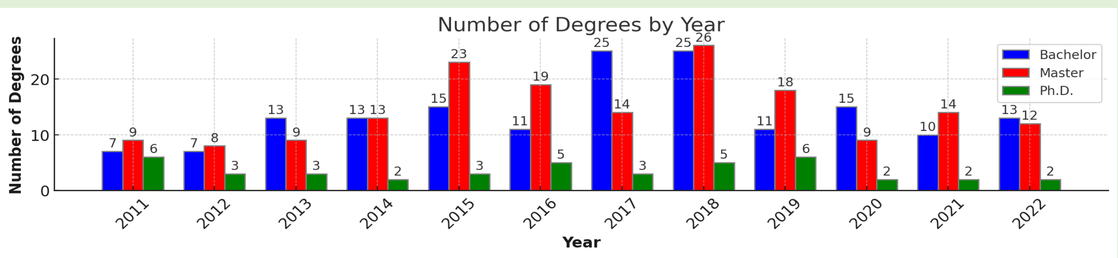


Fig. 9