日本天文学会早川幸男基金渡航報告書

申請者氏名	仲宇星 (会員番号 7967)
連絡先住所	〒 169-8555 東京都新宿区大久保 3 丁目 4-1
所属機関	早稲田大学
職あるいは学年	PD：学振
任期 (再任昇格条件)	1 年 3 月 (再任不可)
渡航目的	共同研究
講演・観測・研究題目	A first look at the RLAGNs in the Euclid Deep Fields
渡航先 (期間)	Italy(2025 年 6 月 1 日〜8 月 29 日)

From June 1st to August 29th, I have stayed in Rome as a visiting researcher at Roma Tre University. I worked with Dr. Federica Ricci on *Euclid* first Quick data release (Q1). We aim to provide a first look at radio-loud active galactic nuclei (RLAGNs) in the *Euclid* Deep Fields North (EDFN) and Fornax (EDFF) and prepare for the *Euclid* DR1.

During my stay in Italy, I have also traveled to Sexten to attend the conference "Dancing in the Dark: When Galaxies Shape Galaxies". This conference focuses on the theoretical and observational studies related galaxy mergers across cosmic time, trying to understand the fundamental questions including how mergers change the morphology of the galaxies, to what extent do mergers contribute to new star formation in galaxies at different epochs, and how is the supermassive black hole (SMBH) of galaxies affected by accretion events and mergers. At the conference, I gave a 20-min contributed talk, introducing my previous study of a young, radiatively efficient RLAGN hosted by a starburst major merger at $z = 1.92$. This case study suggests that galaxy mergers around the cosmic noon ($z \sim 2$–3) can trigger the simultaneous star formation, SMBH growth, and AGN radio activities, implying an indispensable stage of galaxy-SMBH co-evolution.

As part of my current research project and connected with the ongoing *Euclid* projects, I also introduced my RLAGN catalog by cross-matching the Ultraviolet Near Infrared Optical Northern Survey (UNIONS) and the radio VLA Sky Survey (VLASS) at 3 GHz, aiming for establishing a statistical understanding of the connection galaxy mergers and RLAGN activities. One of the key problems in this research project is to have robust identifications of mergers for the RLAGN host galaxies. During the conferences, various talks have introduced the methodologies on merger identifications, including visual investigations, morphological parameters, and machine learning (ML) techniques. However, none of these methods is perfect and all of them are subject to misclassifications. Therefore, continuous efforts have to be put into this field to increase both efficiency and correctness of the merger identifications. Of these talks, the one given by Antonio La Marca is of great importance since his study of the ML-based approach successfully identified mergers in EDFs for galaxies at $z < 2$ and reached a correctness of 80%. These

results have been applied to my current research and this method is promising in future *Euclid* data releases.

This visit to Roma Tre University yielded fruitful results. Applying my experience in UNIONS-VLASS to *Euclid* Q1 data, I constructed the *Euclid*-VLASS radio galaxy (RG) catalog. Then, I performed spectral energy distribution (SED) fittings to search for the photometric redshifts (photo-z) of *Euclid* RGs and compute the AGN and host galaxy properties. To validate the uncertainty of the estimated photo-z and physical properties, I have communicated with Brivael Laloux working the SED fitting of *Euclid* AGNs. By comparing our estimated photo-z with the spectroscopic redshifts compiled by Laloux, $\sim 25\%$ of our RGs can be outliers considering their large uncertainties in the photo-z estimates. This outlier fraction is much better than that of UNIONS-VLASS because the photo-z estimates in UNIONS do not incorporate AGN templates. Therefore, this method in *Euclid*-VLASS will be applied to UNIONS-VLASS in follow-up studies. Additionally, by comparing the physical properties between ours and those computed by Laloux, I found good consistency, and the large discrepancies are attributed to the differences in redshifts. I examine the difference in the star formation rates between my RGs and star-forming main sequence galaxies as a function of host galaxy stellar masses, spectral luminosity at 1.4 GHz, AGN bolometric luminosity, and redshifts. I find two distinct RG populations: one resides in massive quiescent galaxies with relatively low AGN activity, and the other is associated with star-forming systems hosting rapidly growing SMBHs. Furthermore, towards higher redshifts ($z > 1$), an RG is more likely to be the star-forming one.

For the morphological classifications, we incorporate the results provided by La Marca. There are 360 of our RGs identified by La Marca, and over half of them are associated with mergers. This suggests a tight connection between the emergence of RLAGN and galaxy interaction/mergers, in line with the study performed by Manuela Magliocchetti, who studied *Euclid*-LOw-Frequency ARray (LOFAR) RGs, of which I joined as a collaborator. I further compared the AGN and host galaxy properties of mergers with non-mergers but found no significant differences in these properties between the difference populations. These results then suggest that, although RLAGNs favor mergers, galaxy mergers and interactions may not be critical for triggering AGN radio activity. The critical question then comes to the ages of RLAGNs and the host galaxies' merger history. This requires multi-frequency radio data to answer, which have been compiled for UNIONS-VLASS and will done for *Euclid*-VLASS based on the *Euclid* wide survey data.

One critical problem remains for *Euclid* Q1 data is the lack of precise spec-z estimates for quasar candidates due to the design and artifacts of the *Euclid* Near Infrared Spectrometer and Photometer. Therefore, in addition to these paper to be submitted in early October as *Euclid* collaboration, working together with worldwide *Euclid* members, we submit Subaru Prime Focus Spectrograph proposals to determine the spectroscopic redshifts of *Euclid* quasar candidates and galaxies beyond the epoch of re-ionization to fully explore the potential of *Euclid*, benefiting the broader international astronomy community.