Kwansei Gakuin University
Report of Research Outcome

2019/9/23

To President

Department : Science and Technology
Position : Postdoctoral fellow
Name : Dragan SALAK

I report the outcome of the research as follows.

Name of the Fund/Program	□Sabbatical leave with grant □Sabbatical leave with no grant □KGU Joint Research □Individual Special Research ☒Postdoctoral fellow ※Please report by designated form as for “International Research Collaboration”.
Research Theme	Distribution of Neutral Carbon in Nearby Galaxies
Research Site/Venue	Kwansei Gakuin University, Graduate School of Science and Technology
Research period	2019/6/1 ～ 2019/9/30 （ 4 months）

◆ **Summary of the research outcome** （approx. 2,500 words）

Please write down the outcomes in detail regarding the research theme above.

The research results obtained during the designated period are based on the following activities: (1) observations and measurement of the distribution of atomic carbon gas in nearby galaxies using mainly Atacama Large Millimeter/submillimeter Array (ALMA) interferometer and (2) preparation of the K-band receiver to be used on the 54-m telescope of Japan Aerospace Exploration Agency (JAXA) and designing the observations of water maser in nearby active galactic nuclei to estimate the Hubble constant. Below is the summary of the activities and results.

(1)

We completed observations of the central 1 kpc region of the nearby starburst galaxy NGC 1808 in the fine-structure [C I] 3P1-3P0 line of neutral atomic carbon using Atacama Large Millimeter/submillimeter Array (ALMA). The data were reduced and the results were submitted to The Astrophysical Journal in late August. In addition to [C I] data, in the same project we also used ALMA to image CO (J=2-1), as well as 13CO and C18O, that trace the bulk of molecular gas. In order to explore the feasibility of using [C I] as a tracer of molecular gas, we investigated the relationship between [C I] and CO line intensities using this galaxy as a case study.

We found that the [C I] line is linearly correlated with optically thick CO lines (J=2-1 and J=3-2). On the other hand, the correlation is not linear but a power law (exponent 0.7) between [C I] and CO (J=1-0), which we interpret to be a result of optical depth effects. The fact that [C I] is tightly correlated with CO (J=2-1) and CO (J=3-2), which are optically thick, suggests that the [C I] emission, although optically thin, originates from the same regions as that of optically thick CO lines, that is, in the outer layers of molecular clouds. This result is consistent with clumpy photodissociation region models. On the other hand, the correlations are not linear between [C I] and 13CO (2-1) or C18O (2-1), again, supporting the scenario that atomic carbon is distributed more toward the cloud outer layers than the interior where 13CO and C18O are abundant. Finally, we found that the plot of [C I] vs. CO (1-0) supports a linear correlation when the emission from the entire central galactic region is integrated. This result indicates that [C I] can be used as a tracer of molecular gas in galaxies, albeit caution is needed when applied to the nuclear regions of starburst galaxies.

(2)
The K band receiver for the newly completed JAXA 54-m telescope is in the phase of adjustment and modification to cover a wider frequency band including emission from water (H_2O) masers at the frequency of 20 GHz. The science goal of using this receiver is the survey many galaxies that host active galactic nuclei (AGN) or their candidates by observing emission from water masers. The masers have been used as a powerful tool to detect supermassive black holes in the past. At the same time, monitoring of these objects allows us to estimate the distance to the host galaxies. Having measured the distances d and receding velocities V, we can measure the Hubble constant, H_0, which is defined as $V=H_0\ d$. The Hubble constant is one of the most important parameters related to the dynamics of the expansion of the Universe. The results are expected to further constraint the value of H_0, that has been a matter of active research in recent years using various observational methods.

We have investigated previously published papers that report AGN-like activities in nearby galaxies at wavelengths from X-rays to infrared and radio. Priority targets are being prepared for our observations. These include those that can be observed from the northern hemisphere (due to location of the 54-m telescope), are close enough (systemic velocity <10,000 km/s), have strong indicators of AGN activity (e.g., bright X-ray emission), and have not been observed extensively before in the radio regime. Our high priority list includes about 300 targets observable from the site of the 54-m telescope. We acquired the coordinates and receding velocities of the host galaxies by investigating data bases of previous observations. We calculated the receding velocities in radio definition from the acquired velocities in optical definition. First observations are expected to be carried out as soon as the K band receiver is mounted.

Deadline : Within two months after finishing the research period.

Sabbatical leave with grant: Submit this report to President with confirmation by the dean of school you belong to.

※Postdoctoral fellow is required to submit this report with confirmation by the dean of graduate school before the end of employment period.

Where to submit : Organization for Research and Development and Outreach (NUC)

◆We put this report on the web of KGU. If there is any problem about it because of difficulties on your research, please let us know.