Near-infrared Spectroscopy of Nearby Seyfert Galaxies for Examinig the Ionization Mechanism of Narrow-line Regions

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The active galactic nucleus (AGN) feedback, which is a negative/positive feedback effect on star formation activity, has been paid a lot more attention recently. A massive galaxy has a supermassive black hole (SMBH) at its center, and the inflow of interstellar medium (ISM) to SMBH invokes its AGN activity, which releases vast gravitational potential energy to the ISM in the suppression of star-formation activity in its host galaxy.

However, how the AGN activity transmits its energy to the ISM remains a serious mystery. We here focus on a shock ionization of the ISM in narrow-line regions (NLRs) as another possible physical mechanism of the AGN feedback, i.e., the AGN activity inputs its energy to the ISM through a shock heating induced by a jet or AGN wind. Therefore it is interesting to explore whether and how the fast shock contributes the NLR ionization in AGNs.

Although it is widely accepted that NLRs in AGNs are mostly photoionized by photons from a central engine, the possibility of shock ionization induced by a jet or AGN wind at off-nucleus regions. The discrimination between the shock-ionization and photoionization of NLRs in AGNs was extremely difficult. As a reason for that in previous studies of NLRs, optical line-ratio diagnostics have failed to discriminate between the two mechanisms, because optical NLR spectra predicted by the photoionization and shock ionization models are very similar in each other [1].

The near-infrared emission-line flux ratio of [Fe II]1.257 μm/[P II]1.188 μm is a very powerful indicator to discriminate the photoionization and shock ionization [2,3]. The [Fe II]/[P II] ratio in fast shock-excited regions is expected to be high (~20) while that in purely photoionized regions is low (~2).

We carried out the near-infrared spectroscopic observations of 26 nearby Seyfert galaxies with a near-infrared spectrograph (ISLE) boarded on the 188 cm telescope at Okayama Astrophysical Observatory. As a result, we measured the [Fe II]/[P II] flux ratio or its lower limit for 19 objects and 22 Seyfert galaxies from the literature. Based on the collected data, we found that the ionization mechanism of the NLR is the photoionization in most cases ([Fe II]/[P II] < 5) but the fast shock contributes in some Seyfert galaxies ([Fe II]/[P II] > 10). We found that these is no significant correlation between the [Fe II]/[P II] and the radio-loudness (Figure 1). We checked the effect of the shocks from star-formation activities using some starburst indicators (far-infrared luminosity and the mid-infrared PAH emission), and confirmed that the [Fe II]/[P II] ratio is independent the starburst activities. These results suggest that the NLR in some Seyfert galaxies is affected by fast shocks whose origin is the radio jet and other mechanisms such as the powerful AGN wind [4].

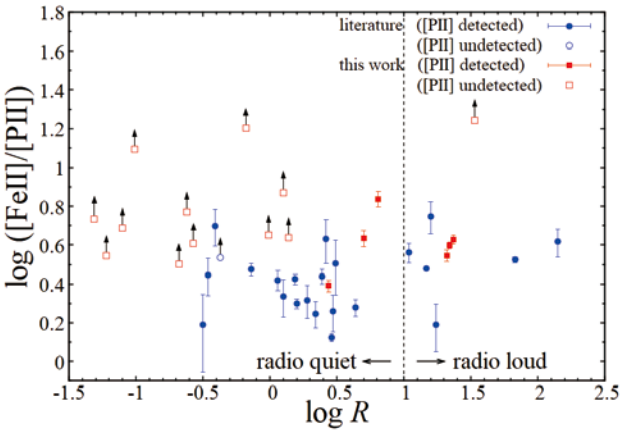

Figure 1: Relation between the [Fe II]/[P II] ratio and the radio-loudness of nearby Seyfert galaxies. Perpendicular dashed line shows the threshold dividing the radio-loud and radio-quiet populations.

References

[1] Allen, M. G., et al.: 2008, *ApJS*, **178**, 20.
[2] Oliva, E., et al.: 2001, *A&A*, **369**, L5.
[3] Hashimoto, T., et al.: 2011, *PASJ*, **63**, L7.
[4] Terao, K., et al.: 2016, *ApJ*, **833**, 190.