日本天文学会2026年秋季年会

The Jet and Arc Molecular Cloud Towards the Galactic Candidate PeVatron Microquasar GRS 1915+105

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The origin of Galactic cosmic rays (CRs) remains one of the most compelling open questions in astrophysics. The recent LHAASO detection of ultra-high-energy gamma-ray emission from Galactic microquasars has established them as efficient CR accelerators capable of reaching PeV energies (i.e., PeVatrons), with the interaction between their jets and the surrounding interstellar medium (ISM) as promising acceleration sites. GRS 1915+105 is one among reported candidate PeVatron, which is an extensively studied, archetypical Galactic microquasar having relativistic bipolar jets. We investigate the molecular gas associated with GRS 1915+105 using ^{12}CO(J=1—0) observations from the FUGIN survey with NRO 45-m telescope (~20'') along with ^{12}CO(J=2—1) observation with NANTEN2 (~90''). We identify large scale jet and arc-like molecular cloud structures along the high-energy jet direction at a radial velocity of ~ 68 km/s. One of the clumps within jet cloud spatially coincides with the previously reported radio continuum region. Considering a distance of 9.4 kpc, the jet clouds extend over ~ 70pc and a width of ~10pc, while the arc cloud spans ~55pc with a width of ~70pc. Using the standard X_{CO} conversion factor, we estimated masses of ~4x10^3 $M_\odot$ and 3x10^4 $M_\odot$ for jet and arc clouds respectively. The ^{12}CO(J=2–1)/(J=1–0) intensity ratio is moderately enhanced toward both structures, suggesting altered physical conditions in these regions. Position-velocity analysis reveals a velocity distribution suggestive of a sinusoidal pattern along the jet cloud further suggesting presence of jet-ISM interaction in this system. Furthermore, in the vicinity of the compact object, we identify a molecular cavity and an expanding shell with a mass of ~10^4 $M_\odot$ and momentum of ~4.5x10^4 $M_\odot$ km/s, consistent with a wind-blown bubble possibly originated by the progenitor of the black hole. We discuss the implications of our findings in the context of CR acceleration in by Galactic microquasar jets.