IGRINS-2 SV Observation Evaluation Form

Title: High-velocity Supernova Ejecta Knots in Cas A

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Description of the primary goals and the main findings

The primary goal of this proposal is to detect CO 2.3 μm emission from the fast-moving supernova ejecta knots (FMKs) in Cas A supernova remnant. We selected two knots bright in [Fe II] 1.644 μm located in the northeast (FMK_NE) and southwest (FMK_SW) of the remnant that have high F444W/F356W ratio from the recent JWST/NIRCam observations. Their high F444W/F356W ratios likely come from the fundamental CO emission at 4.5 μm, which suggests the possibility that the CO 2.3 μm emission exists as well. The secondary goal is to investigate the velocity structure of [Fe II] lines to explore the kinematics. Both knots are very faint with the [Fe II] 1.644 μm line flux of (1-2.5) x 10^{-15} erg cm^{-2} s^{-1}, and FMK_SW is about twice brighter than FMK_NE.

The observation was carried out on 2024 July 18 UT under the CC50/IQ20 condition. We observed the targets with the nodding-along-slit mode (ABBA) since the size of the knots is comparable to the slit width (~0.3″). The total exposure time is 4800 sec and 2400 sec for FMK_NE and FMK_SW, respectively. For the expected CO 2.3 μm line flux of (1-2) x 10^{-15} erg cm^{-2} s^{-1}, which is assumed to be ~10% of the F444W flux, the estimated signal-to-noise ratio (S/N) from the IGRINS-2 ITC is 15 for FMK_NE and 20 for FMK_SW.

Data reduction was done using the igrins2-dev branch of IGRINS PLP version 3. In the IGRINS-2 spectra, we detected several [Fe II], [Fe III], and maybe He I lines as well as the bright [Fe II] 1.644 μm line. Unfortunately, we have not detected the CO 2.3 μm emission in either target. From the [Fe II] 1.644 μm line, the radial velocities of FMK_NE and FMK_SW were estimated as -3056 km s^{-1} and +4050 km s^{-1}, respectively. The non-detection of CO is likely due to the overestimation of the expected flux. Even if there is CO, it could have been too faint to be detected. Our assumption that CO 2.3 μm is about 10% of F444W flux is from the previous CO imaging study (Rho, J. et al. 2009, ApJ, 693, L39) that compares the CO 2.3 μm and 4.5 μm (Spitzer IRAC 2) flux, but the sample size is too small. The F444W flux can also contain other emissions rather than CO due to wide filter width.

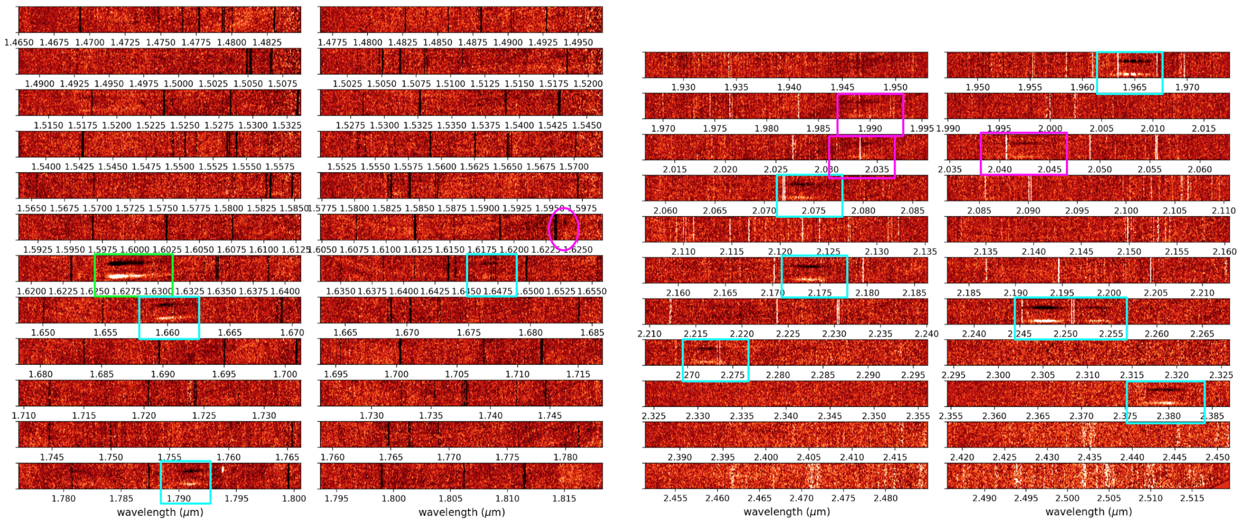

Figure 1: (left) H-band 2D spectra of FMK_NE. The green box marks [Fe II] 1.644 μm. (right) K-band 2D spectra of FMK_SW. In both panels, cyan boxes mark the iron forbidden lines. The lines marked by magenta boxes are not yet identified.

Some lines show velocity structures. For example, while the [Fe II] 1.644 μm line of FMK_SW appears a simple broad gaussian, that of FMK_NE shows two components with an additional tail-like feature. This line profile indicates that the layers of the knot show different kinematics.

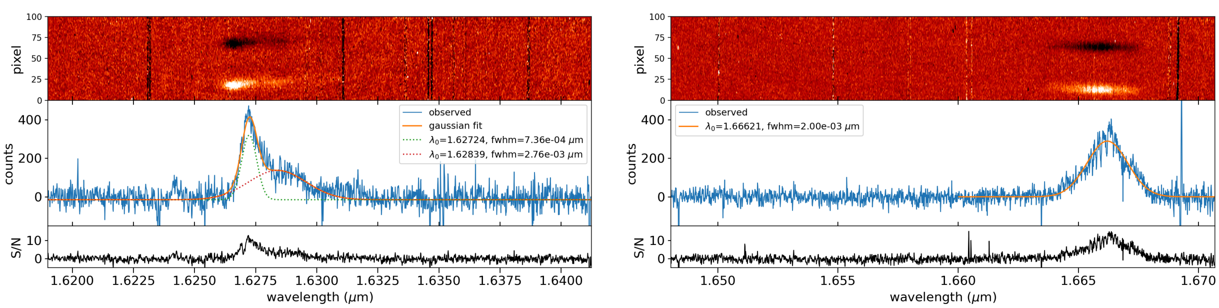

Figure 2: [Fe II] 1.644 μm line of FMK_NE (left) and FMK_SW (right). Top, middle, and bottom panels show the 2D spectra, 1D spectra with gaussian fitting, and S/N.

As shown in Figure 2, the peak S/N of [Fe II] 1.644 μm is ≲15 which is quite lower than estimated by ITC: 28 and 40 for FMK_NE and FMK_SW, respectively. The reason for this discrepancy could be the slit loss because they are extended sources although their size is comparable to the slit width. The discrepancy between ITC and the observed spectrum also can be a reason for non-detection of CO emission.

Additional comments on IGRINS-2 performance:

It may need to investigate the sensitivity for faint sources in detail with more samples.

Suggestions for improvements:

N/A

Any additional comments about IGRINS-2 SV

N/A