IGRINS-2 SV Observation Evaluation Form

Title: Characterizing the Members of Halo Wide Binary Systems with IGRINS-II
Program ID: GN-2024B-SV-105
Authors: Dongwook Lim, Zachary Hartman

Description of the primary goals and the main findings

- Science goals:

The release of the Gaia data over the past decade has revolutionized many fields of stellar astronomy. In particular, it has allowed for the identification of many more wide visual binary systems, which can be used by astronomers to study a number of different scientific questions. We propose to observe several wide binary systems that were found in previous surveys through their similar astrometric properties. Our goal is two- fold: Compare the chemical compositions of the wide binary pair and search for signs of possible third components in these systems. By characterizing the components in these systems, we can further our understanding of the formation and evolution of these binary systems. We will combine the IGRINS-II data with Gaia RVs to search for possible signs of third companions. In particular, we will examine metal-poor Galactic halo star wide binaries, which have yet to be fully examined.

- Targets & Observations

We observed two stars in a wide binary system. The primary star, G139-46, has a K magnitude of 12.61, and the secondary star, G139-46B, has a K magnitude of 14.32. We used the A0V telluric standard star (HIP 87643) for both target stars, as they are located nearby. The total exposure time was 3360 seconds for the primary star and 3800 seconds for the secondary star. Each exposure time was estimated to achieve a peak signal-to-noise ratio (SNR) of approximately 100 for G139-46 and ~30 for G139-46B in the H-band region using the ITC. The actual SNRs obtained were 120 for G139-46 and 50 for G139-46B at 1.63 µm, which exceeded our expectations.
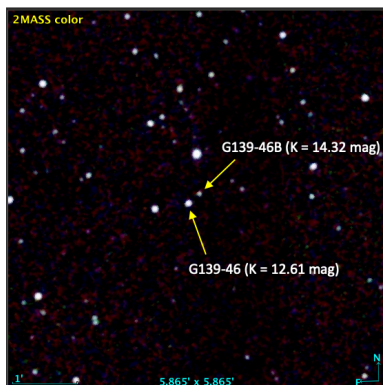


```
+-----+-----------+------------+----------+-------------+-----------+
| GID | Obj. Name | Recip      | ExpTime  | ObsIDs      | Frames    |
+-----+-----------+------------+----------+-------------+-----------+
|  57 | G 139-46  | STELLAR_AB | 120 x 28 | 57-78,80-85 | (ABBA)x7  |
|  86 | HIP 87643 | A0V_AB     | 40 x 4   | 86-89       | ABBA      |
|  90 | G 139-46B | STELLAR_AB | 475 x 8  | 90-97       | (ABBA)x2  |
|  98 | Blank sky | SKY        | 300 x 1  | 98          | -         |
|  99 | FLAT ON/OFF | FLAT     | 30 x 20  | 99-118      | Sx10 0x10 |
+-----+-----------+------------+----------+-------------+-----------+
```

- Radial velocity and binary identification

After data reduction using PLP, we generated a continuous 1D spectrum by combining spectral orders. From this spectrum, we measured the radial velocities of the targets using the cross-correlation method with a template spectrum. Both stars show similar heliocentric radial velocities: 77.35 km/s for G139-46 and 76.54 km/s for G139-46B, with small measurement errors of 0.29 km/s and 0.27 km/s, respectively. This similarity supports the conclusion that these two stars are not just a randomly co-moving pair but an actual binary system. Our estimate of the radial velocity for G139-46 is also comparable to that provided by Gaia DR3 (76.02 km/s). The lack of variation in radial velocity across two different epochs indicates that there is no hidden companion around the primary star. We note that the radial velocity for the faint secondary (G139-46B) is not available from Gaia DR3.

- 1D spectrum

The figure below shows the 1D spectra for G139-46 (in blue) and G139-46B (in red). The two stars exhibit quite different spectral features, despite being components of the same binary system with similar chemical properties. This difference may be attributed to the varying atmospheric parameters (e.g., effective temperature) between the two stars. On the other hand, the weak Fe absorption lines in G139-46 indicate the low metallicity of this star, although a precise abundance ratio will be measured after determining the atmospheric parameters.
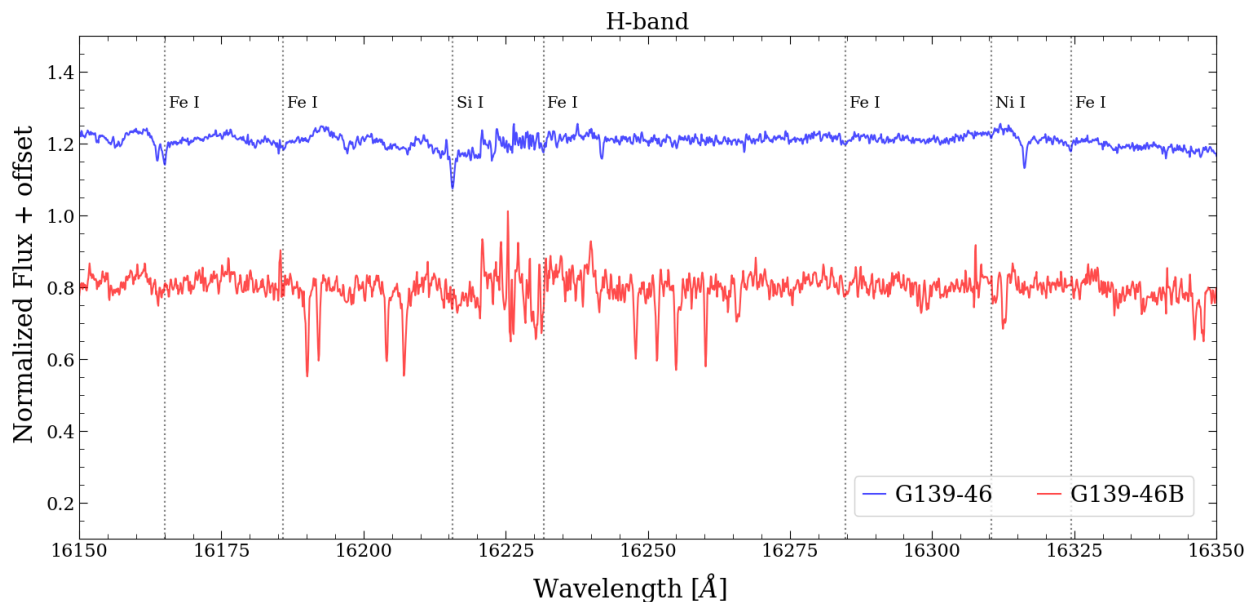
Additional comments on IGRINS-2 performance:

- IGRINS-2 capability of radial velocity measurement

Our results suggest that IGRINS-2 can reliably measure radial velocity for stars with K magnitudes less than 14.32 at an SNR of around 50.

Suggestions for improvements:

- Gaps in K-band region after dividing A0V standard

We observed that some gaps appeared between different orders in the K-band spectrum after dividing by the A0V standard (see figure below). While this is suspected to be due to low signal in this region, some revisions to the data reduction code may be necessary.
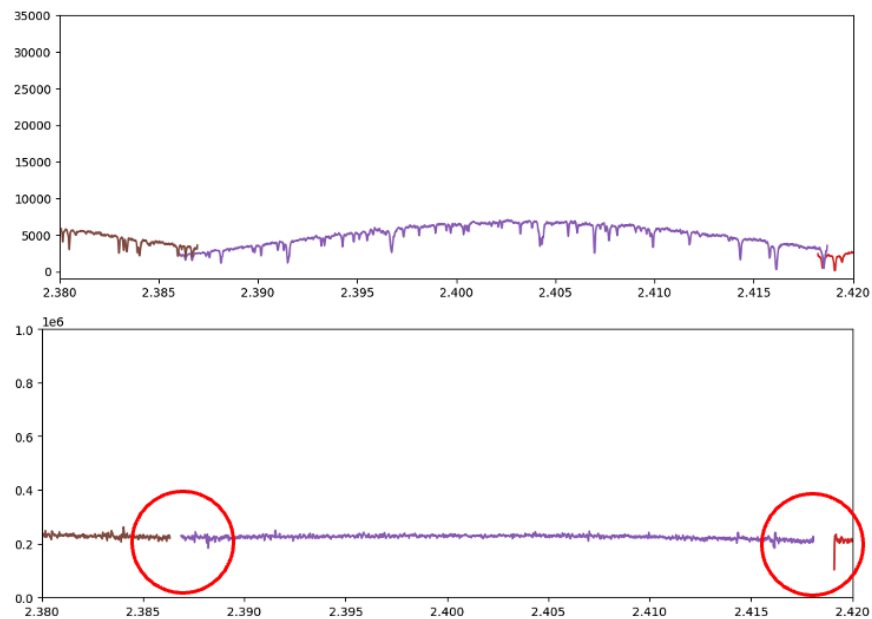
Any additional comments about IGRINS-2 SV

Thank you for all of your service.