IGRINS Newsletter

Dear IGRINS Community

IGRINS was unpacked at Gemini South on March 8th, installed on the telescope on March 21st, and then successfully commissioned between April 2-6, 2018. In the Gemini queue there were 20 approved IGRINS programs with ∼350 hours of awarded time. Many of the programs without strict timing requirements were completed! With the Gemini visit completed, we are now preparing IGRINS for a third visit to Lowell Observatory's Discovery Channel Telescope between September 2018 and April 2019. Calls for DCT queue requests and Korean proposals will be sent out in mid-August 2018.

In this newsletter we discuss a few of the changes made to IGRINS for the Gemini visit. More detail can be found in our recent SPIE paper (Mace et al. 2018). Note to Gemini PIs, all IGRINS data distribution is currently being handled outside the Gemini Online Archive and you should contact Kim Sokal (ksokal@utexas.edu), Greg Mace (gmace@utexas.edu) and/or Hwihyun Kim (hkim@gemini.edu) with questions.

Finally, we take this opportunity to remind the IGRINS community that the full proprietary period is 24 months. We are actively considering our options for an online archive and we anticipate making IGRINS data available to non-PIs sometime in 2019. If you need help finding your IGRINS data, reducing the data, or getting to publication then let us know! We are eager to get your results out too!

With best wishes,
Dan Jaffe and the IGRINS Team

Contents

1 Updates

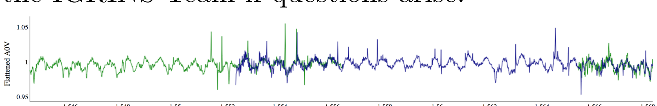
1.1 Current IGRINS Status and Performance

IGRINS has completed its 3-month visit to Gemini South and is now headed back to Austin. In August we will swap the input optics back to the default assembly required for the DCT. We will also verify that the IGRINS was not damaged in transit from Chile. It has now been 4 years since IGRINS was commissioned and we need to consider maintenance of more durable components than we have in our annual maintenance intervals.

We report slit dimensions and limiting magnitudes (SNRsim100 in 1 hour with seeing∼0.8") of ∼1"×15" and K=10.2 mag on HJST, K=11.2 mag and ∼0.6"×9" on the DCT, and K=11.9 mag and ∼0.34"×5" at Gemini South with 0.6" seeing.

1.2 Fringing in IGRINS Spectra

Discussions during SPIE 2018 motivated the review of fringing in IGRINS spectra. Other instruments have experienced fringing effects, and it is generally traced back to the anti-reflection coatings on optics. When optics are developed and coated for large wavelength ranges, the number and thickness of the coating layers increases, which can cause fringing. The ∼1μm operating range of IGRINS is large, but not as large as the 1-5μm range of other variable-setting, near-IR spectrographs. We find that IGRINS data from the 2.7m at McDonald Observatory does not show fringing. However, there is fringing with amplitudes <4% in the K band at the DCT, and in both the H and K bands in Gemini data. In the figure below, we show how the fringes repeat ∼28 times across the detector with a fixed frequency and amplitude. Because the fringing is in both the science data and the flat fields, it is removed by the standard flat-fielding process. However, residuals in the correction will persist for science that does not use the standard reduction process or for the brightest and faintest targets. Observers should consider this effect, check their spectra, and contact the IGRINS Team if questions arise.



1.3 Scientific Data from the McDonald Commissioning Runs

Any member of the astronomical community may examine the IGRINS commissioning data to help form their future proposals. The data format remains unchanged and this early data from IGRINS is still representative of what it can produce. Science verification data from the commissioning runs were processed using the current pipeline and available online http://kgmt.kasi.re.kr/igrins/pipeline/. Please be sure to read the Sample Data Policy, also available on the same website. More information on these data can be found in previous newsletters: HERE.

1.4 IGRINS @ DCT

The upcoming visit to the DCT is the third visit since Fall 2016. The original agreement between the IGRINS Team and Lowell Observatory was for 3 visits, of 6 months each, over 3 years. IGRINS will be at the DCT from September 2018 to April 2019. The schedule for IGRINS at the DCT has already been made for the 2018B semester, with ∼72 nights of IGRINS use. UT/KASI time at the DCT will continue to be queue scheduled based on an online request form and through the Korean TAC. A call for proposals will be made in August 2018.

1.5 IGRINS @ Gemini

The primary change made to IGRINS for Gemini South was the exchange of the input optics. The default input optics for IGRINS convert the telescope beam from f/8.8 to f/10 at the slit. The new input optics convert an f/16 beam to the same f/10 at the slit. This change is required in order to keep the H and K spectral formats unchanged between facilities. Additional changes to IGRINS include a new instrument mount and modifications to software and observing practices. Logistical requirements of shipping IGRINS to Chile and to conforming to the Gemini queue requirements also required our effort. The IGRINS Team thanks Hwihyun Kim and Brian Chinn at Gemini South for their communication and support throughout the Gemini visit.

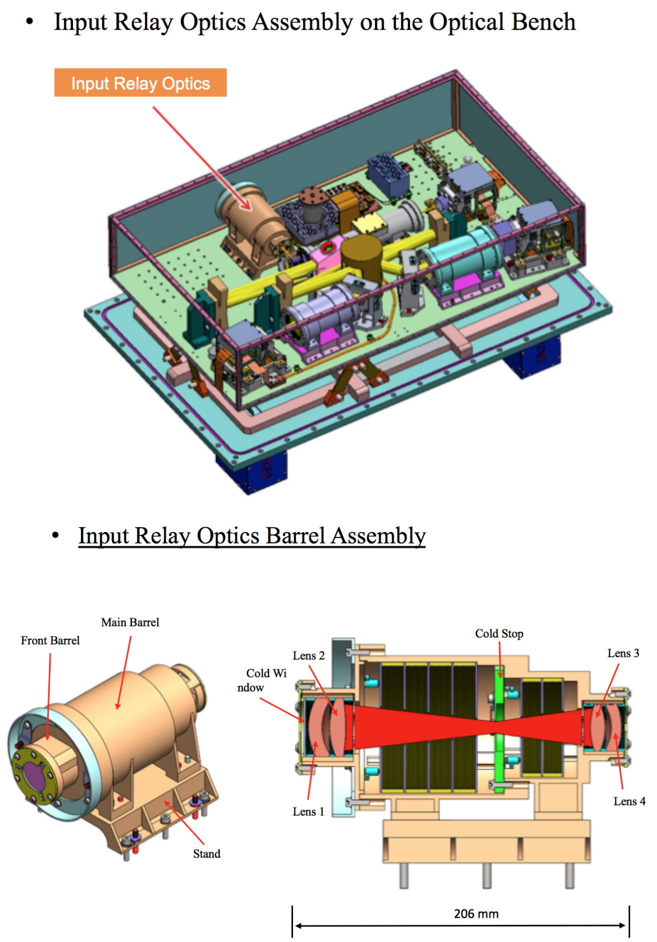


Figure 1 *Top: The IGRINS optical layout with the input optics identified. Bottom: A closeup and cut-away of the input optics.*

1.6 IGRINS in 2019

We have not made a decision on where IGRINS will be located after the DCT visit ends in 2019A. Options include the 2.7m at McDonald, the 4.3m at DCT, the 4.1m SOAR telescope, and a return to Gemini South. A survey requesting input from the IGRINS community will be distributed to help us make a choice that agrees with the majority of science goals.

1.7 IGRINS PLP

In previous newsletters a few different versions of the data reduction pipeline were referenced. There is now a single version (2.2) that should be used for all data reduction https://github.com/igrins/plp/releases. With this release, Anaconda Python and conda environments can be used for easier installation https://github.com/igrins/plp/wiki/How-to-run-pipeline.

2 Recent Publications

Here we highlight recent IGRINS publications. A full list of publications can be found HERE. If you have plans to publish IGRINS results soon, then be sure to contact the IGRINS Team to make sure that your work follows team guidelines. General publication guidelines can be found at the end of the newsletter.

2.1 Wolf 1130: A Nearby Triple System Containing a Cool, Ultramassive White Dwarf

Mace et al. 2018 - Following the discovery of the T8 subdwarf WISE J200520.38+542433.9 (Wolf 1130C), which has a proper motion in common with a binary (Wolf 1130AB) consisting of an M subdwarf and a white dwarf, we set out to learn more about the old binary in the system. We find that the A and B components of Wolf 1130 are tidally locked, which is revealed by the coherence of more than a year of V-band photometry phase-folded to the derived orbital period of 0.4967 days. Forty new high-resolution, near-infrared spectra obtained with the Immersion Grating Infrared Spectrometer provide radial velocities and a projected rotational velocity (v sin i) of 14.7 ± 0.7 km/s for the M subdwarf. In tandem with a Gaia parallax-derived radius and verified tidal locking, we calculate an inclination of i = 29 ± 2 degrees. From the single-lined orbital solution and the inclination we derive an absolute mass for the unseen primary (1.24 -0.15+0.19 Msun). Its non-detection between 0.2 and 2.5 microns implies that it is an old (>3.7 Gyr) and cool (Teff < 7000 K) ONe white dwarf. This is the first ultramassive white dwarf within 25 pc. The evolution of Wolf 1130AB into a cataclysmic variable is inevitable, making it a potential SN Ia progenitor. The formation of a triple system with a primary mass >100 times the tertiary mass and the survival of the system through the common-envelope phase, where $\sim$80% of the system mass was lost, is remarkable. Our analysis of Wolf 1130 allows us to infer its formation and evolutionary history, which has unique implications for understanding low-mass star and brown dwarf formation around intermediate-mass stars.

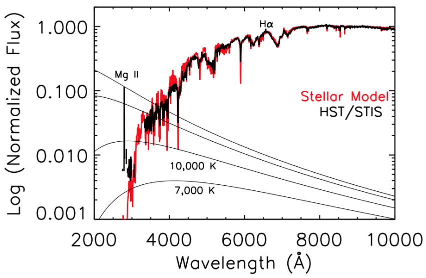


Figure 2. The HST/STIS spectrum of Wolf 1130AB where signal-to-noise is >5. Mg II and Hα emission are marked. The inclusion of the best fit BT-SETTL model (Allard 2014) with T_{eff}=3500 K, log g=4.83, and [Fe/H]= -1.3 illustrates the absence of flux from the more massive companion. Scaled Planck functions for 7,000, 10,000, 15,000 and 20,000 K black bodies are included for comparison. As discussed in Section 4.2, we find the temperature of the massive companion to be ≤7000K when we assume a white dwarf radius of 0.005 $R_{\odot}$.

2.2 High-resolution Near-IR Spectral Mapping with H2 and [Fe II] Lines of Multiple Outflows around LkHα 234

Oh et al. 2018 - We present a high-resolution, near-IR spectroscopic study of multiple outflows in the LkHα 234 star formation region using the Immersion GRating INfrared Spectrometer (IGRINS). Spectral mapping over the blueshifted emission of HH 167 allowed us to distinguish at least three separate, spatially overlapped outflows in H2 and [Fe II] emission. We show that the H2 emission represents not a single jet but rather complex multiple outflows driven by three known embedded sources: MM1, VLA 2, and VLA 3. There is a redshifted H2 outflow at a low velocity, VLSR <+50 km/s, with respect to the systemic velocity of VLSR = -11.5 km/s, that coincides with the H2O masers seen in earlier radio observations 2" southwest of VLA 2. We found that the previously detected [Fe II] jet with —VLSR— > 100 km/s driven by VLA 3B is also detected in H2 emission and confirm that this jet has a position angle of about 240 degrees. Spectra of the redshifted knots at 14"-65" northeast of LkHα 234 are presented for the first time. These spectra also provide clues to the existence of multiple outflows. We detected high-velocity (50-120 km/s) H2 gas in the multiple outflows around LkHα 234. Since these gases move at speeds well over the dissociation velocity (>40 km/s), the emission must originate from the jet itself rather than H2 gas in the ambient medium. Also, position-velocity and excitation diagrams indicate that emission from knot C in HH 167 comes from two different phenomena, shocks and photodissociation.

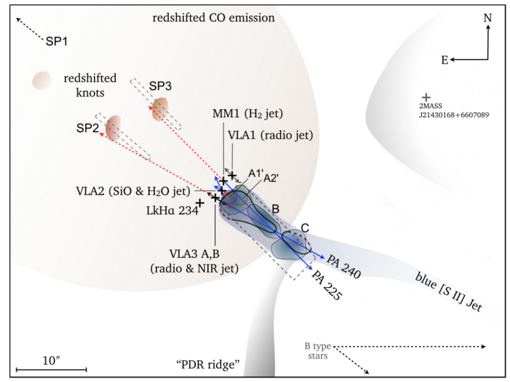


Figure 10. Schematic diagram of multiple outflows around LkHα 234. The crosses and solid arrows show the locations of YSOs and axes of the outflows, respectively. The regions within thin and thick solid lines represent 3σ level of H_2 1$-$0 S(1) and [Fe II] λ1.644 μm emission, respectively. The peaks A1′, A2′ and knots B, C are marked. The area of spectral mapping is marked with a dashed rectangle. The position of blueshifted [S II] jet is taken from Ray et al. (1990). Two red, dashed arrows are extensions of the blueshifted emission, which has PA of 240 and 225.

2.3 Magnetic Inflation and Stellar Mass II: On the Radii of Single, Rapidly Rotating, Fully Convective M Dwarf Stars

Kesseli et al. 2018 - Main sequence, fully-convective M dwarfs in eclipsing binaries are observed to be larger than stellar evolutionary models predict by as much as 10-15%. A proposed explanation for this discrepancy involves effects from strong magnetic fields, induced by rapid-rotation via the dynamo process. Although, a handful of single, slowly-rotating M dwarfs with radius measurements from interferometry also appear to be larger than models predict, suggesting that rotation or binarity specifically may not be the sole cause of the discrepancy. We test whether single, rapidly rotating, fully convective stars are also larger than expected by measuring their Rsini distribution. We combine photometric rotation periods from the literature with rotational broadening (vsini) measurements reported in this work for a sample of 88 rapidly rotating M dwarf stars. Using a Bayesian framework, we find that stellar evolutionary models underestimate the radii by 10-15%+3-2.5, but that at higher masses (0.18<M<0.4Msun) the discrepancy is only about 6% and comparable to results from interferometry and eclipsing binaries. At the lowest masses (0.08<M<0.18Msun), we find the discrepancy between observations and theory is 13-18%, and we argue that the discrepancy is unlikely to be due to effects from age. Furthermore, we find no statistically significant radius discrepancy between our sample and the handful of M dwarfs with interferometric radii. We conclude that neither rotation nor binarity is responsible for the inflated radii of fully convective M dwarfs, and that all fully-convective M dwarfs are larger than models predict.

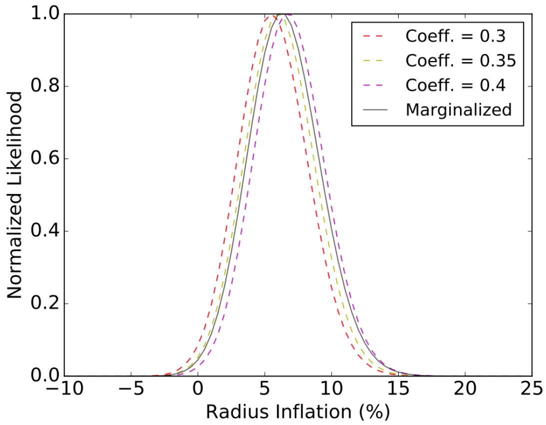


Figure 7. The resulting likelihood functions using a linear limb darkening coefficient of 0.3 (red) and 0.35 (yellow) and 0.4 (magenta), and the likelihood function marginalized over the limb darkening coefficient (grey). By using a limb darkening coefficient at the top and bottom of the range set by our stellar sample, we change the peak likelihood by $\sim$ 1%. This value is within our 1-sigma error bars for the likelihood function.

2.4 LHS 1610A: A Nearby Mid-M Dwarf with a Companion That Is Likely a Brown Dwarf

Winters et al. 2018 - We present the spectroscopic orbit of LHS 1610A, a newly discovered single-lined spectroscopic binary with a trigonometric distance placing it at 9.9 $\pm$ 0.2 pc. We obtained spectra with the TRES instrument on the 1.5 m Tillinghast Reflector at the Fred Lawrence Whipple Observatory located on Mt. Hopkins in AZ. We demonstrate the use of the TiO molecular bands at 7065-7165 Angstroms to measure radial velocities and achieve an average estimated velocity uncertainty of 28 m/s. We measure the orbital period to be 10.6 days and calculate a minimum mass of 44.8 $\pm$ 3.2 M Jup for the secondary, indicating that it is likely a brown dwarf. We place an upper limit to 3σ of 2500 K on the effective temperature of the companion from infrared spectroscopic observations using IGRINS on the 4.3 m Discovery Channel Telescope. In addition, we present a new photometric rotation period of 84.3 days for the primary star using data from the MEarth-South Observatory, with which we show that the system does not eclipse.

2.5 Multi-band high resolution spectroscopy rules out the hot Jupiter BD+20 1790b. First data from the GIARPS Commissioning

Carleo et al. 2018 - Context. Stellar activity is currently challenging the detection of young planets via the radial velocity (RV) technique. Aims: We attempt to definitively discriminate the nature of the RV variations for the young active K5 star BD+20 1790, for which visible (VIS) RV measurements show divergent results on the existence of a substellar companion. Methods: We compare VIS data with high precision RVs in the near-infrared (NIR) range by using the GIANO-B and IGRINS spectrographs. In addition, we present for the first time simultaneous VIS-NIR observations obtained with GIARPS (GIANO-B and HARPS-N) at Telescopio Nazionale Galileo (TNG). Orbital RVs are achromatic, so the RV amplitude does not change at different wavelengths, while stellar activity induces wavelength-dependent RV variations, which are significantly reduced in the NIR range with respect to the VIS. Results: The NIR radial velocity measurements from GIANO-B and IGRINS show an average amplitude of about one quarter with respect to previously published VIS data, as expected when the RV jitter is due to stellar activity. Coeval multi-band photometry surprisingly shows larger amplitudes in the NIR range, explainable with a mixture of cool and hot spots in the same active region. Conclusions: In this work, the claimed massive planet around BD+20 1790 is ruled out by our data. We exploited the crucial role of multi-wavelength spectroscopy when observing young active stars: thanks to facilities like GIARPS that provide simultaneous observations, this method can reach its maximum potential.

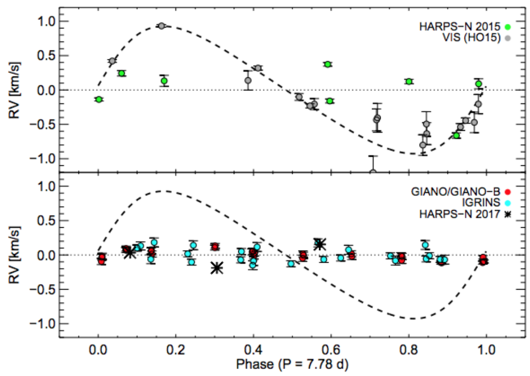


Fig. 1. Orbital fit at 7.78 days found by HO15 compared to phase-folded visible and NIR RVs. Top panel: Orbital fit (black dashed line) obtained with the visible data (FOCES, SARG, and HERMES RVs from HO15, grey dots) and HARPS-N 2015 RVs (green dots). Bottom panel: Orbital fit (black dashed line), GIANO/GIANO-B (red dots), IGRINS (light blue dots), and HARPS-N 2017 (black asterisks, two acquired in GIARPS mode) RVs.

3 Publication Policy

Observing PIs are expected to analyze and publish their data promptly. The current proprietary period is 24 months from the date the data are taken. Decisions about authors and author orders of publications are the responsibility of the proposal PI. The IGRINS team member(s) on the observing proposal(s) should be included as paper authors. Wherever possible, PI's should seek reasons to give first authorships to junior team members, in particular to students and postdocs. All authors should have intellectual ownership of the material and have contributed to the work. The IGRINS team is committed to ethics in publication and does not condone courtesy authorships. For this reason, please involve junior team members throughout the scientific process.

Acknowledgements: The standard acknowledgement for IGRINS is: "This work used the Immersion Grating Infrared Spectrometer (IGRINS) that was developed under a collaboration between the University of Texas at Austin and the Korea Astronomy and Space Science Institute (KASI) with the financial support of the US National Science Foundation under grants AST-1229522 and AST-1702267, of the University of Texas at Austin, and of the Korean GMT Project of KASI." The facility that IGRINS is used at should also be acknowledged. IGRINS' spectral resolution is R$\sim$45,000. Any paper using IGRINS science or engineering data must reference the designated IGRINS instrument citations(s):

Park, C. et al., Design and early performance of IGRINS (Immersion Grating Infrared Spectrometer), Proc. SPIE 9147 (2014).

Jae-Joon Lee, Kevin Gullikson, & Kyle Kaplan. (2017, August 18). igrins/plp 2.2.0. Zenodo. http://doi.org/10.5281/zenodo.845059

Mace, G. et al., 300 nights of science with IGRINS at McDonald Observatory, Proc. SPIE 9980 (2016).

Refereeing: The IGRINS team has an internal refereeing process for observing and instrumentation papers. We strongly recommend that all papers to be submitted to a refereed journal, and using IGRINS data or technical information, go through the IGRINS internal refereeing process. Papers for non-refereed conference proceedings may also make use of this service. Revisions in response to these comments can be made at the discretion of the authors. First authors should inform Jae-Joon Lee (leejjoon@kasi.re.kr), Kimberly Sokal (ksokal@utexas.edu), and/or Lisa Prato (lprato@lowell.edu) of submitted papers. At the time of acceptance, please provide us with the title, journal, volume, and full author list.