# Searching for Hidden Black Holes in APOGEE-2

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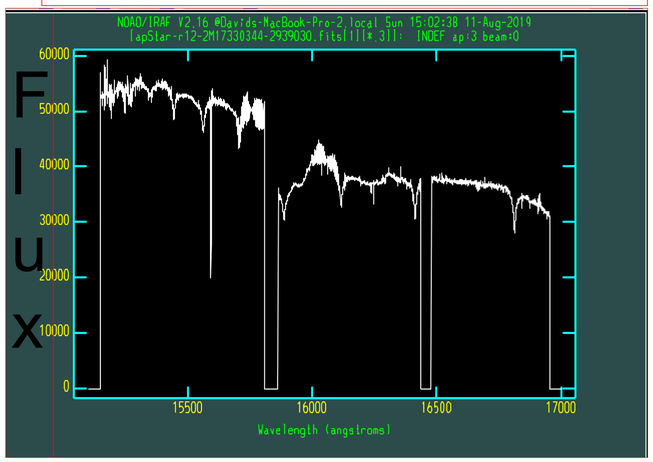
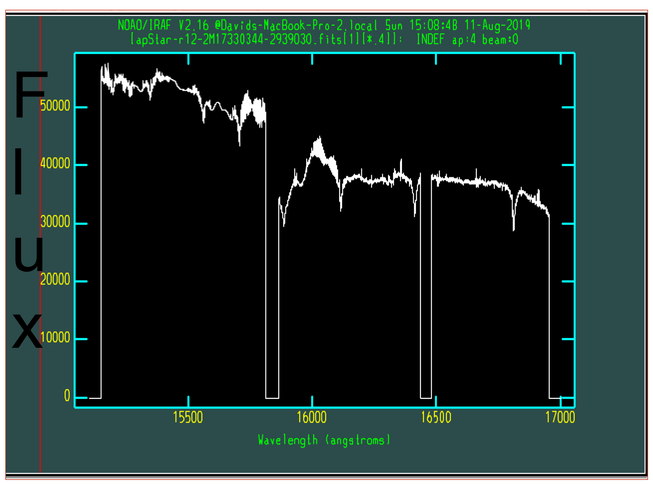
## Abstract

The Milky Way is believed to contain thousands of stellar mass black hole X-ray binaries, but only about 50 candidates are known. I discuss an examination of the APOGEE-2 data for X-ray sources in the Swift Galactic Bulge Survey region. The object HD 158902 stood out as warranting further investigation, because it showed a radial velocity discrepancy between archival data and APOGEE-2. I discuss my work in determining whether this is due to binary motions or other causes.


## Introduction

I worked with APOGEE-2 data, whose primary goal was to map the chemistry and dynamics of cool stars using high resolution infrared spectroscopy. But this data set is big enough to be used for other purposes. I took APOGEE-2 infrared data and matched it with SWIFT and CHANDRA X-ray data. After doing so I found 4 matches, one of which is interesting. This object happens to be HD158902, a very bright blue giant. Because this star is so bright, 7.2 magnitude, there has been multiple explorations of this object. We have 4 counts in 2000 seconds with Chandra (see Jonker et al. 2014) and 4 counts in 120 seconds with Swift (Bahramian et al, from the Swift Galactic Bulge Survey project). Using Poisson statistics there's about a 1 in 10,000 chance of getting that much variability between X-ray detections. This makes it most likely for accretion since there isn't much variability in detections from stellar wind X-rays. We also get the count rate to read a flux of 10^-12 erg/sec/cm^2. From Gaia we can calculate the distance to be about 1.55 kpc, that gives 3*10^32 erg/sec at the bright epoch, and 1.7*10^31 at the faint end. What makes this interesting is the radial velocity (see Zentelis 1983) is -45.7km/s, while the new data from APOGEE-2 shows a velocity closer to +10km/s. Using various methods we were also able to calculate an approximate radius and velocity. Because of the X-ray luminosity we can assume the star is not Roche Lobe filling, so the orbit is probably significantly more than 6 days and thus wind fed.

## SIMBAD

**Basic data :**

**HD 158902** -- Star

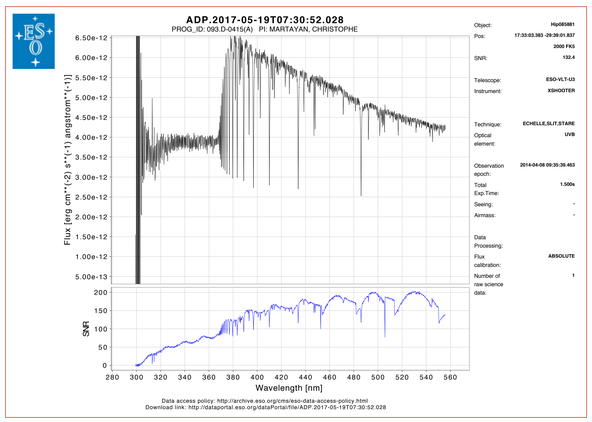
| | |
|---|---|
| Other object types: | * (Ref,HD,...), V* (ASAS), IR (2MASS), UV ([SC96]), X (CXOGBS) |
| **ICRS** coord. *(ep=J2000) :* | 17 33 03.4409083968 -29 39 03.038562608 (Optical) [ 0.0457 0.0410 90 ] |
| **FK4** coord. *(ep=B1950 eq=1950) :* | 17 29 51.9427259171 -29 36 58.411314081 [ 0.0457 0.0410 90 ] |
| **Gal** coord. *(ep=J2000) :* | 357.9361159077809 +01.9376504919312 [ 0.0457 0.0410 90 ] |
| Proper motions *mas/yr* : | -0.594 -2.381 [0.088 0.067 90] A 2018yCat.1345....0G |
| Radial velocity / Redshift / cz : | V(km/s) -45.70 [2.4] / z(~) -0.000152 [0.000008] / cz -45.70 [2.40] C 2006AstL...32..759G |
| Parallaxes *(mas)*: | 0.6449 [0.0558] A 2018yCat.1345....0G |
| Spectral type: | B3II C 1982MSS...C03....0H |
| Fluxes (8) : | U 7.31 [~] D 2003AJ....125.2531R |
| | B 7.535 [0.015] D 2000A&A...355L..27H |
| | V 7.217 [0.011] D 2000A&A...355L..27H |
| | R 8.18 [0.21] E 2012yCat.1322....0Z |
| | G 7.0728 [0.0007] C 2018yCat.1345....0G |
| | J 6.274 [0.021] C 2003yCat.2246....0C |
| | H 6.170 [0.034] C 2003yCat.2246....0C |
| | K 6.063 [0.023] C 2003yCat.2246....0C |

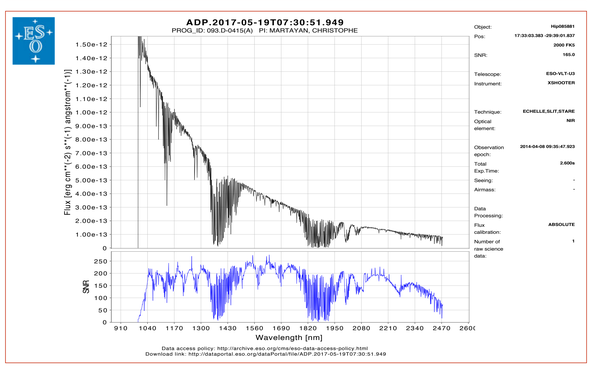
## Preliminary Results

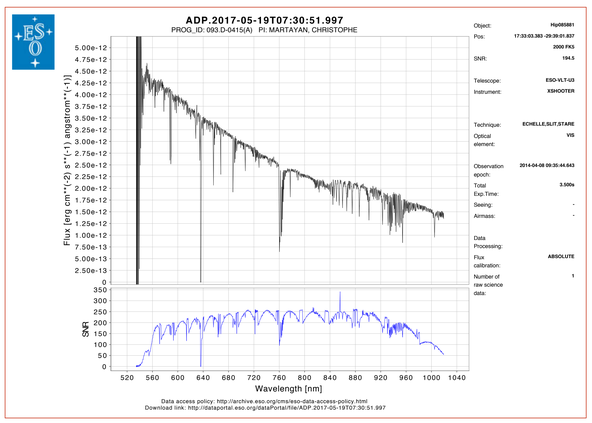
| Velocity | AVG Velocity | STANDEV |
|---|---|---|
| -14.46631044 | 8.841507594 | 19.72156245 |
| 10.87864483 | | |
| -8.482908867 | | |
| 6.494746896 | | |
| 45.89264018 | | |
| 28.11272396 | | |
| -0.731185679 | | |
| 3.03370987 | | |

| Velocity | AVG Velocity | STANDEV |
|---|---|---|
| -14.26671037 | 4.498697259 | 21.49012072 |
| -8.022922636 | | |
| 44.38177137 | | |
| 10.98444181 | | |
| -8.225838883 | | |
| 2.141442261 | | |

## ESO Archive




## References:


Jonker, 2014, *The Galactic Bulge Survey: Outline and X-ray Observations.*

Zentelis, 1983, A&AS, *Radial velocities for early type stars in six galactic regions.*


## Methods

$$\frac{R_{BG}}{R_{DW}} = \left(\frac{F_{BG}}{F_{DW}}\right)^{1/2}\left(\frac{d_{BG}}{d_{DW}}\right)$$

$$\frac{P_{RLOF}}{10h} = \left(\frac{p}{p_*}\right)^{-1/2}$$

v_giant = 33 km/sec (P/6 days)^(-1/3) for a 1.4 solar mass neutron star and 10 solar mass bright giant.

v_giant = 160 km/sec (P/6 days)^(-1/3) for a 10 solar mass black hole and a 10 solar mass bright giant.

## Conclusion

In conclusion, the data from APOGEE-2 suggests a significant change in radial velocity. To follow up, we will use the ESO archive data to cross correlate with the multiple visits and calculate the radial velocity shifts. We will then look into crossing out the idea this is a star-star binary system. If needed, we will look into getting more data through the Gemini poor weather submissions.