

# MUSE integral field unit observations of the compact objects in the globular cluster NGC 6397

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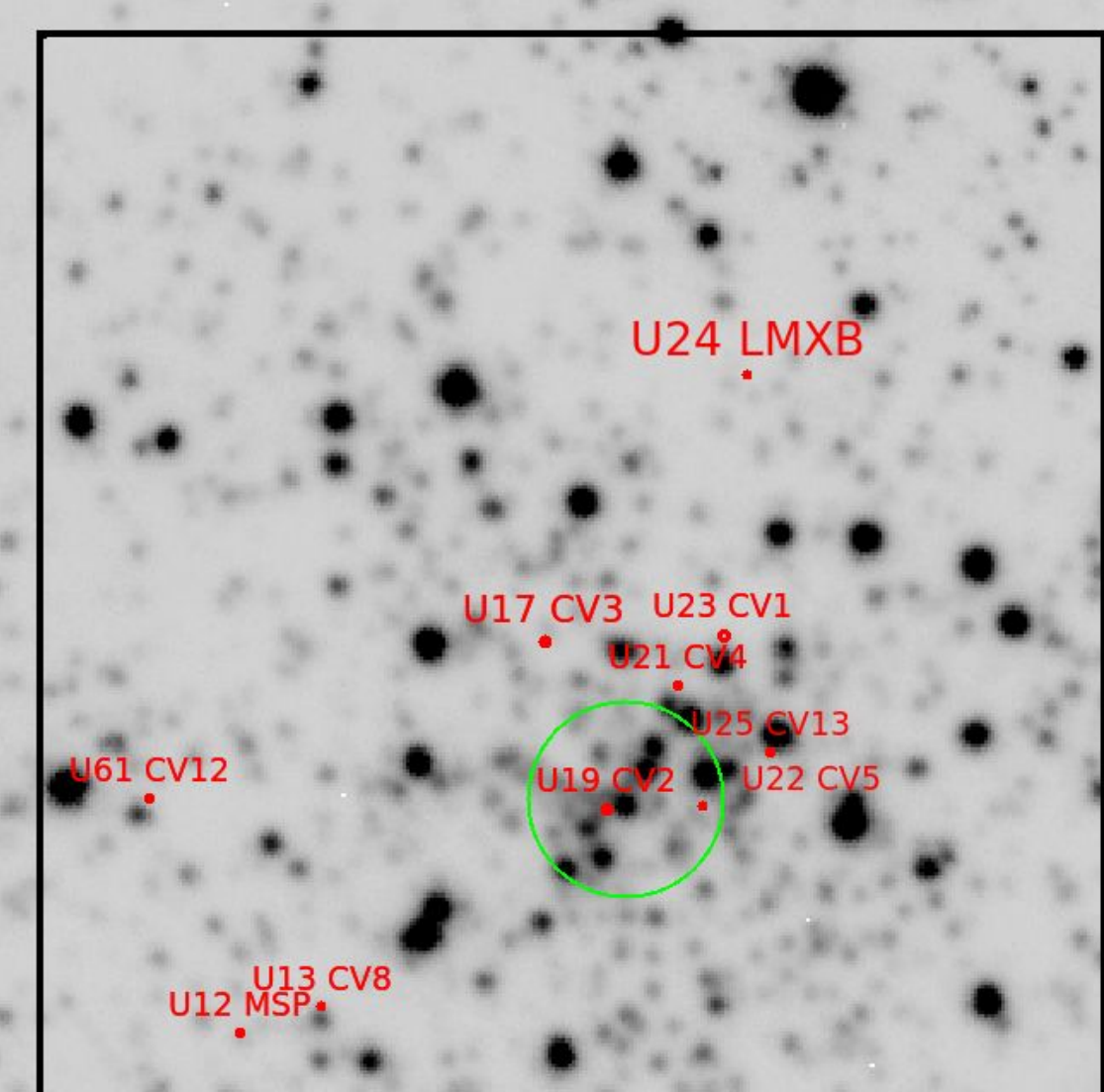
## Abstract

Globular clusters are very old groups of stars. Due to their age and the gravitational interactions dominating the dynamics of the clusters, they are home to a significant fraction of compact binaries. The formation and evolution of these kinds of binaries is still not completely understood. Using MUSE and Hubble archival data we plan to characterize the compact binary population in them. With MUSE, in the cluster NGC 6397, we have been able, so far, to spectroscopically confirm two new cataclysmic variables (CV) candidates as well as retrieve higher quality spectra of the four previously identified CVs and of a candidate millisecond pulsar (MSP). With Hubble archival data we have been able to recover the period for the brightest CVs, as well as for the MSP candidate. The observed 1.9 days period for the MSP, suggest that it is a new redback pulsar candidate in a globular cluster. Altogether we have demonstrated how an IFU like MUSE, and archival data from Hubble can be used to efficiently study the population of compact objects in globular clusters.

## Goals

- Spectroscopically confirm the CV and AB population in NGC 6397.
- Find orbital periods of the compact binary population of NGC 6397

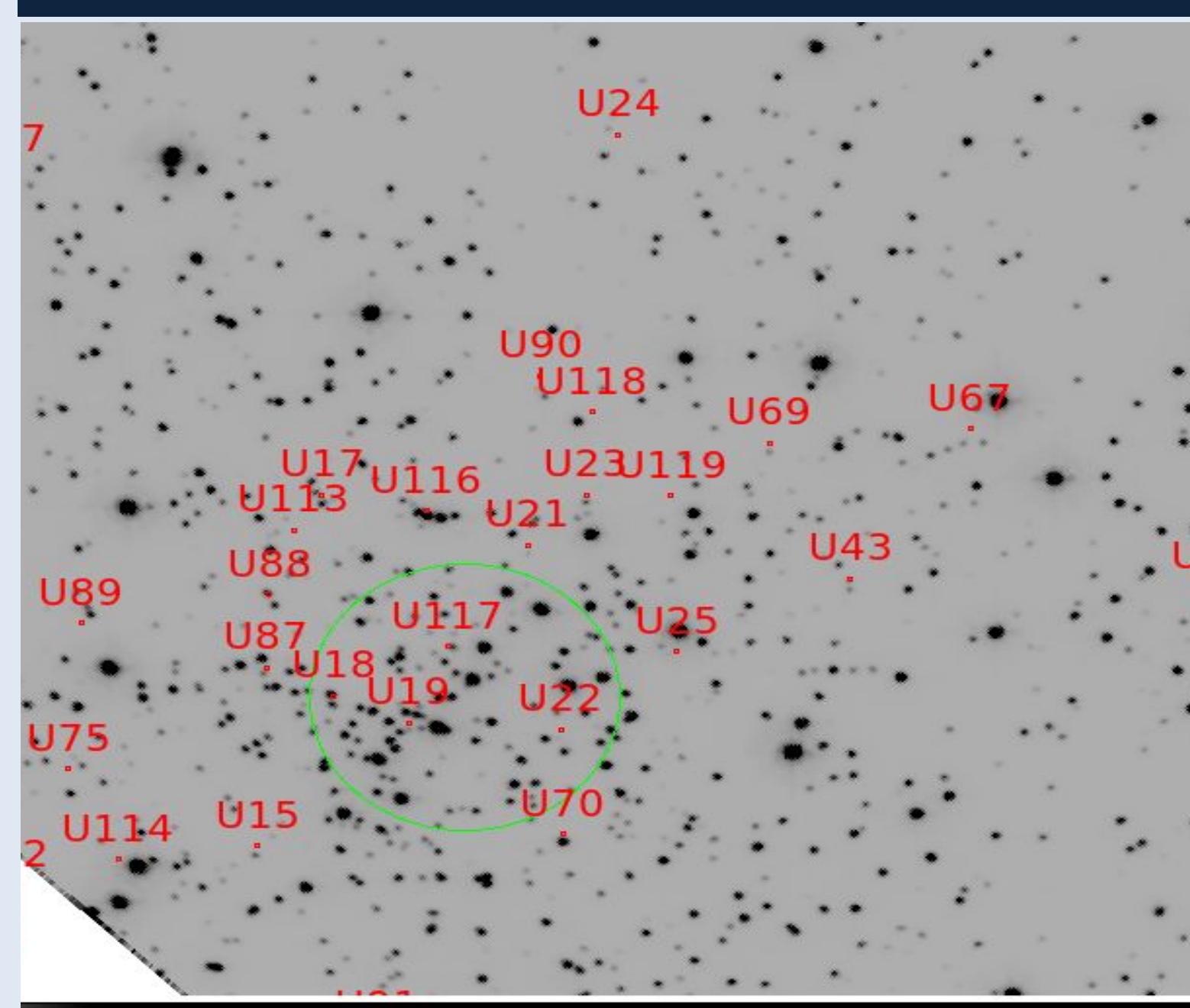
## MUSE



- Integral-Field Spectrograph
- Range of 480-930 nm
- 1' X 1' FOV
- 5 CVs with strong H $\alpha$  emission (0.07' to 1.21' from the center)
- 2 new CV spectra (U10 and U22)

Fig. 1. MUSE exposure of the central region of NGC 6397. The black square represents the 1" FOV and the green circle the core radius. Each of the red points corresponds to a compact object (Cohn 2010).

## NGC 6397



- 2.3 kpc (Harris 1996)
- 15 CV candidates
- Only 4 spectroscopically confirmed
- All 4 CVs proposed to be magnetic.
- 2 CVs known periods [4]
- 1 qLMXB
- 2 MSPs
- 0.05' core radius
- 2.9' half-light radius

Fig. 2. (2015) Hubble Space Telescope image of the cluster (126 exposures 500-700 s exp. time).

## The two new spectra

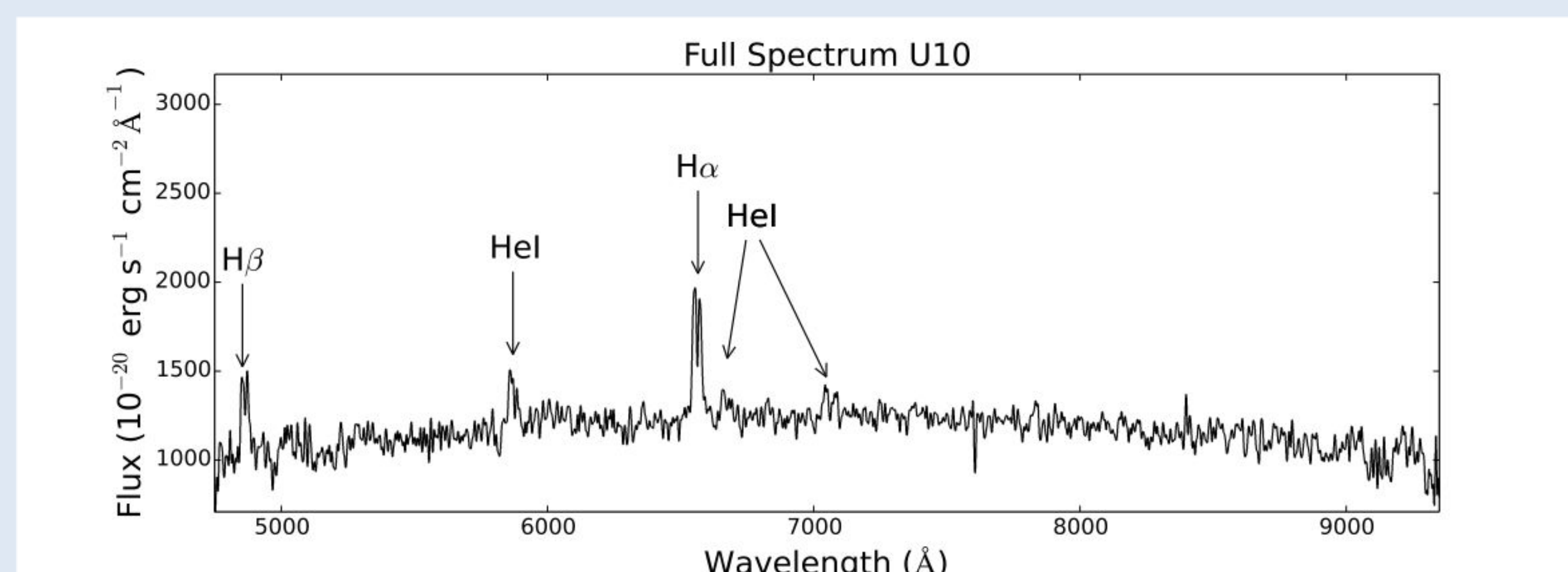


Fig. 3. Spectrum of U23 with strong Hydrogen double peaked emission (characteristic of an accretion disk), and strong Helium I lines.

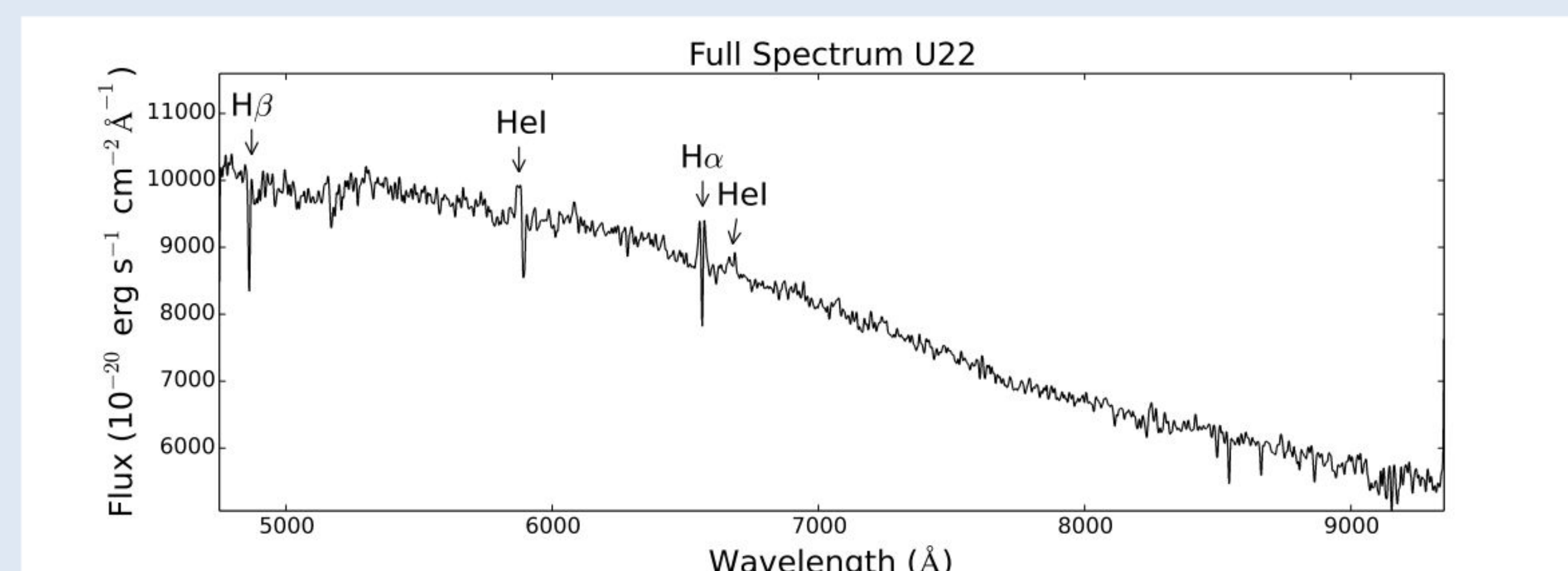


Fig. 4. Spectrum of U22 with strong H $\alpha$  double peaked emission, absorption in the H $\beta$  line, and Helium I lines.

## New light-curves

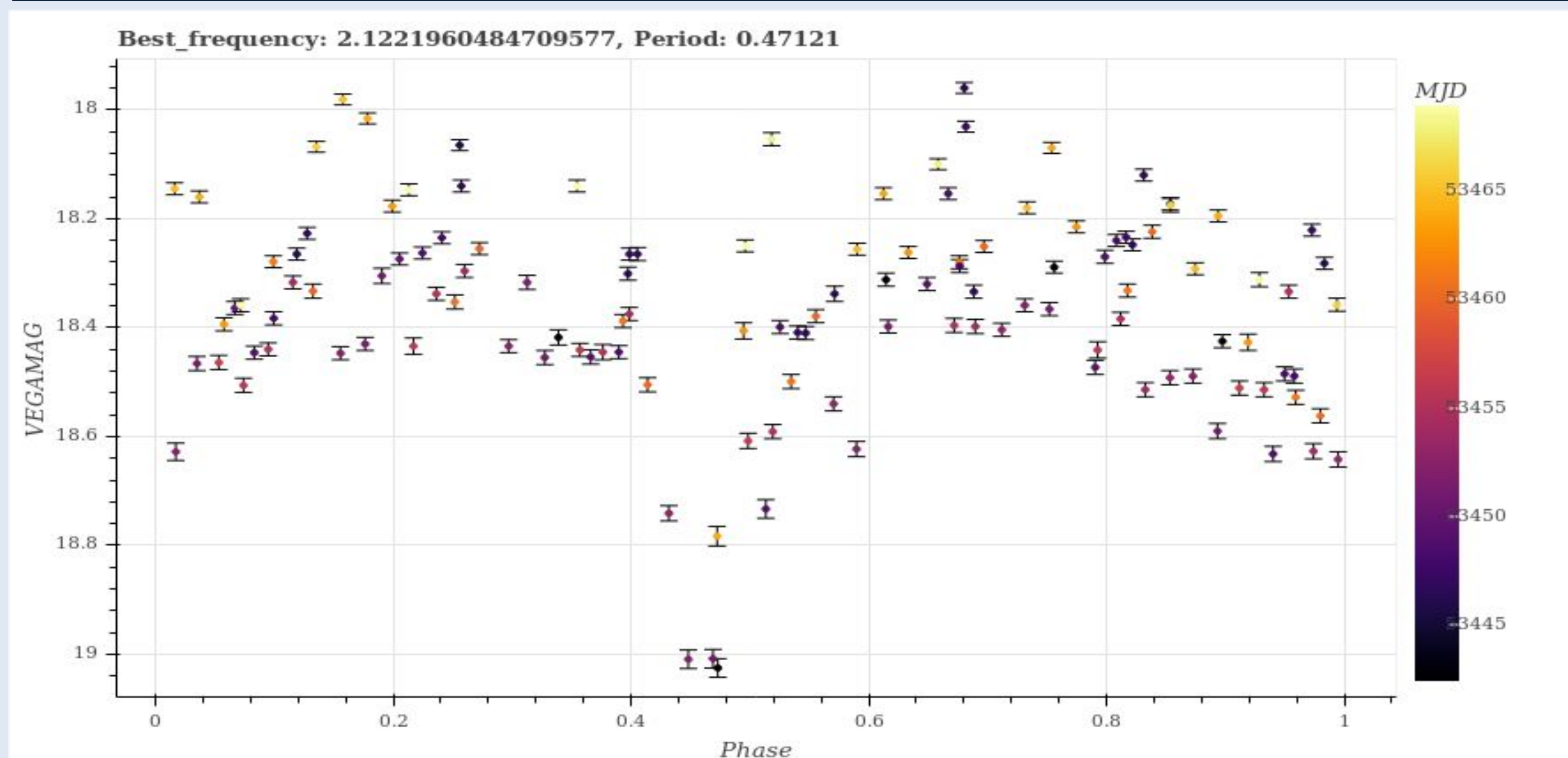


Fig. 5. Example folded light-curve for CV1 (U23) with a period of 0.47 days, showing a possible eclipse in the light-curve

## New redback candidate

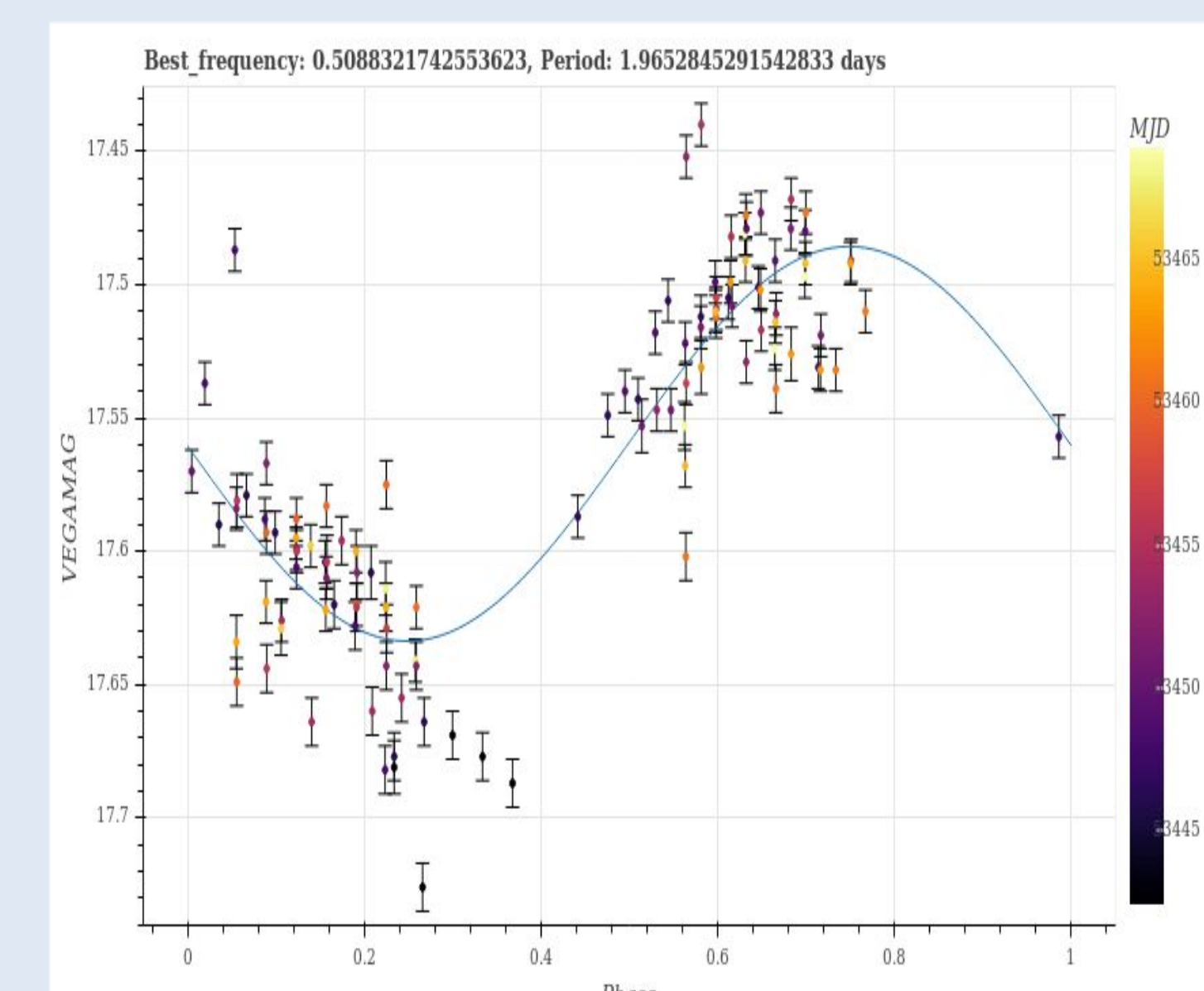


Fig. 6. Phased-fold light-curve light for U18. The found period of 1.9 days of the millisecond pulsar candidate and the emission line variability found by Kamman et al. (2018) suggest it is a 'redback'.

- U18 is a candidate MSP (Bogdanov 2016)
- MSP candidate near center
- Massive NS in GCs
- Large radial velocity ( $> 140$  km/s. (Kamman et al. 2018)
- K sub-giant companion with cooler and hotter side (redback).
- Total mass  $\sim 0.4$  Solar Masses.

## Results and Discussion

- Two new spectrally confirmed CVs (U10 and U22). U10 at a distance of 1.21' from the cluster center
- Presence of helium lines in all detected CVs and comparable H $\beta$  EW. Possibly all are magnetic
- Period found for a redback MSP candidate
- 10 known variables in the HST field-of-view
- 4 CVs in the Hubble FoV with UV light-curves
- Work in progress to finish searching for variability and orbital periods of all X-ray sources in the cluster.

## Acknowledgements

This project started in the University Paul Sabatier under the supervision of Natalie Webb and Sebastien Guillot and continued at TTU under the supervision of Thomas Maccarone. I will like to acknowledge also the help of Liliana Rivera Sandoval and Anna McLeod at TTU.

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